Phase 2

Remedial Investigation Report

for

Naval Weapons

Industrial Reserve Plant

Bethpage, New York

Volume I

Northern Division

Naval Facilities Engineering Command

Contract Number N62472-90-D-1298

Contract Task Order 0089

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PHASE 2
REMEDIAL INVESTIGATION REPORT
FOR
NAVAL WEAPONS INDUSTRIAL RESERVE PLANT
BETHPAGE, NEW YORK

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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NYSDEC 033209

EXECUTIVE SUMMARY

This report addresses the Phase 2 Remedial Investigation (RI) activities conducted at the Naval Weapons Industrial Reserve Plant (NWIRP) Bethpage, New York. A Phase 1 RI was completed in May 1992. The results of the Phase 1 RI indicated the presence of soils contaminated with metals, polychlorinated biphenyl (PCBs), and solvents and groundwater contaminated with solvents and metals. The investigation was limited to onsite soils and groundwater. The overall objective of this Phase 2 RI was to further characterize the nature and extent of environmental contamination and associated risks to human health and the environment at the NWIRP. The primary areas addressed during the Phase 2 RI were to determine the nature of soils contaminated with PCBs and to determine the extent of offsite groundwater contaminated with volatile organics. In addition, an investigation was conducted in an attempt to locate the source of significant TCE contamination in groundwater southwest of Plant No. 3. The data collected during the Phase 2 RI, in conjunction with the Phase 1 results, will be used to develop and evaluate potential remedial options in a Feasibility Study (FS). The FS is being prepared concurrently and will be issued under separate cover.

The following summary of the nature and extent of contamination is structured by site or location and the types of investigative activities conducted.

Site 1: Former Drum Marshaling Area

The Phase 1 and Phase 2 soil testing program indicated wide spread low-level PCB contamination of the surface soils at Site 1. The majority of the contaminated soils contain PCBs at a concentration of 10 mg/kg or less. However, soils at two locations contain PCBs at concentrations greater than 10 mg/kg. One area is near the southwestern portion of Site 1 (30 mg/kg PCBs) and the other area is along the western edge of Site 1 (1,470 mg/kg PCBs). VOC and inorganic contamination of the soils was also detected during the Phase 1 RI.

As a result of the presence of PCBs in surface soils at a concentration significantly greater than 50 mg/kg, an interim action was taken to protect human health. This interim action reduced overall risks to offsite residents and onsite workers by a factor of approximately 5 and 20, respectively. The current excess cancer risk to offsite residents and onsite workers, resulting from Site 1 soils, is less than $1x10^{-6}$ and approximately $1x10^{-5}$, respectively.

The groundwater monitoring program results at Site 1 continue to indicate that this site is a significant source of volatile organic contamination. The two temporary monitoring wells installed during the Phase 2 investigation and placed immediately upgradient and downgradient of the northern (cinder-based) former pad appear to confirm that this location is a significant contributor to the contamination.

There is sufficient information available to proceed with a FS for Site 1. However, additional PCB and arsenic testing of site soils may be required as part of predesign testing.

NYSDEC 033210

Site 2: Recharge Basin Area

Similar to Site 1, PCBs were widely found in the surface soils at Site 2, with a maximum concentration of 7.4 mg/kg. Subsurface (3 to 5 feet deep) PCB soil contamination is likely limited to the southeast corner of Site 2 (6.8 mg/kg) and the northern edge of the Site 2, near the former sludge drying beds (36.6 mg/kg). VOC and inorganic contamination of the soils was detected during the Phase 1 RI. Limited PCB contamination of the basin sediments were also found. However, basin sediment is routinely removed by Grumman Corporation.

Based on the results of groundwater investigations and computer modeling, it is likely that the recharge basins at Site 2 act as a secondary source of solvent contaminated groundwater. Contaminated water extracted from production wells at other areas of the NWIRP and Grumman Corporation are reintroduced into the groundwater at Site 2. Grumman is actively pursuing treatment of this water prior to reinjection.

There is sufficient information available to proceed with a FS for Site 2. However, additional PCB testing of site soils may be required as part of predesign testing.

Site 3: Salvage Storage Area

The Phase 1 and 2 RI data indicate that PCBs are not a significant concern at the areas tested at Site 3. The Phase 1 RI data did find VOC and inorganic soil and groundwater contamination at Site 3.

There is sufficient information available to proceed with a FS for Site 3.

HN-24 Area

Trichloroethene (TCE) is a significant groundwater contaminant in this area and is associated with a dense clay layer at a depth of approximately 135 feet bgs. However, direct sampling and analysis of this clay did not find similar levels of contamination. The source of the TCE contamination is not likely to be Site 1, the former coal pile area, Plant No. 10, or the Hooker/RUCO Superfund Site. The exact source of this contamination has not been identified and all potential sources have been investigated without success. Based on the ring of monitoring wells, groundwater remediation in this area can be addressed in an FS without an exact known source.

Solvent contamination was found in the NWIRP and Grumman production wells. Contamination of the NWIRP wells has been likely caused by a combination of Site 1 sources, recharge basin water, and upgradient industrial facilities. Vinyl chloride was detected in one production well at a very high concentration.

NYSDEC 033211

Plant No. 3

A two stage soil gas program was conducted to determine if there are sources of solvent contamination in Plant No. 3. Additionally, this data was used to supplement the Phase 1 RI soil gas survey and determine the need for remediation of soils under and near Plant No. 3. The first stage of the Phase 2 soil gas program was semi-quantitative using an OVA to provide real-time readings of the concentration of total organic compounds in the soil gas at each sampling location. This soil gas survey was designed to be a relatively non-intrusive, preliminary field screening technique. The second stage soil gas program was quantitative with a gas chromatograph (GC) used to determine chemical specific soil gas concentrations.

The findings from the soil gas program indicate that VOC contaminated soils are present under Plant No. 3 in the areas of the former Honeycomb Area and the current Flo-Coat Area. This contamination may be associated with these processes and/or it may result from Site 1 contamination.

The former TCE storage tanks located outside the northeast corner of Plant No. 3 are not a source of significant volatile organic contamination. Soil gas samples taken at the locations of these two former TCE tanks were found to contain only TCE at 0.7 ug/l and 0.03 ug/l, and PCE at 0.2 ug/l.

Drum Area near Northern Warehouses

Grumman operates a drum area for raw materials on a concrete pad located north of the Northern warehouses. Analytical results from soil gas samples taken at this pad indicate that this drum area is not a likely source of significant volatile organic contamination. TCE was detected at a maximum concentration of 12 ug/l and PCE was detected at a maximum concentration of 3 ug/l.

Offsite: Residential Neighborhood

A temporary monitoring well program and a permanent monitoring well program were conducted in the residential neighborhood to the east of the NWIRP to determine the extent of groundwater contamination in this area.

Based on the offsite monitoring well program, as well as computer modeling results, the shallow groundwater contamination associated with Site 1 is limited to areas within approximately 100 feet east of Site 1, but continues on south to near the Long Island Railroad. Additional shallow groundwater contamination from the Site 2 - recharge basins likely exists at several locations. Intermediate-depth groundwater contamination in the residential neighborhood extends east toward Stewart Avenue and south to the Long Island Railroad. A portion of this contamination may be directly attributable to Site 1. However, the majority of the contaminated area is likely associated with the Site 2 - recharge basin water.

NYSDEC 033212

The Phase 1 RI (HNUS 1992) developed a full range of potential migration routes, including dust migration and transport via groundwater. Contaminant fate considerations were also presented in the Phase 1 RI report. Since new contaminants were not observed during the Phase 2 RI, contaminant fate considerations were not repeated in this report.

The general objectives of the RI computer modeling were to provide data on the overall groundwater flow in the area of the NWIRP and to determine the potential flow directions of contaminants which may originate at the NWIRP. The specific objectives of the computer modeling at Bethpage NWIRP are as follows.

- Provide a general characterization of the subsurface conditions underlying Bethpage NWIRP.
- Develop a flow model which accurately represents groundwater flow in the area around the Grumman site, with an emphasis on the groundwater flow in and around the NWIRP.
- Model the flow directions of simulated contaminant releases under a variety of production well and NWIRP recharge basin pumping conditions.

Particle tracking indicates that under current pumping conditions, particles released from Site 1 will all be captured by Grumman production wells, and Bethpage Water District (BWD) wells will not capture particles from the NWIRP Site 2 - recharge basins. Under high pumping conditions (historic) at Grumman and average BWD usage rates, Site 1 particles are again all captured by Grumman production wells. However, a small number of particles may effect BWD well BP-08, and to a lesser extent, BWD well BP-09. If Grumman production wells and BWD wells pump at a high rate for sustained periods (as simulated by the steady-state model), all Site 1 particles are again captured by Grumman production wells, and 19% of the particles released may move from the NWIRP Site 2 - recharge basins to BWD wells. These pumping conditions may have occurred in the past, although the high pumping conditions may not have continued for extended periods of time as simulated in the steady-state model runs. Assuming no Grumman production well or recharge basin activity and average pumping conditions at the BWD wells, Site 1 particles move to the southern constant head boundary, and the capture zone of the BWD wells is not effected by NWIRP Site 2 - recharge basins. Under high BWD well pumping rates and no Grumman production wells operating, particles released from Site 1 are captured by BWD wells BP-10 and BP-11 (Plant 4).

NYSDEC 033213

1.0 INTRODUCTION

1.1 PURPOSE OF REPORT

The work to be performed under Contract N62472-90-D-1298, Contract Task Order (CTO) 0089, is to conduct a Phase 2 Remedial Investigation (RI) and a Feasibility Study (FS) at the Naval Weapons Industrial Reserve Plant (NWIRP), Bethpage, New York. This report specifically addresses the Phase 2 RI activities. A Phase 1 RI was completed in May 1992. A FS is being prepared concurrently and will be issued under separate cover.

This work is part of the Navy's Installation Restoration (IR) Program, which is designed to identify contamination of Navy and Marine Corps lands/facilities resulting from past operations and to institute corrective measures, as needed. There are typically four distinct stages. Stage 1 is the Preliminary Assessment (formerly known as the Initial Assessment Study). Stage 2 is a Site Investigation, which augments the information collected in the Preliminary Assessment. Stage 3 is the Remedial Investigation/Feasibility Study (RI/FS), which characterizes the contamination at a facility and develops options for remediation of the site. Stage 4 is the Remedial Action, which results in the control or cleanup of contamination at sites. This report was prepared under Stage 3 (RI/FS).

1.2 SCOPE AND OBJECTIVES

The overall objective of this Phase 2 RI is to further characterize the nature and extent of environmental contamination and associated risks to human health and the environment at the NWIRP. A Phase 1 RI was completed in May 1992 (HNUS, 1992). The results of this RI indicated the presence of soils contaminated with metals, PCBs, and solvents and groundwater contaminated with solvents and metals. A summary of the Phase 1 results is presented in Section 1.4. The data collected during the Phase 2 RI, in conjunction with the Phase 1 results, will be used to develop and evaluate potential remedial options in the FS. The specific objectives for the Phase 2 RI are as follows.

- Further define the horizontal extent of volatile organic-contaminated groundwater, particularly in offsite areas south and east of the former drum marshaling area and the vertical extent of volatile organic-contaminated groundwater in the area south of the former drum marshaling area.

- Quantify the concentration of PCBs in onsite soils. PCBs were confidently detected in most site soil samples in which they were analyzed. However, PCBs were tentatively identified in many site soils in which no PCB analysis was performed.

- Determine groundwater flow conditions at and adjacent to the NWIRP site.

NYSDEC 033215

Similar investigations are currently under way at the Grumman Corporation Bethpage and RUCO Polymer Corporation (RUCO) facilities. Other potential sources of this contamination may exist.

1.3 ACTIVITY BACKGROUND INFORMATION

1.3.1 Activity Location and Description

The NWIRP is situated on 108 acres in Nassau County in the Hamlet of Bethpage, Town of Oyster Bay, New York (see Figure 1-1). The NWIRP lies entirely within the Grumman Aerospace complex, which covers approximately 605 acres (see Figure 1-2). The NWIRP is bordered on the north, west, and south by Grumman facilities, and on the east by a residential neighborhood.

The climate at NWIRP is described as a fairly humid, modified continental climate. The nearby Atlantic Ocean and Long Island Sound tend to reduce the temperature range commonly encountered further inland. The highest monthly mean temperature occurs in July (74.9 degrees); the lowest occurs in January (31.4 degrees). The mean annual precipitation is 45 inches, and the mean annual evapotranspiration is about 22 inches (RGH, 1986).

1.3.2 Activity History

The histories of the NWIRP and Grumman Aerospace facilities are discussed in detail in the Initial Assessment Study of the NWIRP (RGH, 1986) and the RI/FS Work Plan for the Grumman facility prepared by Geraghty and Miller (G&M, 1990). The following synopsis is from those discussions.

The NWIRP was established in 1933. Since its inception, the plant's primary mission has been the research prototyping, testing, design engineering, fabrication, and primary assembly of military aircraft.

The facilities at NWIRP (see Figures 1-2 and 1-3) include four plants (Nos. 3, 5, and 20, used for assembly and prototype testing; and No. 10, a group of quality control laboratories), two warehouse complexes (north and south), a salvage storage area, water recharge basins, the Industrial Wastewater Treatment Plant (to process chemical effluent from the activity's manufacturing operations), and several smaller support buildings.

An Initial Assessment Study (IAS) of NWIRP Bethpage, New York, and NWIRP Calverton, New York, conducted in 1986 (RGH, 1986) indicated that three areas at the NWIRP Bethpage may pose a threat to human health or the environment. These three sites are Site 1 - Former Drum Marshaling Area (identified as Site 7 in the IAS), Site 2 - Recharge Basin Area (identified as Site 8 in the IAS), and Site 3 - Salvage Storage Area (identified as Site 9 in the IAS). These sites were renumbered to avoid confusion with the site designations at the Calverton NWIRP. Figure 1-3 presents the location and general layout of the three sites at Bethpage.

NYSDEC 033216

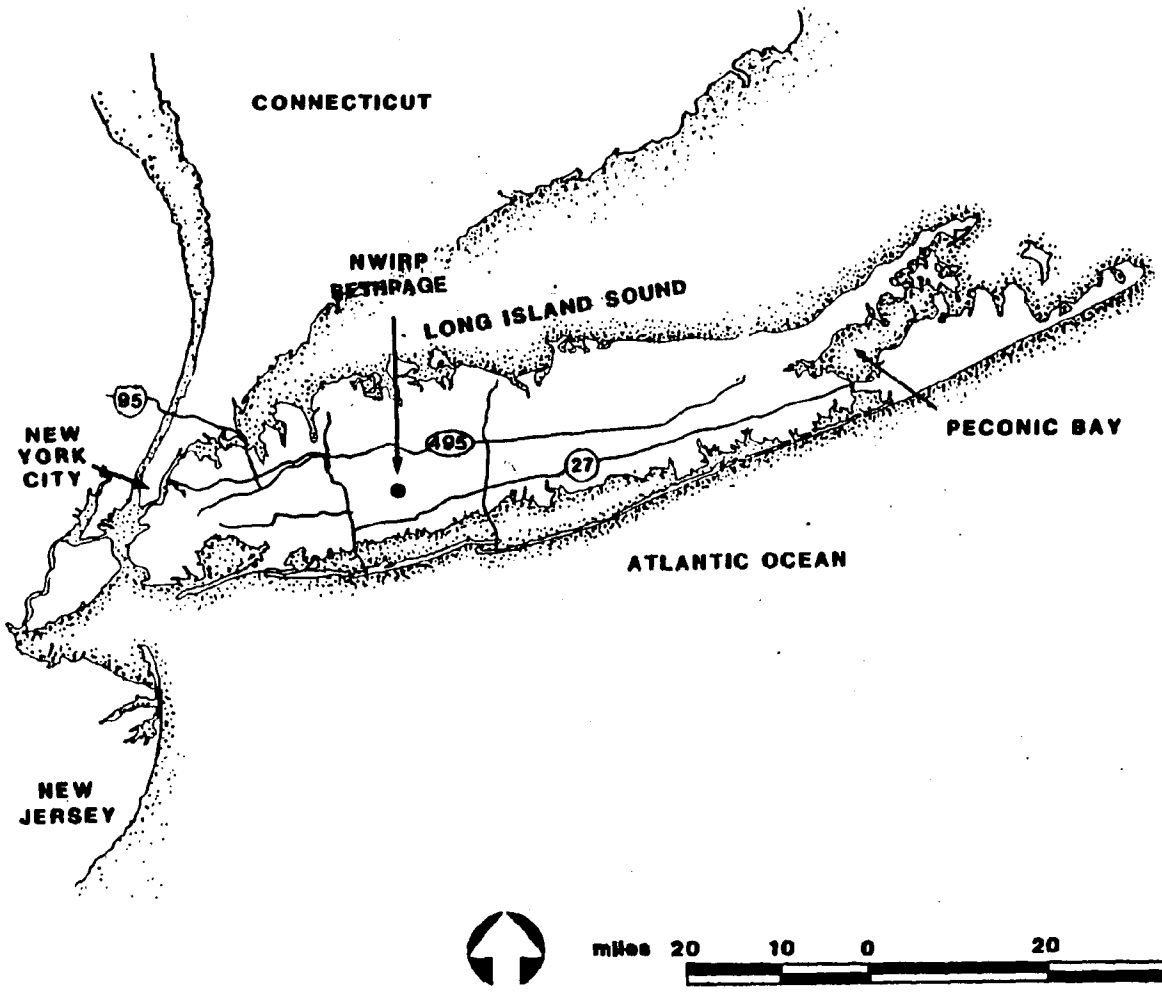


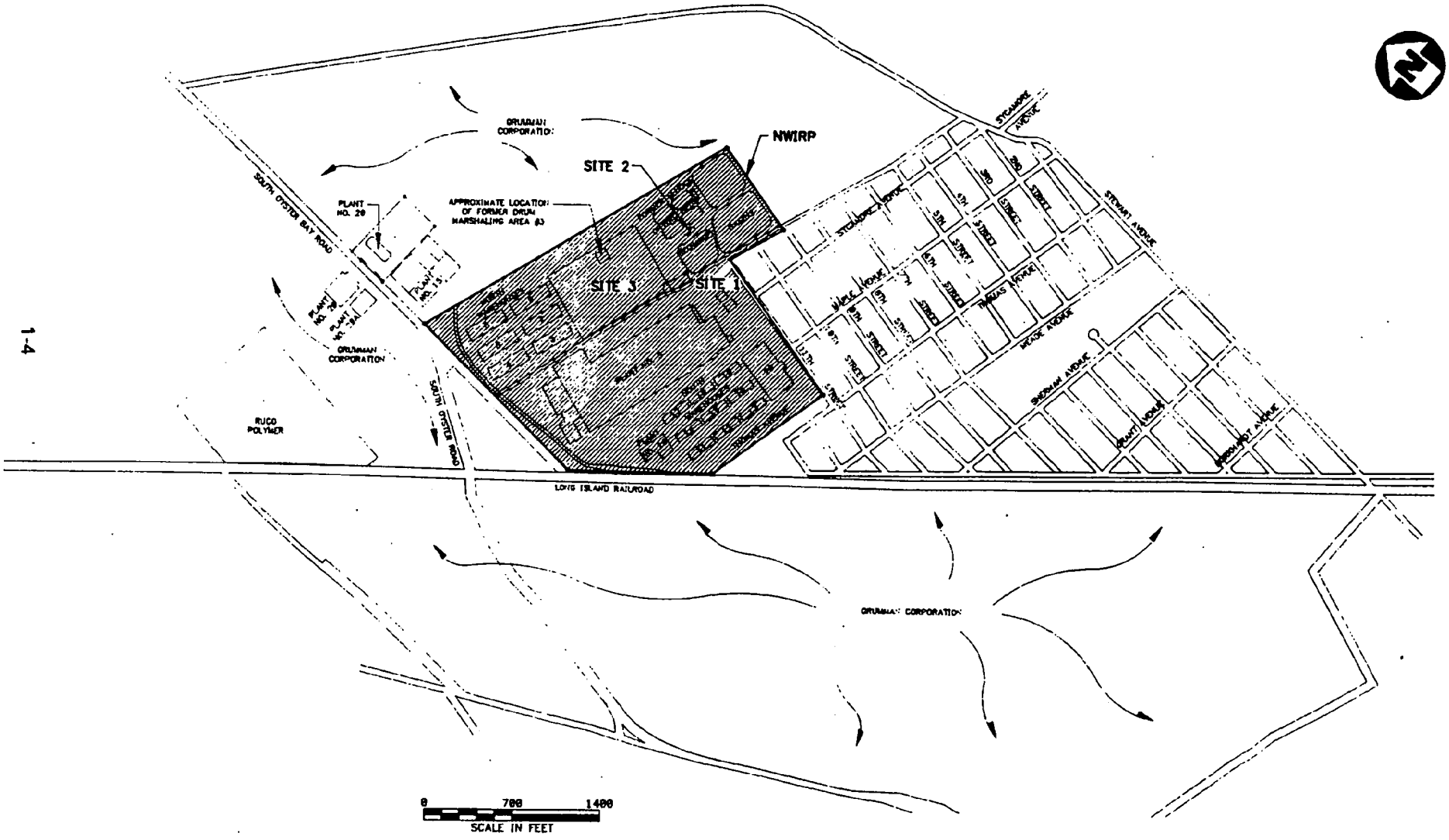
Figure 1–1

General Location Map,
NWIRP Bethpage, New York

Naval Weapons Industrial
Reserve Plant
Bethpage
Long Island, New York

NYSDEC 033217

ACAD: 3281\BASE.DWG 5/24/93 MJJ



SITE LAYOUT MAP
PHASE 2 – REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

FIGURE 1-2

HALLIBURTON NUS
Environmental Corporation

NYSDEC 033218

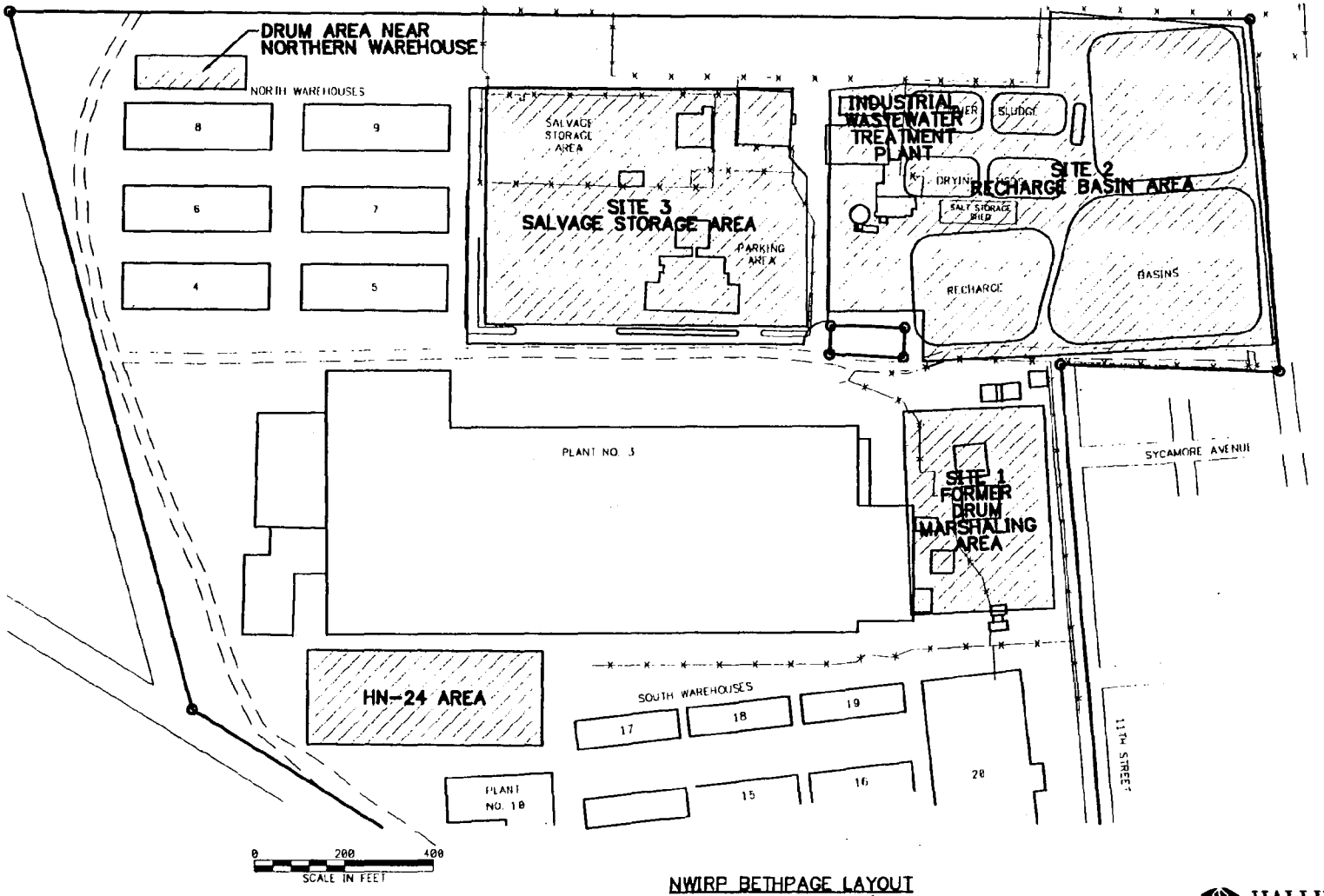


FIGURE 1-3

NWIRP BETHPAGE LAYOUT
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

HALLIBURTON NUS
Environmental Corporation

NYSDEC 033219

Based on the historic data presented in the IAS, there was the potential for volatile organic, semivolatile organic, and inorganic contamination at each of the three sites. In May 1992, a RI (Phase 1) was completed at the site. The results of the Phase 1 RI are summarized in Section 1.4.

1.4 SUMMARY OF PHASE 1 RI RESULTS

1.4.1 Site 1: Former Drum Marshaling Area

History

Hazardous waste management practices for Grumman facilities on Long Island included marshaling of drummed wastes on the Navy property at NWIRP Bethpage. Such storage first took place on a cinder-covered surface over the cesspool field east of Plant No. 3. From the early 1950s through about 1978, drums containing liquid cadmium waste were stored here. In 1978, the collection and marshaling point was moved a few yards south of the original unpaved site, to an area on a 100- by 100-foot concrete pad. This pad had no cover, nor did it have berms for containment of spills. In 1982, drummed waste storage was transferred to the present Drum Marshaling facility, located in the Salvage Storage Area (Site 3); a cover was added in 1983.

Reportedly, all drums of waste marshaled at the Former Drum Marshaling Areas were taken off-activity by a private contractor for treatment or disposal. There are no reports of leaks or spills of drum contents.

Materials stored at the Former Drum Marshaling Areas included waste halogenated and nonhalogenated solvents. Cadmium and cyanide were also stored in this area from the early 1950s through 1974. Reportedly, 200 to 300 drums were stored at each area at any one time.

An abandoned septic drainage system underlies nearly the entire Site 1 area.

Field Activities

The Phase 1 RI field investigation consisted of collecting 32 soil-gas samples at 16 locations, 7 surface soil samples, 18 subsurface soil samples at 10 locations, and 10 temporary monitoring well samples; installing 7 permanent monitoring wells at 3 locations; and sampling 8 permanent monitoring wells.

All of the samples were analyzed for volatile organic constituents. The surface soil samples, shallow subsurface soil samples (less than 5 feet deep), surface water, sediment, and groundwater samples were analyzed for inorganic and semivolatile organic constituents. The groundwater samples were also analyzed for soluble inorganic constituents (less than 0.45 microns) and hexavalent chromium. In addition, subsurface soils that were observed to be oil stained were analyzed for PCBs and pesticides. Select soil and groundwater samples were analyzed for engineering-type parameters. For soil, these engineering parameters included total organic carbon (TOC), bulk density, grain size, moisture content

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and pH. For groundwater the engineering parameters included, pH, total dissolved solids (TDS), alkalinity, hardness, biochemical oxygen demand (BOD_5), total organic carbon (TOC), and total suspended solids.

Nature and Extent of Contamination

During the Phase 1 RI, volatile organic compound (VOC) contamination, especially by chlorinated ethanes and chlorinated ethenes, was evident in soil and groundwater at Site 1. VOC monitoring well concentrations were significantly greater in downgradient monitoring wells than in upgradient monitoring wells. Also, significant VOC contamination was detected in the soils near the former drum marshaling areas. Both the increase in groundwater concentrations across Site 1 and soil contamination are indications that Site 1 is a source of groundwater concentration.

PCBs were reported at various locations in soil. Notable levels of certain inorganics, including chromium, arsenic, and cyanide, were detected in onsite media. There is no clear pattern in the concentrations of inorganics in groundwater.

Conclusions

Based on volatile organic isoconcentration contour maps developed during the Phase 1 RI, Site 1 was determined to be a likely source of on-site and near-site (Grumman) groundwater contamination. It was determined that a Phase 2 RI would be required to define the overall extent of groundwater contamination, particularly in the areas to the south and east of Site 1 (residential neighborhood).

The soils at Site 1 were measured to contain sufficient residual volatile organic contamination to confirm the source of groundwater contamination as being near or at the former drum marshaling areas.

PCBs were identified as TICs (tentatively identified compounds) in many of the soil samples tested during the Phase 1 RI. Because of the toxicity of PCBs, the Phase 1 RI recommended that PCB sampling be conducted during a Phase 2 RI in order to quantify the nature of these contaminants.

1.4.2 Site 2: Recharge Basin Area

History

Surface water drainage on Long Island is, for the most part, locally controlled, with numerous recharge basins used to channel this resource back to the groundwater. Several such recharge basins are located at NWIRP Bethpage.

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Prior to 1984, some Plant No. 3 production-line rinse waters were discharged to the recharge basins. The Environmental/Energy Survey of the activity, published in 1976, states that 1.85 million gallons per week were discharged to the recharge basins. These waters were directly exposed to chemicals used in industrial processes (involving the rinsing of manufactured parts). Reportedly, these discharges of dilute rinse waters did not contain chromates, based on the Initial Assessment Study (IAS).

Since about 1977, the discharge rate to the recharge basins has been 14 million gallons per week of noncontact cooling water. The noncontact cooling water is obtained from the facility groundwater production wells. All contact wastewater discharge currently goes to the Industrial Wastewater Treatment Plant.

Also, adjacent to the recharge basins are the former sludge drying beds. Sludge from the Plant No. 2 Industrial Waste Treatment Facility (south Grumman Complex) was dewatered in the drying beds before offsite disposal.

On at least one occasion, sampling performed by the Nassau County Department of Health detected levels of hexavalent chromium in excess of allowable limits. Grumman was notified of this noncompliance and asked to perform remedial actions necessary to eliminate the problem. Reportedly, Grumman complied with the request.

Contaminants of concern include hexavalent (and other valence) chromium, aluminum, nitric acid, and sulfuric acid.

Field Activities

The Phase 1 field investigation consisted of collecting 48 soil-gas samples at 24 locations, 13 surface soil samples, 14 subsurface soil samples at 13 locations, 11 temporary monitoring well samples, 2 surface water samples, and 4 sediment samples; installing 3 permanent monitoring wells at 2 locations; and sampling 3 permanent monitoring wells.

All of the samples were analyzed for volatile organics constituents. The surface soil samples, shallow subsurface soil samples (less than 5 feet deep), surface water, sediment, and groundwater samples were analyzed for inorganic and semivolatile organic constituents. The groundwater and surface water samples were also analyzed for soluble inorganic constituents (less 0.45 microns) and hexavalent chromium. In addition, surface and subsurface soils that were observed to be oil stained were analyzed for PCBs and pesticides. Select soil and groundwater samples were analyzed for engineering-type parameters.

Nature and Extent of Contamination

During the Phase 1 RI, VOC contamination, especially by chlorinated ethanes and chlorinated ethenes, was determined to be present in soil, surface water, and groundwater at Site 2. The concentration of

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VOCs detected in soils and groundwater at Site 2 are lower than detected at other areas of the NWIRP. Also, the upgradient monitoring wells for Site 2 were observed to contain similar concentrations of volatile organics. Inorganic groundwater contamination was found. However, there was no clear pattern established for the inorganics in groundwater; notable levels of metals, including arsenic, vanadium, chromium, lead and cyanide, were reported in some wells.

VOC contamination was greater in subsurface soils than in surface soils. PCBs were reported at various locations in soil. Recharge basin surface water and sediment exhibited trace to low levels of VOCs. Notable levels of certain inorganics, including chromium, arsenic, and cyanide, were detected in onsite soils.

Conclusions

Based on volatile organic isoconcentration contour maps developed during the Phase 1 RI, it was determined that Site 2 is not a likely source of onsite groundwater contamination. However, the surface water entering the recharge basins was measured to contain sufficient concentrations of volatile organics to result in the potential for low-level groundwater contamination.

Based on the relative concentration of volatile organics found in the production wells, a likely scenario developed was that the recharge basins redistribute contaminated groundwater from other sources. Also, it was noted that since the concentration of volatile organics in the surface water was lower than in the production wells, the system likely resulted in lowering of the VOC concentration in groundwater by natural volatilization. Grumman Corporation, under their existing SPDES permit, is adding a treatment system to the recharge basins by the end of 1993. This treatment system is expected to result in drinking water quality water being discharged to the basins.

PCBs were identified as TICs (tentatively identified compounds) in many of the soil samples tested during the Phase 1 RI. Because of the toxicity of PCBs, the Phase 1 RI recommended that PCB sampling be conducted during a Phase 2 RI in order to quantify the nature of these contaminants.

1.4.3 Site 3: Salvage Storage Area

History

The NWIRP Bethpage Salvage Storage Area is located north of the Plant No. 3. Fixtures, tools, and metallic wastes were stored here from the early 1950s through 1969, prior to recycling.

Stored materials included aluminum and titanium scraps and shavings. While in storage, cutting oils dripped from some of this metal. In 1985, IAS team members observed oil-stained ground at the site. However, soil tests performed by Grumman in 1984 revealed that oil stains were superficial; oil residues were not detected below the top several inches of soil material in the Salvage Storage Area at the locations tested.

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About 1960, the Salvage Storage Area was reduced in size to accommodate parking. About 1970, it was reduced again for the same reason. Consequently, storage facility locations at this site have been periodically moved to accommodate changes in storage area size.

In addition to salvage storage, a 100- by 100-foot area within the boundary of the Salvage Storage Area was used for the marshaling of drummed waste. This area was covered with coal ash cinders. Drum marshaling continued here from the early 1950s to 1969. Wastes marshaled throughout the area included waste oils as well as waste halogenated and nonhalogenated solvents. The exact location of this former drum marshaling area is uncertain, however, it is suspected to be near the current drum marshaling area.

Potential contaminants of concern at Site 3 (from both drum marshaling and salvage storage) include cutting oils, aluminum, titanium, and halogenated and nonhalogenated solvents.

Field Activities

The Phase 1 field investigation consisted of collecting 60 soil-gas samples at 30 locations, 8 surface soil samples, 14 subsurface soil samples at 9 locations, and 9 temporary monitoring well samples; installing 5 permanent monitoring wells at 2 locations; and sampling 5 permanent monitoring wells and four production wells.

All of the samples were analyzed for volatile organic constituents. The surface soil samples, shallow subsurface soil samples (less than 5 feet deep), surface water, sediment, and groundwater samples were analyzed for inorganic and semivolatile organic constituents. The groundwater and production well samples were also analyzed for soluble inorganic constituents (less 0.45 microns) and hexavalent chromium. In addition, surface and subsurface soils that were observed to be oil stained were analyzed for PCBs and pesticides. Select soil and groundwater samples were analyzed for engineering-type parameters.

Nature and Extent of Contamination

During the Phase 1 RI, VOC contamination, especially by chlorinated ethanes and chlorinated ethenes, was evident in soil and groundwater at Site 3. VOCs were detected in groundwater at greater concentrations downgradient of Site 3 than upgradient, indicating a potential source area at Site 3. Based on the relative concentration of solvents found in the downgradient monitoring wells, this source is less significant than that present at Site 1. Inorganic groundwater contamination was found at Site 3. However, there was no clear pattern established for the inorganics in groundwater; notable levels of metals, including arsenic, vanadium, chromium, lead and cyanide, were reported in some wells. Notable levels of certain inorganics, including lead, arsenic, and cyanide, were detected in Site 3 soils.

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Conclusions

Based on volatile organic isoconcentration contour maps developed during the Phase 1 RI, Site 3 was determined to be a likely source of onsite groundwater contamination. The Phase 1 RI concluded that the contaminated groundwater plumes from Site 1 and Site 3 merge and that an investigation associated with Site 1 groundwater contamination would also identify any further Site 3-related groundwater contamination.

Also, because the contamination found at HN-24I was found to be more concentrated and homogenous (only TCE was detected) than any of the sites identified, a separate source area for this contamination was possible. Potential source areas identified at the NWIRP included sumps and tanks at Plant No. 3 and a former coal storage pile near Plant No. 3. It was recommended that a Phase 2 RI be conducted to further investigate these potential sources.

PCBs were identified as TICs (tentatively identified compounds) in one of the soil samples tested during the Phase 1 RI. Because of the toxicity of PCBs, the Phase 1 RI recommended that PCB sampling be conducted during a Phase 2 RI in order to quantify the nature of these contaminants.

1.5 DESCRIPTION OF OTHER AREAS CONSIDERED DURING THE PHASE 2 RI

1.5.1 HN-24 Area

The HN-24 area is currently being considered separately from the three sites identified in the IAS, because of the high concentration of TCE that was found at depth and because of the absence of other Sites 1-, 2-, or 3-related solvents.

HN-24 Area is located near the southwest corner of Plant No. 3, (see Figure 1-3). There are no reports of waste disposal and/or storage activities in this area. However, a portion of this area was used in the past for the bulk storage of coal for an adjacent power plant. Solvents may have been applied to the coal. There is no current evidence of the location of the former coal pile. Based on areal photographs and interviews with plant workers, the former coal pile is believed to have been located immediately north of Plant No. 10. Currently, the area consists of a grass covered field as well as parking lots for Plant No. 3 and Plant No. 10.

During the Phase 1 RI activities, TCE at a concentration of 58,000 ug/l was found in groundwater at a depth of approximately 140 to 160 below grade surface (bgs) (HN-24I). This contamination appears to be associated with a 10-foot thick clay layer at a depth of approximately 140-150 feet bgs. Based on the TCE concentration measured, this contamination is potentially DNAPL (dense non-aqueous phase liquid) in nature. Also supporting the potential DNAPL concept is the lack of significant TCE contamination in the shallower groundwater at this location. In order to determine the source of this contamination, several potential source areas were investigated. These sources include Site 1, Plant No. 3, the coal pile, and offsite areas hydraulically upgradient of the NWIRP (north and west).

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1.5.2 Plant No. 3

Plant No. 3 was constructed in the 1940s for the production of aircraft parts. Current and/or former operations conducted in Plant No. 3 include plating, anodizing, heat treatment, solvent cleaning, chemical milling, painting, and paint stripping operations, (see Figure 1-4). Chemicals and wastes associated with Sites 1, 2, and 3 are likely to have been used and/or generated in Plant No. 3. Specific chemicals used in Plant No. 3 include acids, caustics, solvents, and heavy metals. Currently, raw acid and solvent (PCE) tanks are located on the east end of Plant No. 3. These tanks are located in secondary containment units.

TCE is also used in the plant. Raw and waste TCE is transported to and from current units in 55-gallon drums. Historically, two bulk tanks were located outside and adjacent to Plant No. 3. One was located at the northeast corner of Plant No. 3 and another tank was located along the north central wall of Plant No. 3.

Based on the Phase 1 RI results, there was no direct evidence of any contaminant sources within Plant No. 3. However, soil gas testing conducted at Site 1 indicated that the extent of soil gas contamination in the west end of Site 1 (east end of Plant No. 3) is undefined. Additionally, Plant No. 3 is hydraulically upgradient of monitoring well HN-24, which was found to be the most contaminated groundwater at the site.

1.5.3 Drum Area Near Northern Warehouses

Grumman operates a drum area north of the northern NWIRP warehouses, (see Figure 1-3). Because raw materials, instead of waste materials, are handled here and because there have been no reports of leaks or spills of hazardous materials, this area has not been identified for investigation in the past. The primary reason for investigating this area is because of the TCE contamination found at HN-24I and the consideration that this area is hydraulically upgradient of HN-24.

1.5.4 Offsite: Residential Neighborhood

A residential neighborhood is located to the east and south of the NWIRP. Predominant groundwater flow patterns for the NWIRP range from the southeast to the southwest. There are no known residential groundwater wells in the immediate vicinity of NWIRP. Bethpage Water District (BWD) operates potable water supply wells 3200 feet east of the NWIRP (Plant #1 - Adams Avenue Plant - Wells 7-A, 8-A, and 9 and Well BGD) and a line of water supply wells approximately 7500 feet south of the NWIRP (Plant #s 4, 5, and 6), (see Figure 1-5).

Recent analytical data from these wells is summarized in Table 1-1. Based on this data, the water in several of wells to the south and one of the wells to the east has been measured to contain detectable levels of solvents (greater than 0.5 ug/l). Of these wells, the water in only one well currently exceeds

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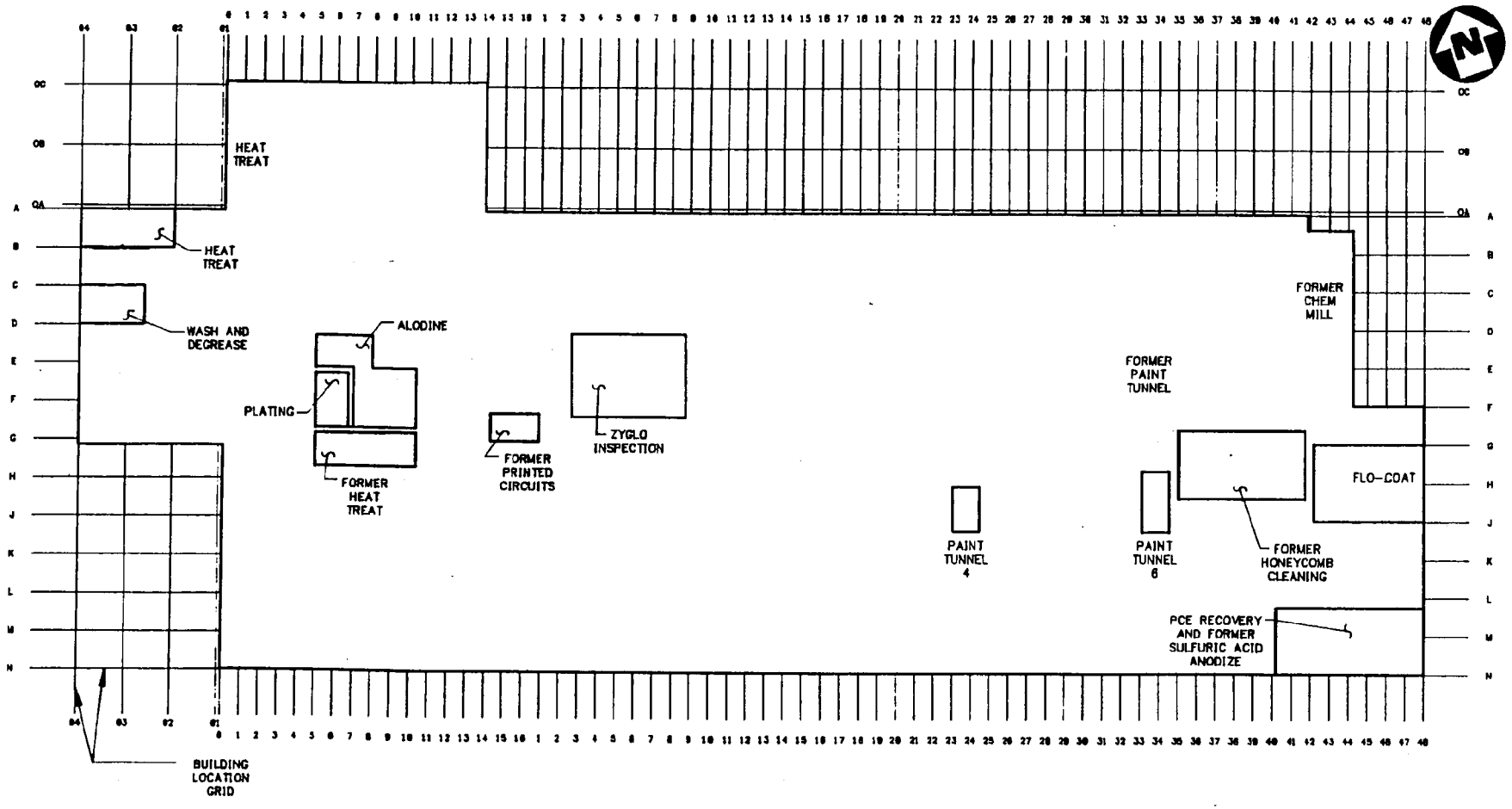

1-13

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PLANT No. 3 LAYOUT
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NY

APPROXIMATE SCALE
0 100 200
SCALE IN FEET

FIGURE 1-4

HALLIBURTON NUS
Environmental Corporation

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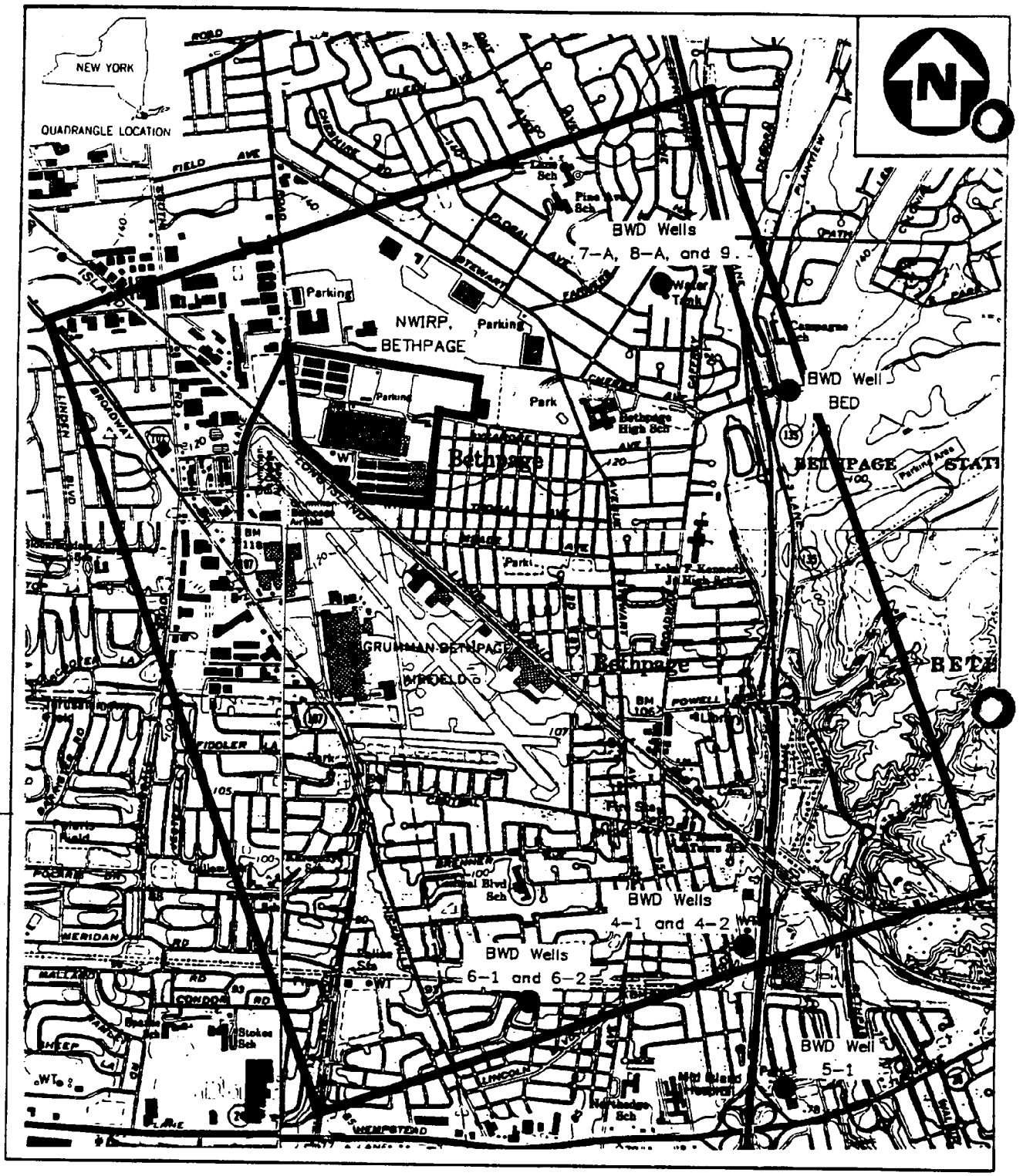

FIGURE 1-5

LOCATION OF PUBLIC WATER SUPPLY WELLS
PHASE 2 REMEDIAL INVESTIGATION/
FEASIBILITY STUDY/NWIRP
BETHPAGE, NEW YORK

HALLIBURTON NUS
Environmental Corporation

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TABLE 1-1
SUMMARY OF BETHPAGE WATER DISTRICT
WATER QUALITY DATA, 1990 TO 1992[a]
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NY

Well	Location	Screen Depth (feet)	Sample Date	Maximum Concentration (ug/l)			
				TCE	PCE	TCA	NO_3
4-1 (10)	Plant #4-Sophia St	540-603	1992	1.2	ND	ND	2.8
			1991	ND	ND	ND	1.3
			1990	2.6	ND	ND	2.7
4-2 (11)	Plant #4-Sophia St	556-606	1992	0.5	ND	ND	2.3
			1991	ND	ND	ND	2.7
			1990	ND	ND	ND	0.8
5-1	Plant #5-Broadway	675-735	1992	ND	ND	ND	ND
			1991	ND	ND	ND	0.4
			1990	ND	0.6	ND	0.2
6-1[b]	Plant #6-Park La.	321-381	1992	240	9.9	3.3	ND
			1991	200	ND	5.3	5.0
6-2	Plant #6-Park La.	710-770	1992	ND	ND	ND	5.0
			1991	ND	ND	ND	0.6
			1990	ND	ND	ND	1.5
BGD-1	Plant BGD-Plainview Rd.	542-602	1992	ND	ND	ND	0.7
			1991	ND	ND	ND	0.5
			1990	ND	ND	ND	0.3
7-A	Plant #1-Adams Ave.	590-656	1992	ND	ND	ND	ND
			1991	ND	ND	ND	3.0
			1990	ND	ND	ND	ND
8-A	Plant #1-Adams Ave.	617-677	1992	ND	ND	ND	2.3
			1991	ND	ND	ND	1.2
			1990	ND	ND	ND	1.0
9	Plant #1-Adams Ave.	225-275	1992[c]	ND/ND	1.3/1.8	2.1/2.9	-/19.2[e]
			1991	1.2	ND	2.0	19
			1990	ND	ND	1.4	6.2

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TABLE 1-1 (continued)
SUMMARY OF BETHPAGE WATER DISTRICT
WATER QUALITY DATA, 1990 TO 1992[a]
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NY
PAGE 2

ND Not detected. Detection limits were 0.5 ug/l for volatile organics and 0.1 mg/l for nitrates.

a Source: BWD 1993. Drinking water criteria are 5 ug/l for volatile organics and 10 mg/l for nitrates. Data presented is the maximum result reported for that year from regular sampling events.

b Groundwater receives treatment prior to distribution. Distributed water meets drinking water criteria. Additional organics beyond that listed are also present.

c No data available for Well 6-1 in 1990.

d Samples dates are January 1992 and December 1992, respectively. 1,1 DCA was also detected in Well No. 9 at concentrations of 3.7 ug/l and 5.0 ug/l, respectively.

e Nitrate data for January 1992 was not available.

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drinking water criteria for solvents. Well #6-1, which is directly south of the NWIRP and Grumman Corporation, was measured to contain a maximum TCE concentration of 240 ug/l. Because of this contamination, the water in this well is treated to remove the contamination prior to use. Analytical data on the treated water from this well indicates that the treatment is effective. Analytical data on the other BWD wells indicate limited to no solvent contamination. Well #4-1, which is the second most affected well, was measured to contain a maximum TCE concentration of 2.6 ug/l, (drinking water criteria is less than 5 ug/l). A treatment system for VOCs is currently being designed for BWD Well 4-1.

For the BWD wells to the east, only Well #9 was found to contain detectable levels of solvents, with 1,1 DCA found at a maximum concentration of 5.0 ug/l. This concentration is equal to the drinking water criteria for this chemical. The water in this well also contained lower, but similar, levels of other solvents. Currently, this well is shut down because of concerns with the VOC concentrations in the water exceeding drinking water criteria. In addition to the VOC concerns, this well contained significant concentrations of nitrate, with a maximum concentration of 19 mg/l reported, (drinking water criteria is less than 10 mg/l). Nitrate is a common contaminant associated with fertilizers used for farming.

Of note is the fact that Well #9 is relatively shallow for potable water supply wells in the area, with a screened depth of 225 to 275 feet below grade surface (bgs). Solvents were not found in the two deeper wells in this area, (Wells #7-A and #8-A), with screened depths of approximately 600 to 700 feet bgs.

1.6 SUMMARY OF GRUMMAN and HOOKER/RUCO RI/FS ACTIVITIES

1.6.1 Grumman Phase I Remedial Investigation

Grumman Corporation completed a Phase I RI of the Grumman-owned portions of the Bethpage Plant in January 1992, (G&M, 1992). This investigation included surface water/sediment sampling, soil gas testing, soil sampling, monitoring well installation and monitoring well sampling.

The investigation found solvents (PCE: 4 ug/kg and toluene: 5 ug/kg), phthalates and polynuclear aromatic hydrocarbons (1,375 ug/kg), and PCBs (1.020 mg/kg) in the recharge basin sediments. The soil gas testing results indicated potential solvent contamination east of Plant No. 2 (south Grumman property) and Plant No. 15 (north Grumman property). Soil testing also found significant solvent contamination (TCE: 130,000 ug/kg) east of Plant No. 2.

The groundwater investigation found low concentrations of solvents in the hydraulically upgradient intermediate-depth monitoring wells (G&M-1I, TCA: 3 ug/l; GM-3I, PCE: 5 ug/l; and G&M-5I, PCE: 17 ug/l). Upgradient shallow monitoring wells were not found to be contaminated. The most contaminated monitoring wells, observed during the Grumman Phase I RI, are located just south of the NWIRP, with 3,100 ug/l of TCE measured in GM-12I. With the exception of monitoring wells at the

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GM-12 cluster and nearby GM-13 and GM-14 clusters, solvent concentrations in groundwater monitoring wells on the Grumman property ranged from ND to 88 ug/l.

Grumman production wells, with screened depths of 400 to 600 feet bgs, were found to contain TCE at concentrations up to 4,300 ug/l. This data indicates that a deep solvent contaminant plume exists beneath the Grumman (and NWIRP) properties.

Three of the Grumman monitoring well clusters are located north of Site 2 and Site 3, (GM-6, GM-7, and GM-8). These well clusters were used for upgradient monitoring wells for the NWIRP.

1.6.2 Grumman Phase II Remedial Investigation

Grumman is currently conducting a Phase II Remedial Investigation to further define the nature and extent of soil and groundwater contamination. This investigation includes the installation of additional onsite and offsite groundwater monitoring wells, and sampling and analysis of additional soils and groundwater. In addition, Grumman is conducting monthly monitoring well water level measurements to be used to determine groundwater flow patterns. The Grumman Phase II RI field activities were initiated in the summer of 1992 and are expected to be completed in the summer of 1993. A RI report will follow.

1.6.3 Hooker/RUCO Remedial Investigation

The Hooker/RUCO Site is on the National Priorities List (NPL) and is located approximately 1,000 feet west of the NWIRP. RI activities conducted to date include a soil-gas study, an electromagnetic terrain conductivity survey, recharge basin water and sediment sampling, shallow and deep soil sampling and groundwater sampling.

This investigation found sediments contaminated with phthalates (9,580 ug/kg), PAHs (2,180 ug/kg), and solvents (toluene: 260 ug/kg and 1,2-DCE: 76 ug/kg). Soil contaminants detected include solvents (TCE: 7,600 ug/kg, PCE: 57,000 ug/kg, ethylbenzene: 950 ug/kg, and toluene: 390 ug/kg), PAHs (7,770 ug/kg), phenols (120,000 ug/kg), phthalates (120,000 ug/kg), and PCBs (2.1 mg/kg).

Onsite groundwater results found solvents (PCE: 85 ug/l, TCE: 14 ug/l, DCE: 24 ug/l, and vinyl chloride: 560 ug/l).

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2.0 FIELD PROGRAM DESCRIPTION AND RATIONALE

This section presents the basis for the Phase 2 RI scoping and a description of each of the field investigation tasks performed at the NWIRP Bethpage to meet the objectives of the RI.

Between October 1992 and June 1993, the following field activities were conducted:

- Inspection of potential source areas within Plant No. 3 (Section 2.2).
- Soil gas survey and analysis at 32 locations within Plant No. 3 (Section 2.2).
- Soil gas survey using GC testing at 6 locations within Plant No. 3 and 4 locations outside Plant No. 3 (Section 2.2).
- Sampling and analysis at 18 surface soil locations (Section 2.3).
- Sampling and analysis of 8 subsurface soil samples from 2 boreholes at location HN-24 (Section 2.4).
- Drilling and installation of 11 temporary off-site wells in the community east of NWIRP Bethpage in order to sample and analyze groundwater (Section 2.5).
- Drilling and installation of 2 temporary wells on site at Site 1 (Section 2.5).
- Drilling and installation of 7 monitoring wells off site and 2 monitoring wells on site and the conversion of 2 temporary wells to permanent piezometers (Section 2.6).
- Drilling and installation of a high capacity pumping well (Section 2.7).
- The execution of two long-term aquifer pumping tests (Section 2.8).
- Groundwater sampling and analysis of the newly installed monitoring wells and of selected existing monitoring and production wells (Section 2.9).
- Water-level measurements of groundwater obtained from the monitoring wells (Section 2.10).
- Surveying the horizontal locations and vertical elevations of all newly installed monitoring wells, two modified existing monitoring wells, and all temporary well locations (Section 2.11).

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2.1 SCOPING OF REMEDIAL INVESTIGATION

2.1.1 Data Limitations and Requirements

The Phase 1 Remedial Investigation produced several results which indicated that additional investigation and analysis was required. Specific areas of concern were PCB concentrations in soil as well as the extent of groundwater contamination in the areas of the offsite neighborhood and HN-24 Area. Because of the complex groundwater flow patterns, computer modeling was also conducted to evaluate contaminant migration.

PCBs

Polychlorinated biphenyls (PCBs) were confidently identified in soil samples that were submitted for PCB analysis. In addition, PCBs, as tentatively identified compounds (TICs), were identified at potentially significant concentrations in many other soil samples taken from the three NWIRP sites. The locations, where PCBs were identified as TICs, were resampled during the Phase 2 RI for Target Compound List (TCL) PCB and pesticide analyses in order to quantify the nature and extent of PCB contamination, to assess its impact on the existing Risk Assessment, and to evaluate the need for and extent of remediation.

Offsite Groundwater

During the Phase 1 RI, significant volatile organic contamination of the groundwater was discovered at Site 1, the former drum marshaling area. An analysis of flow patterns constructed from the monitoring well network revealed the potential for this contaminated groundwater to flow eastward and offsite beneath the adjacent residential neighborhood. Therefore, it became necessary to monitor the offsite groundwater quality. To accomplish this, an initial temporary monitoring well survey was conducted to identify any immediate problem areas and to delineate the general nature and extent of shallow offsite groundwater contamination. The results of this field-screening were used to assist in the determining the location for one of the three permanent offsite monitoring well clusters. The location of the other two well clusters was selected based on the Phase 1 RI data, which indicated that the extent of intermediate-depth contamination near the Long Island Railroad was undefined. Each cluster consisted of a shallow- and an intermediate-depth monitoring well.

Plant No. 3 and HN-24 Area

Significant volatile organic contamination of the groundwater was discovered at well cluster HN-24, which is located immediately southwest of Plant No. 3. This result was problematic for several reasons. The contamination here consisted almost solely of TCE, whereas other contaminated locations contained a mixture of volatile organic compounds. Also, the TCE concentration (58,000 ug/l) at HN-24 was an order of magnitude greater than that found elsewhere. In addition, this contamination

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occurred at intermediate depths and was apparently associated with a dense clay layer; the shallow monitoring well had very low levels of contamination. A comparison of contaminant presence/absence and contaminant concentrations from other NWIRP and Grumman well locations did not reveal a likely source area for this contamination.

Several field investigations were conducted in an attempt to identify the source of contamination at HN-24. A visual inspection was conducted in Plant No. 3 to identify potential solvent source areas. Following this, a semi-quantitative soil gas survey was conducted inside Plant No. 3 to determine if it was a potential source of the contamination. A second phase soil gas survey then quantitatively sampled the locations inside Plant No. 3 that were identified as likely potential sources of contamination. Three intermediate depth monitoring wells were placed between HN-24I and Plant No. 3, Plant No. 10 (which reportedly uses solvents), and the offsite Hooker/Ruco site to determine if these facilities could be the source of the contamination, to further investigate the relationship of the contamination to the clay layer, and to investigate the lateral continuity of the clay. The well near Plant No. 10 was located in the area of a former coal storage pile. Solvents may have been used with the coal.

Computer Modeling

Groundwater flow patterns beneath the NWIRP and adjacent areas are very complex due to the combination and interaction of regional gradients, complex geology, pumpage of facility production wells and nearby public supply wells, and the reinjection of groundwater via the facility recharge basins. As part of the Phase 2 RI, a computer model of the local groundwater regime was generated to assist in the delineation of potential source areas, to determine the impact of the known source areas, and to project the potential impact of the site-generated contamination on offsite receptors such as the nearby public supply wells.

The hydraulic characteristics of the Magothy aquifer were only known in a general and regional sense from data obtained from the published literature. Site-specific information such as the vertical and horizontal conductivity, the transmissivity, and the storativity of the aquifer were needed to generate the computer model and to support a Feasibility Study and Remedial Design. Two long-term aquifer pumping tests were conducted to determine the site-specific hydraulic characteristics of the Magothy aquifer.

2.1.2 Data Quality Objectives

The objective of the Phase 2 RI was to further quantify and characterize the nature and extent of the environmental contamination that was discovered at the NWIRP during the initial field investigation. The results were used to refine the risks to human health and the environment via a revised Risk Assessment. In addition, the data collected was used to evaluate potential remedial options through a concurrent Feasibility Study. The overall objective of the entire NWIRP-Bethpage environmental

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investigation is to identify the locations and concentrations of organic and inorganic contamination of the soil and groundwater, and to develop strategies and options for their remediation.

The NWIRP Bethpage is listed in the registry entitled "Inactive Hazardous Waste Disposal Sites in New York State" as site number 1-30-0003B. The facility is not on the CERCLA National Priorities List (NPL). In accordance with the Naval Energy and Environmental Support Activity (NEESA) guidance, Data Quality Objective (DQO) Level D quality control and CLP methods and protocol were used.

DQO Level D quality control includes review and approval of the laboratory QA plan, the site work plan, and the field QA plan. The laboratory must successfully analyze a performance sample, undergo an audit, correct deficiencies found during the audit, and provide monthly progress reports on their QA. The laboratory that performs the Level D quality control must have passed the performance sample furnished through the Superfund Contract Laboratory Protocol (CLP) and must be able to generate the CLP deliverables.

2.2 SOIL GAS SURVEY

The Phase 2 RI soil gas survey consisted of a preliminary visual inspection of Plant No. 3 and two stages of soil gas testing. The visual inspection of Plant No. 3 was conducted to help identify potential source areas of solvent contamination. Based on the findings of this inspection and historic information, the first stage soil gas survey was conducted at suspected locations. The first stage survey was semi-quantitative with an OVA used to measure the presence of elevated total organic concentrations in the soil gas. Using the first stage soil gas survey results, the second stage survey was conducted at areas where elevated OVA readings were obtained. The second stage survey was more quantitative with GC testing used to determine concentrations of specific organic compounds.

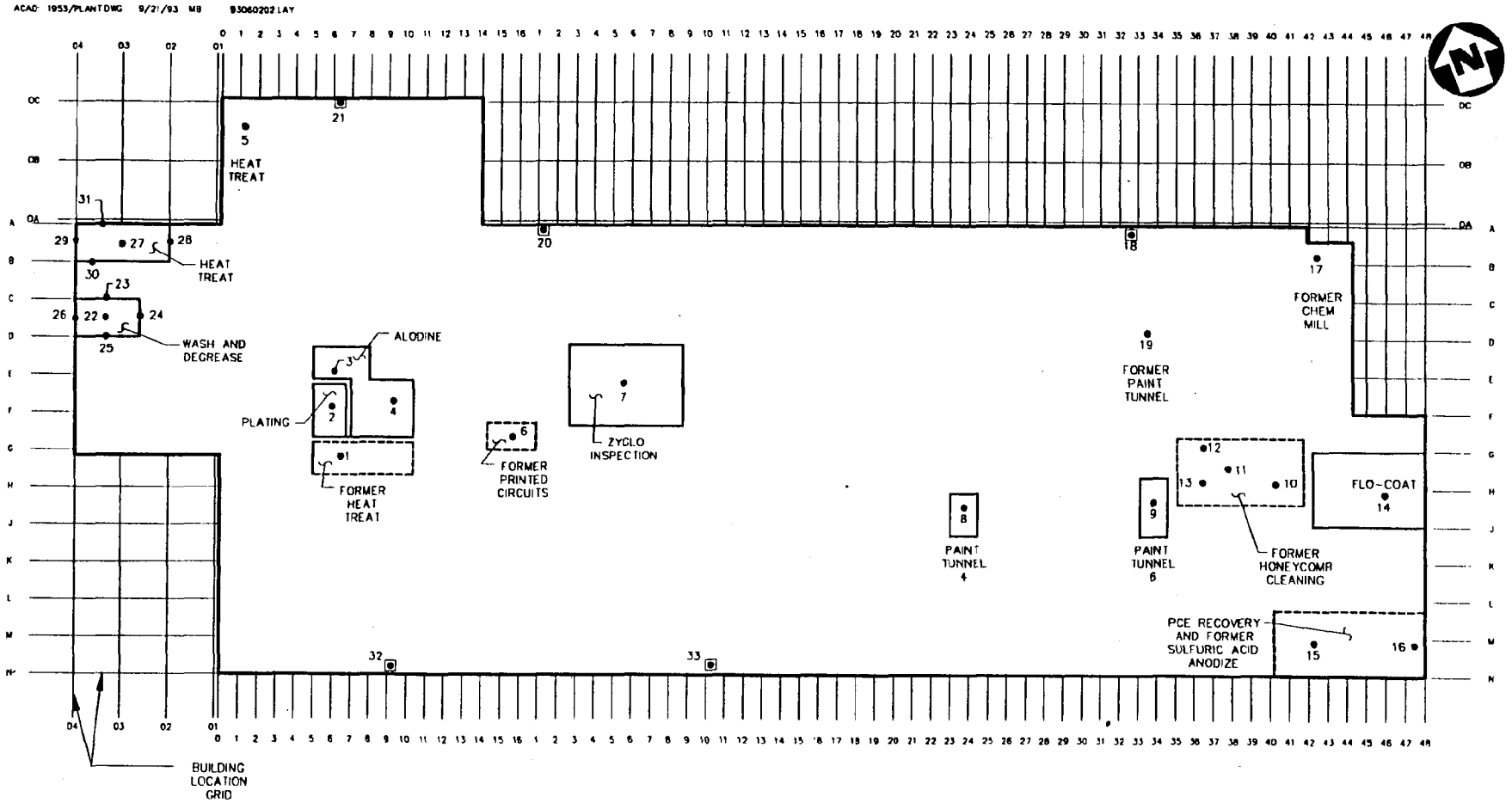
2.2.1 First Stage Soil Gas Survey

The first stage soil gas survey was performed inside of Plant No. 3 on March 17 and 18, 1993. The purpose of the soil gas survey was, in general, to determine if there are source areas of solvent-contaminated soils in Plant 3 and, specifically, to confirm or eliminate each potential source area of contamination identified in the Plant 3 reconnaissance of October, 1992 (see Appendix A).

The first stage soil gas survey was designed to be a relatively non-intrusive, preliminary field screening technique. An organic vapor analyzer (OVA) was used to provide real-time readings of the amount of total organic compounds in the soil gas at each sampling location.

A total of 32 soil gas readings were obtained in or near each of the known or suspected areas where solvents were used and/or stored in Plant No. 3. Sampling locations are shown in Figure 2-1. A minimum of one soil gas point was placed in each potential source area. Additional soil gas points were located in selected areas based on the size of the process unit and the initial soil gas result for

NYSDEC 033237



LEGEND

25 SAMPLING LOCATION

20 BACKGROUND SAMPLE LOCATION

SAMPLING LOCATIONS
PLANT 3 – FIRST STAGE
SOIL GAS SURVEY – PHASE 2 RI/FS
NWIRP, BETHPAGE, NY

APPROXIMATE SCALE
0 100 200
SCALE IN FEET

FIGURE 2-1

HALLIBURTON NUS
Environmental Corporation

NYSDEC 033238

that area. Small, non-complex areas required only a single point to demonstrate the presence or absence of a contaminant source. For larger areas, one high soil gas reading (e.g. 10 to 15 ppm above background) was used to confirm the presence of a source. However, several consistently low soil gas readings across a large potential source area were required to confirm that the area was not a source. To determine the relative significance of positive soil gas detections, the readings were compared to background OVA readings obtained from presumably clean areas of Plant No. 3. Five of the 32 sampling locations were used to determine the background soil gas levels in Plant No. 3. The background soil gas samples were obtained in roughly the four corners of the plant and the north-central portion of the plant; all background samples were located at least 100 feet away from any potential source area.

The soil gas survey procedure consisted of drilling a hole through the concrete building foundation, driving a steel rod into the underlying soil, extracting the rod, and extracting a soil gas sample through a hollow wand attached to a Century Model-128 OVA. Each soil gas boring was completed by drilling a 5/8-inch hole through the concrete floor or wall using an electric, 20-lb., rotary/percussion hammer. Water was sprayed onto the drill bit and cuttings during the drilling to minimize dust generation. All drill cuttings were collected and placed into onsite trash receptacles. A 1/2-inch steel rod was driven into the underlying soils to approximately 3 feet below the floor using the rotary/percussion hammer. The steel rod was extracted using pipe wrenches.

A 4-foot length of 1/4-inch copper tubing was inserted to near the bottom of the borehole and connected to the OVA by a 2-foot length of clear, flexible plastic tubing. The annular space at the top of the borehole was temporarily sealed with putty. The OVA was used to extract a soil gas sample through the tubing into the OVA sample chamber and the real-time readings of soil gas levels were recorded. The highest reading obtained at each location was recorded. Between sampling locations, the tubing was purged using the OVA until non-detect readings (ambient air) were obtained. Prior to sampling, the response time of the OVA was determined to be approximately 17 seconds by using a known source (a marker pen). Upon completion, all boreholes were backfilled to the surface with a non-shrink grout.

2.2.2 Second Stage Soil Gas Survey

The second stage soil gas survey was conducted on June 17 and 18, 1993. This soil gas survey was conducted at six locations within Plant No. 3, at two locations near former TCE bulk tanks just north of Plant No. 3, and at 2 drum areas near the northern warehouses (see Figures 2-2 and 2-3). The purpose of the survey within Plant No. 3 was to quantify the nature of the contamination that was discovered during the first stage (field screening) soil gas survey. The purpose of the surveys near the former TCE tanks and the drum marshalling area was to either identify or eliminate these areas as sources of volatile organic contamination; these areas were not investigated during the first stage soil gas survey.

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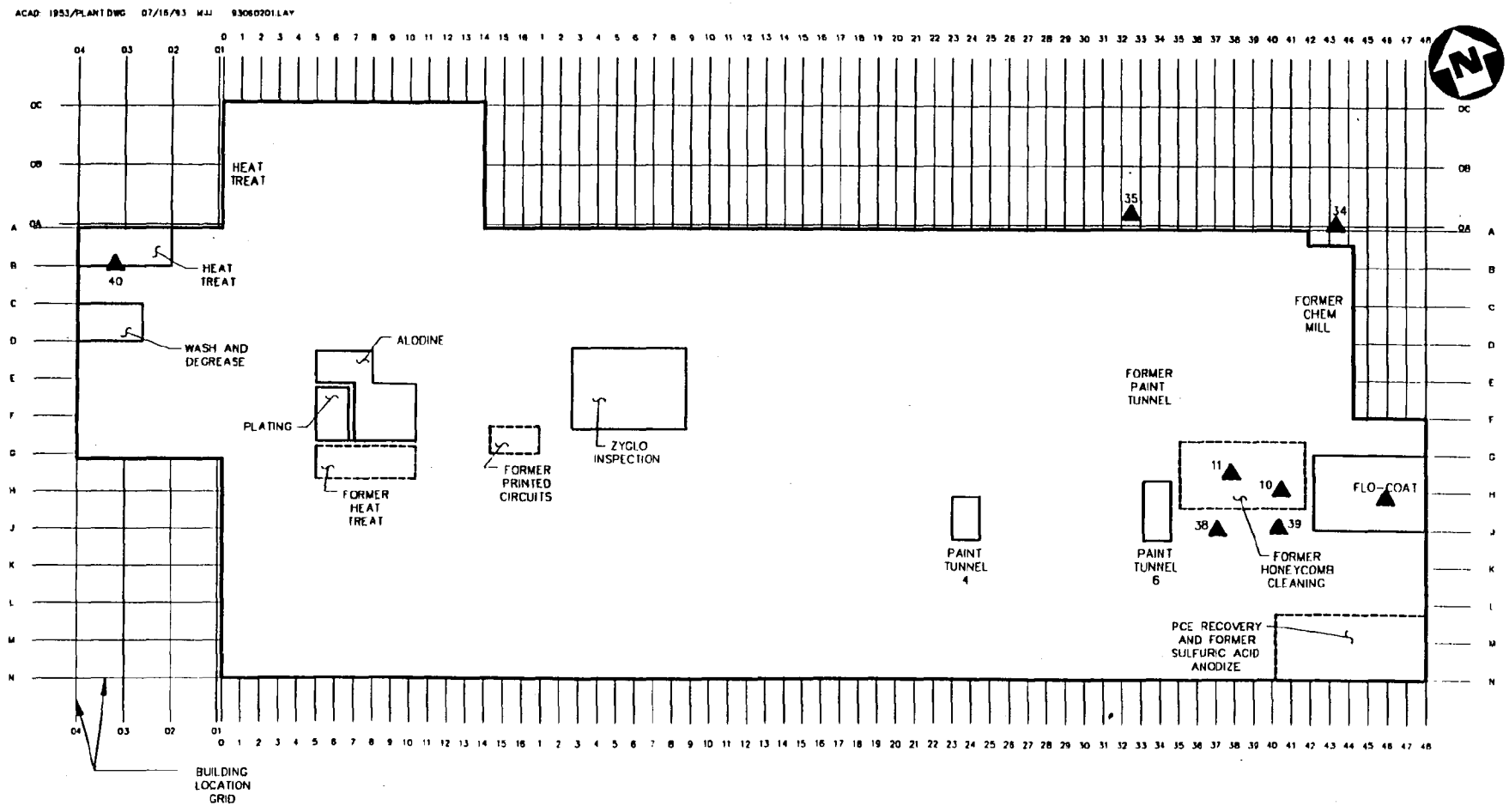

SECOND STAGE SOIL GAS SURVEY SAMPLE LOCATIONS INSIDE PLANT No. 3
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

APPROXIMATE SCALE
0 100 200
SCALE IN FEET

FIGURE 2-2

HALLIBURTON NUS
Environmental Corporation

NYSDEC 033240

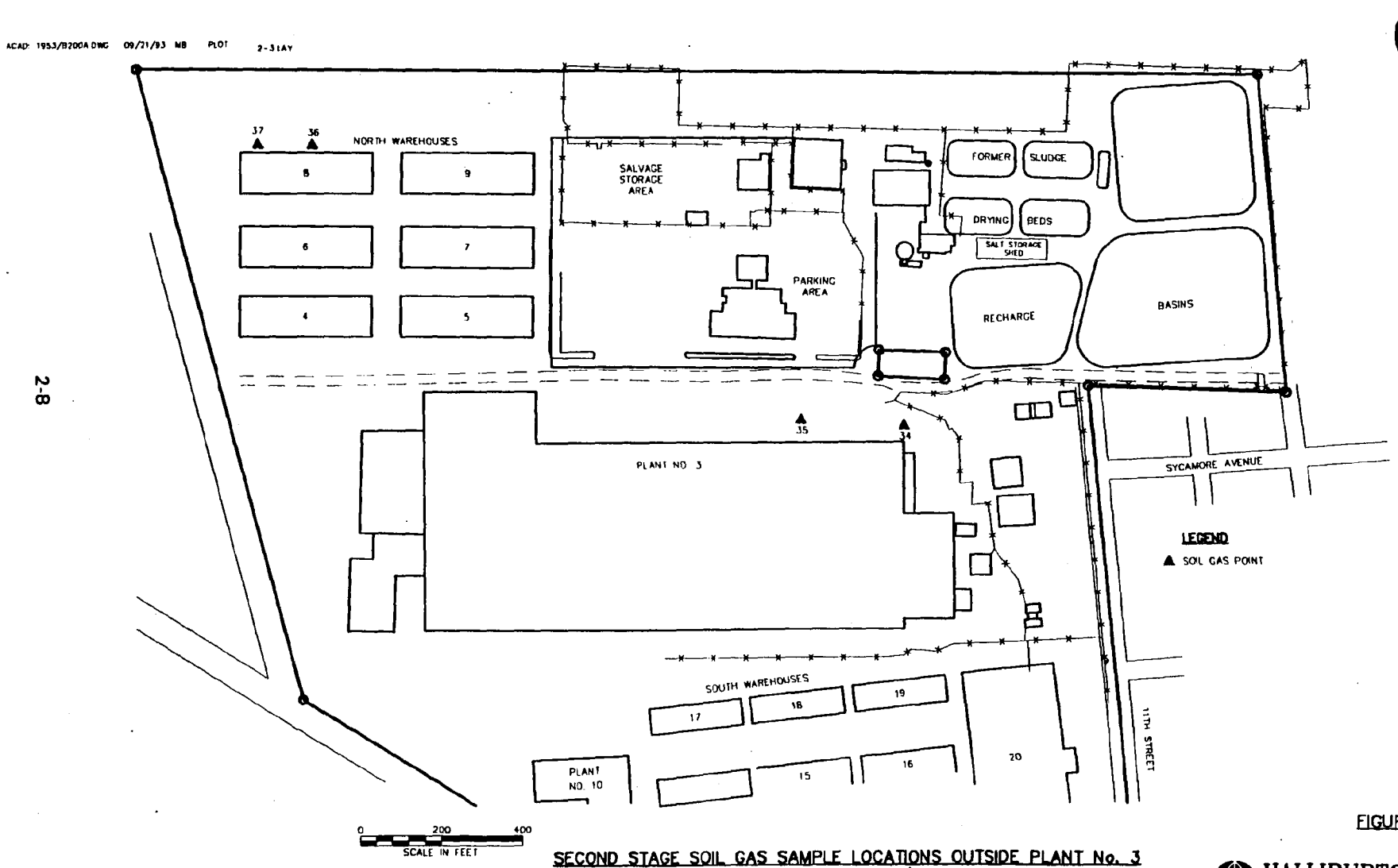

FIGURE 2-3

SECOND STAGE SOIL GAS SAMPLE LOCATIONS OUTSIDE PLANT No. 3
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

HALLIBURTON NUS
Environmental Corporation

NYSDEC 033241

The second stage soil gas survey was performed by Tracer Research Corporation. The survey procedure basically consisted of drilling a hole through building foundation material (where necessary), driving a hollow steel rod into the underlying soil, and extracting a soil gas sample through the rod.

The steel sampling rod was equipped with a drive point. Upon reaching the desired sampling depth, the drive point was detached by pulling back on the rod, which allowed soil gas to enter the rod. The top of the rod was fitted with an aluminum reducer (manifold) and a length of polyethylene tubing that was connected to a vacuum pump. The volume of air within the probe was purged by evacuating 2 to 5 probe volumes of gas.

The soil gas sample was withdrawn by inserting a syringe needle through a silicone rubber segment in the evacuation line near the steel probe. The vacuum was monitored by a vacuum gauge to ensure that an adequate gas flow from the vadose zone was maintained. The steel rods were withdrawn after the sample was obtained (sacrificing the drive point), and the boreholes were sealed to the surface with a bentonite powder and a non-shrink grout.

A total of nine field samples and two ambient air (QA/QC) samples were collected and analyzed. One field sampled was duplicated for QA/QC purposes. The planned sample to be taken below the active TCE tank containment sump (location no. 40) could not be obtained because the concrete floor could not be completely penetrated, despite three attempts. This floor is reportedly reinforced with overlapping layers of 1.5-inch diameter steel re-bar.

The soil gas samples were analyzed in the field with a portable gas chromatograph (GC) unit. Each sample was analyzed for the following compounds: 1,1-dichloroethene; 1,1-dichloroethane; cis-1,2-dichloroethene; 1,2-dichloroethane; trichloroethane; trichloroethene; tetrachloroethene; and vinyl chloride.

2.3 SURFACE SOIL SAMPLING

Surface or 3-foot depth soil samples were collected from 18 locations in order to quantify the nature and extent of PCB contamination at the NWIRP, to assess its impact on the existing Risk Assessment, and to evaluate the need for and extent of remediation as directed by NYSDEC-mandated action levels. The sample locations are illustrated in Figure 2-4. These locations were chosen because each had PCBs tentatively identified from samples taken during Phase 1 of the Remedial Investigation.

All samples were taken either from the surface soil or from a depth of three feet below the surface. The three-foot depth soils were obtained through the use of a hand auger. The samples were collected with a stainless-steel sampling trowel and were placed directly in the appropriate jars for shipping and analysis. All samples were analyzed for TCL PCBs and pesticides. The sample log sheets and the chain-of-custody forms are included in Appendix B.

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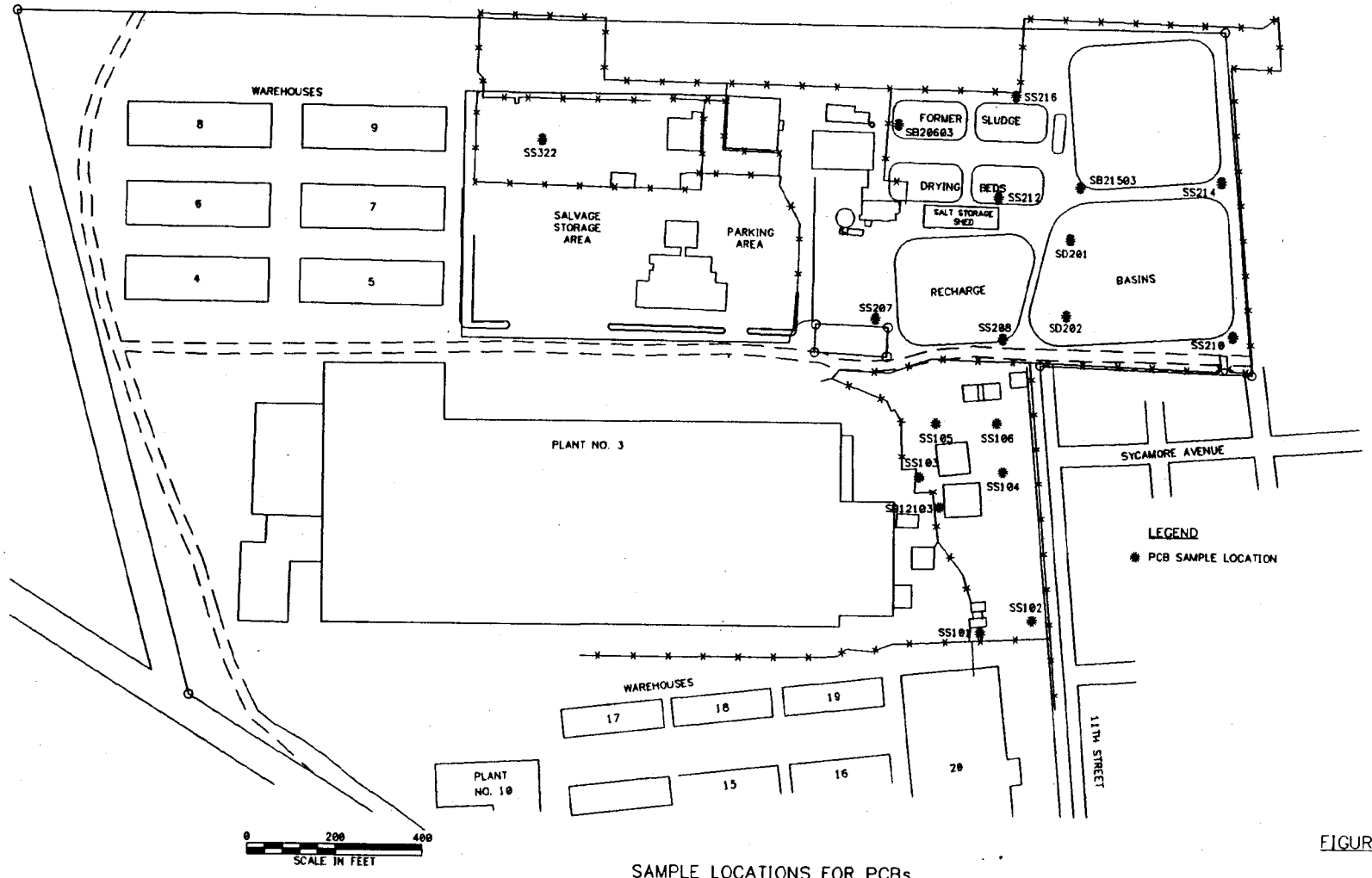

FIGURE 2-4

SAMPLE LOCATIONS FOR PCBs
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

HALLIBURTON NUS
Environmental Corporation

NYSDEC 033243

2.4 SOIL BORINGS AND SOIL SAMPLING

Eight subsurface soil samples were collected from two borings at location HN-24 during the installation of monitoring wells HN-24I1 and HN-24I2. These wells were installed to further delineate and possibly identify the source of the significant TCE contamination discovered at HN-24I during Phase 1 of the Remedial Investigation. The highest levels of contamination in that well (as determined by headspace analysis of split-spoon samples) were associated with a dense clay layer located at a depth of approximately 135 feet.

One sample from each boring was collected from the vadose zone in order to evaluate whether that location could be a source (as reflected in shallow soil contamination) of the deeper groundwater contamination. The three other samples were collected from depths ranging from 130 to 160 feet in an attempt to sample immediately above, within, and below the clay layer seen at HN-24I.

The subsurface soil samples were collected by driving a 2-inch-outside-diameter by 24-inch (or 18-inch) length split-barrel sampler with repeated blows using a 140-pound weight falling a distance of 30 inches. Soil samples were collected from depths of 10, 20, 30, 40, 130, 140, 150, and 160 feet for potential TCL-volatile analyses. A portion of each sample was placed in the appropriate laboratory-supplied jars for shipping and analysis. Another portion of each sample was placed in a clean jar and covered with aluminum foil for a headspace analysis performed in the field. The headspace analysis was performed with an HNU photo-ionization detector.

The depth of the shallow sample to be selected for laboratory analysis was determined by the highest HNU readings of the headspace. The depths of the three deeper samples to be selected for laboratory analysis was determined by the results of the headspace analysis and by the lithology encountered at each horizon. Sample log sheets for all soil samples and chain-of-custody forms are included in Appendix B.

2.5 TEMPORARY MONITORING WELL SURVEY

A temporary monitoring well survey was conducted to evaluate the off-site shallow groundwater contamination to the east and south of Site 1 and to aid in the placement of permanent, off-site monitoring wells. The well locations were chosen and spaced to allow for the identification and delineation of any off-site contamination and to determine what part(s) of the contamination may originate at the NWIRP. The well locations were placed in a general grid pattern, (see Figure 2-5).

Thirteen temporary wells were installed, sampled, and analyzed for the following parameters: vinyl chloride; 1,1,-dichloroethene; trans-1,2-dichloroethene; 1,1-dichloroethane; cis-1,2-dichloroethene; 1,1,1-trichloroethane; 1,2-dichloroethane; trichloroethene; and tetrachloroethene. Eleven of the temporary wells were installed off-site and two of the wells were installed on the NWIRP at Site 1; these two wells were later converted into piezometers for subsequent pumping tests. The locations of the temporary wells are illustrated in Figure 2-5.

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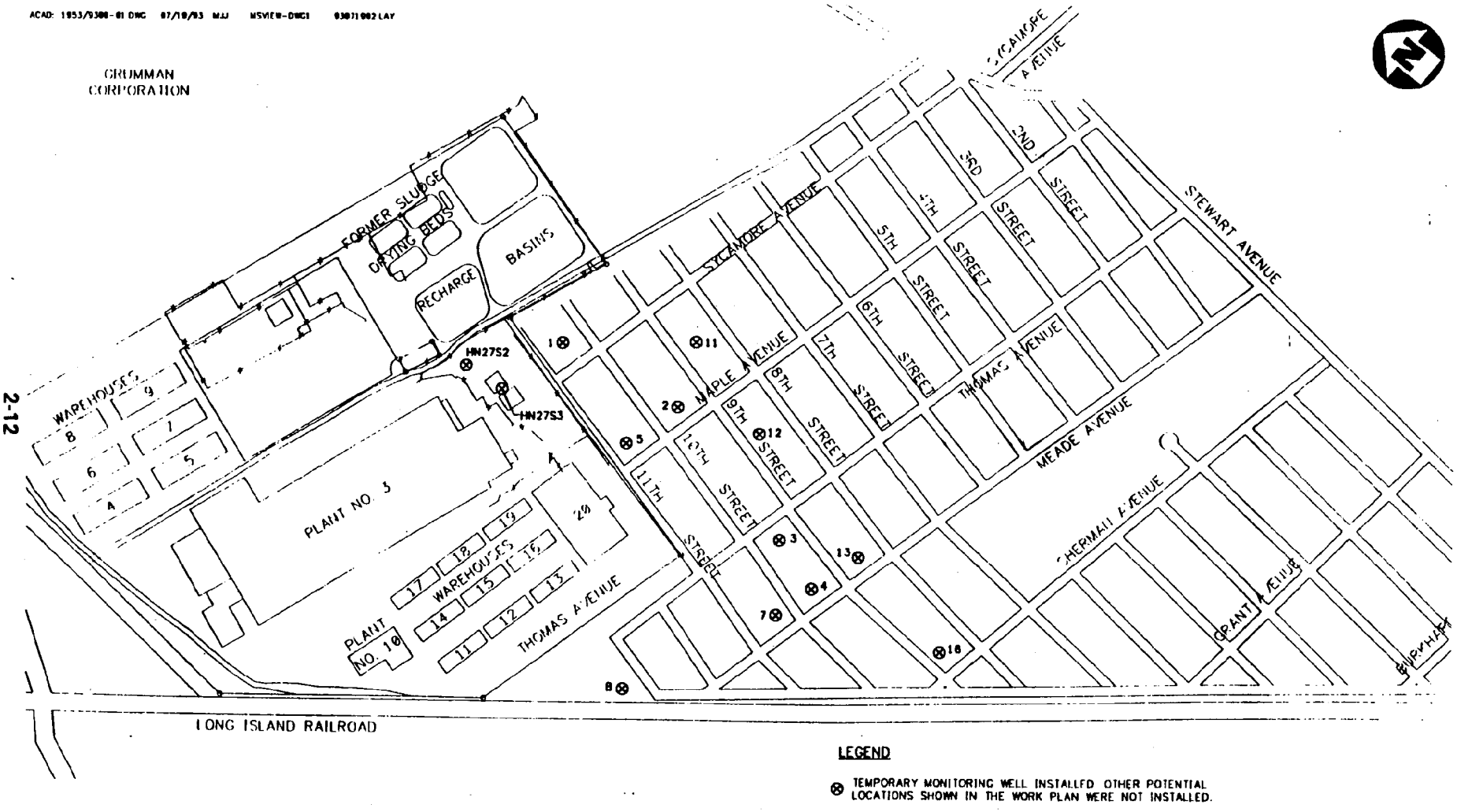

2-12

TEMPORARY MONITORING WELL POINT LOCATIONS
PHASE 2 – REMEDIAL INVESTIGATION FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

FIGURE 2-5

HALLIBURTON NUS
Environmental Corporation

NYSDEC 033245

The temporary wells were drilled with either a Mobile B-57 or Mobile B-61 drilling rig. Hollow-stem augers (3.25-inch inner diameter) were used to advance the borings through the unconsolidated deposits. Each borehole was drilled to a depth of approximately five feet below the static water level; the depths of the boreholes ranged from 59 to 62 feet (see temporary well boring logs, Appendix C). The well point consisted of a 2-inch diameter well screen installed through the hollow-stem auger; the augers were pulled back to expose the screen. All temporary wells were constructed with 2-inch inner diameter, Schedule 40, flush-joint threaded, polyvinyl chloride (PVC) pipe and a 10-foot section of PVC screen with a slot size of 0.010 inches and a PVC bottom cap. The well was purged a minimum of three well volumes with a PVC bailer, and sampled immediately afterward with the same bailer.

2.6 MONITORING WELL INSTALLATION

Permanent monitoring wells were installed at various locations during Phase 2 of the Remedial Investigation in order to further quantify and delineate the groundwater contamination discovered during the previous investigation. Monitoring wells were installed in the residential neighborhood located to the east and south of the NWIRP in order to evaluate the impact of the NWIRP on the local off-site groundwater quality. Three of the intermediate monitoring wells were installed on-site or near-site at locality HN-24 to identify the source of and further delineate the lateral extent of significant TCE contamination discovered at this locality during the Phase 1 Remedial Investigation.

A total of 11 monitoring wells (5 shallow and 6 intermediate) were installed during Phase 2. The location of these monitoring wells is provided in Figure 2-6 and Figure 2-7. The intermediate wells and the off-site shallow wells were installed with a Failing F-10 WT drilling rig. The shallow wells/piezometers at Site 1 were installed with a Mobile B-61 drilling rig. Hollow-stem augers were used to advance the borings through the overburden with a minimum borehole diameter of 10 inches. The shallow wells were constructed to be screened across the water table. The depth of each well was selected so that approximately 8 feet of the 10-foot screen was below the water table and 2 feet was above the water table.

The potential screened interval for the intermediate wells ranged from 100 to 150 feet for the off-site wells to 100 to 160 feet for the wells at HN-24. To determine the screened interval for the intermediate wells, a pilot hole was drilled at each intermediate well location with 6-inch outside diameter (OD) hollow-stem augers. Split-barrel samples were taken every 10 feet through the potential screened interval and put in glass jars. Headspace readings for each sample were taken with a photoionization detector (HNU). A gamma ray geophysical logger was run in each pilot hole to identify the lithologies present at the non-sampled intervals. The screened interval was determined by the results of the gamma ray log and the headspace readings. In general, the screen was placed across the zone of maximum contamination as determined by the headspace readings. If the headspace analysis did not reveal contamination, then the screen was placed across the shallowest, lithologically favorable zone (as determined by the gamma ray log) in the potential screened interval. Complete boring logs and gamma ray logs are included in Appendix C.

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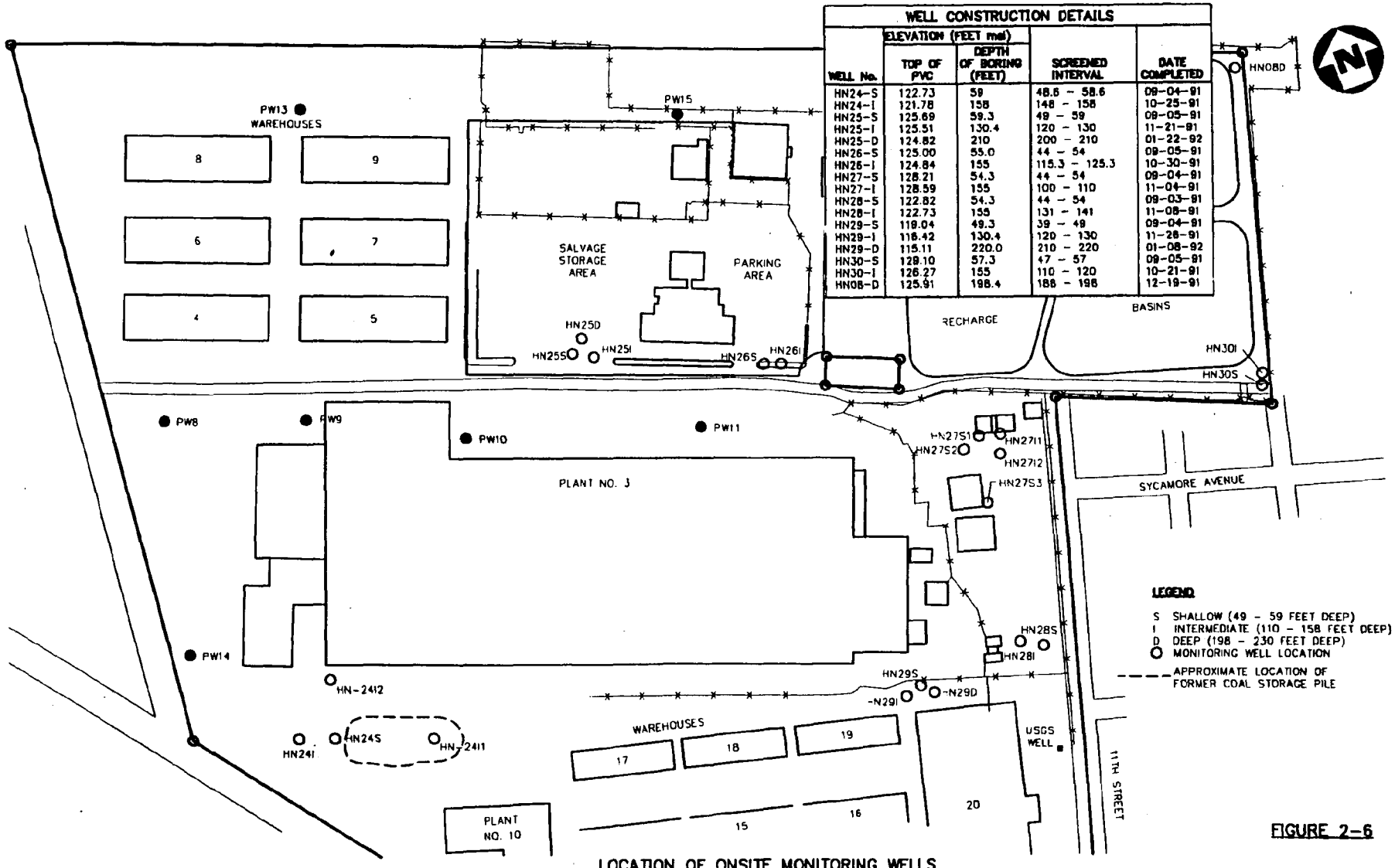

FIGURE 2-6

LOCATION OF ONSITE MONITORING WELLS
PHASE 2 - REMEDIAL INVESTIGATION FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

HALLIBURTON NUS
Environmental Corporation

2-14

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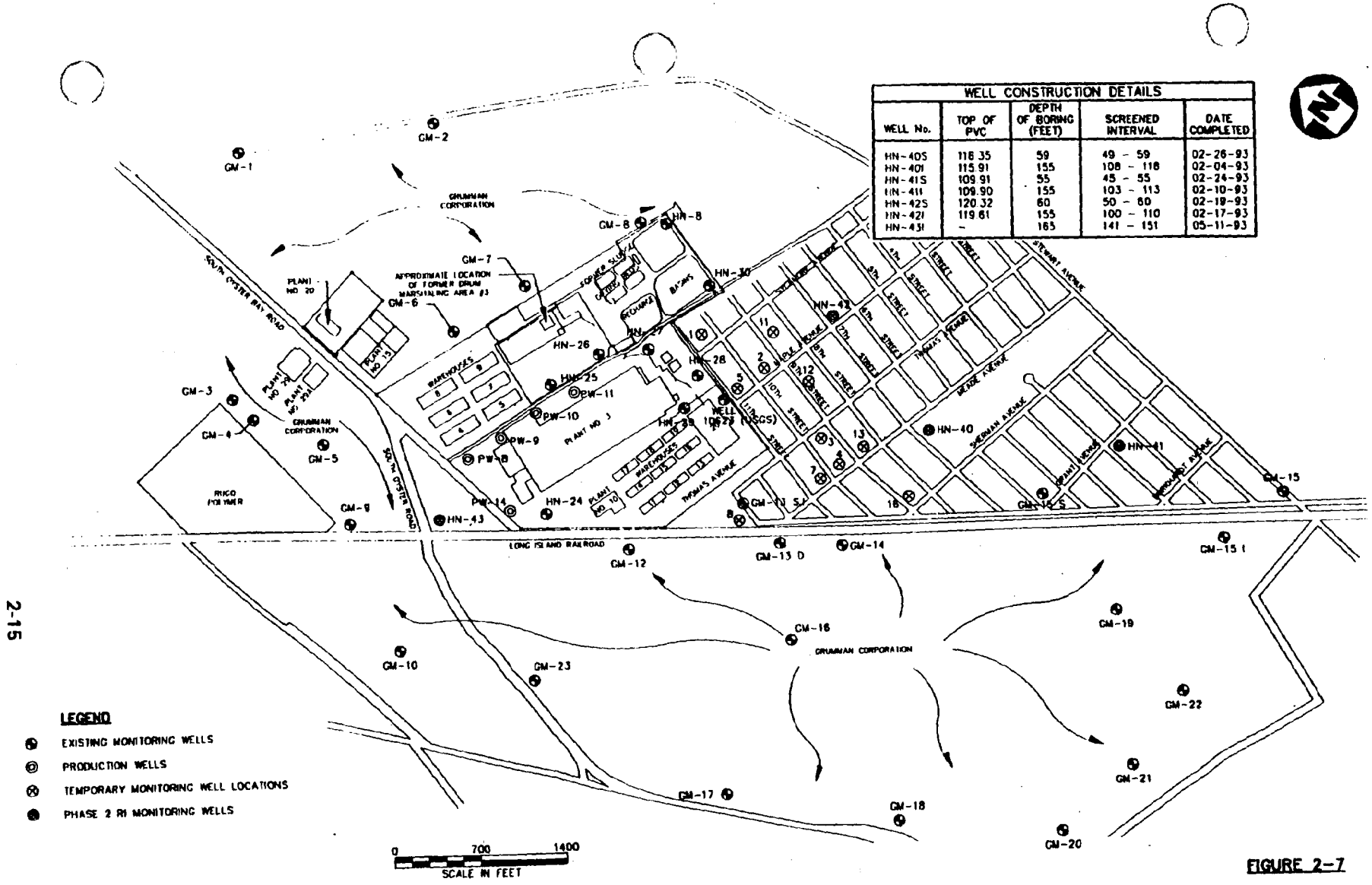

FIGURE 2-7

OFFSITE MONITORING WELLS
PHASE 2 - REMEDIAL INVESTIGATION FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

HALLIBURTON NUS
Environmental Corporation

NYSDEC 033248

The monitoring wells were constructed with 4-inch diameter, flush-joint and threaded Schedule 40 PVC well casing and 4-inch diameter, Schedule 40, 010-slot PVC well screen fitted with a PVC bottom cap. The annular space between the well screen and the borehole was packed with Morie No. 1 quartz sand to a height of approximately 3 feet above the top of the screen. A masonry sand seal approximately 2 feet thick was emplaced above the sand pack. A bentonite seal with a minimum thickness of 3 feet was emplaced above the filter pack. For the shallow wells, bentonite pellets were poured down the borehole and activated with potable water. For the intermediate wells, a bentonite slurry was pumped and emplaced by tremie. The remainder of the annulus for all wells was backfilled with a bentonite/cement grout. Well construction logs are included in Appendix D.

The shallow wells/piezometers at Site 1 were constructed with 2-inch diameter, flush-joint and threaded Schedule 40 PVC well casing and 2-inch diameter, Schedule 40, 020-slot PVC well screen fitted with a bottom cap. The annular space between the well screen and the borehole was packed with Morie No. 2 quartz sand to a height of approximately 3 feet above the top of the screen. A bentonite seal was emplaced with bentonite pellets in one well and by bentonite slurry in another. The remainder of the annulus above the seal was backfilled with a bentonite/cement grout. Well construction diagrams are included in Appendix D.

The intermediate wells and the off-site shallow wells were developed a minimum of 48 hours after installation. The groundwater temperature, pH, and conductivity were monitored during development. The shallow wells were developed with a submersible pump, and the intermediate wells were developed by air-lifting. The amount of water developed from the wells was based upon the stabilization of the monitored parameters and a visual, qualitative judgement of water clarity. For the intermediate wells, the amount of water developed from the well was controlled by the amount of water added to the borehole to control running sands during hollow-stem auguring and split-spoon sampling. In all cases, the amount of water removed during development greatly exceeded the amount introduced during well installation.

2.7 PUMPING WELL INSTALLATION

Well HN-27I2 was installed in the northern portion of Site 1 (see Figure 2-6) to serve as a pumping well for aquifer testing. The well was installed with a Failing Jed-A drilling rig. The borehole was drilled by the reverse-circulation drilling method; potable water was used as the circulation fluid.

Well HN-27I2 was installed to a depth of 135 feet. An 18-inch diameter borehole was drilled to a depth of 145 feet. The borehole was then logged with a gamma ray geophysical logger to ensure that the lithology through the prospective screened interval was favorable or conducive to the development of a high-yielding well. The gamma ray log did not reveal the presence of any significant clay layers. The bottom 10 feet of the borehole was backfilled and packed with Morie No. 2 quartz sand. The well was screened from 110 feet to 135 feet. The well screen is 8 inches in diameter by 25 feet in length and is constructed of continuous-slot, wire-wound screen with a slot opening of .020 inches. The riser pipe consists of threaded, 8-inch diameter steel well casing. The screen was packed with Morie No. 2

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quartz sand to a height of approximately 20 feet above the top of the screen. A masonry sand seal approximately 4 feet thick was emplaced above the sand pack, followed by a bentonite seal with an approximate thickness of 4 feet. The remainder of the annulus was backfilled with a bentonite/cement grout. The well construction diagram is included in Appendix D. The gamma ray log is included in Appendix C.

The well was developed with a high-capacity submersible pump 5 days after installation. The development consisted of alternately pumping and backwashing. The well was pumped at a rate of about 480 gpm for a period of 4 hours.

2.8 AQUIFER PUMPING TESTS

Two groundwater pumping tests were conducted in order to define the water yielding characteristics of the aquifer, to determine groundwater velocity values, and to determine aquifer parameters such as horizontal and vertical hydraulic conductivity, storativity, and dispersivity. Pumping Test 1 involved the pumping of the newly installed intermediate-depth pumping well HN-2712 and the monitoring of water level changes in nearby shallow and intermediate depth observation wells. Pumping Test 2 involved the pumping of Production Well No. 11 (a deep well) and the monitoring of water level changes in nearby shallow, intermediate, and deep observation wells and deep production wells.

Each pumping test consisted of a pre-pumping stabilization period, the long-term pumping test, and a final recovery phase. Water levels in appropriate observation wells were monitored prior to the pumping in order to establish baseline water level elevations. During all phases of the pumping tests, an attempt was made to keep all nearby production wells either constantly on or off; that is, to keep the study area's hydraulic condition constant. This was accomplished at all times except during Pumping Test 2, when facility demands required that nearby PW-13 be turned on several times. The possible effects of this pumpage are discussed in the pumping test data reduction and interpretation (see Appendix E).

Pumping Test 1

The first pumping test involved the pumping of the newly installed intermediate depth well HN-2712 (135 feet deep). The purpose of this test was to determine the hydraulic characteristics of the Magothy aquifer from the water table to the general depth of the intermediate monitoring well network. A submersible pump with a capacity of 500 gpm was temporarily installed in the well to conduct the test. All groundwater produced during the pumping of this well was discharged via a 6-inch hose into a 48-inch storm drain that emptied directly into the NWIRP recharge basin.

A step-drawdown test was conducted prior to the long-term pumping test to determine the optimal pumping rate for the well; that is, the maximum rate the well could be pumped without causing an excessive drawdown that exposed the pump. The test occurred on January 15, 1993 and involved the pumping of HN-2712 at three progressively higher rates (or "steps") for approximately 100 minutes each and observing the drawdown in the pumping well. The results of this test are included in Appendix E.

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Water levels in the pumping well and nearby observation wells were continuously monitored over the next 48 hours to ensure that the water levels had recovered to pre-pumping elevations and to establish the baseline pre-pumping water elevations for the long-term test.

The long-term pumping test commenced on the morning of January 18, 1993. Well HN-27I2 was pumped at a rate of 448 gpm; the flow was measured and periodically monitored by means of a manometer installed in the discharge line. Pressure transducers were placed in observation wells HN-27S2, HN-27S3, HN-27I, HN-28I, HN-26I, HN-30S, HN-30I, the USGS well, and the southeastern recharge basin, which was the only basin active at the time of the test. Water level measurements were periodically taken by hand with an independent measuring device (an M-scope) as a check on the automatic recording instruments. The test proceeded without incident for 69 hours, and the pump was turned off the morning of January 21. No precipitation fell during the pumping period. Water level recovery data was measured at each observation well for a period of about 22 hours, or to the morning of January 22. All wells had recovered to at least 90 percent of their pre-pumping level by this time. A minor rain event occurred during the overnight recovery period but did not noticeably affect the recovery data because most wells had already recovered before the start of precipitation.

The results of Pumping Test 1, including the raw data, data reduction, and interpretation, are included in Appendix E.

Pumping Test 2

The second pumping test involved the pumping of the deep facility production well PW-11 (490 feet deep). The purpose of this test was to determine the hydraulic characteristics of the deeper Magothy aquifer to the general depth of the Grumman production well network. Well PW-11 is equipped with a permanent turbine pump with a capacity of about 1200 gpm. Groundwater produced during the pumping of the well was fed into the facility system to satisfy part of the normal Grumman industrial demand and was ultimately discharged to the recharge basins.

Pressure transducers were placed in observation wells HN-27S2, HN-27I2, HN-28I, HN-29S, HN-29I, HN-29D, HN-25S, HN-25I, and HN-25D. Pressure gauges were placed on the drawdown tubes in production wells PW-8, PW-9, PW-10, PW-11, and PW-14. The observation wells common to both pumping tests already had transducers installed; these had been continuously recording since the end of the first test. The transducers in the new observation wells began recording water level elevations on the morning of January 25. A round of water level measurements was also taken at the production wells. This was done to establish the baseline pre-pumping water elevations for the long-term test.

The pumping test commenced on the afternoon of January 25. Well PW-11 was pumped at a rate of 890 gpm; the flow was measured and periodically monitored by means of a flowmeter permanently installed in the well's plumbing. The flow rate was measured to average 890 gpm over the test with a variance of 880 gpm to 960 gpm. This variance is believed to result from the changes in system demand. When demand rose and pressure dropped, the flow would increase and decrease relative to the system pressure. As in the first test, water level measurements were periodically taken by hand with an independent measuring device (an M-scope) as a check on the automatic recording instruments.

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The pumping test proceeded without incident for 72 hours, and the pump was turned off the afternoon of January 28. No precipitation fell during the pumping period. Water level recovery data was measured at most observation points for a period of about 18 hours; the transducers in the observation wells at clusters HN-25 and HN-29 were allowed to run for a period of about 70 hours, or to the morning of February 1. The results of Pumping Test 2, including the raw data, data reduction, and interpretation, are included in Appendix E.

2.9 GROUNDWATER SAMPLING

Sampling and analysis of groundwater was conducted to determine the current level and extent of contamination both on the NWIRP and in the adjacent residential neighborhood and to provide data for use in the revised risk assessment and the evaluation of remedial action alternatives for the Feasibility Study. The groundwater sampling was conducted from March 11 through May 26, 1993, and included 22 wells: 16 shallow, intermediate, and deep monitoring wells, 1 USGS well, and 5 deep facility production wells. Well locations are shown in Figures 2-6 and 2-7.

The groundwater sampling and analysis program and sampling procedures are described in the Final RI Work Plan Addendum and Quality Assurance Plan.

Field measurements collected during sampling were pH, temperature, and specific conductivity. These results are provided on the sample log sheets, which are included in Appendix B. Groundwater samples were submitted to a Naval Energy and Environmental Support Activity (NEESA) - approved laboratory using CLP methods. All groundwater samples were analyzed for Target Compound List (TCL) volatile organic compounds.

Quality control samples, including field duplicates, trip blanks, and rinsate blanks, were collected and analyzed as required by NEESA Level D sampling protocol and as specified and discussed in the Final RI Work Plan Addendum and Quality Assurance Plan.

The analytical results of the groundwater sampling are discussed in Section 4.0.

2.10 WATER-LEVEL MEASUREMENTS

Groundwater-level measurements are taken monthly on all NWIRP, Grumman, and many local USGS monitoring wells by Geraghty and Miller, Inc. on behalf of their client, the Grumman Corporation. Upon request, Grumman has periodically supplied this data to the Navy. These groundwater-level measurements were used during Phase 2 of the RI in the construction and calibration of a computer-generated groundwater model and in the construction of groundwater contour maps. The monthly groundwater-level measurements for the period from August, 1991 to September, 1992 are included in Appendix F. Groundwater-level measurements for April, 1993 are included in Section 3.3.

NYSDEC 033252

2.11 HORIZONTAL LOCATION AND VERTICAL ELEVATION SURVEY

Horizontal locations and vertical elevations were surveyed at the eight newly installed monitoring wells, (well HN-43I had not been installed at the time of the surveying), the two newly installed piezometers, and the eleven temporary monitoring well locations. In addition, wells HN-24I and HN-27I were resurveyed. Well HN-24I had been converted from a flush-mount to an above-grade completion. Well HN-27I had been repaired and recompleted after being damaged.

The surveying for all points, except for Well HN-43I, occurred between April 21, 1993 and April 29, 1993. Well HN-43I was surveyed in September 1993. The surveying for each well and piezometer included its horizontal location, the elevation of the ground surface adjacent to the well, and the elevation of the top of the PVC casing (TOC). The surveying of the temporary monitoring wells included their horizontal location and the elevation at the spot of the grouted borehole.

Elevations (TOC) for each monitoring well are included in Table 2-1. Surveying notes are included in Appendix G.

NYSDEC 033253

TABLE 2-1

WELL (TOP OF CASING) AND GROUND ELEVATIONS FOR MONITORING WELL NETWORK
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP-BETHPAGE, LONG ISLAND, NEW YORK

WELL	GROUND ELEVATION (FEET MSL)	TOP OF PVC CASING (FEET MSL)
HN-8D	127.08	125.91
HN-24S	123.03	122.73
HN-24I	122.69	125.80
HN-24I1	121.20	120.46
HN-24I2	123.29	122.89
HN-25S	126.09	125.69
HN-25I	125.85	125.51
HN-25D	125.21	124.82
HN-26S	125.37	125.00
HN-26I	125.33	124.84
HN-27S1	125.50	128.21
HN-27S2	125.14	124.88
HN-27S3	124.67	124.39
HN-27I1	125.17	127.28
HN-27I2	125.53	125.06
HN-28S	123.26	122.82
HN-28I	122.95	122.73
HN-29S	116.93	119.04
HN-29I	117.07	116.42
HN-29D	115.66	115.11
HN-30S	127.18	129.10
HN-30I	126.72	126.27
HN-40S	116.64	116.35
HN-40I	116.51	115.91
HN-41S	110.23	109.91
HN-41I	110.29	109.90

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TABLE 2-1
WELL (TOP OF CASING) AND GROUNDWATER ELEVATIONS FOR MONITORING WELL NETWORK
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP-BETHPAGE, LONG ISLAND, NEW YORK

WELL	GROUND ELEVATION (FEET MSL)	TOP OF PVC CASING (FEET MSL)
HN-42S	120.59	120.32
HN-42I	119.98	119.61
HN-43I	127.89	127.55
USGS (N-10623)	121.25	120.84

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3

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

The Phase 1 RI report discussed the site specific, local, and regional geology and hydrogeology of the NWIRP and Bethpage area in detail. This report focuses on the results of the Phase 2 RI drilling and aquifer testing programs, and compares or contrasts these data to the results of the Phase 1 RI program. The new data is presented and discussed, and the results are incorporated into the current hydrogeological interpretation.

3.1 SURFACE FEATURES

The NWIRP-Bethpage is located on Long Island, New York. The site is located on a relatively flat and featureless glacial outwash plain. The site and nearby vicinity are highly urbanized. Because of this, most of the natural physical features have been reshaped or destroyed. The topography of the activity is relatively flat, with a gentle slope toward the south. Elevations range from approximately 140 feet above mean sea level (MSL) in the north to approximately 110 feet above MSL at the southwest corner (RGH, 1986).

The NWIRP is about 108 acres in size. The dominant features at the activity are Plant No. 3 (the manufacturing plant) and the three groundwater recharge basins located at Site 2. The recharge basins range is size from approximately 1.5 to 2.5 acres in area and are about 30 feet deep. Other notable features of the NWIRP are a wastewater treatment plant at Site 2, a drum marshalling area at Site 3, and a series of warehouses (with a temporary drum area) northwest of Plant 3.

3.2 GEOLOGY

3.2.1 Introduction and General Considerations

The NWIRP and surrounding area is underlain by approximately 1,100 feet of unconsolidated sediments that unconformably overlie crystalline bedrock. The unconsolidated sediments consist of four distinct geologic units that, in descending order, are the Upper Glacial Formation, the Magothy Formation, the Raritan Clay Member of the Raritan Formation, and the Lloyd Sand Member of the Raritan Formation. The crystalline bedrock consists primarily of metamorphic and igneous rocks including schist, gneiss, and granite. The regional dip of the bedrock is to the south and southeast. All of the geologic units dip in these directions, although to varying degrees (Isbister, 1966).

The Upper Glacial and the Magothy Formations were penetrated and sampled; the Raritan Formation lies below the depth of this investigation. The Upper Glacial Formation, which is about 30 to 45 feet thick, consists chiefly of coarse sands and gravels. The Magothy Formation has been penetrated and sampled to a total depth of 250 feet by this study; the total thickness of the Magothy is approximately 650 feet. The upper Magothy Formation consists chiefly of coarse sands to a subsurface depth of

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about 100 feet, below which finer sands, silts, and clays predominate. Clay lenses are fairly common but laterally discontinuous; no individual clay horizon of regional extent underlies the NWIRP.

3.2.2 Stratigraphy

UPPER GLACIAL FORMATION

The Upper Glacial Formation (commonly referred to as glacial deposits) forms the surface deposits across the entire NWIRP. The glacial deposits beneath the site consist of coarse sands and gravels. These deposits are generally about 30 to 45 feet thick; local variations in thickness are common due to the irregular and undulating contact of the glacial deposits with the underlying Magothy Formation. The contact between the two formations was defined in the field as the horizon where gravel becomes very rare to absent, and variegated finer sands, silts, and clays predominate. The generally coarse nature of both formations near their contact, however, may make this differentiation either difficult or rather subjective (HNUS, 1992).

The results of the Phase 2 RI drilling program indicate that the general characteristics of the Upper Glacial Formation do not change offsite to the east and southeast of the NWIRP. The glacial deposits penetrated during the temporary monitoring well program consisted chiefly of sands and gravels (see borings logs, Appendix C; and well locations, Figure 2-5). The thickness of the glacial deposits was generally about 35 feet, although this can only be considered an approximation because the lithology was determined through an examination of the drill cuttings and no split-spoon samples were taken.

MAGOTHY FORMATION

The Magothy Formation beneath the NWIRP consists of sands, silts, and clays. The formation, at least to the depth of investigation of this study, is generally composed of alternating sequences where one of these lithologies is dominant, but the others are present to varying degrees. Stratigraphic intervals containing only one of these lithologically distinct end-members are rare. The basal Magothy reportedly consists of a highly permeable and productive gravel. This horizon was not penetrated or sampled by this investigation (HNUS, 1992; Isbister, 1966).

Relatively thick and lithologically distinct clay units were encountered within the Magothy Formation during the Phase 1 RI drilling program. These clays were found to be laterally discontinuous in their distribution; no clays of "activity wide" extent were noted. These results agree with the results noted in published reports (HNUS, 1992; S-F, 1988)

A general lithologic trend observed in the Magothy Formation during the Phase 1 RI drilling program was a decrease in average grain size with increasing depth. The relative abundance of finer-grained sediments such as silts and clays increases sharply below a subsurface depth of about 100 feet.

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The Magothy Formation was drilled and examined at several locations during the Phase 2 RI drilling program. The nature of the upper Magothy (to a subsurface depth of about 60 feet) was investigated through an examination of the drill cuttings during the offsite temporary monitoring well program. A deeper interval of the Magothy Formation was investigated during the installation of the permanent monitoring wells both offsite (at locations HN-40, HN-41, and HN-42) and onsite at locations HN-24 and HN-43. For the deeper wells, split-spoon samples were taken from a subsurface depth of 100 feet to the pilot hole total depth of either 150 feet (offsite) or 160 feet (HN-24 and HN-43). The entire borehole was subsequently logged with a gamma ray geophysical instrument.

The upper Magothy sediments consisted chiefly of sand with minor silt. Clays were rare. Because the lithology was determined only through drill cuttings, however, it is possible that relatively thin, indiscernible clay layers were penetrated. The gamma ray logs from the pilot boreholes revealed several clayey intervals. Thin clays were common in the upper Magothy sediments on the NWIRP, which were sampled with a split-spoon sampler during the Phase 1 RI drilling program. A sticky, gray clay was encountered in the upper Magothy at location HN-8; this clay plugged the lead auger and made sampling difficult.

The deeper Magothy sediments (from 100 to 160 feet) that were drilled offsite consisted of sand, silt, and clay. Several of the sands were fairly coarse and clean. Several of the clay layers were relatively thick; a very sticky to stiff clay penetrated at location HN-42 was at least 15 feet thick. The lateral continuity and/or the stratigraphic equivalency of the various horizons is uncertain due to the distance between the wells. The gamma ray logs of the pilot holes indicate that, like the NWIRP boreholes, the amount of clay in the Magothy generally increases significantly below a subsurface depth of 100 feet.

The Magothy Formation was investigated in more detail at location HN-24. Here, significant TCE groundwater contamination is apparently associated with a very stiff and dense black clay about 10 feet thick that occurs at a subsurface depth of approximately 135 feet in monitoring well HN-24I. Three additional wells (HN-24I1, HN-24I2, and HN-43I) were installed during Phase 2 RI to determine a potential source(s) of the contamination and to evaluate the lateral continuity of the clay layer, its true rate and direction of dip, and its relationship to the contamination. Although all sedimentary units on Long Island generally dip to the south and southeast (Isbister, 1966), neither the regional nor local direction or rates of dip of the individual units within this section of the Magothy are known.

Monitoring well HN-24I2 was installed between well HN-24I and Plant No. 3 to evaluate the plant as a potential source of the TCE contamination. A comparison of the boring logs and the gamma ray logs reveals that the lithology at HN-24I and HN-24I2 is very similar. The Magothy Formation at both locations consists chiefly of fine- to medium sands, silty sands, and silts. Like well HN-24I, a very stiff and dense black clay about 10 feet thick was encountered in well HN-24I2 at a subsurface depth of approximately 135 feet. Similarly, a sticky gray clay about 8 to 10 feet thick was encountered in both wells at a subsurface depth of approximately 110 feet. As will be discussed in Section 4, the TCE contamination discovered in well HN-24I2 is also apparently associated with the dense black clay layer.

Monitoring well HN-24I1 was drilled east of HN-24I at the site of the former coal pile and near Plant No. 10 to evaluate if either of these may be a source of the TCE contamination. The boring log and

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gamma ray log from HN-241I reveals that the two thick clay horizons encountered at HN-241 and HN-2412 are absent. Rather, these facies have graded into somewhat clayey, fine to medium sands.

Monitoring well HN-431 was installed in a regionally upgradient and geologically updip position from the HN-24 location to determine the upgradient extent of the TCE contamination observed at HN-24 and to determine the updip extent or continuity of the dense clay layer associated with the TCE. The boring log and gamma ray log from HN-431 indicate that the distinct clay horizons encountered at HN-241 and HN-2412 do not extend updip to this location. The gamma ray log indicates the presence of several clayey intervals at depths of 125 to 130 feet and at 150 feet, but the split-spoon samples from these intervals reveal that the lithology is dominantly silt and fine sand (see Appendix C for gamma ray and boring logs).

The results of the drilling program at location HN-24 and surrounding well locations (HNUS, 1992) appear to confirm the regional observation that there are no singular, areally extensive clay units beneath the NWIRP. The installation of multiple wells at Sites 1 and 3, at location HN-24, and in the offsite residential neighborhood further indicates that there does not appear to be any clay units of significant local extent. Clay units encountered at any particular location do not persist along strike or in either direction of dip. The stratigraphic section at and below subsurface depths of about 100 feet may be considered "clay-prone" because the number of individual clay units significantly increases below this depth, but none of these clays are laterally persistent.

3.2.3 Hydrogeology

INTRODUCTION AND GENERAL CONSIDERATIONS

The Upper Glacial Formation and the Magothy Formation comprise the aquifer of concern at the NWIRP. Regionally, these formations are generally considered to form a common, interconnected aquifer as the coarse nature of each unit near their contact and the lack of any regionally confining clay unit allows for the unrestricted flow of groundwater between the formations.

The water table beneath the NWIRP was found only within the Magothy Formation. A published report indicates that the water table to the south and west of the NWIRP, and possibly beneath part of the NWIRP, occurs within the glacial deposits, although this boundary was based on limited data and was considered approximate (S-F, 1988).

Static water elevations from the NWIRP monitoring wells collected at regular intervals from August, 1991, to September, 1992 (see Appendix F) indicate that although the water table exhibits a seasonal fluctuation, it does not rise to the Upper Glacial Formation. Annual fluctuations of the water table over this period ranged from as little as 3.07 feet at location HN-29 to as much as 8.64 feet at location HN-30. The average fluctuation during this period was about 4.5 feet. This agrees well with published reports that state that the ambient water table elevation locally varies by three to four feet (Isbister, 1966; S-F, 1988).

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The influence of the NWIRP recharge basins on local groundwater elevations is demonstrated by the effects caused by the periodic abandonment and activation of the different basins. Wells HN-27S and HN-26S were installed to a depth of 8 feet below the water table at a time (8/91) when the southwestern recharge basin was active. These wells, however, were dry at a time (3/93) that this recharge basin was inactive. A piezometer (HN-27S2) installed near HN-27S in March indicated that the static water level was just below the level of the dry well, or about 8 feet below its level when the well was installed. A comparison of water level elevations over this same period from a more distant well (HN-24S) indicates that about 3 to 4 feet of this fluctuation is seasonal and the rest is due to the abandonment of the recharge basin. One published report (S-F, 1988) also noted the profound local effects of the NWIRP recharge basins on the local water table. This report noted that the groundwater elevation near the basin may be as much as 7 feet above the ambient elevation.

AQUIFER CHARACTERISTICS

UPPER GLACIAL FORMATION

The Upper Glacial aquifer is no longer an important source of potable water in the immediate area because of its poor quality; it is now pumped only for minor industrial use (S-F, 1988). In parts of Long Island, however, this aquifer is still is a major source of potable water. The Upper Glacial aquifer is generally a high yielding unit with favorable hydraulic characteristics. The glacial deposits are characterized by a moderate to high primary porosity and permeability; the porosity is reported to exceed 30 percent. Well yields as high as 1,100 gpm have been reported (Isbister, 1966; McClymonds and Franke, 1972; S-F, 1988; B-M, 1992).

The published estimated average value of horizontal hydraulic conductivity (Kh) for the Upper Glacial aquifer ranges from 230 feet/day to 270 feet/day and the reported vertical hydraulic conductivity (Kv) is about 23 feet/day. The anisotropy of the aquifer, therefore, is 10:1. The hydraulic characteristics of the aquifer could not be calculated by the recent pumping tests because, as discussed, the formation occurs above the water table. A calculation of the vertical hydraulic conductivity of the aquifer beneath the recharge basins, however, yielded a result of 23.4 feet/day (see Section E), which is in close agreement with the published value (McClymonds and Franke, 1972; B-M, 1992; S-F, 1988).

Although the water table beneath the NWIRP occurs below the glacial deposits, they are hydrogeologically important because their high permeability allows for the rapid recharge of precipitation to the underlying Magothy Formation. In addition, the large quantities of groundwater withdrawn daily from the Magothy passes back through part of the glacial deposits via the recharge basins to the Magothy Formation.

MAGOTHY FORMATION

The Magothy aquifer is the major source of public water in Nassau County. The most productive water-bearing zones are the discontinuous lenses of sand and gravel that occur within the generally siltier matrix. The major water-bearing zone is the basal gravel.

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The hydraulic characteristics of the Magothy Formation beneath the NWIRP were investigated by two pumping tests (Appendix E) in order to obtain site-specific values. The published literature contains many references to the regional hydraulic characteristics of this aquifer. Because of the extreme lateral and vertical lithologic heterogeneity of the Magothy, any hydraulic values obtained are strongly dependent on both the geographic location of the test and the stratigraphic (vertical) section covered by the test. Site-specific values were needed to support the groundwater modeling study, the Feasibility Study, and the Remedial Design of the NWIRP.

The results of the current pumping tests indicate that the horizontal hydraulic conductivity (Kh) of the Magothy Formation beneath the NWIRP is about 100 feet/day. The individual conductivity values determined by various calculation methods are included in Table 3-1; the calculation methods are discussed in detail in Appendix E. A horizontal conductivity value of 100 feet/day is believed to be representative of the Magothy because it is the result obtained from the distance-drawdown method that uses data from many wells. This value also compares favorably with the geometric mean value of Kh (94 feet/day) obtained for the individual wells by the Neuman, Ferris, and Dupuit methods (see Appendix H for the calculation of the geometric mean Kh). The representative horizontal hydraulic conductivity value of 100 feet/day is in general agreement with the published estimated value of 50 feet/day (S-F, 1988; B-M, 1992).

The vertical hydraulic conductivity (Kv) of the upper Magothy aquifer was calculated at three locations. The Kv values ranged from a high of 10.27 feet/day at HN-26 to a low of 3.98 feet/day at HN-28. It is not unexpected that well HN-28I would exhibit the lowest vertical conductivity because this well was completed in a particularly clayey interval (HNUS, 1992). The magnitude of the Kv values, however, was somewhat unexpected; the published average value of Kv for the Magothy aquifer is 0.5 feet/day (b-m,1992). As a result of the high Kv values, the anisotropy (Kh/Kv) calculated for the NWIRP wells ranged from 7.0 to 15.6, which is significantly lower that the commonly accepted anisotropy value of 100. It should be noted that because of the extreme lateral and vertical lithologic heterogeneity of the Magothy, any hydraulic values obtained will be strongly dependent on both the geographic location of the test and the stratigraphic (vertical) section covered by the test. (S-F, 1988; B-M, 1992).

The Magothy aquifer is commonly regarded to function overall as an unconfined aquifer at shallow depths and a confined aquifer at deeper depths. The drilling program on the NWIRP has revealed that clay zones beneath the facility are common but laterally discontinuous (see borings logs, Appendix C; HNUS, 1992). No confining clay units of facility-wide extent were encountered. This agrees with observations noted in the literature (S-F, 1992).

The degree of confinement within the Magothy aquifer is reported to generally increase with depth due to the cumulative effect of the silts and clays (Isbister, 1966; McClymonds and Franke, 1972). The lack of a singular, continuous confining unit beneath the NWIRP and the dependence of confinement on the occurrence of multiple fine-grained units should make the relationship of confinement to depth laterally inconsistent due to the extreme lithologic heterogeneity of the formation.

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TABLE 3-1

SUMMARY OF HYDRAULIC CHARACTERISTICS - AQUIFER PUMPING TESTS - JANUARY 1993
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP - BETHPAGE, LONG ISLAND, NEW YORK

WELL	SCREENED INTERVAL (FEET)	TRANSMISSIVITY (FT²/DAY)	HORIZONTAL CONDUCTIVITY (Kh) (FT/DAY)	VERTICAL CONDUCTIVITY (Kv) (FT/DAY)	ANISOTROPY (Kh/Kv)	STORATIVITY	SPECIFIC YIELD	CALCULATION METHOD
HN275Z	51 - 61	7002 3	41 19		--	0 054	--	NEUMAN*
		24511	144	--	--	--	--	FERRIS
		24467	144	--	--	--	--	DUPUIT
HN275J	51 - 61	13198 8	77 64	--	--	0 044	--	NEUMAN*
HN26I	115 3 - 125 1	16340 4	96 12	10 27	9 36	0 0012	--	NEUMAN
		39218	231	--	--	--	--	FERRIS
		38071	224	--	--	--	--	DUPUIT
HN27I	100 - 110	6862 9	40 37	5 76	7 01	0 0041	--	NEUMAN
		5718 8	33 64	--	--	0 0045	--	NEUMAN*
		18740	98	--	--	--	--	FERRIS*
		20126	118	--	--	--	--	DUPUIT*
HN28I	131 - 141	10558 7	62 11	3 98	15 61	0 0012	--	NEUMAN
		18549	109	--	--	--	--	FERRIS
		19574	115	--	--	--	--	DUPUIT
HN26I,HN27I,HN28I HN275Z,HN275J	--	17918	105 4	--	--	--	0.175	DISTANCE-DRAWDOWN AT 1000 MINUTES*
		17136	100 8	--	--	--	0.33	DISTANCE-DRAWDOWN AT 4000 MINUTES*
PW 11	430 - 490	60000	85.7	--	--	0 26	--	DISTANCE-DRAWDOWN AT 4000 MINUTES
		59723	85 3	--	--	--	--	SPECIFIC CAPACITY
RECHARGE BASIN			--	23 36	--	--	--	PERMEABILITY

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The storativity values of the upper Magothy as calculated by the drawdown in the shallow and intermediate observation wells ranges from 0.0012 to 0.054 (see Table 3-1). Generally, unconfined aquifers have storativity values of greater than about 0.01, while values of less than 0.005 are indicative of confined aquifers (Fetter, 1988; Freeze and Cherry, 1979). The results of the pumping tests, therefore, reveal that groundwater in the shallow Magothy aquifer is under both unconfined and semi-confined conditions, depending on lithology.

The response of the Magothy aquifer to production well pumping suggests that groundwater occurs under at least semi-confined conditions in deeper portions of the aquifer. As discussed in Appendix E, a cycling of water level elevations was seen in several observation wells during the tests. It was hypothesized that the cycling may represent the aquifer's response to the pumping of an unidentified well(s). The plots of time versus drawdown for the various observation wells indicate that any particular drawdown occurs at approximately the same time at each well. This rapid lowering of head across a wide geographic area is characteristic of confining conditions.

The static water levels of the NWIRP and offsite monitoring wells for April, 1993 are presented in Table 3-2. These data suggest that the Magothy aquifer is either unconfined or semi-confined, but not confined, to at least the total depth of the monitoring well network (about 250 feet). For any well cluster, the difference in static water level elevations between the shallow and intermediate or deep wells is fairly small, ranging from 0.01 to 3.43 feet. According to one published report, the potentiometric surface of confined aquifers in central Long Island is typically 30 to 40 feet below the water table (McClymonds and Franke, 1972).

The distribution of hydraulic head within the Magothy aquifer further attests to the leaky nature of the aquifer, at least to the depths of the intermediate well network. Contour maps of the water elevations for the shallow and intermediate wells for April, 1993 are included as Figures 3-1 and 3-2. As would be expected, the groundwater injection at the recharge basins produces a pronounced mounding of the water table that affects the shallow monitoring wells. Note, however, that the intermediate wells near the recharge basins also reflect this groundwater mounding. If the aquifer at this depth was truly confined, it would not be affected by the addition of groundwater to the shallower zones.

GROUNDWATER FLOW CHARACTERISTICS

HORIZONTAL FLOW

Long Island is bisected by an east-west trending, regional groundwater divide. The NWIRP lies to the south of this divide. Groundwater beneath the site, therefore, flows in a generally southward direction, towards the Atlantic Ocean. Most published data indicate that the regional flow is to the south or slightly to the southeast (S-F, 1988). The site-specific data generated during both phases of the NWIRP investigation, however, indicate a strong southwestward component of groundwater flow beneath the facility.

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TABLE 3-2

GROUNDWATER ELEVATION DATA USED FOR CONTOUR MAP GENERATION
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP-BETHPAGE, LONG ISLAND, NEW YORK

WELL	GROUNDWATER ELEVATION (FEET MSL)	WELL	GROUNDWATER ELEVATION (FEET MSL)
	4/30/93		4/30/93
HN-8D	69.42	GM-5I	72.03
HN-24S	70.74	GM-6S	71.93
HN-24I	69.50	GM-6I	66.39
HN-24I1	69.71	GM-7S	71.84
HN-24I2	69.59	GM-7I	71.59
HN-25S	71.04	GM-7D	69.76
HN-25I	70.48	GM-8S	73.44
HN-25D	68.14	GM-8I	74.04
HN-26S	73.06	GM-9S	71.59
HN-26I	71.74	GM-9I	71.38
HN-27S1	72.90	GM-10S	70.21
HN-27I1	73.38	GM-10I	70.16
HN-27I2	71.61	GM-12S	69.98
HN-28S	70.84	GM-12I	69.38
HN-28I	-	GM-13S	69.32
HN-29S	70.86	GM-13I	69.56
HN-29I	69.58	GM-13D	67.58
HN-29D	67.43	GM-14S	68.28
HN-30S	71.75	GM-14I	68.12
HN-30I	71.02	GM-15S	73.22
HN-40S	67.32	GM-15I	65.61

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TABLE 3-2 (Continued)
GROUNDWATER ELEVATION DATA USED FOR CONTOUR MAP GENERATION
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP-BETHPAGE, LONG ISLAND, NEW YORK
PAGE 2

WELL	GROUNDWATER ELEVATION (FEET MSL)	WELL	GROUNDWATER ELEVATION (FEET MSL)
	4/30/93		4/30/93
HN-40I	67.31	GM-16S	68.50
HN-41S	65.47	GM-16I	68.44
HN-41I	65.40	GM-17S	70.29
HN-42S	69.37	GM-18S	66.51
HN-42I	69.27	GM-18I	66.65
GM-1S	73.81	GM-19S	66.05
GM-1I	73.72	GM-19I	66.12
GM-2S	73.80	GM-20S	65.25
GM-2I	72.73	GM-20I	65.20
GM-3S	73.25	GM-20D	64.28
GM-3I	72.32	GM-21S	64.76
GM-4S	75.02	GM-21I	64.56
GM-4I	72.41	GM-22S	66.00
GM-5S	72.37	GM-22I	67.23

NOTE: Groundwater elevations measured by Geraghty & Miller, Inc..

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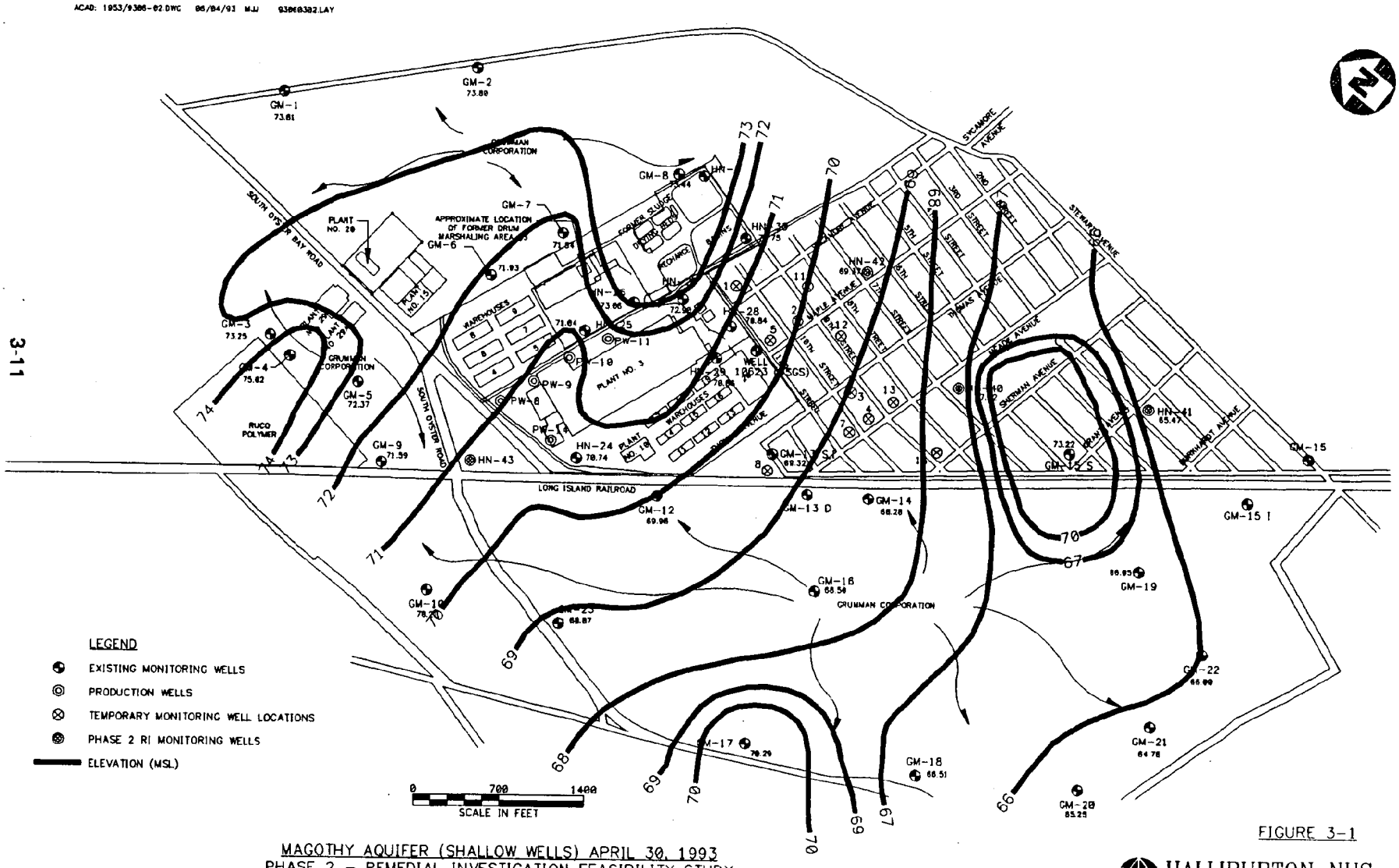

MAGOTHY AQUIFER (SHALLOW WELLS) APRIL 30, 1993
PHASE 2 - REMEDIAL INVESTIGATION FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

FIGURE 3-1

HALLIBURTON NUS
Environmental Corporation

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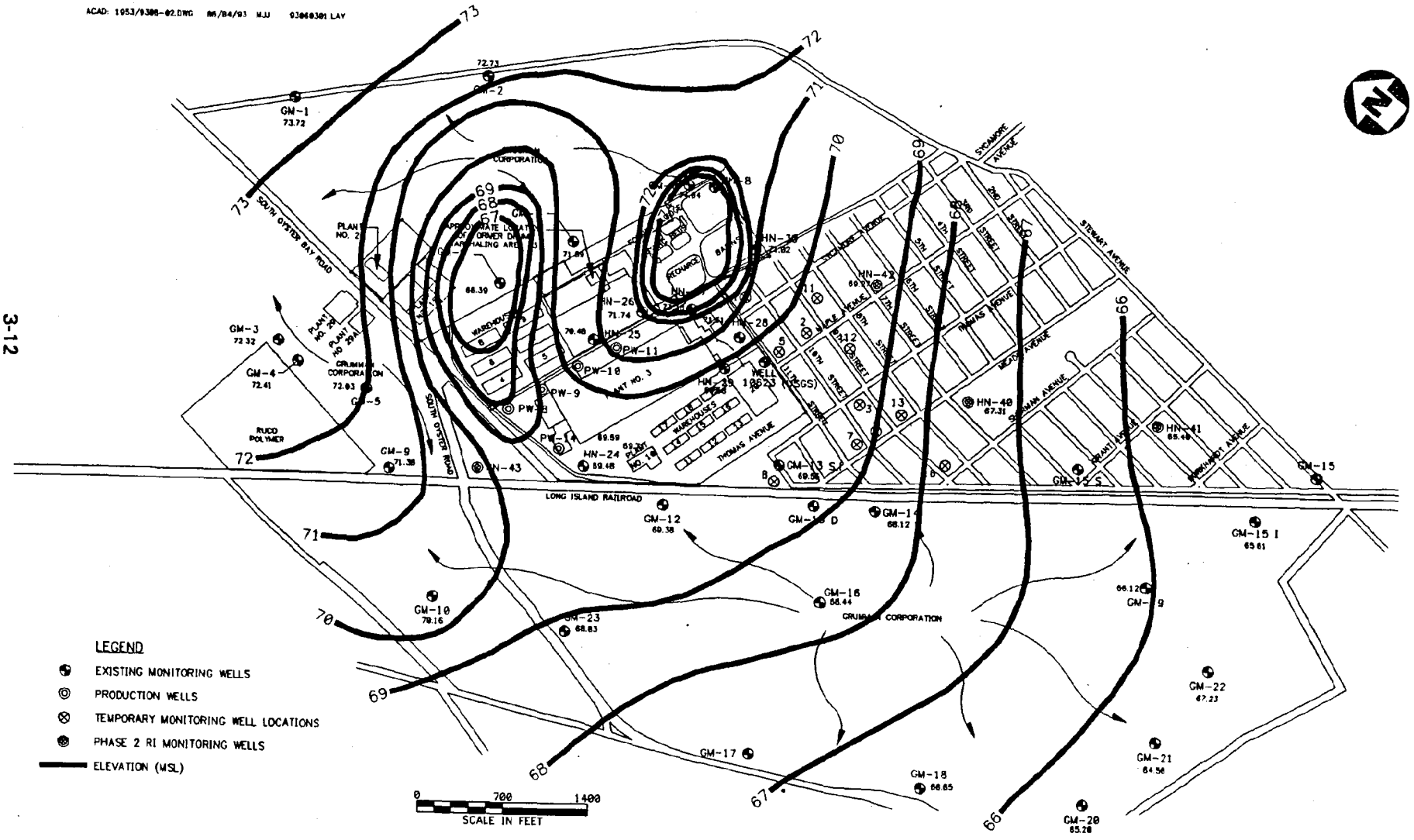

MAGOTHY AQUIFER (INTERMEDIATE WELLS) APRIL 30, 1993
PHASE 2 - REMEDIAL INVESTIGATION FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

FIGURE 3-2

HALLIBURTON NUS
Environmental Corporation

NYSDEC 033268

The groundwater flow dynamics beneath the NWIRP and Grumman are complex. A total of 16 deep production wells (7 on the NWIRP and 9 on Grumman property) are located on the facility. Throughout the year, these wells are pumped in various combinations. Depending on facility demand, any particular well may be turned on and off at frequent intervals, or may be turned on or off for extended periods. In addition, at least one well (Well No. 16), has a variable speed motor, which can vary the well yield depending on demand. The resultant cones of depression formed by the possible well-usage combinations make local variations in the overall groundwater pattern difficult to predict.

Recharge basins have the potential to greatly affect local water elevations and hence, local groundwater flow patterns. Recharge basins within the immediate study area that may influence the local groundwater regime include the NWIRP recharge basins, the Grumman recharge basins (located south of the Long Island Railroad tracks), several industrial recharge basins (including the Hooker/Ruco complex), and two municipal stormwater recharge basins located west of the NWIRP on South Oyster Bay Road and southeast of the NWIRP in the residential neighborhood, at the corner of Burkhardt Avenue and Third Street.

The local groundwater flow pattern beneath the NWIRP is greatly influenced by the recharge basins located at Site 2. Here, the groundwater pumped by the facility wells located north of the Long Island Railroad is recharged to the aquifer through the basins. The basins additionally receive storm runoff drainage. This influx of large quantities of water creates a "mounding" or local high of the water table. The amount of water recharged through these basins is dependent on the amount of water withdrawn by the wells (generally greater in warmer weather) and the amount of precipitation.

The water table configuration and groundwater flow paths beneath the NWIRP and adjacent grounds were determined through the static water elevations of the monitoring well network and were calculated for the water table (Figure 3-1) and for the intermediate zone (100- to 160-foot depth) of the Magothy aquifer for April, 1993. The iso-elevation lines were generated via interpolation between the individual data points.

The water table configuration beneath and adjacent to the NWIRP is illustrated in Figure 3-1. The dominant direction of shallow groundwater flow beneath the NWIRP appears to be dominantly to the southwest and, to a lesser extent, to the south. Radial flow from the Site 2 recharge basin mounding may also introduce a component of southeastward flow from the recharge basins toward the residential neighborhood. The other recharge basins also appear to affect the local groundwater pattern. Groundwater mounding is evident to the west of the NWIRP and is apparently an effect of either (or both of) the Hooker/Ruco basins or the municipal basin. Similarly, groundwater mounds have formed beneath the Grumman recharge basins and the basin located in the residential neighborhood, and have apparently influenced the local groundwater flow.

A comparison of the water table contour map of April, 1993 with those of December, 1991, and January, 1992 (HNUS, 1992) reveals that the configuration of the water table throughout the year appears to remain generally consistent. The depth to the water table may change due to seasonal fluctuations and changes in the magnitude or pattern of groundwater withdrawal and subsequent recharge, but the overall configuration (and hence, the flow pattern) remains basically consistent.

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The groundwater mounding at the Site 2 recharge basins is also reflected in the intermediate zone contour map for April, 1993 (Figure 3-2). Another feature of this interpretation is the apparen depression in the hydraulic head near monitoring well GM-6, in the area immediately north of the NWIRP northern warehouse complex. This phenomenon was also evident in the contour maps of the intermediate zone constructed for December, 1991, and January, 1992 (HNUS, 1992). The cause of this depression is not known. This area may simply be a "saddle" between the groundwater mounds caused by the NWIRP and Hooker/Ruco and municipal recharge basins, although the magnitude of the depression makes this unlikely. The head here is lower than that in wells located to the south that are beyond the likely influence of the basins. Other possible causes include a local lowering of head due to the pumping of nearby well(s) or a local variation in the hydraulic characteristic of the Magothy Formation.

The horizontal gradients across the NWIRP are very low. As would be expected, the highest gradients are located near the recharge basins. The average north-south gradient across the NWIRP, as measured from well GM-2 in the north to well GM-14 in the south (in April, 1993), was about 0.001 (see Appendix H). This value agrees well with the regional gradient of 0.001 published in the literature (S-F, 1988). It must be restated, however, that this is an average value. The gradient below any one particular location may vary due to that point's proximity to a discharge (well) or recharge (basin) structure and/or due to variations in the local geology. Additionally, these gradients may vary seasonally due to variations in well pumpage and volume of water returned to the basins.

Groundwater velocities for the Magothy Formation that are predicted in regional ground water modeling studies range from 0.1 to 1.0 foot/day (B-M, 1992). The average linear velocity of the groundwater at the water table in April, 1993 was approximately 0.33 foot/day; the average linear velocity of the groundwater at subsurface depths of about 150 feet during this same time was approximately 0.32 foot/day. These values were calculated using the hydraulic conductivities derived from the Phase 2 RI pumping tests, the gradients as measured in the facility monitoring wells, and an assumed effective porosity of 30 percent (see Appendix H for groundwater velocity calculations).

VERTICAL FLOW

Regional studies of groundwater flow on Long Island reveal that the vertical gradients are very low. The steepest gradients typically occur below the recharge zone near the center of the island, and decrease from there in both a northerly and southerly direction (Isbister, 1966; S-F, 1988).

The static water elevations for the well clusters on the NWIRP and in the adjacent residential neighborhood indicate that this is an area of groundwater recharge. The vertical gradients are in a downward direction, but are very low. As would be expected, the steepest gradients occur near the recharge basins and pumping wells. This is consistent with the local hydrogeology as described in published reports (S-F, 1988).

An understanding of the local vertical component of groundwater flow is critical to the determination of the ultimate fate of the known contamination that occurs in the shallow groundwater beneath the

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NWIRP. Moreover, since the deeper Magothy aquifer is also contaminated (as evidenced by the facility production wells and some nearby public supply wells), the local vertical flow patterns must be considered to evaluate the potential sources of this contamination, including the possible contribution of the shallow NWIRP contamination. As discussed, the lack of hydraulically confining layers beneath the NWIRP allow for the potential vertical migration of groundwater within the Magothy.

Regionally, the horizontal component of groundwater flow is more dominant than the vertical component (B-M, 1992). Vertical gradients, and therefore vertical flow, would be expected to increase near discharge points such as pumping wells. Because of the high transmissivity of the Magothy aquifer and the depth of the nearby production wells it is unlikely that any particular well can pump at sufficient rates to substantially affect the shallower zones. For example, in this investigation's pumping test no. 2 (see Section E), the pumping of PW-11 at nearly 1,000 gpm for 72 hours produced little or no measurable drawdown in the nearby observation wells or other production wells. It may be possible, however, that the heavy pumpage of multiple deep wells in close proximity (which occurs with both the facility and public supply wells) could significantly affect the entire water column.

A groundwater model of the immediate area was constructed as part of this investigation. It was concluded that the computer modeling study was the most efficient way to delineate the local flow regime and determine the influence of the heavy pumpage of the facility wells (with subsequent groundwater recharge at the basins) and the offsite public supply wells. As discussed, the groundwater flow patterns beneath the NWIRP are believed to be extremely complex due to the multiple well pumpage and recharge patterns.

The results of the computer modeling study are discussed in detail in Appendix F. Briefly, the results indicate that, as hypothesized, the pumpage of multiple supply wells can induce sufficient vertical migration to affect the shallow portions of the Magothy aquifer beneath the NWIRP.

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4.0 NATURE AND EXTENT OF CONTAMINATION

The nature and extent of environmental contamination at the NWIRP-Bethpage site is discussed in this section. The validated analytical data generated during both phases of the Remedial Investigation (RI) provide the basis for this discussion. However, since the Phase 2 RI activities were limited to supplemental sampling and analysis for PCBs in soils and volatile organics in groundwater, the Phase 2 RI report will focus on these results. Additional data on the metals and semivolatile organic results for soils and groundwater are summarized in Section 1.0 and are discussed in detail in the Phase 1 RI (HNUS 1992). The results of the various field screening techniques are also included in this section (but qualified) in order to provide the most complete and comprehensive analysis possible of the contamination at each site. The complete analytical data base generated during Phase 2 RI is included as Appendix I. The remainder of this section is structured by site or location and the types of investigative activities conducted.

4.1 SITE 1: FORMER DRUM MARSHALING AREA

4.1.1 Surface Soils

Two surface soil samples were analyzed during the Phase 1 RI for PCBs/pesticides. During the Phase 2 RI, seven additional surface and subsurface soil samples were collected at Site 1 and analyzed for PCB/pesticides. (Note that one sample location was sampled during both phases of the RI, for a total of only eight individual sample locations).

The results of both phases of testing are presented in Table 4-1 and Figure 4-1. PCBs were detected at all 8 soil sample locations. Detected PCB concentrations ranged from 1.21 mg/kg to 1,470 mg/kg. For comparison, Federal and state criteria for acceptable PCB concentrations are 1 mg/kg and 10 mg/kg for residential-use and industrial-use scenarios, respectively. Pesticides were detected at a maximum concentration of 240J ug/kg (Chlordane).

The finding of PCBs in all 8 locations (6 of which were random) is an indication of wide spread surface soil PCB contamination at Site 1. PCBs were measured at a concentration of between 1 mg/kg and 10 mg/kg at five locations, and at a concentration exceeding 10 mg/kg at three locations. As evidenced during the soil boring activities, the soils in the majority of Site 1 are highly disturbed with oil-type staining of the soils, common. Historically, drums containing waste materials were stored on marshaling pads in the center of the site. Equipment, piping, and general debris are currently stored throughout the site. The location where PCBs were not detected is an active staging area used by Grumman for soils, nonhazardous waste, and debris. Materials are regularly deposited and picked up in this area.

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TABLE 4-1

OCCURRENCE AND DISTRIBUTION OF SURFACE AND NEAR-SURFACE PCBS AND PESTICIDES
SITE 1: FORMER DRUM MARSHALING AREA
NWIRP BETHPAGE, NEW YORK (ug/kg)

MDL	LOCATION	101	102	103	104	105	106	121	125
	SAMPLE DEPTH	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	3 FEET	SURFACE
1.37	4,4 DDE		27J						
1.50	4,4 DDT		37						
4.00	Aroclor 1242					25000			
8.33	Aroclor 1248	25000	1100/7900*	1300000	2500		1700	1000J	7500*
6.99	Aroclor 1254	5000J	660J	170000J	530J		400J	210J	

J: Estimated
*: Phase 1 result.

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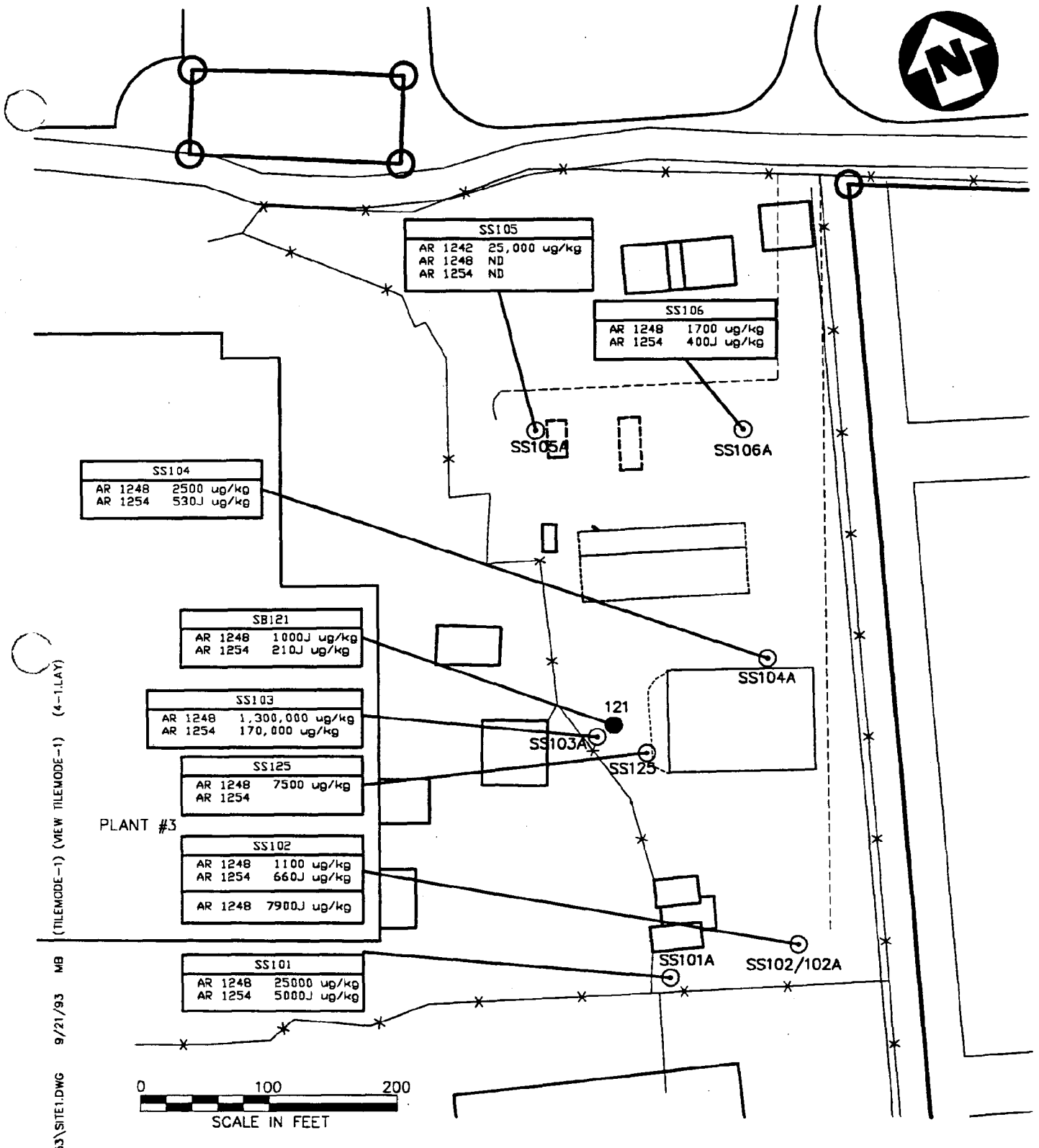

FIGURE 4-1

SITE 1 – PCB SOIL RESULTS
PHASE 2
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NY

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Surface soil (SS) sample location SS103, which was measured to have a PCB concentration of 1,470 mg/kg, corresponds to a equipment/material lay down area at Site 1. Soil sample testing at this area was somewhat random (i.e. the area was not targeted as a likely PCB contamination location), although the material does have some visual signs of being oil stained. Soil boring (SB) sample number SB121 was collected at a depth of 3 to 5 feet below grade surface (bgs) and within a few feet of SS103. The PCB concentration at this depth was measured to be 1.21 mg/kg, indicating that the most significant PCB contamination is limited to the surface soils. This finding is consistent with the general concept that PCBs are not very mobile in soils.

The areal extent of the PCB contamination near SS103 is not well defined. Typically on a preliminary basis, the presence/absence of visible oil staining of soils is effective at identifying the extent of PCB contamination. However at Site 1, the majority of the soil at the site has the appearance of being oil stained. Testing of other oil stained soils found PCBs at concentrations less than 50 mg/kg. As a result, the presence of staining is not a good indication of contamination at this site. Prior to remediation of soils near SS103, additional testing in this area may be required.

The other locations in which PCBs were measured to exceed 10 mg/kg are SS101 and SS105, where the total PCB concentrations were measured to be 30 mg/kg and 25 mg/kg, respectively. These areas are relatively small, and as with SS103, are located along the same fence. These areas are similar to other areas at Site 1 with the current use being an equipment storage area.

Overall at Site 1, PCB contamination is not expected to extend significantly below the surface soils. During the Phase 1 RI, PCBs were found as TICs in each of the surface soils. This was the basis for retesting the sample locations for PCBs. With the exception of SB121, PCBs were not found as TICs in any of the subsurface soils.

4.1.2 Temporary Monitoring Wells

Two temporary monitoring wells were installed and sampled at Site 1 as part of the Phase 2 RI. These wells, which were subsequently converted into permanent wells, were installed primarily to serve as piezometers for the aquifer pumping test program. The wells were screened across the water table and were sampled and analyzed for the following parameters: vinyl chloride; 1,1-dichloroethene; trans-1,2-dichloroethene; 1,1-dichloroethane; cis-1,2-dichloroethene; 1,1,1-trichloroethane; 1,2-dichloroethane; trichloroethene; and tetrachloroethene.

The locations of the temporary monitoring wells are illustrated in Figure 2-6. Both wells are in close proximity to the northern (cinder-covered) former drum marshaling pad. This area was identified during the Phase 1 RI as a likely source of significant volatile organic contamination. Well HN-27S2 is located immediately upgradient of the former pad, and well HN-27S3 is located either within or immediately downgradient of the former pad.

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Table 4-2 provides a summary of the analytical data for these two wells. These data are similar to and appear to confirm the Phase 1 RI conclusion that the northern pad is a source of significant volatile organic contamination. The total volatile contamination of well HN-27S3 is an order of magnitude greater than that of HN-27S2. Volatile organic contaminants in well HN-27S3 include tetrachloroethene at 637 ug/l (versus 22 ug/l in HN-27S2), trichloroethene at 141 ug/l (versus 10 ug/l in HN-27S2), and 1,1,1-trichloroethane at 113 ug/l (versus 19 ug/l in HN-27S2).

4.1.3 Groundwater Data

The permanent monitoring wells at Site 1 that were installed and sampled during the Phase 1 RI were resampled as part of the Phase 2 investigation. Wells HN-27S and HN-28S could not be resampled because the water table had dropped below their screened interval. All samples taken during both sampling rounds were submitted for TCL volatile organic analysis.

The monitoring well locations are shown in Figure 4-2. Well location HN-27 serves as the upgradient monitoring well for Site 1, and locations HN-28, HN-29, and the USGS well serve as the downgradient monitoring wells.

Table 4-3 provides a summary of the analytical data for both sampling rounds. These same results are illustrated by location for the shallow-depth (water table) monitoring wells in Figure 4-2 and for the intermediate-depth (100 to 150 feet bgs) monitoring wells in Figure 4-3. Contour maps of the total volatile organic contamination across the NWIRP as well as offsite locations are included as Figure 4-4 for the shallow-depth well network and Figure 4-5 for the intermediate-depth well network.

A comparison of the two sampling rounds of Site 1 analytical data indicates that the groundwater contamination patterns are similar to that found during the Phase 1 RI. Downgradient groundwater at Site 1 is significantly more contaminated that upgradient groundwater. However, the concentration of solvents in some wells have decreased significantly, whereas in other wells, remained constant or increased slightly. For example, the concentration of 1,1,1 TCA in Well HN-29S decreased from 10,000 ug/l in 1991 to 690 ug/l in 1993. Conversely, the concentration of TCE in the USGS well increased from 12 ug/l in 1991 to 100 ug/l in 1993. The relative significance and cause of these differences cannot be determined at this time. The switching of active recharge basins during this period (which redirects local groundwater flow patterns) may be in part responsible.

Other general trends noted during the Phase 1 RI and observed during the Phase 2 RI are that the shallow groundwater is significantly more contaminated than the intermediate and deeper groundwater. For example, at location HN-29 (a downgradient well), the total volatile organic concentration in the water table well in 1993 was 2,800 ug/l, but at intermediate-depths (130 feet bgs) and deep well (220 feet bgs) the concentrations were only 22 ug/l and 39 ug/l, respectively. Individual contaminant concentrations included tetrachloroethene at 1,400 ug/l in the water table well (versus 5 and 26 ug/l in the intermediate and deep wells, respectively), 1,1,1-trichloroethane at 690 ug/l in the water table

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TABLE 4-2

OCCURRENCE AND DISTRIBUTION OF GROUNDWATER
VOLATILE ORGANIC CONTAMINATION - SITE 1
TEMPORARY MONITORING WELLS
NWIRP BETHPAGE, NEW YORK (ug/l)

MDL	WELL LOCATION	HN-27S3	HN-27S2
	SAMPLING DATE	12/92	12/92
0.18	Trichloroethene	141	9.8
0.03	Tetrachloroethene	637	22.2
0.03/ 0.18	1,1,1-Trichloroethane	113	18.9
0.18	Vinyl chloride		
0.13	1,1-Dichloroethene	3.4	0.82
0.07	1,1-Dichloroethane	6.3	1.9
0.03	1,2-Dichloroethane		
0.34	cis-1,2-Dichloroethene	22.5	0.86
0.10	trans-1,2-Dichloroethene	8.8	

MDL: Method Detection Limit

NOTE: Blank indicates that the parameter was not detected at a concentration above the method detection limit (MDL).

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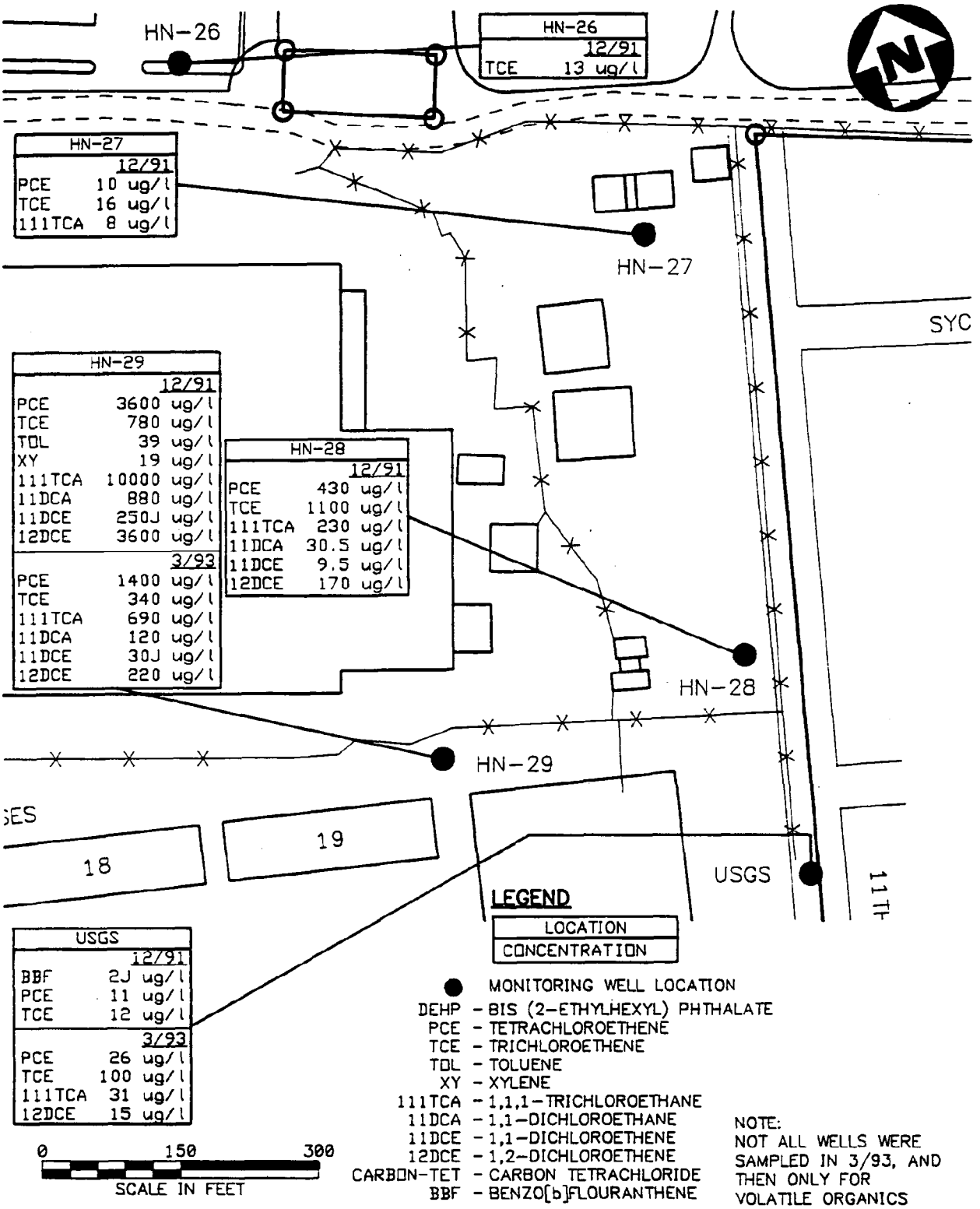

SHALLOW GROUNDWATER ORGANICS
ABOVE MCLS, ALS, RFD – SITE 1
PHASE 2 REMEDIAL INVESTIGATION/
FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

FIGURE 4-2

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TABLE 4-3

OCCURRENCE AND DISTRIBUTION OF GROUNDWATER VOLATILE ORGANIC CONTAMINATION - SITE 1 NWIRP BETHPAGE, NEW YORK (ug/l)

MDL	WELL LOCATION	HN-27S		HN-27I		HN-28S		HN-28I		HN-29S		HN-29I			HN-29D		USGS	
	SAMPLING DATE	12/91	3/93 DRY	12/91	3/93	12/91	3/93 DRY	12/91	3/93	12/91	3/93	12/91	3/93	3/93 (dup)	2/92	3/93	12/91	3/93
0.91	Trichloroethene	16		13	4J	1100		9	9J	780	340	6	17	17	11	13	12	100
1.00	Tetrachloroethene			2J		430		2J		3600	1400	2J		5J	10	26	11	26
2.29	1,1,1-Trichloroethane	8		3J		220				10000	690	2J	4J		48		4J	31
1.57	1,1-Dichloroethane	10				29				880	120				4J			4J
4.34	1,1-Dichloroethene					9				250	30J				2J			
4.89	1,2-Dichloroethene					160				3600	220				7			15
0.73	Ethylbenzene									3J								
0.92	Xylenes									19								
1.61	Toluene									39								

J: Estimated
MDL: Method Detection Limit

NOTES:
1. MDL Applies only to results of 3/93.
2. A blank indicates a concentration below reported detection limits.
3. All samples were analyzed for TCL volatiles. Contaminants not listed were not found above reported detection limits.
4. Wells HN-27S and HN-28S were dry in 3/93; no groundwater samples could be obtained.

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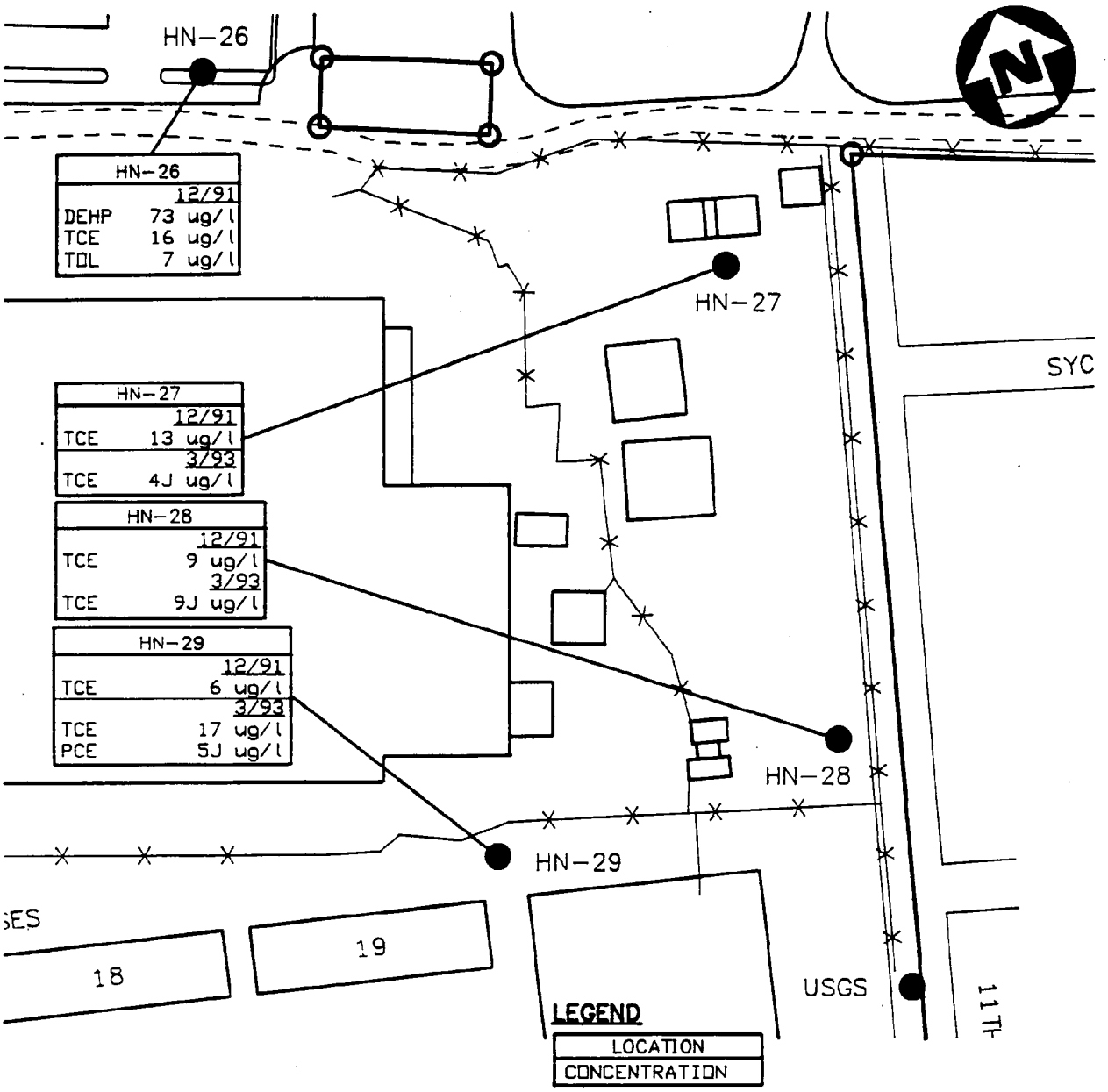

INTERMEDIATE GROUNDWATER ORGANICS
ABOVE MCLS, ALS, RFD - SITE 1
PHASE 2 REMEDIAL INVESTIGATION/
FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

FIGURE 4-3

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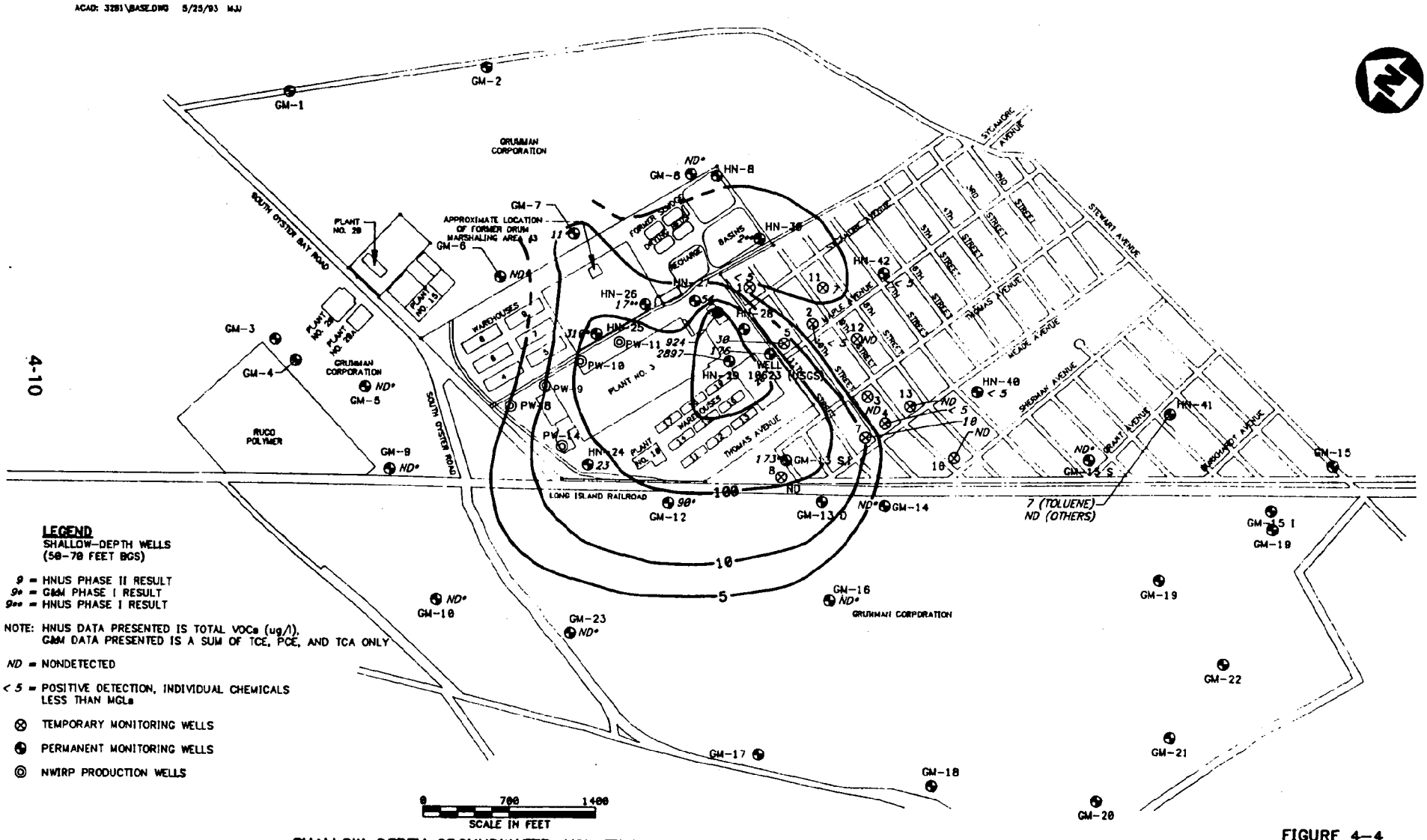

4-10

SHALLOW-DEPTH GROUNDWATER-VOLATILE ORGANICS
ISOCONCENTRATION CONTOURS
PHASE 2 - REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

FIGURE 4-4

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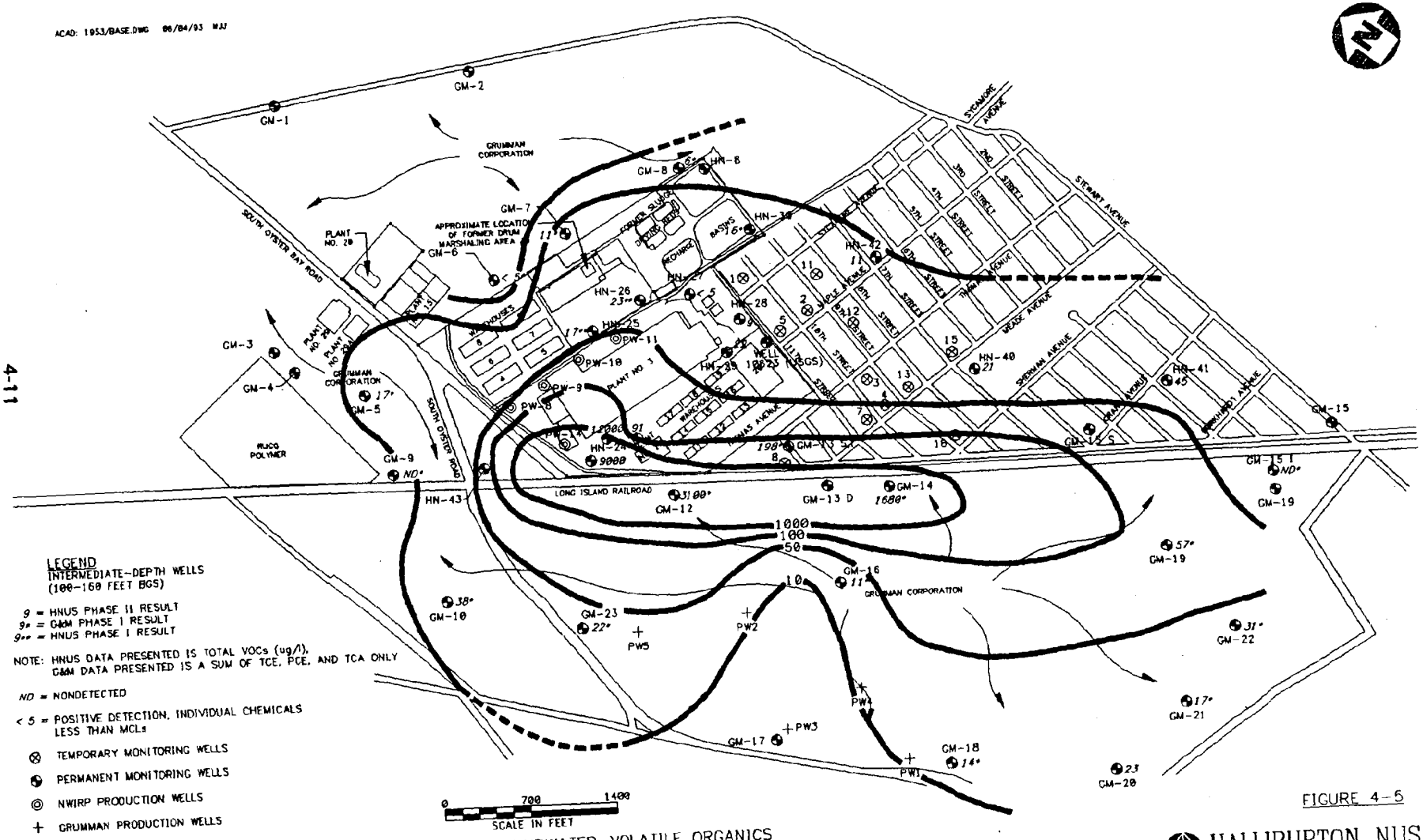

INTERMEDIATE-DEPTH GROUNDWATER-VOLATILE ORGANICS
ISOCONCENTRATION CONTOURS
PHASE 2 - REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

FIGURE 4-5

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well (versus 4 ug/l in the intermediate well and non-detection in the deep well), trichloroethene at 340 ug/l in the water table well (versus 17 and 13 ug/l in the intermediate and deep wells, respectively), and 1,2-dichloroethene at 220 ug/l in the water table well (versus non-detection in the deeper wells).

4.1.4 Summary

The soil testing program indicates wide spread low-level PCB contamination of the surface soils at Site 1. The majority of the contaminated soils contain PCBs at a concentration of 10 mg/kg or less. However, soils at two locations contain PCBs at concentrations greater than 10 mg/kg. One area is near the southwestern portion of Site 1 (30 mg/kg PCBs) and the other area is along the western edge of Site 1 (1,470 mg/kg PCBs). The area near the western edge of Site 1,(SS-103) requires additional characterization prior to remediation.

The groundwater monitoring program results at Site 1 continue to indicate that this site is a source of volatile organic contamination. The two temporary monitoring wells installed during the Phase 2 investigation and placed immediately upgradient and downgradient of the northern (cinder-based) former pad appear to confirm that this location is a significant contributor to the contamination. It is uncertain whether or not other point sources, such as the former septic drainage system, are contributing to the contamination.

4.2 SITE 2: RECHARGE BASIN AREA

4.2.1 Surface Soils

Two soil samples were analyzed during the Phase 1 RI for PCBs/pesticides. During the Phase 2 RI, ten additional surface and subsurface soil samples (plus two duplicates) were collected at Site 2 and analyzed for PCB/pesticides.

The results of both phases of testing are presented in Table 4-4 and Figure 4-6. Detected PCB concentrations ranged from 0.048 mg/kg to 33.6 mg/kg. For comparison, Federal and state criteria for acceptable PCB concentrations are 1 mg/kg and 10 mg/kg for residential-use and industrial-use scenarios, respectively. Pesticides were detected at a maximum concentration of 620 ug/kg (4,4 DDT).

PCBs were found in all twelve of the locations sampled. Of these twelve locations, PCBs were measured at concentrations ranging from 1 mg/kg to 10 mg/kg in six locations, and at a concentration exceeding 10 mg/kg at one location. There is no apparent trend to the PCB contamination at Site 2, other than the higher PCB concentrations are in areas of more site frequent use (former sludge drying beds area and along earthen roads). Oil, potentially used for dust control, is a potential mechanism

NYSDEC 033284

TABLE 4-4

OCCURRENCE AND DISTRIBUTION OF SURFACE AND NEAR-SURFACE PCBS AND PESTICIDES
SITE 2: RECHARGE BASIN AREA
NWIRP BETHPAGE, NEW YORK (ug/kg)

	LOCATION	207	207(DUP)	208	210	210(DUP)	212	214
MDL	SAMPLE DEPTH	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE	SURFACE
1.37	Dieldrin							7.2J
1.37	4,4-DDE	93J	130J					
1.6	Endrin		4.7					
1.33	4,4 DDD		6.3J					
1.5	4,4 DDT	170	620J			4.4		13J
8.33	Aroclor 1248		230	73J	50J	75	2500	2200
6.99	Aroclor 1254		61J				490J	580J

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TABLE 4-4 (Continued)
OCCURRENCE AND DISTRIBUTION OF SURFACE AND NEAR-SURFACE
PCBS AND PESTICIDES (ug/kg)
PAGE 2

CRQL	LOCATION	228*	226(DUP)*	229*	216	208	215	201	202
	SAMPLE DEPTH	SURFACE	SURFACE	3 FEET	SURFACE	3 FEET	3 FEET	BASIN SEDIMENT	BASIN SEDIMENT
0.63	Heptachlor Epoxide							12J	
1.37	Dieldrin							7.9J	
8.33	Aroclor-1248	1800	2000	6800	6200	33000	280	2600	48J
6.99	Aroclor 1254				1000J	3600J	91J		

J: Estimated.
*: Phase 1 RI result.

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ACAD: 1953/SITE2.DWG 06/06/93 MJJ

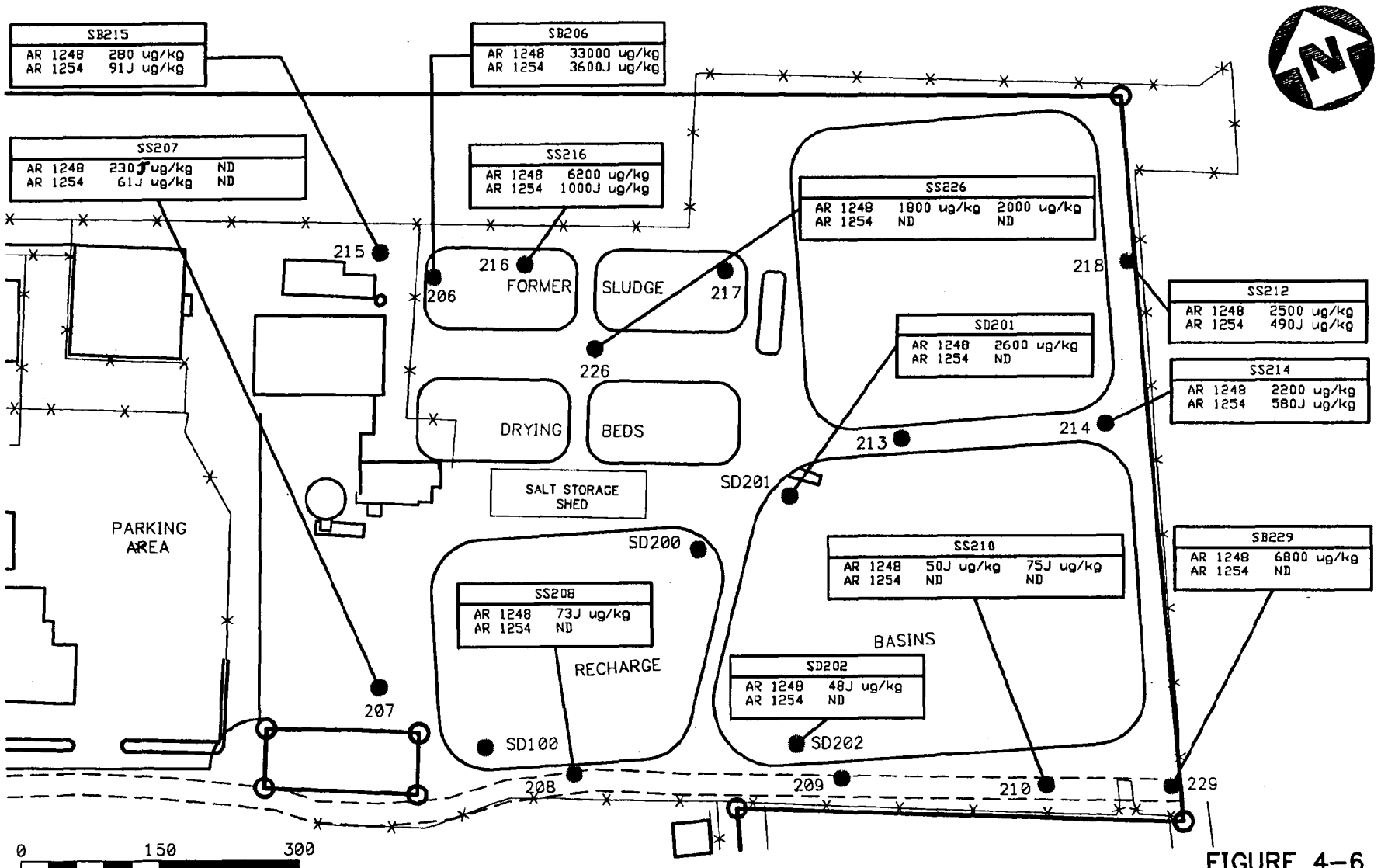

FIGURE 4-6

SITE 2 – PCB SOIL RESULTS
PHASE 2 – REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NY

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for spreading PCBs along the earthen roads. The origin of PCBs in the former sludge drying bed area and in the subsurface near the southeast corner of Site 2 is uncertain. Both of these areas contain disturbed soils. Also of note is that PCBs were detected at a concentration of 2.6 mg/kg in one of the four recharge basin sediment samples. The recharge basin sediment is regularly skimmed from the basins and staged in the area of the former sludge drying beds. PCBs were detected at a concentration of only 0.048 mg/kg in the other sediment sample in that basin and were not detected as TICs in the second recharge basin. The third recharge basin sediment was not sampled since it had been recently skimmed.

The only location in which PCBs was measured to exceed 10 mg/kg at Site 2 is SB206, where the total PCB concentration was measured to be 33.6 mg/kg. SB206 is in the area of the former sludge drying beds. During the drilling activities, there was no visual evidence of residual sludges. This location was analyzed for PCBs, because PCBs showed up as TICs on the Phase 1 RI semivolatile organic scan at this location. Currently, the area is used for the staging of soils excavated from the recharge basins.

Soil sample SB206 was collected at a depth of 3 to 5 feet bgs. Another sample collected at the same depth in an adjacent soil boring (SB215), approximately 40 feet west of SB206, was measured to contain only 0.371 mg/kg of PCBs. Results from other soil borings installed approximately 300 feet to the north and east did not indicate the presence of PCBs (as TICs) indicating the probable absence of PCB contamination at these locations. Surface soil samples collected 100 and 150 feet to the east were measured to contain 7.2 mg/kg and 2 mg/kg of PCBs, respectively.

4.2.2 Summary

Similar to Site 1, PCBs were widely found in the surface soils at Site 2, with a maximum concentration of 7.4 mg/kg. Subsurface soil contamination with PCBs is likely limited to the southeast corner of Site 2 (6.8 mg/kg) and the northern edge of the Site 2, near the former sludge drying beds (36.6 mg/kg). Limited PCB contamination of the basin sediments were also found. However, basin sediment is routinely removed by Grumman.

Groundwater testing was not conducted at Site 2 during the Phase 2 field investigation, and as a result was not discussed in this section. Additional consideration of the recharge basin water and potential contamination of offsite groundwater is provided in Section 4.7.

4.3 SITE 3: SALVAGE STORAGE AREA

4.3.1 Surface Soils

Six soil samples were analyzed during the Phase 1 RI for PCBs/pesticides analysis. During the Phase 2 RI, one additional surface soil sample was collected at Site 3 and analyzed for PCB/pesticides.

NYSDEC 033288

The results of both phases of testing are presented in Table 4-5 and Figure 4-7. PCBs were detected at 3 of the 7 soil sample locations (Phase 1 and Phase 2 results). Detected PCB concentrations ranged from 0.044 mg/kg to 0.830 mg/kg. For comparison, Federal and state criteria for acceptable PCB concentrations are 1 mg/kg and 10 mg/kg for residential-use and industrial-use scenarios, respectively. Pesticides were detected at a maximum concentration of 62 ug/kg (chlordane).

The data indicates that PCBs are not a significant concern at the areas tested at Site 3.

4.4 HN-24 AREA

4.4.1 Subsurface Soils

Subsurface soil samples were obtained from boreholes HN-2411 and HN-2412 during the installation of permanent monitoring wells at these localities. These samples were taken in order to evaluate this area as a potential source of the significant groundwater volatile organic contamination (with trichloroethene levels up to 58,000 ug/l) discovered here during the Phase 1 RI, and to evaluate the relationship of this contamination with a dense clay layer that preliminary headspace analysis of drill cuttings indicated was closely associated with the highest contamination. HN-2411 was installed in the suspected area of the former coal pile storage area. The location of the boreholes is shown in Figure 4-8. Table 4-6 provides a summary of the analytical data.

Generally low levels of trichloroethene, toluene, and carbon disulfide were found in most samples at HN-2411. The near-surface (10-foot depth) soil sample contained trichloroethene at 4 ug/kg and toluene at 13 ug/kg. The deeper samples near the suspected clay horizon (the clay did not actually occur in this borehole) contained trichloroethene at levels ranging from 3 ug/kg at 160 feet to 17 ug/kg at 140 feet, toluene at levels ranging from 6 ug/kg at 160 feet to 27 ug/kg at 140 feet, and carbon disulfide at levels ranging from 11 ug/kg at 150 feet to 12 ug/kg at 140 and 160 feet. There does not appear to be any significant relationship between the subsurface depth and the level of contamination in this borehole. Additionally, the low levels of contamination in the near-surface sample indicate that this location is not a likely source of the deeper groundwater contamination found in this area.

The majority of the subsurface soil samples obtained from borehole HN-2412 were free of volatile organic contamination. The sample obtained from within the clay layer at a depth of 140 feet contained trichloroethene at 36 ug/kg and the sample obtained from above the clay layer contained toluene at 5 ug/kg. Although the trichloroethene contamination was discovered in association with the clay layer, the level of soil contamination was very low compared to that of the groundwater. Additionally, the absence of contamination in the near-surface (20 foot depth) sample indicates that this location is not a likely source of the groundwater contamination found in this area.

NYSDEC 033289

TABLE 4-5

OCCURRENCE AND DISTRIBUTION OF SURFACE AND NEAR-SURFACE PCBS AND PESTICIDES
SITE 3: SALVAGE STORAGE AREA
NWIRP BETHPAGE, NEW YORK (ug/kg)

MDL	LOCATION	322	327*	328*	329*	316*	329*	328*
	SAMPLE DEPTH	SURFACE	SURFACE	SURFACE	SURFACE	3 FEET	3 FEET	3 FEET
0.57	Heptachlor	17						
1.37	Dieldrin	5J						
1.37	4,4-DDE	6.9						
1.50	4,4-DDT	9.1						
1.07	Endrin Ketone							
0.70	alpha-Chlordane	48						
0.67	gamma-Chlordane	62						
8.33	Aroclor-1248		830	250	445			
6.99	Aroclor-1254			530				

J: Estimated
*: Phase 1 RI Result.

NYSDEC 033290

ACAD: 1953/SITE3.DWG 06/06/93 MJJ

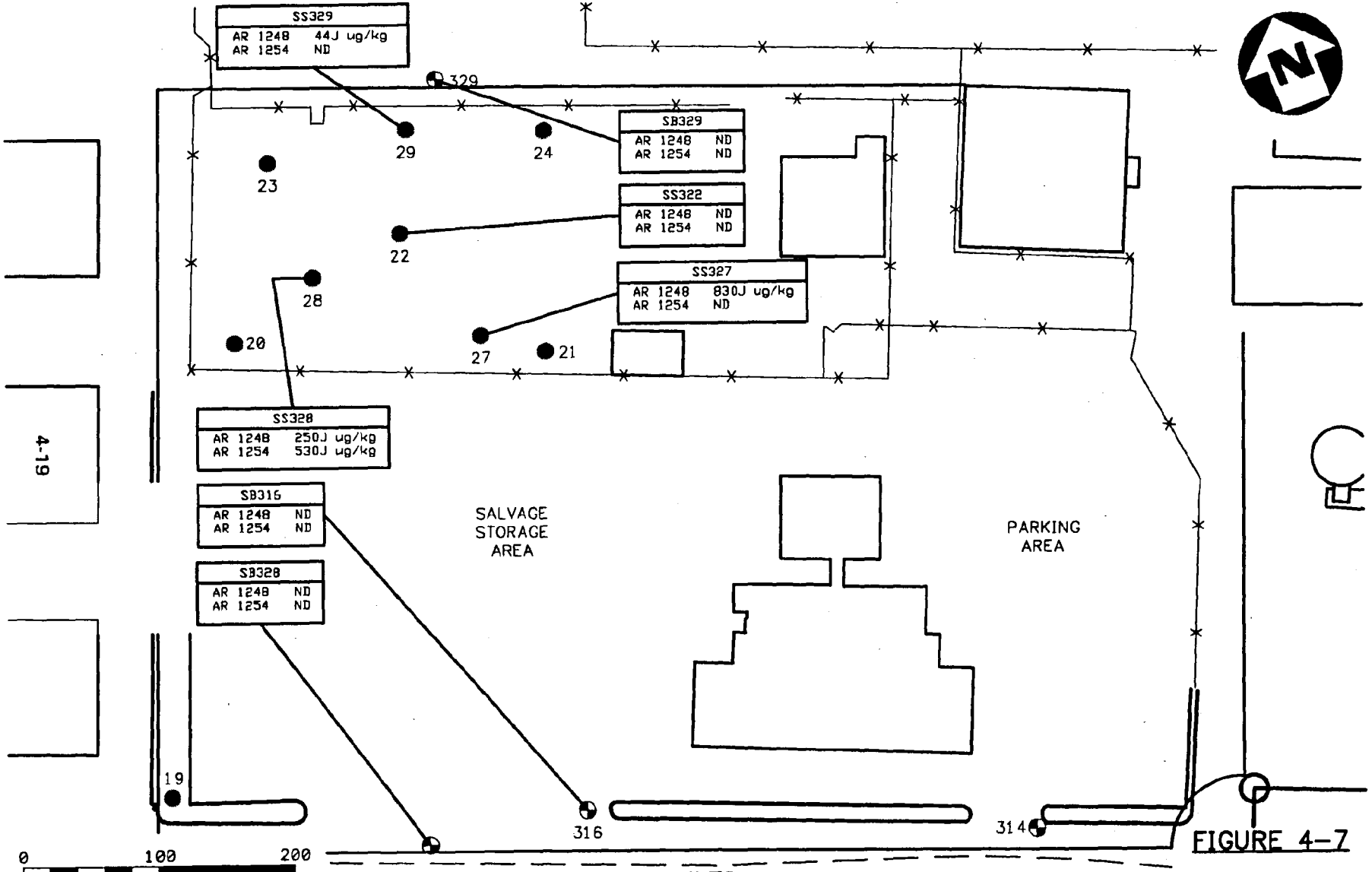

FIGURE 4-7

SITE 3 - PCB SOIL RESULTS
PHASE 2 - REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NY

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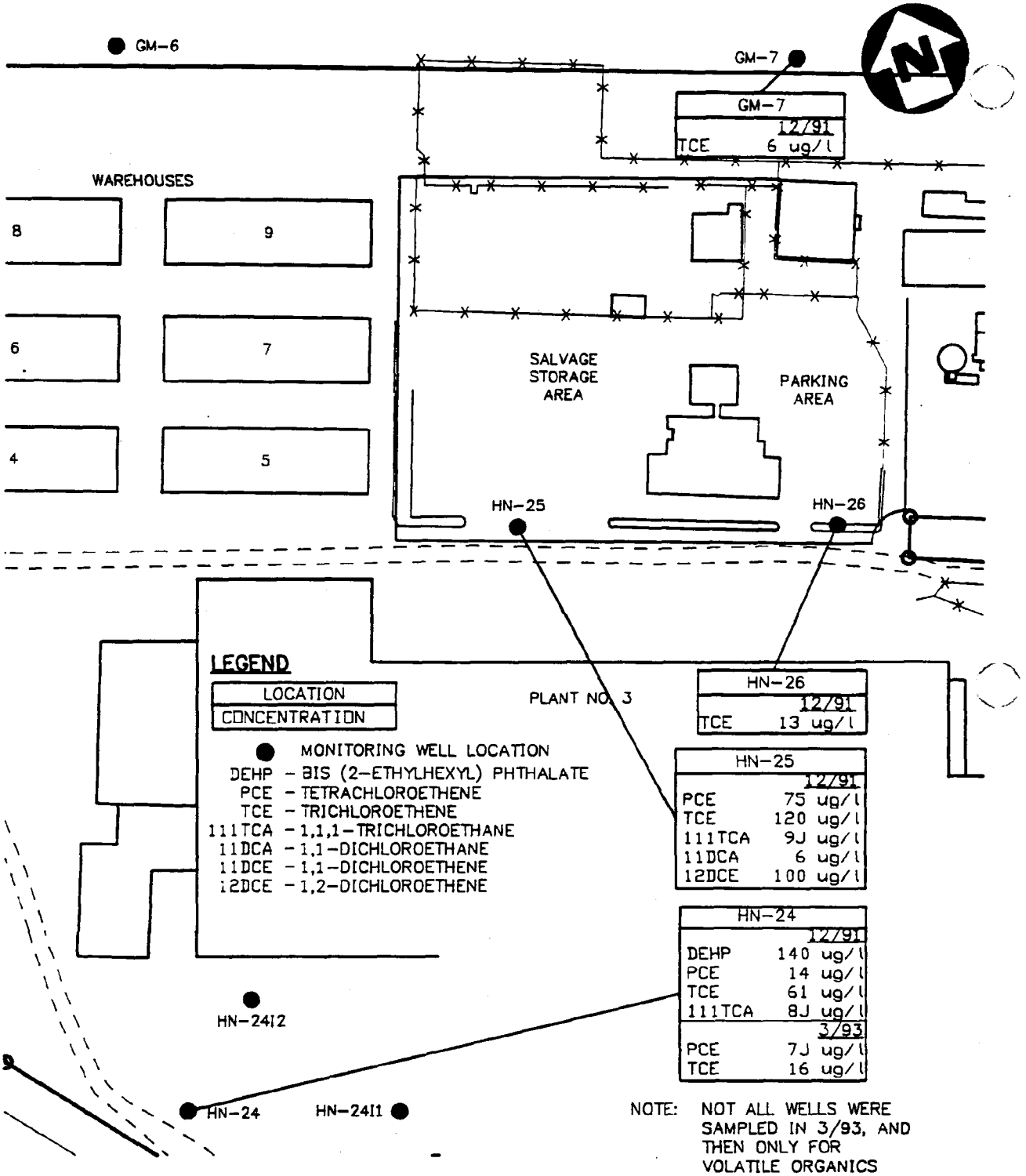


SHALLOW GROUNDWATER ORGANICS
ABOVE MCLS, ALS, RFD - HN-24 AREA
PHASE 2 REMEDIAL INVESTIGATION/
FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK 4-20

FIGURE 4-8

HALLIBURTON NUS
Environmental Corporation

TABLE 4-6

OCCURRENCE AND DISTRIBUTION OF SUBSURFACE SOIL
VOLATILE ORGANIC CONTAMINATION - HN-24 AREA
NWIRP BETHPAGE, NEW YORK (ug/kg)

MDL	BOREHOLE LOCATION	HN-2411					HN-2412			
	SAMPLING DEPTH (FT)	10	140	150	150 (DUP)	160	20	130	140	150
0.91	Trichloroethene	4J	17	8J	10J	3J			36	
1.61	Toluene	13J	27	12	16	6J		5J		
3.86	Carbon Disulfide		12J	11J	11J	12J				

J: Estimated
MDL: Method Detection Limit

Notes: 1. Blanks indicate concentrations below reported detection limits.
2. All samples were analyzed for TCL volatiles. Contaminants not listed were not found above reported detection limits.

NYSDEC 033293

4.4.2 Monitoring Well Groundwater Data

Significant volatile organic contamination of the intermediate-depth groundwater was discovered at HN-24 during the Phase 1 RI. Trichloroethene (TCE) was measured to be 58,000 ug/l in well HN-24I (which is at a depth of 148 to 158 feet bgs). Of interest is that TCE was essentially the only solvent found at this location and depth. The sum of the other solvents equaled only 34 ug/l. At all other locations at the NWIRP with contaminated groundwater, TCA and PCE were always found at similar concentrations to that of TCE, (within an order of magnitude). This data indicates that the contamination at this location may result from a second independent source. Also of note is that the groundwater in the shallow well in this area (HN-24S) contained only 61 ug/l of TCE and PCE at 14 ug/l and TCA at 8J ug/l were present at similar concentrations to the TCE. This data indicates that the shallow contamination at this location may be of Site 1 origin.

Based on current and historic groundwater flow patterns, potential sources of the TCE contamination in the intermediate-depth well (HN-24I) include: a former coal pile in this area; Site 1; offsite areas to the northwest (Hooker/RUCO Superfund Site); Plant No. 3; and areas to the north (north warehouses). A soil gas program was conducted to investigate potential source areas in Plant No. 3 and the north warehouses. This soil gas program is discussed in Sections 4.5 and 4.6. Monitoring wells were installed in this area to investigate the potential sources at the former coal pile, Site 1, and Hooker/RUCO. The results of the monitoring well program are discussed in this section.

The analytical data for the intermediate-depth wells are presented in Table 4-7 and Figure 4-9. A comparison of the 1991 versus 1993 results for HN-24I indicates that the TCE concentration in this well has decreased from 58,000 ug/l to 12,000 ug/l. Based on only two data points, it is uncertain if this decrease is significant.

Monitoring well HN-2411 was placed in the location of the former coal pile area and was placed adjacent to Plant No. 10 and in between Site 1 and HN-24I. The measured TCE concentration in this well was only 91 ug/l. Also, as mentioned previously, the clay layer associated with the elevated TCE concentrations was not present at this location. The absence of similar contamination at this location compared to HN-24I indicates that the TCE contamination at HN-24I does not likely originate from Plant No. 10 or Site No. 1.

Monitoring well HN-2412 was placed between HN-24I and potential sources areas to north, including Plant No. 3, Hooker/RUCO Superfund Site, and the drum area near the northern warehouses. Analytical testing in well HN-2412 found nearly identical conditions to that at HN-24I, including TCE at a concentration of 12,000 ug/l, the absence of other solvents, and the clay layer.

Monitoring well HN-43I was placed further upgradient approximately half way between the Hooker/RUCO Superfund Site and HN-24I. Gamma ray logging results and evaluation of split spoon samples did not indicate the presence of significant contamination at this location. The results of the

NYSDEC 033294

TABLE 4-7

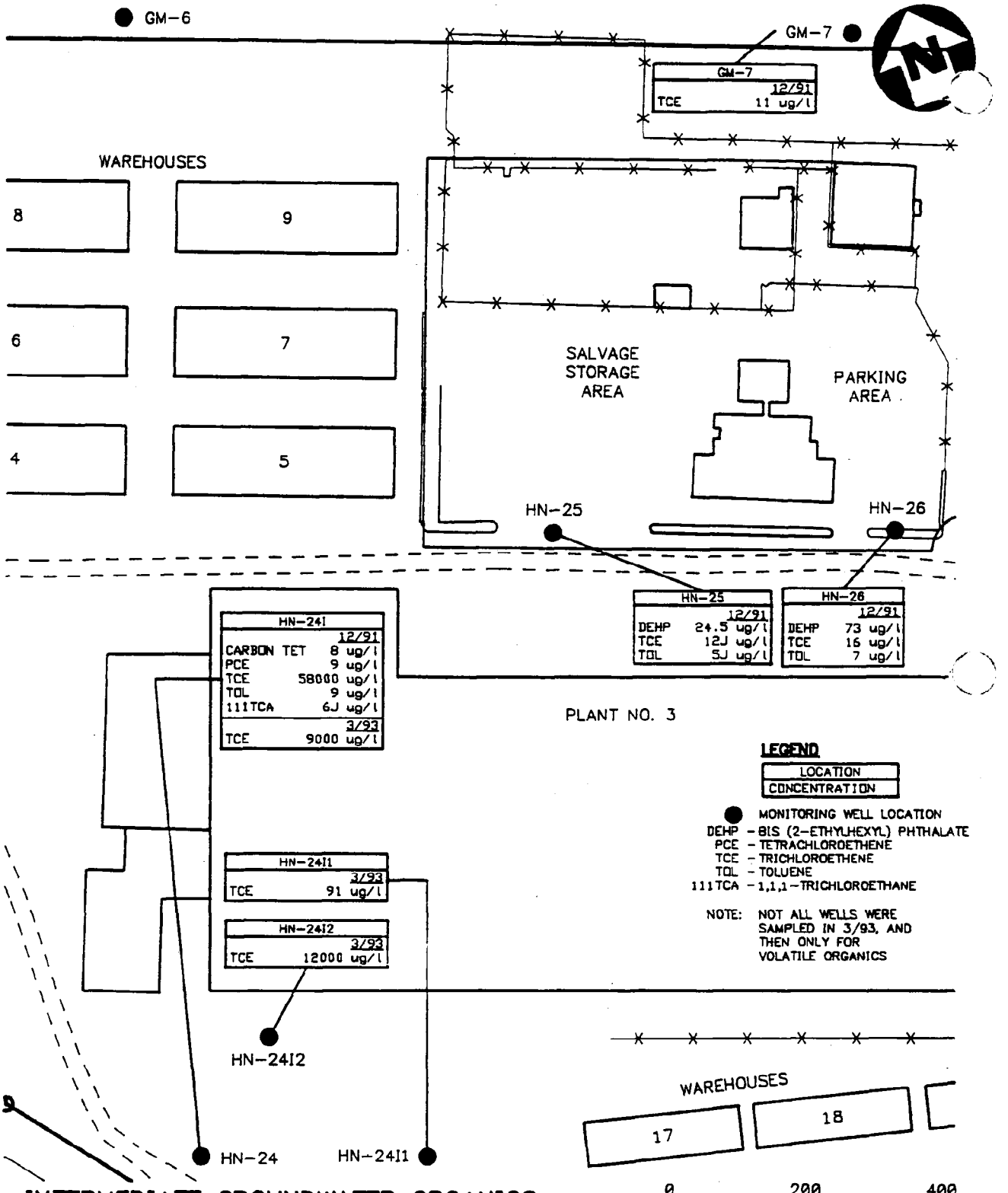
OCCURRENCE AND DISTRIBUTION OF GROUNDWATER
VOLATILE ORGANIC CONTAMINATION - HN-24 AREA
NWIRP BETHPAGE, NEW YORK (ug/l)

	WELL LOCATION	HN-24S		HN-24I		HN-24I1	HN-24I2	HN-43I
MDL	SAMPLING DATE	12/91	3/93	12/91	3/93	3/93	3/93	5/93
0.91	Trichloroethene	61	16	58,000	9,000	91	12,000	
1.00	Tetrachloroethene	14	7J	9				
2.29	1,1,1-Trichloroethane	8J		6J				
4.34	1,1-Dichloroethene	2J		2J				
1.61	Toluene			9				3J/4J
1.58	Carbon Tetrachloride			8				

J: Estimated.
MDL: Method Detection Limit

Notes: 1. MDL applies only to results of 3/93
2. Blank indicates concentrations below reported detection limits.
3. All samples were analyzed for TCL volatiles. Contaminants not listed were not found above report detection limits.

NYSDEC 033295



INTERMEDIATE GROUNDWATER ORGANICS ABOVE MCLS, ALS, RFD - HN-24 AREA
PHASE 2 REMEDIAL INVESTIGATION/ FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK 4-24

FIGURE 4-9

HALLIBURTON NUS
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monitoring well testing found toluene at a concentration of 3J to 4J ug/l. This data indicates that the TCE contamination found at well HN-24I may not be directly attributable to Hooker/RUCO. However, because of the presence of clay lenses in the area, non-linear pathways are possible.

4.4.3 Production Well Data

As part of the Phase 2 RI, the production wells around Plant No. 3 were sampled in April 1993. In addition, Grumman conducts periodic sampling of these wells. The presence of solvents in these monitoring wells is an indication of deep (300 to 700 feet bgs) groundwater contamination. Two of the wells (PW-8 and PW-14) are no longer normally operated because of historic contamination. As will be discussed, contamination of these wells, and in particular PW-14 may not be site-related or may only be partially site-related. Analytical data for the period of 1991 to 1993 is provided in Table 4-8. The location of the NWIRP productions wells is provided on Figure 2-6.

The production well data indicates that there is wide spread solvent contamination of the deep groundwater. Solvent contamination of the NWIRP production wells (Wells 8, 9, 10, 11, 13, and 15) appears to be distributed between TCE, TCA, and PCE. This blend of solvents and relative concentration is consistent with the contaminants found in the groundwater at Site 1.

The contamination at PW-14 is primarily vinyl chloride plus TCE and PCE, and TCA is absent from the groundwater. Vinyl chloride has not been identified as a NWIRP or Grumman contaminant. Vinyl chloride, as well as TCE and PCE have been found at significant concentrations in the hydraulically upgradient Hooker/RUCO Superfund Site groundwater. Based on these considerations it is likely that the contamination at PW-14 is more related to Hooker/RUCO contamination than contamination from the NWIRP or Grumman.

PW-16, which is hydraulically upgradient of the NWIRP as well as Grumman manufacturing operations, was measured to contain low, but significant solvent concentrations (TCA: 10 ug/l and TCE: 8 ug/l). This contamination may result from the NWIRP recharge basins and/or an upgradient source.

Contamination was also noted in south Grumman production wells (PW-2 and PW-5). This contamination appears to be predominantly TCE (3,750 ug/l - maximum). Additional solvents are present in these wells, but at concentrations less than 50 ug/l. Other production wells in the south Grumman complex are not as contaminated, including wells between the NWIRP and PW-2/PW-5. The absence of contamination in the well points between PW-2/5 and the NWIRP indicates that there may be an additional source of the TCE contamination in the south Grumman complex, other than that found at HN-24.

NYSDEC 033297

TABLE 4-8

OCCURRENCE AND DISTRIBUTION OF GROUNDWATER VOLATILE ORGANIC CONTAMINATION NWIRP PRODUCTION WELLS AND SELECTED OFFSITE (GRUMMAN) PRODUCTION WELLS[a] NWIRP BETHPAGE, NEW YORK (ug/l)

WELL NUMBER	8 (NWIRP)			9 (NWIRP)			10 (NWIRP)			11 (NWIRP)			13 (NWIRP)		14 (NWIRP)			15 (NWIRP)	
SAMPLING DATE	91	92	93	91	92	93	91	92	93	91	92	93	91	92	91	92	93	91	92
Acetone	4	4													3	<1			
Benzene														<1					
Carbon Tetrachloride	2												<1						
1,1,1-Trichloroethane	100	182	300/420J	7	9	12	3	22	3J	2	7	3J		3	3	12		3	12
1,1-Dichloroethane			/12J																
1,1-Dichloroethene	57	245	250/350	3	5	7J	2	7		1	1		<1		1	4		1	3
1,2-Dichloroethene (total)	2	2		<1	<1		<1	<1		<1			<1		<1	6	57J	<1	6
Trichloroethene	95	106	160/220	18	67	30	25	92	13	10	16	13	<1	1	72	57	280	8	54
Tetrachloroethene	85	99	190/310	3	9	9J	3	14	3J	2	5	3J		1	5	24	250		23
Chloroform	3	4	/5J	<1	<1		<1	<1		<1	<1		<1		1			<1	
Methylene Chloride	57	7			2										<1	<1			<1
Methyl Ethyl Ketone	10	4		1	2		<1			<1			1		3			2	
Methyl Isobutyl Ketone	5	4		<1			<1			2			<1			2		2	<1
Toluene								3					<1						
Trichlorofluoroethane	4			6	10		4	6		3	1		3	2				5	
Vinyl Chloride															1	4	1400		4
Xylenes	<1	<1		<1			<1			<1	2		<1	<1	<1			<1	

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TABLE 4-8 (Continued)
OCCURRENCE AND DISTRIBUTION OF GROUNDWATER
VOLATILE ORGANIC CONTAMINATION (ug/l)
PAGE 2

WELL NUMBER	2 (Grumman - downgradient of NWIRP)		5 (Grumman - downgradient of NWIRP)		16 (Grumman - upgradient of NWIRP)	
SAMPLING DATE	91	92	91	92	91	92
Acetone	1			1		
Benzene						
Carbon Tetrachloride		1			< 1	3
1,1,1 Trichloroethane	8	7	19	4	5	10
1,1 Dichloroethene	17	24	23	< 1	1	4
1,2 Dichloroethene (total)	14	17	7	5	1	< 1
Trichloroethene	2186	3750	2226	66	6	8
Tetrachloroethene	41	42	43	15	< 1	4
Chloroform		3	< 1		1	< 1
Methylene Chloride	< 1	2				
Methyl Ethyl Ketone	9	9	6		4	
Methyl Isobutyl Ketone	3			< 1		
Toluene	< 1				< 1	< 1
Trichlorofluoroethane	195	64	21	1	6	
Vinyl Chloride	5	< 1		11		
Xylenes	< 1	< 1			< 1	2

(a) 1991 and 1992 analytical data represents annual monitoring data supplied by Grumman Corporation. 1993 analytical data was collected during the HNUS Phase 2 RI.

NYSDEC 033299

4.4.4 Summary

TCE is a significant groundwater contaminant in this area and is associated with a dense clay layer at a depth of approximately 135 feet bgs. However, direct sampling and analysis of this clay did not find similar levels of contamination. The source of the TCE contamination is not likely to be Site 1, the former coal pile area, Plant No. 10, or the Hooker/RUCO Superfund Site. Potential sources include Plant No. 3 and the drum area near the northern warehouses. These areas are discussed in Sections 4.5 and 4.6.

Solvent contamination was found in the NWIRP and Grumman production wells. Contamination of the NWIRP wells has likely been caused by a combination of Site 1 sources, recharge basin water, and the Hooker/RUCO Superfund Site.

4.5 PLANT NO. 3

4.5.1 Soil Gas Survey

A two stage soil gas program was conducted to determine if there are sources of solvent contamination in Plant No. 3. Additionally, this data was used to supplement the Phase 1 RI soil gas survey and determine the need for remediation of soils under and near Plant No. 3. The first stage of the Phase 2 soil gas program was semi-quantitative using an OVA to provide real-time readings of the concentration of total organic compounds in the soil gas at each sampling location. This soil gas survey was designed to be a relatively non-intrusive, preliminary field screening technique. The second stage soil gas program was quantitative with a field GC used to determine chemical-specific soil gas concentrations.

First Stage Soil Gas Program

A total of 32 soil gas readings were obtained in or near each of the known or suspected areas where solvents were used and/or stored in Plant No. 3. Sampling locations are shown on Figure 4-10. To determine the relative significance of positive soil gas detections, the readings were compared to background OVA readings obtained from presumably clean areas of Plant No. 3. Of the 32 sampling locations, five points were used to determine background soil gas levels in Plant No. 3. The background soil gas samples were obtained in roughly the four corners of the plant, the north central portion of the plant, and at least 100 feet away from any potential source area.

During the testing it was reported that currently the structures at the honeycomb cleaning area are significantly different than those present during historic operations. At this time, the area is an open bay with no significant surface features. It was reported that the area used to consist of processing equipment in a recessed area, approximately 8 feet deep. During the dismantling of this unit, the recessed area was filled with soil and a concrete cap (current plant floor) was placed over it. The soil

NYSDEC 033300

gas results obtained were from within this capped area and therefore may not reflect conditions below the sump area.

The results of the soil gas survey are presented on Table 4-9 and Figure 4-10. Areas of highest soil gas readings included the former honeycomb cleaning area (29 to 88 ppm), paint tunnel number 4 (18 ppm), paint tunnel number 6 (30 ppm), the zyglo inspection area (11 ppm), the flo-coat line (>100 ppm), and the tetrachloroethene (PCE) recovery area (2.4 to 12 ppm). Readings of greater than 10 ppm were obtained from all of these areas. Readings of about 10 ppm or less were not considered significant, because of natural organics such as methane and offgasing from contaminated groundwater in this area.

The evaluation of the soil gas results includes a comparison of the chemicals used at each area versus the chemical TCE found in HN-24I, the volume and method of solvent use, and the soil-gas result obtained relative to background conditions.

The paint tunnels use non-chlorinated solvents such a toluene and methyl ethyl ketone as a paint thinner. The paints are sprayed onto parts and allowed to dry. A water-based spray curtain is used to treat the paint overspray and air for the ventilation system. Solvents are present in this area in 55-gallon drums.

The zyglo process may use a 1,1,1-trichloroethane-based or a non-chlorinated based solution, (TCE and PCE are not believed to be used in this process). Parts are dipped into the solution and then visually evaluated for surface defects under specific light conditions.

The former honeycomb cleaning area is reported to have used significant quantities of TCE (13,000 gallons per year). The exact process and configuration is uncertain.

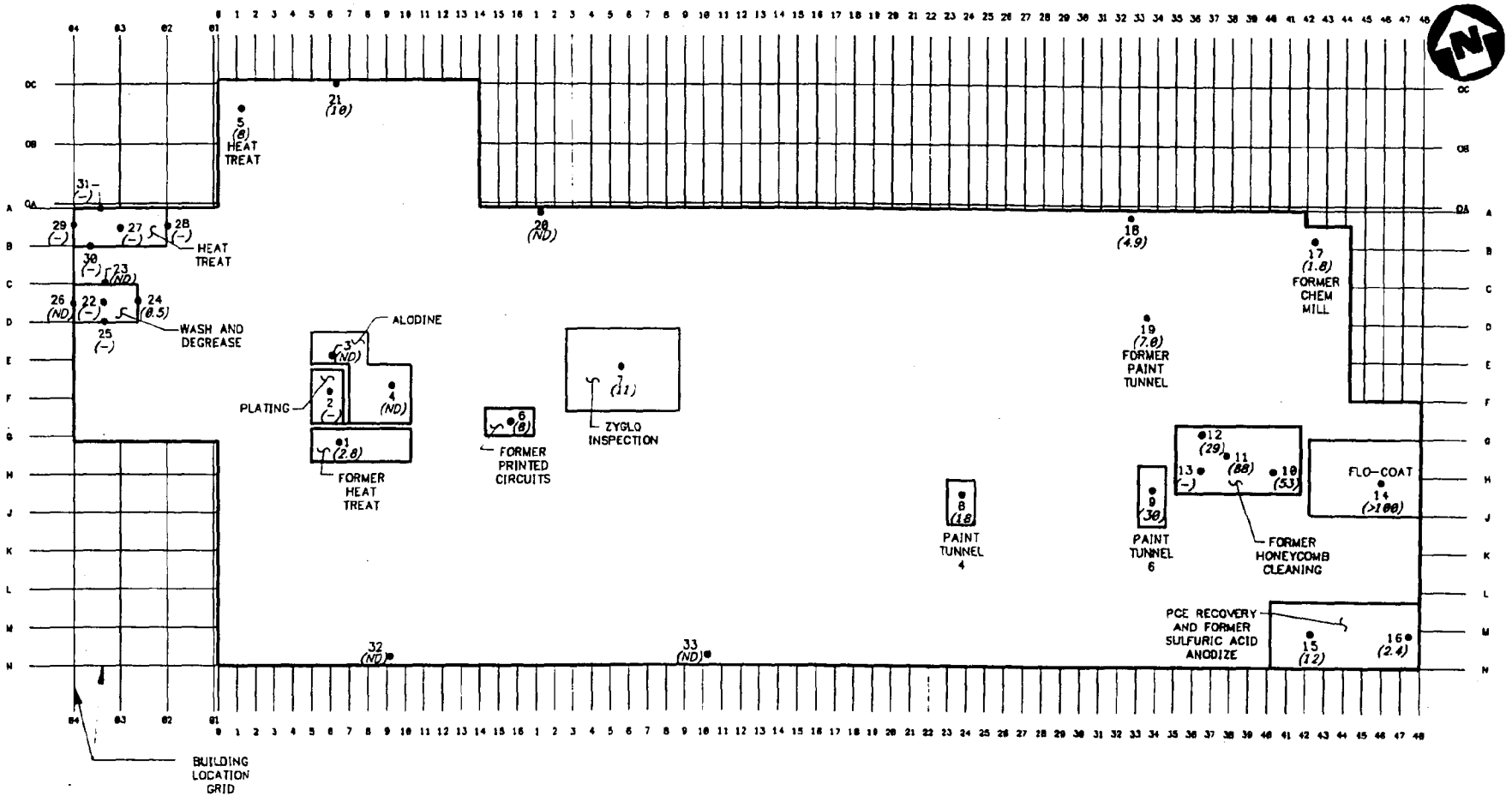
The flo-coat area and PCE recovery area currently use and recover PCE, respectively. Parts are dipped into tanks containing the flo-coat material. The flo-coat material consists of a mixture of PCE and a rubbery material. The mixture is a thick viscous semi-fluid. Excess material is allowed in drip off back into the tank as well as onto the concrete floor adjacent to the tank. The coating is allowed to dry (PCE is volatilized) and baked. The PCE recovery system treats the off gas from the flo-coat line.

The findings from the Stage 1 soil gas program are as follows.

1) Based on the history of the facility and soil gas results, most areas of Plant No. 3 can be eliminated as potential sources of the contamination at HN-24I. These areas are as follows.

   - Alodine, Former Heat Treat, and Plating Shop Area
   - Wash and Degrease Area
   - Former Printed Circuit Area
   - Zyglo Inspection Area

NYSDEC 033301



LEGEND

- 20 SAMPLING LOCATION
- (4.2) OVA READING – ppm
- (–) NOT MEASURED
- (ND) NON DETECT

STAGE 1 – SOIL GAS RESULTS
PLANT 3
PHASE 2 – REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

APPROXIMATE SCALE
0 100 200
SCALE IN FEET

FIGURE 4-10

HALLIBURTON NUS
Environmental Corporation

NYSDEC 033302

TABLE 4-9

FIRST STAGE SOIL GAS SURVEY RESULTS - PLANT NO. 3
NWIRP BETHPAGE, NEW YORK

SAMPLE LOCATION	BUILDING COORDINATE	OVA (ppm)	DEPTH (ft)	COMMENTS
1	G6	2.8	2.5	Former heat treat area
2	F6	--	--	Concrete > 18 inches thick, no sample taken
3	E6	ND	2.5	Alodine area
4	F9	ND	2.5	Alodine area
5	OC1	8.0	3.0	Adjacent to heat treat area; above ground tanks located outside
6	G14	8.0	3.0	Former printed circuits area, adjacent to paint locker
7	E6	11.0	2.5	Zyglo inspection area
8	H23	18	3.0	Paint tunnel #4; methyl ethyl ketone (MEK)
9	H32	30.0	3.0	Paint tunnel #6; MEK; zeroed out 5 ppm background in air
10	H40	53.0	3.0	Former honeycomb cleaning area; backfilled containment unit
11	H38	88.0	2.5	Same as above; obstruction at 2.5 feet
12	G36	29.0	3.0	Same as above; thin concrete (4-inches)
13	--	--	--	Same as above; no sample taken
14	H45	>100 [60]	3.0	Chem mill, flo-coat line, drilled through the drip-dry floor; 60 ppm sustained reading (100 ppm peak); 6 ppm background in air
15	M42	12.0	3.0	Former sulfuric acid anodize area; current PCE recovery area
16	M48	2.4	3.0	Same as above
17	B42	1.8	2.5	Former chem mill, current shot peen area
18	A32	4.9	3.0	Background sample taken in machine shop near Permasol-60 drum
19	D33	7.0	3.0	Machine shop, flammable waste drum marshalling area
20	A1	ND	3.0	Background sample; near outside doors
21	OC6	10.0	3.0	Background sample, machine shop
22	A04	--	--	TCE solvent tanks; wash and degrease pit; floor; concrete > 18 inches thick;no sample
23	A04	ND	3.0	Same as above; south wall
24	A04	0.5	3.0	Same as above, east wall
25	A04	--	--	Same as above; north wall; concrete > 18 inches thick; no sample
26	A04	ND	3.0	Same as above; west wall
27	A02	--	--	Heat treat area; pit floor; concrete > 18 inches thick; no sample

NYSDEC 033303

TABLE 4-9 (Continued)
FIRST STAGE SOIL GAS SURVEY - PLANT NO. 3
PAGE 2

SAMPLE LOCATION	BUILDING COORDINATE	OVA (ppm)	DEPTH (ft)	COMMENTS
28	A02	--	--	Same as above; wall; no sample
29	A02	--	--	Same as above; wall; no sample
30	A02	--	--	Same as above; wall; no sample
31	A02	--	--	Same as above; wall; no sample
32	N9	ND	3.0	Background sample; behind stairwell near outside doors
33	N10	ND	3.0	Background sample; drill and rivet shop

NYSDEC 033304

- Paint Tunnels
- Former Paint Tunnels
- Former Chem Mill Area
- PCE Recovery and Former Sulfuric Acid Anodize Area

2) The only potential source area of HN-24I contamination from within Plant No. 3 identified during this study is the Former Honeycomb Cleaning Area. The testing in this area did not penetrate a reported sump and as a result it is uncertain if contamination exists underneath the sump.

3) Final conclusions cannot be developed for the Heat Treat Area, because testing was not conducted. However, soil gas results from an area within 50 feet and hydraulically downgradient of the Heat Treat Area sump were 0.5 ppm and less. This indicates that the Heat Treat Area sump may not be a potential source of HN-24I contamination.

4) The elevated soil gas readings at the Flo-Coat Area may result from PCE used in the process. Also note that this area is immediately adjacent to Site 1, which was found to have similar elevated soil gas results.

5) The stage 2 soil gas program will be used to resolve these issues.

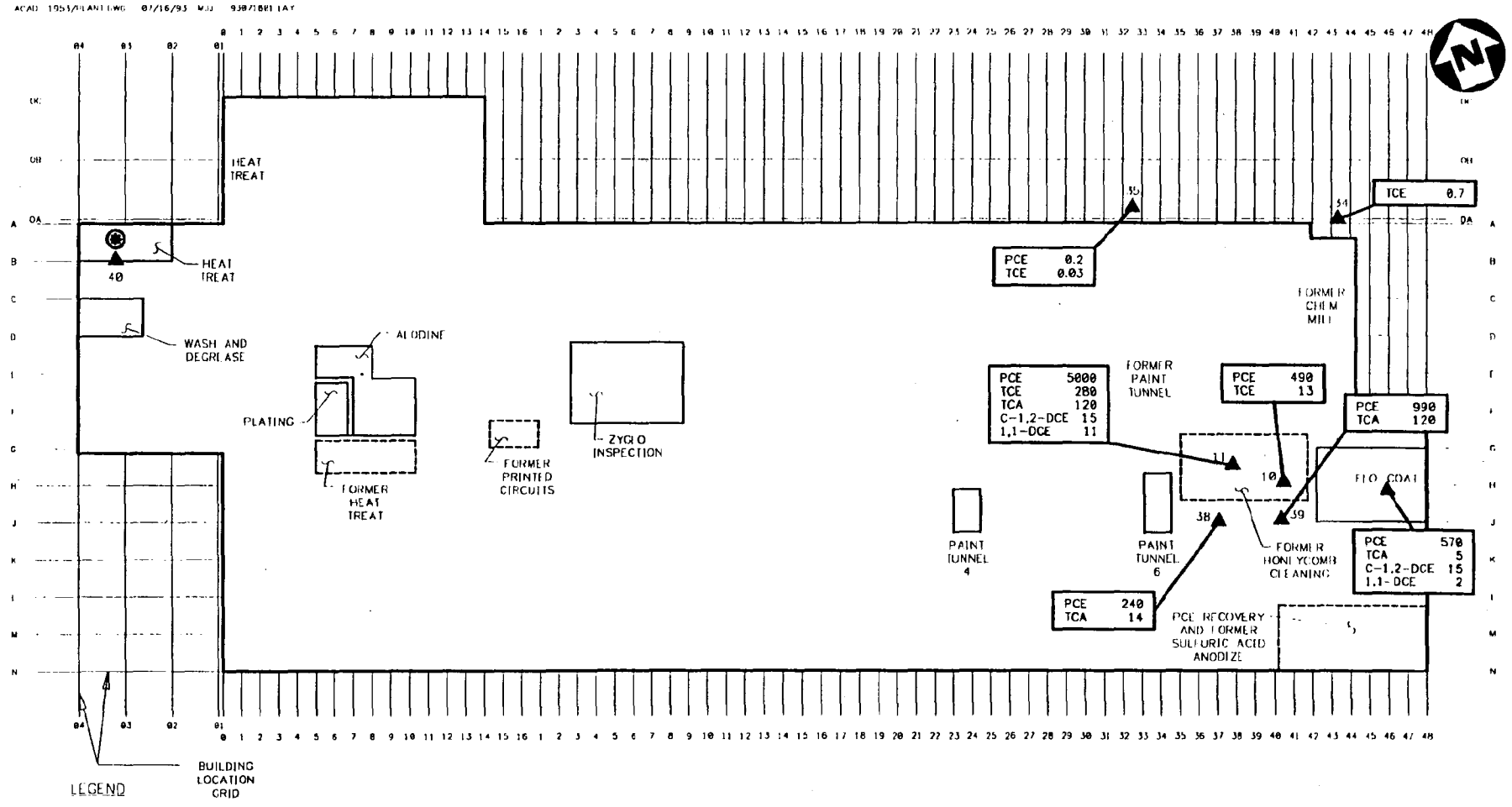
Second Stage Soil Gas Program

A total of 7 soil gas readings were obtained within and immediately outside of Plant No. 3. Sampling locations are shown on Figure 4-1.1. The samples located within Plant No. 3 were taken to quantify the nature of the contamination that was discovered during the first stage soil gas program. The samples located immediately outside of the plant were taken to either identify or eliminate two former TCE tank areas as sources of volatile organic contamination; these areas were not investigated during the first stage soil gas program.

The results of the second stage soil gas program are presented in Table 4-10. Significant volatile organic contamination was detected at the honeycomb cleaning area. Sample SG-11, located in the southeastern corner of the former sump area, contained PCE at 5,000 ug/l, TCE at 280 ug/l, and TCA at 120 ug/l. Sample SG-10, located in the north-central portion of the former sump, contained PCE at 490 ug/l and TCA at 13 ug/l. Samples SG-38 and SG-39 were taken outside (south) of the former sump. These samples contained PCE at 240 ug/l and 990 ug/l, respectively, and TCA at 14 ug/l and 120 ug/l, respectively. Neither of these samples contained TCE at detectable levels.

The soil gas results indicate that the honeycomb cleaning area is a probable source area of volatile organic contamination. The high levels of contamination detected outside of the former sump area apparently indicate that not all of the volatile organic compounds used during this process were captured or contained by the sump. However, because the honeycomb cleaning area is located

NYSDEC 033305



SOIL GAS SURVEY SAMPLE LOCATIONS AND RESULTS (µg/l)
INSIDE PLANT No. 3
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

APPROXIMATE SCALE
0 100 200
SCALE IN FEET

FIGURE 4-11

HALLIBURTON NUS
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NYSDEC 033306

TABLE 4-10

SECOND STAGE SOIL GAS SURVEY RESULTS - PLANT NO. 3
NWIRP BETHPAGE, NEW YORK
(ug/l)

SAMPLE	DEPTH (FEET)	1,1-DCE	1,1-DCA	C-1,2-DCE	1,2-DCA	TCA	TCE	PCE	VINYL CHLORIDE	COMMENTS
SG-10	3	<96	<510	<280	<180	13	<3	490	<1	Honeycomb area; within former sump.
SG-11	3	11	<1	15	<140	120	280	5000	<1	Honeycomb area; within former sump.
SG-38	6	<96	<510	<280	<180	14	<3	240	<1	Honeycomb area; south of sump; general plant floor.
SG-39	6	<96	<510	<280	<180	120	<3	990	<1	Honeycomb area; south of sump; concrete "pad".
SG-FC	2.5	2	<3	15	<180	5	<3	570	<1	Active Flo-Coat area.
SG-40		--	--	--	--	--	--	--	--	Active TCE containment sump. No sample taken.
SG-34	3	<0.5	<3	<1	<0.9	<0.01	0.7	<0.02	<1	Former TCE tank area.
SG-35	3	<0.5	<3	<1	<0.9	<0.01	0.03	0.2	<1	Former TCE tank area.
N_2 Blank	---	<0.02	<0.1	<0.07	<0.05	<0.0006	<0.0008	<0.001	<0.5	---
H_2O Blank	---	<5	<26	<14	<9	<0.1	<0.2	<0.2	<110	---
System Blank	---	<0.02	<0.1	<0.07	<0.05	<0.0006	<0.0008	<0.001	<0.5	---
Air	---	<0.02	<0.1	<0.07	<0.05	<0.0006	<0.0008	<0.001	<0.5	---
Air	---	<0.05	<0.3	<0.1	<0.09	<0.001	<0.002	0.02	<0.5	---

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downgradient of Site 1, it is possible that some of the soil gas contamination is caused by the flow of contaminated groundwater from Site 1 to beneath Plant No. 3.

Sample SG-FC, taken at the active Flo-Coat area, contained PCE at 570 ug/l and TCA at 5 ug/l. As discussed, PCE is used in the Flo-Coat process. This result indicates that the Flo-Coat area may be a source of PCE contamination. However, because this area is located immediately adjacent to Site 1, it is also possible that some of the soil gas contamination is caused by the flow of contaminated groundwater from Site 1 to beneath Plant No. 3.

Samples SG-34 and SG-35 were taken outside of Plant 3 at the locations of former TCE storage tanks. These samples contained very low levels of contamination. Sample SG-34 contained TCE at 0.7 ug/l. Sample SG-35 contained TCE at 0.03 ug/l and PCE at 0.2 ug/l. These results indicate that the former TCE storage tanks were not significant sources of volatile organic contamination.

4.6 DRUM AREA NEAR NORTHERN WAREHOUSES

4.6.1 Soil Gas Survey

Two soil gas readings were obtained adjacent to and immediately downgradient (south) of the active drum area at the northern warehouses complex. Sampling locations are shown on Figure 4-12.

The results of the soil gas survey are presented in Table 4-11. Low levels of contamination were detected at each location. Sample SG-36 contained TCE at 12 ug/l, PCE at 0.2 ug/l, and TCA at 0.2 ug/l. Sample SG-37 contained PCE at 3 ug/l.

The soil gas results indicate that the drum area near the northern warehouses is potentially only a minor source of volatile organic contamination. Groundwater conditions immediately upgradient of this area are not known (Grumman is conducting an investigation in this area). Therefore, it is possible that some of the contamination detected at this area is caused by the flow of contaminated groundwater beneath the area.

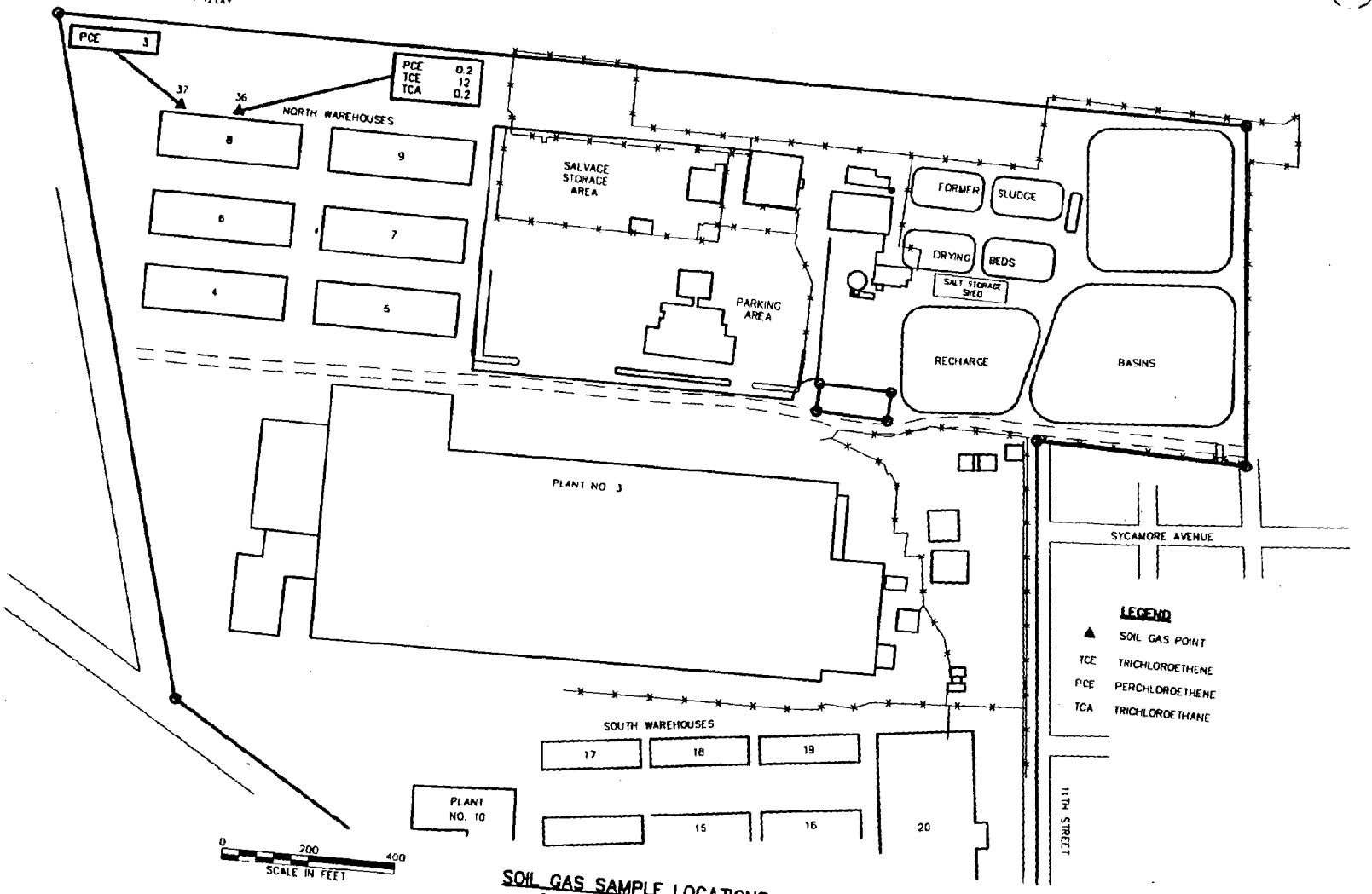
4.7 OFFSITE: RESIDENTIAL NEIGHBORHOOD

A temporary monitoring well program and a permanent monitoring well program were conducted in the residential neighborhood to the east of the NWIRP to determine the extent of groundwater contamination in this area.

4.7.1 Temporary Monitoring Well Program

Eleven temporary monitoring wells were placed in the residential neighborhood to the east of the NWIRP to determine the eastern extent of shallow groundwater contamination associated with Site 1. The location of these wells is present on Figure 4-13 and the analytical results are presented in Table 4-12.

NYSDEC 033308



SOIL GAS SAMPLE LOCATIONS AND RESULTS (µg/l)
DRUM AREA NEAR NORTHERN WAREHOUSES
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

FIGURE 4-12

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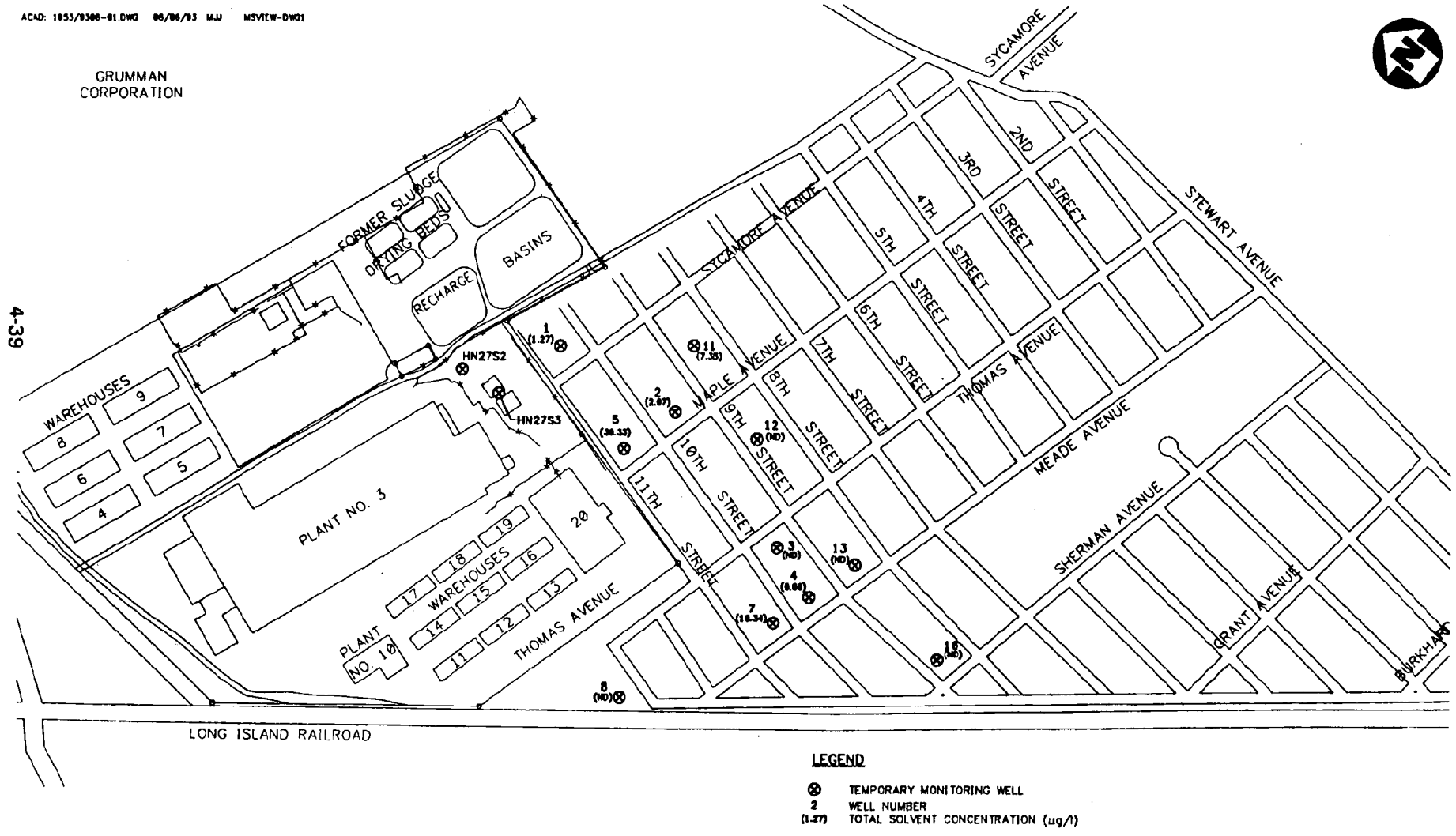
TABLE 4-11

SECOND STAGE SOIL GAS SURVEY RESULTS - DRUM AREA NEAR THE NORTHERN WAREHOUSES
NWIRP BETHPAGE, NEW YORK
(ug/l)

SAMPLE	DEPTH (FEET)	1,1-DCE	1,1-DCA	C-1,2-DCE	1,2-DCA	TCA	TCE	PCE	VINYL CHLORIDE	COMMENTS
SG-36/ SG-36 Dup.	3	<0.5/ <0.5	<3/<3	<1/<1	<0.9/ <0.9	0.2/0.2	13/10	0.2/0.2	<1/<1	Active Drum Area Pad near the Northern Warehouses.
SG-37	3	<0.5	<3	<1	<0.9	<0.01	<0.01	3	<1	Active Drum Area Pad near the Northern Warehouses.
Air	---	<0.2	<1	<0.7	<0.5	<0.006	<0.008	0.05	<0.5	---

NYSDEC 033310



TEMPORARY MONITORING WELL POINT RESULTS
PHASE 2 – REMEDIAL INVESTIGATION FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

FIGURE 4-13

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TABLE 4-12

TEMPORARY MONITORING WELL SURVEY
OCCURRENCE AND DISTRIBUTION OF GROUNDWATER
VOLATILE ORGANIC CONTAMINATION--OFFSITE (RESIDENTIAL NEIGHBORHOOD)
NWIRP BETHPAGE, NEW YORK (ug/l)

MDL	WELL LOCATION	R-01	R-02	R-03	R-04	R-05	R-07	R-08	R-11	R-12	R-13	R-16
	SAMPLING DATE	12/92	12/92	12/92	12/92	12/92	12/92	12/92	12/92	12/92	12/92	12/92
0.18	Trichloroethene	1.27	2.07		0.24	22.49	7.24		6.08			
0.03	Tetrachloroethene				0.11	4.11	1.34		0.33			
0.03/ 0.18	1,1,1-Trichloroethane			*	0.31	3.73	1.76	*	0.94			
0.18	Vinyl chloride											
0.13	1,1-Dichloroethene											
0.07	1,1-Dichloroethane											
0.03	1,2-Dichloroethane											
0.34	cis-1,2-dichloroethene											
0.10	trans-1,2 dichloroethene											

MDL: Method Detection Limit

* 1,1,1-Trichloroethane was detected in this sample at a concentration of 0.18 ug/l. In one field blank sample, 1,1,1-Trichloroethane was also detected at a concentration of 0.18 ug/l. Based on this field blank concentration and the method detection limit, it is likely that the measured contaminant concentrations at these two locations are not representative of groundwater conditions.

NOTE: Blank indicates that the parameter was not detected at a concentration above the method detection limit (MDL).

NYSDEC 033312

The analysis was performed at a non-CLP laboratory with quick turn around on results. As a result this data was not and will not be validated.

The results indicate that Site 1-related groundwater contamination extends only a relatively short distance offsite to the east of Site 1, but may extend as far south as the Long Island Railroad. Temporary monitoring well (R-5), which is the nearest side/downgradient well to Site 1, was measured to contain approximately 22 ug/l of TCE. Well R-1 to the north of R-5, well R-2 to the east of R-5, and wells R-12, 3, 13, 4, 7, and 16 to the southeast of R-5 were all measured to contain less than the drinking water action level of 5 ug/l for this solvent. Well R-7, which is south of Site 1 and R-5, contained 7.24 ug/l of TCE, indicating contamination extends to this location and likely beyond. R-8 was found to contain non-detectable concentrations of solvents. However, this well was located in a storm water management recharge basin, which likely biased the results low.

R-11 provides an interesting result (TCE 6.08 ug/l) in that the concentration at this location is higher than at other locations between R-11 and Site 1. For example, R-1 contained 1.27 ug/l of TCE and R-2 contained 2.07 ug/l. Based on computer modeling results (Section 5.0) and general hydrogeology of the recharge basins, it is suspected that the contamination found in R-11 is related to solvents found in the recharge basin water. In 1991, water entering the recharge basins was measured to contain 35 ug/l of TCE. Because of volatilization, it is likely that the TCE in the water entering the groundwater is less.

4.7.2 Groundwater Data

Three monitoring well clusters were installed in the residential neighborhood to the east of the NWIRP to evaluate the horizontal and vertical extent of solvent-contaminated groundwater in this direction, (HN-40, HN-41, and HN-42). Each cluster included a shallow-depth (water table 50 feet bgs) and an intermediate-depth (100 to 150 feet bgs) monitoring well.

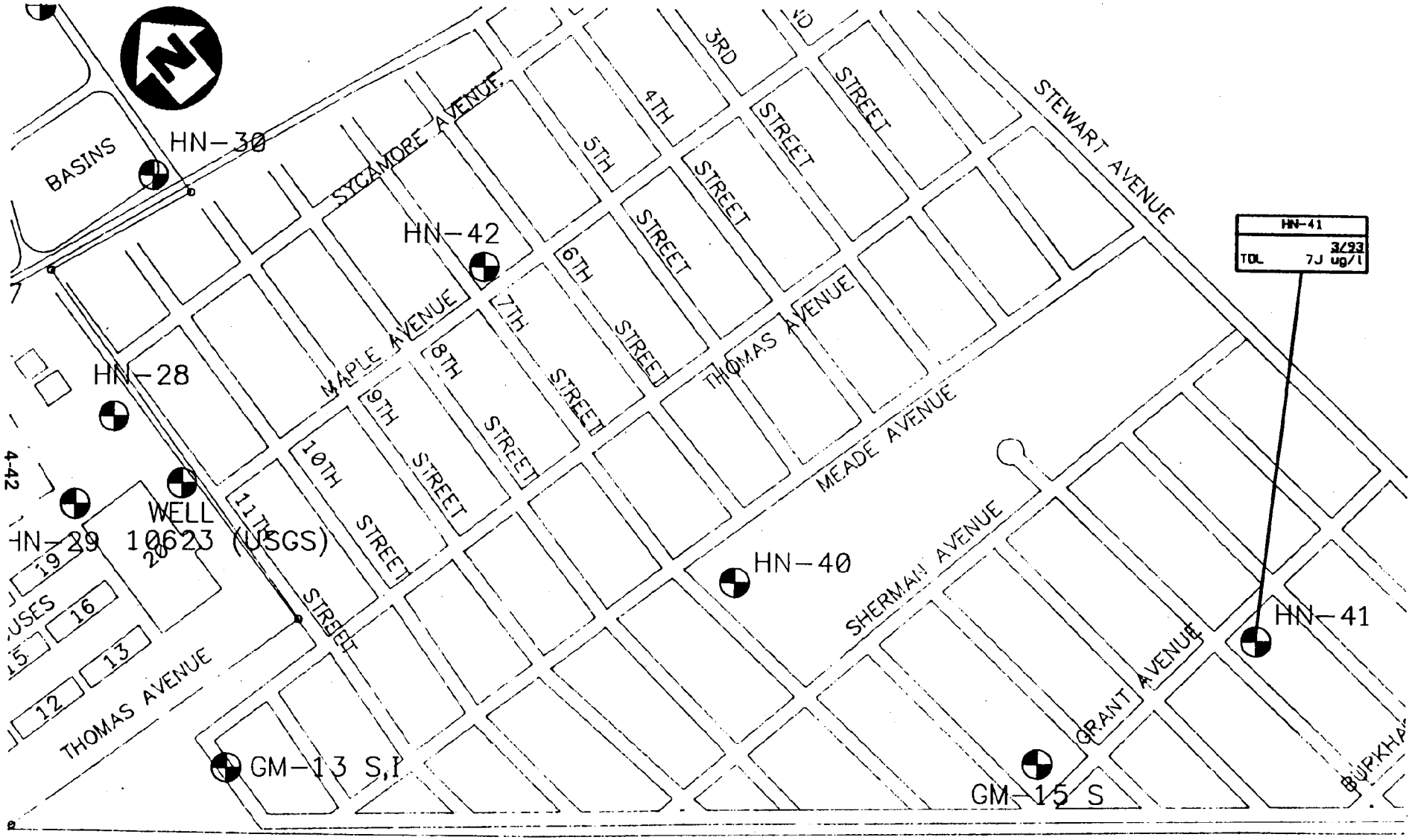
The location of the monitoring wells is provided on Figure 4-14. Wells HN-40 and HN-41 were located based on the Phase 1 RI data indicating significant intermediate-depth groundwater contamination near the Long Island Railroad. Well HN-42 was located based on the Phase 2 temporary monitoring well program results, which indicated the presence of shallow solvent contamination near Maple Avenue and 9th Street. The analytical results for these three monitoring well clusters are summarized in Table 4-13. Figure 4-14 also provides the results of the shallow-depth monitoring wells and Figure 4-15 provides the analytical results of the intermediate-depth monitoring wells.

This groundwater data indicates that the offsite shallow-depth contamination in the residential area, except for the contamination observed immediately adjacent to Site 1, is limited to a single hit of toluene at 7 ug/l at a distance of 2800 feet from the NWIRP. Because of the absence of detectable chlorinated solvents, this contamination may not be site related.

The testing also found that the intermediate-depth groundwater is contaminated at each of the locations. Unlike the shallow groundwater, the intermediate-depth groundwater also contains TCE and

NYSDEC 033313

ACAD: 1953\BASE.DWG 5/24/93 MB (P-HOR)



SHALLOW GROUNDWATER ORGANICS
ABOVE MCLS, ALS, RFD -
OFFSITE: RESIDENTIAL NEIGHBORHOOD
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

FIGURE 4-14

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NYSDEC 033314

TABLE 4-13

OCCURRENCE AND DISTRIBUTION OF GROUNDWATER
VOLATILE ORGANIC CONTAMINATION - OFFSITE (RESIDENTIAL NEIGHBORHOOD)
NWIRP BETHPAGE, NEW YORK (ug/l)

MDL	WELL LOCATION	HN-40S	HN-40I		HN-41S	HN-41I	HN-42S	HN-42I
	SAMPLING DATE	3/93	3/93	3/93 (dup)	3/93	3/93	3/93	3/93
0.91	Trichloroethene		7J	8J				6J
1.00	Tetrachloroethene							2J
2.29	1,1,1-Trichloroethane					16		
1.57	1,1-Dichloroethane					14		
4.34	1,1-Dichloroethene					7J		
1.61	Toluene	4J	7J	8J	7J	8J	4J	3J

J: Estimated
MDL: Method Detection Limit

Notes: 1. MDL applies only to results of 3/93
2. A blank indicates concentrations below reported detection limits.
3. All samples were analyzed for TCL volatiles. Contaminants not listed were not found above reported detection limits.

NYSDEC 033315

ACAD: 1853\BASE.DWG 5/24/93 MB (P-HOR)

INTERMEDIATE GROUNDWATER ORGANICS
ABOVE MCLS, ALS, RFD -
OFFSITE; RESIDENTIAL NEIGHBORHOOD
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP, BETHPAGE, NEW YORK

0 400 800
SCALE IN FEET

FIGURE 4-15

HALLIBURTON NUS
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NYSDEC 033316

TCA. The most contaminated monitoring well is also the furthest from the NWIRP (HN-41). In part based on computer modeling presented in Section 5.0, it is suspected that this solvent contamination is NWIRP-related and results from recharge basin water. The lower concentrations of solvent measured in the wells nearer the recharge basins may result from Grumman's ongoing efforts over time to decrease the concentration of solvents in the recharge basin water.

4.7.3 Summary

Based on the offsite monitoring well program, as well as computer modeling results, the shallow groundwater contamination associated with Site 1 is limited to areas within approximately 100 feet east of Site 1, but continues on south to near the Long Island Railroad. Additional shallow groundwater contamination from the recharge basins likely exists at several locations. Intermediate-depth groundwater contamination in the residential neighborhood extends east toward Stewart Avenue and south to the Long Island Railroad. A portion of this contamination may be directly attributable to Site 1. However, the majority of the contaminated area is likely associated with recharge basin water.

4.8 QA/QC SUMMARY

4.8.1 Field QA/QC Samples

The QA.QC samples generated during this RI are summarized in Table 4-14. Field Samples were collected and analyzed in accordance with Level D data quality requirements. These requirements include duplicate samples at a rate of 1 in 10, field blanks at a rate of 1 per water source per week, trip blanks at a rate of 1 per sample day, and rinsate blanks at a rate of 1 per day - analyze every other day. Chain-of-Custody forms are provided in Appendix B. Field QA/QC sample results are discussed in detail in the full data validation reports (under separate cover). The data validation letters are provided in Appendix J and are summarized as follows:

The following list is parameters and maximum concentrations detected in blank samples.

	Maximum Concentration Detected (ug/l)		
Parameter	Trip Blanks	Field Blanks	Rinsate Blanks
Acetone	20	100	100
2-butanone			8J

These positive detections are an indication of laboratory or field contamination of samples. Data validation is used to ensure the accuracy and usability of the data. In general, all data was usable and of acceptable quality. Acetone and 2-butanone are commonly found as a laboratory contaminant and their presence in the QA/QC samples are not a significant concern. All sample holding times were met. Field duplicate precision were within acceptable criteria.

NYSDEC 033317

TABLE 4-14

FIELD QA/QC SAMPLES
NWIRP BETHPAGE, NEW YORK

Media	Parameters	Number of Field Samples	Number of Duplicates	Number of Trip Blanks	Number of Field Blanks	Number of Rinsate Blanks	Total Number of Samples	Analytical Method	Analytical Laboratory
Soils	PCB/ pesticides	18	2	0	1	2	23	CLP SOW OLM01.8	PACE, Inc. - Hampton
	VOAs	8	1	3	1	2	15	CLP SOW OLM01.8	PACE, Inc. - Hampton
Groundwater	VOAs	16	2	6	1	3	28	CLP SOW OLM01.8	PACE, Inc. - Hampton
Groundwater	VOAs	17	2	0	1	3	23	EPA 601	Volumetric Techniques
Soil Gas	VOAs	9	1	0	3	0	13	GC/FID/ ECD	Tracer Research

NYSDEC 033318

Only 1,1,1-TCA was detected at a concentration of 0.18 ug/l in a field blank sample analyzed at Volumetric Techniques. This data was used to exclude similar results in groundwater samples.

4.8.2 Analytical Methods

The analytical methods used are summarized in Table 4-14 and include CLP SOW OLMO1.8 for organic testing at PACE, Inc. - Hampton, and EPA Method 601 for organic testing at Volumetric Techniques.

4.8.3 Laboratory QA/QC

Methylene chloride was detected at a maximum concentration of 6J ug/l in laboratory blanks. The measured concentration is below the CRQL of 10 ug/l. Also, methylene chloride is a common laboratory contaminant.

PACE experienced problems with surrogate spike recoveries, initial calibration, and continuing calibrations. Also, the quantitative agreement between corollary analyte values generated on both analytical columns was greater than 25% for some samples for pesticides and PCBs. This data was reported as estimated (J).

For several of the PCB samples, the surrogate spike recovery was low. As a result, the non detects on 5 of the 21 sample results were classified as potentially unreliable. Because site specific contaminants were detected in these samples, the usability of the data was not comprised. Overall the data completeness criteria was achieved.

4.8.4 Data Validation

The data validation letters are presented in Appendix J. Data qualifiers were required, but no data was rejected.

NYSDEC 033319

5

5.0 CONTAMINANT FATE AND TRANSPORT

5.1 POTENTIAL MIGRATION ROUTES

This section of the report presents contaminant fate and transport considerations for the Phase 2 RI. The Phase 1 RI (HNUS 1992) developed a full range of potential migration routes, including dust migration and transport via groundwater. Contaminant fate considerations were also presented in the Phase 1 RI report. Since new contaminants were not observed during the Phase 2 RI, contaminant fate considerations will not be repeated in this report.

5.2 GROUNDWATER: SUMMARY OF COMPUTER MODELING STUDY AND RESULTS

The following section summarizes the procedures and results of the computer modeling performed as part of the RI report for the Bethpage NWIRP.

5.2.1 Computer Modeling Objectives

The general objectives of the RI computer modeling were to provide data on the overall groundwater flow in the area of the NWIRP and to determine the potential flow directions of contaminants which may originate on the site. The specific objectives of the computer modeling at Bethpage NWIRP are listed below:

- Provide a general characterization of the subsurface conditions underlying Bethpage NWIRP.
- Develop a flow model which accurately represents groundwater flow in the area around the Grumman site, with an emphasis on the groundwater flow in and around the NWIRP.
- Model the flow directions of simulated contaminant releases under a variety of production well and NWIRP recharge basin pumping conditions.

5.2.2 Summary of Modeling Approach

The flow model was developed in several related steps, which are as follows; (1) Collect existing data and construct the conceptual model, (2) select the appropriate numerical groundwater model, (3) input initial parameters into model, (4) perform calibration on two months of steady-state data, and two sets of transient pump test data (5) perform validation on two months of steady-state data, (6) perform particle tracking simulations, (7) conduct sensitivity analysis for flow model parameters.

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5.2.3 Conceptual Model

To accurately simulate the behavior of groundwater and particle movement, it is first necessary to obtain a detailed understanding of the geologic and hydrogeologic factors which control groundwater flow at a site. The conceptual model of the groundwater system was developed from information gathered on site conditions during a literature review conducted prior to construction of the model. Initial values of geologic and hydrogeologic parameters were obtained from a variety of literature sources and from two pumping tests performed at the NWIRP. A complete discussion of the conceptual model is presented in Appendix F.

Key features of the conceptual model are:

- The water table is present within the upper portion of the Magothy aquifer across most of the modeled area. The Magothy aquifer is considered to be the most significant water-bearing unit in the vicinity of the NWIRP site.
- The upper glacial and Magothy units are considered to function as a single aquifer, as no barrier exists between these units to prevent the exchange of water.
- All Grumman production wells, recharge basins, and Bethpage Water District (BWD) wells are located in the upper glacial aquifer, or within the Magothy aquifer.
- The base of the flow system is the Raritan clay unit, which is considered to be impermeable.
- The aquifer is considered to be unconfined.
- No natural surface water bodies are present within the modeled area which significantly effect groundwater flow in the model area.

Key features of the computer model grid are:

- The model grid covers the NWIRP, Grumman property, and BWD wells to the east and south.
- Model grid columns are oriented parallel to the normal (non-pumping) groundwater flow.
- Grid spacing is most dense in the area of the NWIRP, where the direction of groundwater flow is of primary interest. Grid spacing widens towards the edge of the grid.
- The model grid consists of five layers, which were determined based on the screened intervals of shallow, intermediate, and deep monitoring wells. Layer 1 contains shallow

NYSDEC 033322

wells, layer 2 contains intermediate wells, layer 3 contains deep wells and one BWD well, layer 4 and 5 contain Grumman production wells and BWD wells.

- Constant head boundaries are present along the north and south grid boundaries, and no flow boundaries are present along the east and west grid boundaries.

The location and extent of the computer modeling grid are illustrated in Figure 5-1. The relationship of model layers to the upper glacial and Magothy aquifers is illustrated in Figure 5-2.

5.2.4 Computer Code Selection

The modular three-dimensional finite-difference groundwater flow model (known as MODFLOW) was chosen to be used for this modeling project because it is capable of simulating the conceptual model developed for the NWIRP site. MODFLOW was developed by the U. S. Geological Survey to simulate groundwater flow in a variety of situations (Mc Donald and Harbaugh, 1988). This model can be used for two-dimensional or three-dimensional applications, and can simulate the effects of wells, recharge, drains, and rivers as well as a variety of boundary conditions. MODFLOW has been used extensively at hazardous waste sites for simulation of groundwater flow, evaluation of remedial alternatives, and can be used in conjunction with other programs for modeling of contaminant transport and particle tracking. MODFLOW uses a block-centered grid for solving the finite-difference groundwater flow equations.

MODPATH is a three-dimensional particle tracking code that was developed by the U. S. Geological Survey (Pollock, 1989). MODPATH operates separately from MODFLOW, and utilizes heads calculated in MODFLOW to determine the direction of particle movement with time. Particle flow directions can be traced forward in time to determine where particles released from a potential contaminant source may move, or particles can be tracked in reverse to determine well capture zones.

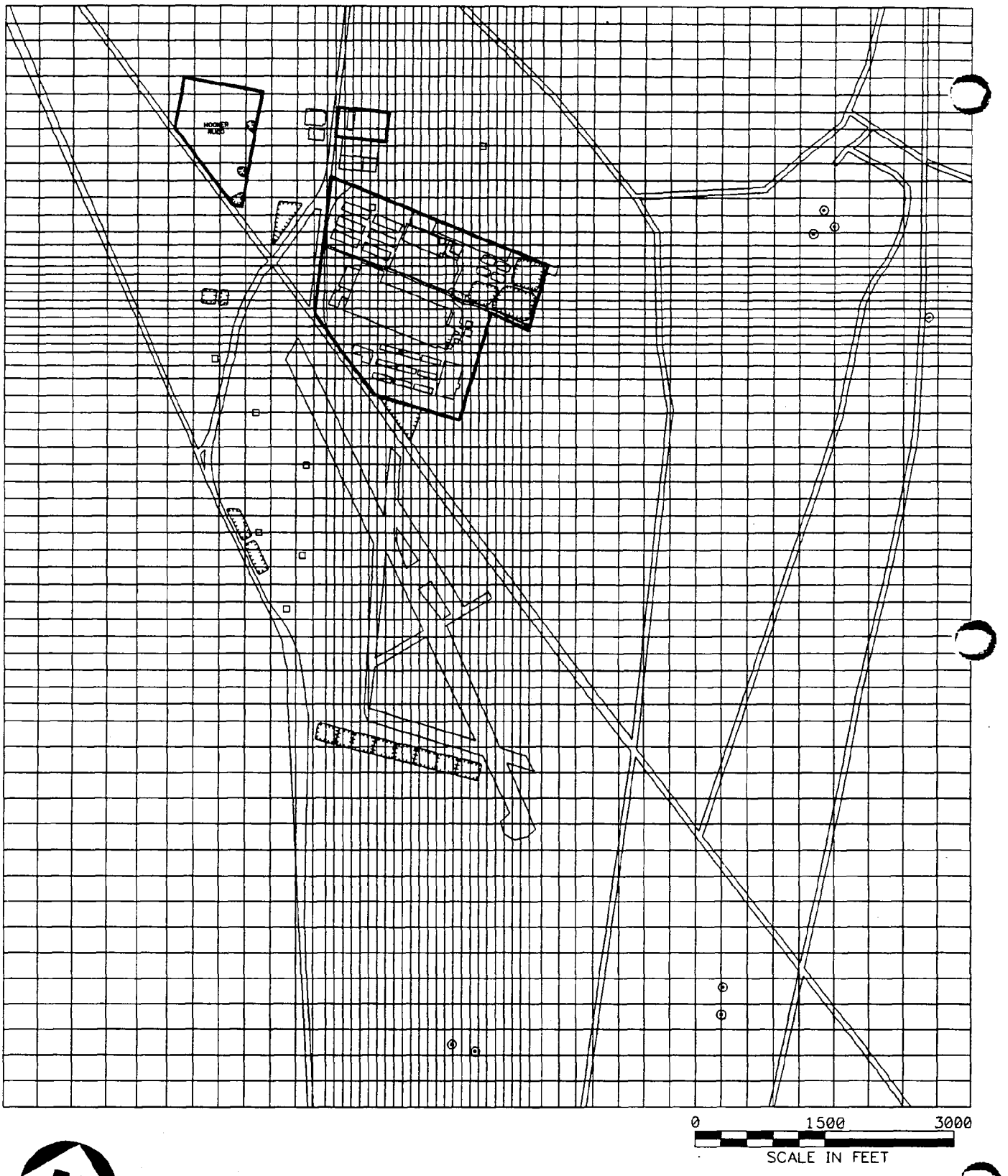
5.2.5 Model Calibration

Model calibration refers to a demonstration that the model is capable of producing water elevations which are comparable to water elevations measured on site. Calibration included performing steady-state simulations for two separate pumping conditions at the Grumman site; low pumping conditions for Grumman production wells during February, 1992, and high pumping conditions for Grumman production wells during August 1992. Calibration also included conducting transient simulations for two pumping tests which were carried out at the NWIRP site. A detailed discussion of model calibration procedures and results is presented in Appendix F.

Model calibration was conducted to generate a best fit for both steady-state and transient conditions. Calibration was performed interactively between transient and steady-state simulations. The final calibrated model minimized the model error for both the steady-state and transient simulations.

NYSDEC 033323

ACAD: 1953/OTHER.DWG 06/04/93 MJJ 93060401.LAY



LOCATION OF THE MODEL GRID
BETHPAGE NWIRP

FIGURE 5-1

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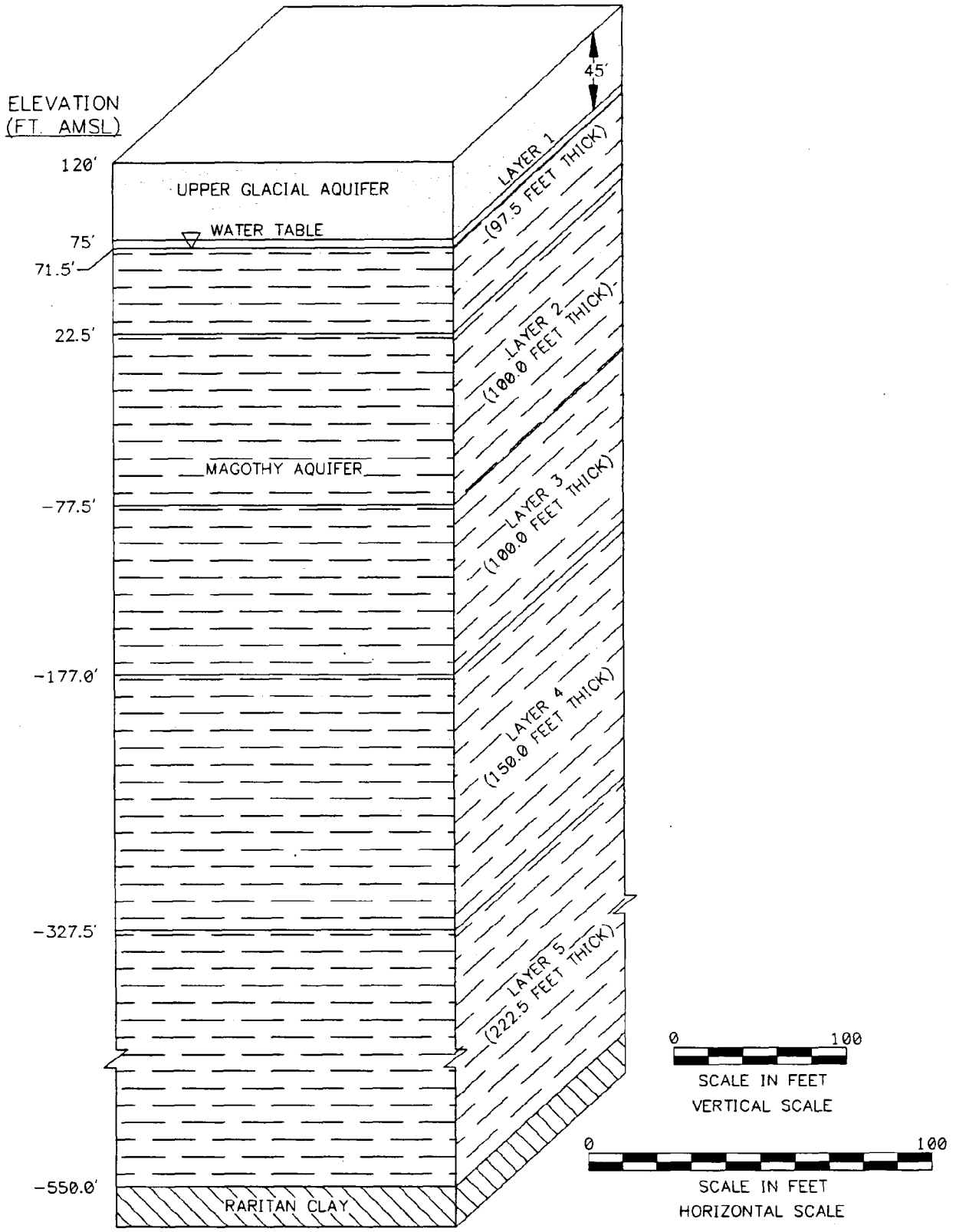

ACAD: 1953/BLOCK.DWG 06/04/93 MJJ

FIGURE 5-2

VERTICAL EXTENT OF MODFLOW LAYERS
BETHPAGE NWIRP

HALLIBURTON NUS
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NYSDEC 033325

Steady-state calibration simulated two monthly pumping scenarios. Simulated water elevation data was compared to measured data at 61 monitoring wells across the modeled area. Steady-state simulations were run until there was less than .0001 ft of change in head during one iteration of the simulation. Both steady-state and transient model calibration was performed by adjusting initial values of aquifer parameters and boundary conditions until an acceptable match of the modeled data was achieved when compared to observed measurements. To more accurately represent natural conditions, recharge was added to 3 recharge basins on Hooker-Ruco property, and to one recharge basin in the vicinity of well GM-15S during model calibration. These basins were activated to compensate for recharge which may have occurred at these basins during the months considered in the model calibration.

Transient (stressed) conditions were calibrated by simulating two pumping tests performed at the NWIRP site. These pumping tests produced drawdowns within a small portion of the model grid and transient calibration efforts were focused on this section of the model. Simulated drawdowns were compared to measured drawdowns for the transient calibration runs.

Calibration Criteria

The steady-state flow model was considered calibrated when the modeled steady-state simulations were within 2.0 ft of measured values at the monitoring wells. The calibration criteria was determined as one-half the natural water table fluctuation across the site. This calibration criteria of ± 2.0 ft was met for all of the 61 monitoring wells on site, with the exception of 8 monitoring wells. These wells which fall outside the calibration criteria are located in the immediate vicinity of active recharge basins or production wells, which may have effected the calibration results. A more rigorous calibration criteria of ± 1.0 ft was met for the modeled versus measured drawdowns for the two transient pumping test simulations. The ± 1.0 ft calibration criteria was used for the pumping test simulations because these pumping tests effected a small portion of the model grid where grid spacing is most dense, and flow in and around the NWIRP is of primary interest as potential sources of contaminants (Site 1) are known to exist in this area.

Calibration Results

For each steady-state calibration run, the difference in head between the measured and modeled heads was noted. The measured minus modeled value indicates if the measured water elevation at a well is within the calibration criteria. In addition to this value, two other quantitative calculations were performed for the calibration runs to determine how closely the modeled data fit the measured data.

The sum of the differences of modeled data to measured data (referred to as the mean error) indicates the amount of positive or negative model error for the calibration run. A zero value of mean error indicates equal amounts of positive and negative model error, (i.e., the model predictions are not consistently high or low). Final calibration results for low pumping conditions have a mean error of -0.01 ft for low pumping conditions, and 0.02 ft for high pumping conditions. The mean error was minimized during model calibration. A small value of mean error alone does not indicate a good

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calibration, as both positive and negative mean errors are incorporated and may cancel out. For this reason, an additional measure of model accuracy (absolute residual value) was calculated.

The absolute residual value is the sum of the absolute values of the differences between measured and modeled data for each monitoring well. A low absolute residual value indicates a good match between measured and modeled data, with a zero value indicating an exact match between measured and modeled data. The absolute residual value for low pumping conditions was 28.26 ft, and for high pumping conditions the absolute residual value was 36.64 ft. The absolute residual value for low pumping and high pumping conditions was minimized during calibration, and these absolute residual values were considered to be acceptable for these simulations.

The outlier wells that fall outside the calibration criteria were not included in the calculation of mean error or absolute residual error because these wells were interpreted to be influenced by active recharge basins and production wells and, therefore do not accurately reflect the modeled conditions. Pumping rates used in the model were derived from monthly averages at each production well and do not reflect daily fluctuations in recharge basin water levels or production well pumping rates. The measured water elevations represent a 'snap-shot' of water conditions, while the modeled conditions reflect steady-state conditions. Therefore, water elevations taken at monitoring wells in the immediate vicinity of active recharge basins or production wells may be influenced by pumping or recharge activities. The majority of monitoring wells are distant enough from recharge basins or pumping wells so that they are not effected by short-term fluctuation caused by pumping or recharge. The average pumping rates used in the model can accurately simulate water levels, as indicated by the close fit of modeled to measured water elevations at most of the monitoring wells during calibration.

In addition to the statistical checks made on calibration solutions noted above, the water balance of each calibration run was checked. This water balance measurement is generated by the MODFLOW model, and is an independent check on the total amount of water entering and leaving the flow system. All calibration runs fell below the ± 0.50 % water balance error criteria.

Statistical analysis on the calibration results was performed to determine how well the model data matched the measured data, and to determine if any trends were present in the distribution of model error. Linear regression data for the calibrated steady-state model indicates that a nearly direct relationship exists between the modeled and measured data. Similarly, a linear regression for the modeled and measured drawdowns for pumping test #1 shows a nearly direct relationship between measured and modeled results. Linear regression results are illustrated in Appendix F. The simulation of pumping test #2 was more difficult to model due to the small amounts of drawdowns produced ($<$ 1.0 ft) in the observation wells. The regression data for this data shows more scatter and a less direct fit of the modeled data. Residual contour plots, which show a contour plot of the model error for the steady-state simulations, indicate no significant trends were present in the modeled data.

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5.2.6 Model Validation

Model validation is a check on how well the model can predict a set of water elevations, utilizing the model parameters established during calibration. Model validation for the flow model consisted of entering the known pumping rates for production wells and recharge basins for two separate months, running the model to a steady-state, and comparing model output to measured data for those months. Two validation scenarios were simulated, January, 1992 and July, 1992.

These two data sets were not used during model calibration and represent independent data sets for model validation. The January and July data sets were chosen for validation because these months occur immediately before February and August, 1992, which were used during calibration. The January and July data was considered to represent the most similar boundary conditions to those used for calibration as they occur in the same seasons as the calibration runs. Precipitation data indicates that January and July are more similar to February and August (rather than March and September, the other months considered for validation). Using months in similar seasons, with similar amounts of precipitation for calibration and validation is important because the total precipitation will effect the water elevations at the north and south constant head boundaries, which effect water elevations across the modeled area. A complete discussion of the model validation is presented in Appendix F.

The January, 1992 validation results show that the difference of modeled to measured water elevation falls within the ±2.0 ft criteria for 56 of 58 monitoring wells. Two wells which fall outside the ±2.0 ft criteria are monitoring wells GM-6I and GM-17S. These two wells are in the immediate vicinity of a production well and recharge basin, and are considered outlier wells and may be biased by the nearby pumping and recharge activity.

Results of the July, 1992 validation show that the difference of modeled to measured water elevation falls within the ±2.0 ft criteria for the majority of the monitoring wells. A total of eight wells fall outside the calibration criteria. Five of these wells, GM-6I, GM-17S, HN-8D, HN-29D and HN-30I, are in the immediate vicinity of a production well or recharge basins, which are considered outlier wells and were not included in calculation of mean error because they may be effected by pumping or recharge activities. Three monitoring wells, GM-7D, GM-8S and HN-28I showed a modeled to measured difference of greater than ±2.0 ft. The remaining 51 of 59 monitoring wells fall within the ±2.0 ft criteria.

5.2.7 Particle Tracking

MODPATH, a module of MODFLOW, was used to track the locations of particles after a simulated release of contaminants from suspected source areas. Particle tracking was performed to determine the possible directions and rates that contaminants will move after a release. Several particle tracking scenarios were performed, each under a different pumping condition of Grumman production wells and recharge basins, and with different BWD well pumping rates. The particle tracking program MODPATH utilizes the groundwater flow data generated by MODFLOW and simulates advective transport of particles. Other contaminant transport parameters such as diffusion, dispersion, and contaminant half-

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life are not considered in the MODPATH simulations. All MODPATH simulations were performed using the aquifer parameters determined during model calibration, for pumping scenarios run to a steady-state.

Particle tracking analysis is used to trace out flow paths, expressed as lines, by tracking the movement of infinitely small imaginary particles placed in the flow field. This process may also be used to determine the capture zone of a well by releasing particles in a grid block, generally a well, and tracking the particles in reverse along pathlines to determine their source.

Particle Release Locations

Particle tracking analysis was performed for three separate release locations, listed below:

- Particles were released from possible contaminant sources at Site 1.
- Particles were released from possible contaminant sources at the NWIRP recharge basins.
- Particles were also released at the eastern BWD wells (BP-07, BP-08 and BP-09)

Particle tracks from the two potential source areas (Site 1 and the NWIRP recharge basins) were tracked in the forward direction to determine where particles will move after a simulated release. Particles were released from each of the three BWD wells to the east of the NWIRP. These particles were tracked backwards to determine where they originated from and to define the capture zone of each well. Particle release locations are illustrated in Appendix F.

Pumping Scenarios

Three pumping conditions were considered for particle tracking simulations. These pumping conditions were determined based on past, current and potential future pumping configurations at the Grumman production wells, recharge basins, and BWD wells. The emphasis of these simulations was to determine where particles will move after a release from potential contaminant sources and what effect, if any, these potential contaminant sources will have on BWD wells. The pumping scenarios are summarized below in Table 5-1:

Current conditions

Current conditions were simulated in order to determine where contaminants may be moving under the pumping conditions that exist currently. Production well pumping rates for current conditions at the Grumman site were determined from 1991 and 1992 average pumping rate data. BWD wells production rate data was determined from 1991 and 1992 average pumping rate data. The BWD wells

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TABLE 5-1

SUMMARY OF PUMPING CONDITIONS USED IN PARTICLE TRACKING SIMULATIONS
NWIRP BETHPAGE, NEW YORK

Pumping Scenario	Grumman Production Well / Recharge Basin Pumping Rate	BWD Wells Pumping Rate	Reason Considered
Current Conditions	1991, 1992 average pumping rate/recharge rate	1991, 1992 average pumping rate	Current average conditions.
High Pumping at Grumman, Scenario 1	All wells at 75% of maximum pumping rate/recharge rate	1991, 1992 average pumping rate	Likely historic conditions.
Scenario 2	All wells at 75% of maximum pumping rate/recharge rate	Maximum pumping rate	Potential worst case historic conditions.
No Pumping at Grumman, Scenario 1	No pumping or recharge	1991, 1992 average pumping rate	Potential future scenario.
Scenario 2	No pumping or recharge	Maximum pumping rate	Potential future scenario.

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were considered to be pumping at 120% of 1991 and 1992 rates, and well BP-09 was considered to be active although it was taken off-line in 1991. These assumptions represent conservative estimates of the current conditions at the BWD wells. Three recharge basins were considered to be active on Hooker-Ruco property, recharging the aquifer at a rate of 202 gpm per basin (the rate determined during model calibration).

The results of the MODPATH particle tracking are presented as maps which show the extent of particle movement within each of the model layers. Figures 5-3 through 5-7 illustrate particle movement in model layer 1 through layer 5. These figures represent the maximum distance particles move in each model layer for current, high pumping and no pumping situations. Although some overlap of Site 1 particle tracks and recharge basin particle tracks may exist, for clarity this overlap is not shown in these figures.

Table 5-2 summarizes the final destinations of the particles released from each site during current pumping conditions, and the minimum and maximum travel time of particles from each release site to their final destinations. Figures which illustrate the particle tracking pathlines for the current pumping situation are provided in Appendix F.

Particle Tracking Results and Conclusions - Current Conditions:

- All particles released from Site 1 under current pumping conditions are captured by Grumman PW-01.
- Particles released from the NWIRP recharge basins show that 30% of particles released are captured by Grumman production wells PW-01, PW-09, PW-10, PW-1, PW-15 and PW-16. The remaining 70% of the particles flow to the south constant head boundary. No particles from the NWIRP recharge basins are captured by BWD wells BP-10 or BP-11.
- The capture zone for BWD wells BP-07, BP-08 and BP-09 extends into the north constant head boundary.

High Pumping Conditions

The high pumping conditions were simulated to determine where particles may have moved from contaminant sources during past pumping conditions. Before 1985 higher rates of pumping/recharge at the Grumman production wells and recharge basins may have occurred due to the increased manufacturing activity at the facility. High pumping conditions at Grumman were simulated by pumping all 14 production wells at 75% of maximum capacity. Three recharge basins were considered to be active on Hooker-Ruco property, recharging the aquifer at the rate of 202 gpm per basin (the rate determined during model calibration).

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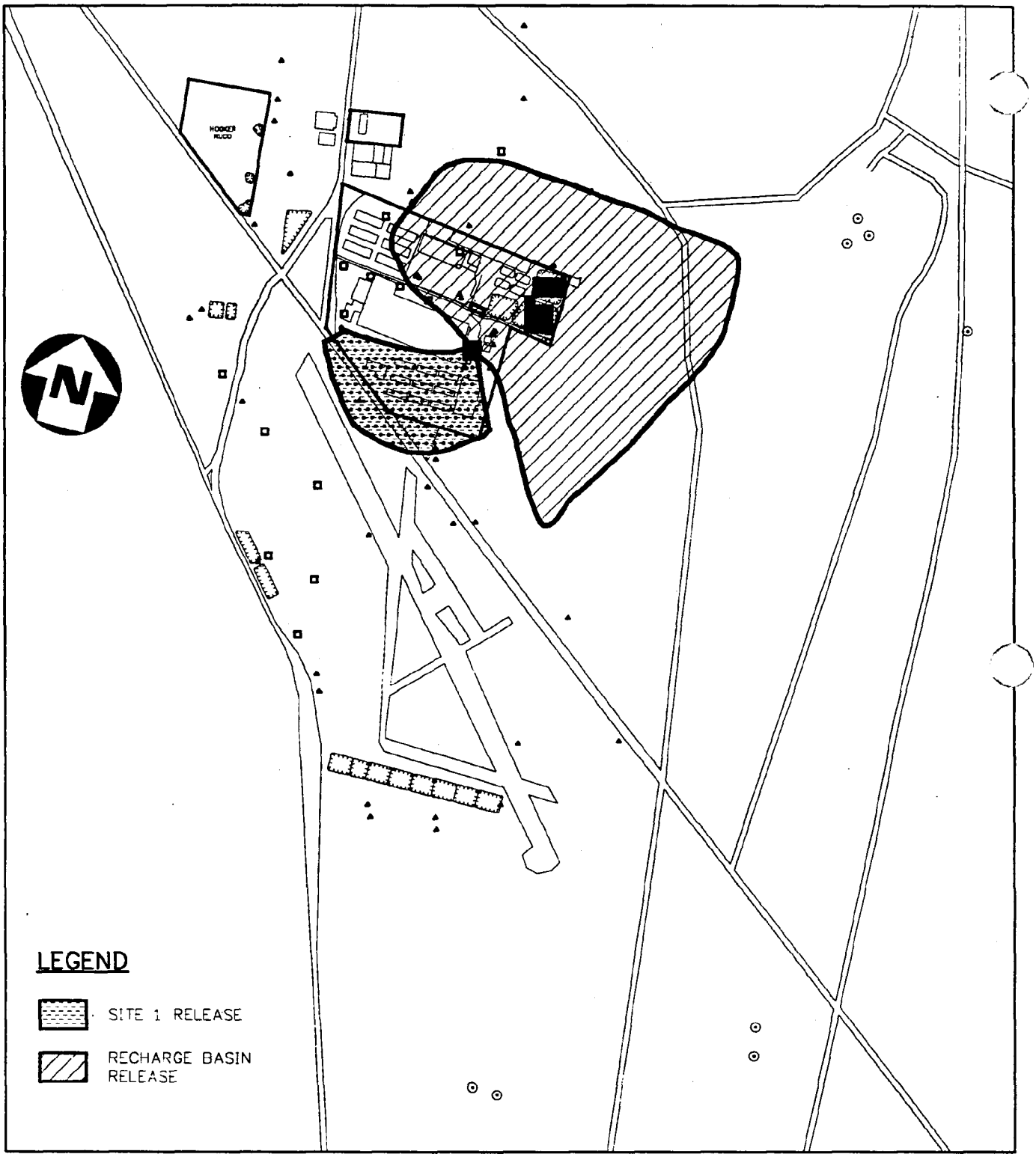


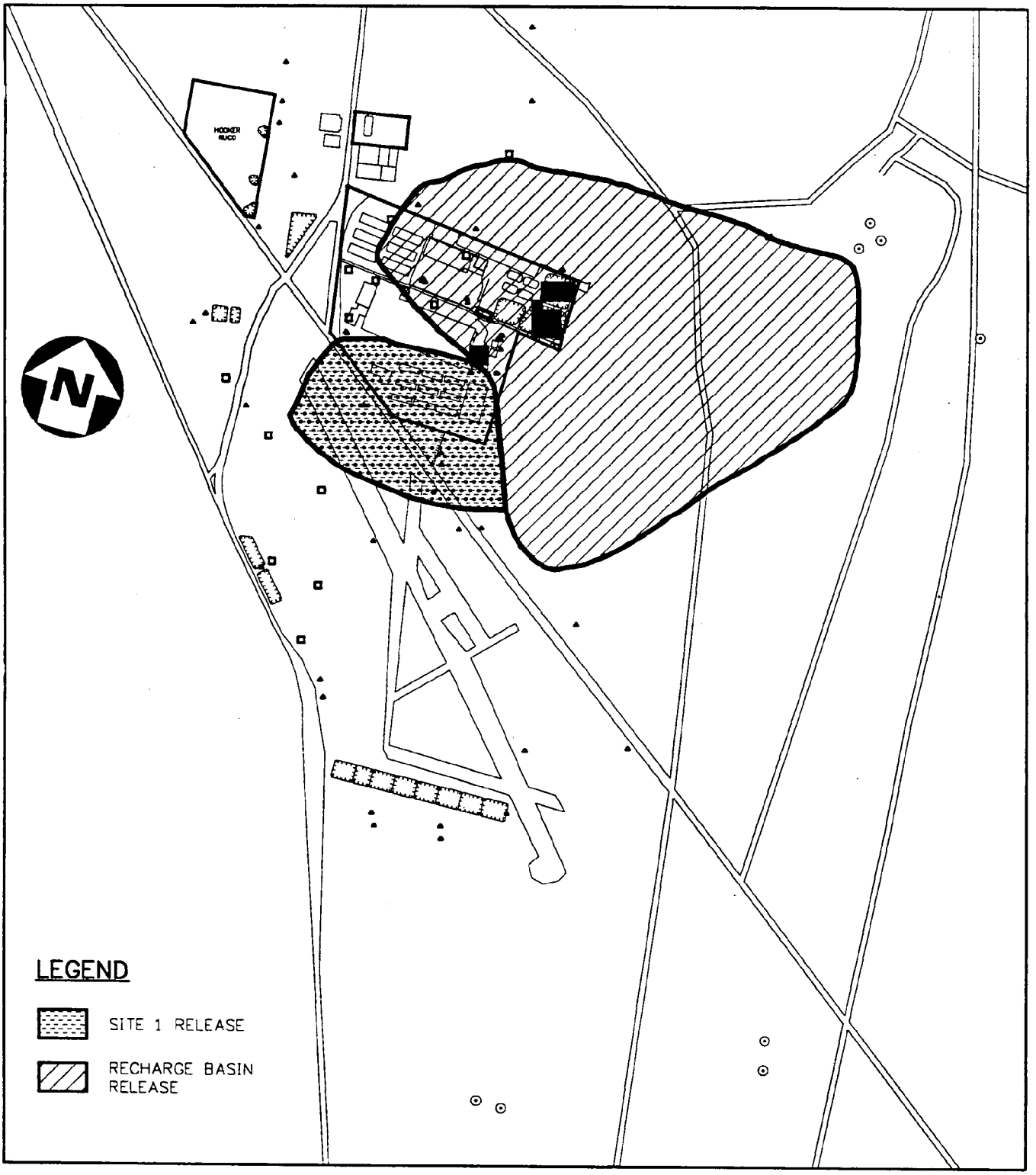
COMBINED PUMPING SCENARIO
PARTICLE LOCATIONS IN LAYER 1
(0 – 100 FEET)
BETHPAGE NWIRP

FIGURE 5-

HALLIBURTON NUS
Environmental Corporation

NYSDEC 033332

ACAD: 1953/OTHER.DWG 07/19/93 MJJ VIEW-AV1 93060403.LAY



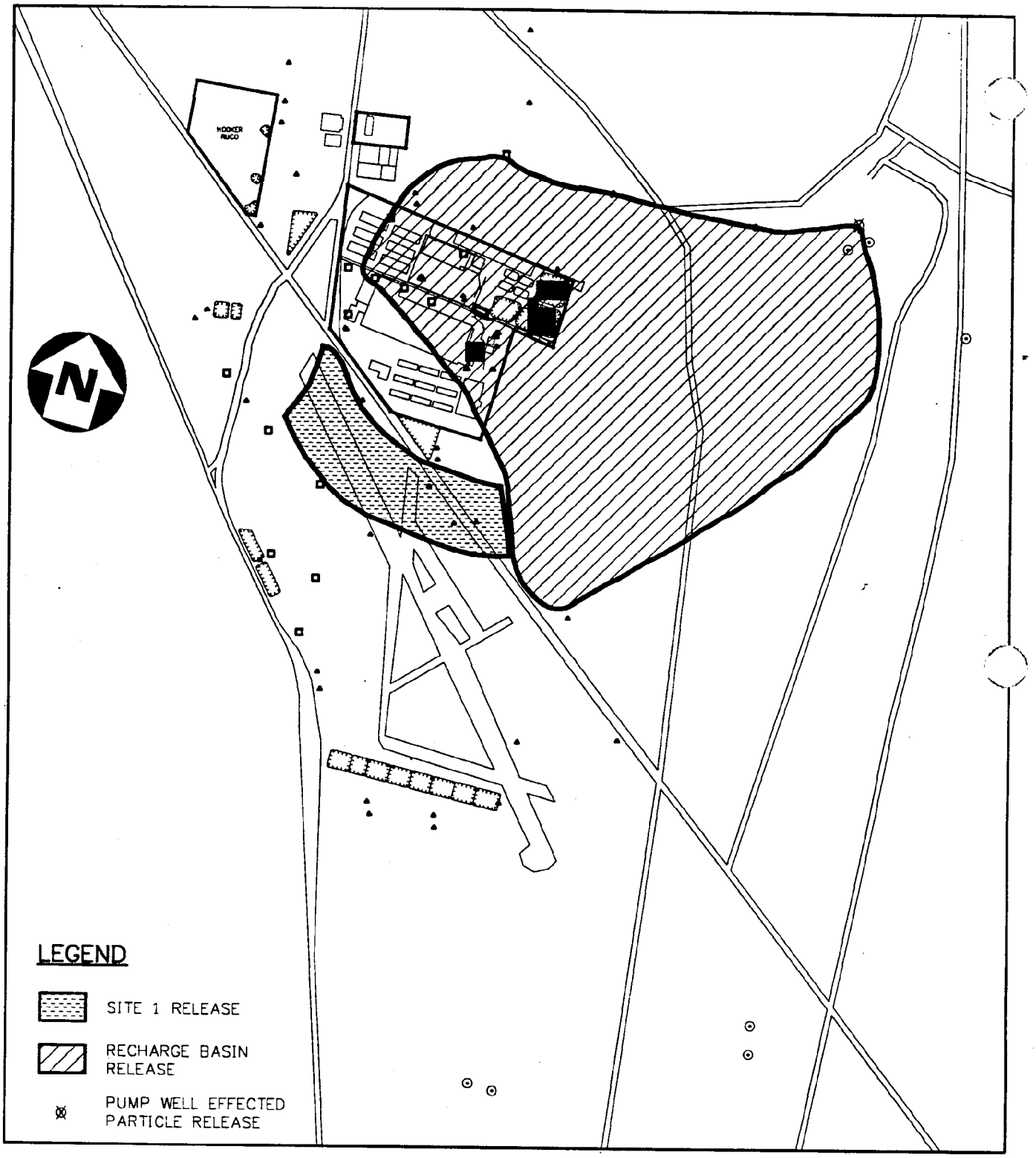
COMBINED PUMPING SCENARIO
PARTICLE LOCATIONS IN LAYER 2
(100 – 200 FEET)
BETHPAGE NWIRP

FIGURE 5-4

HALLIBURTON NUS
Environmental Corporation

NYSDEC 033333

ACAD: 1953/OTHER.DWG 07/19/93 MJJ VIEW-AV1 93060404.LAY

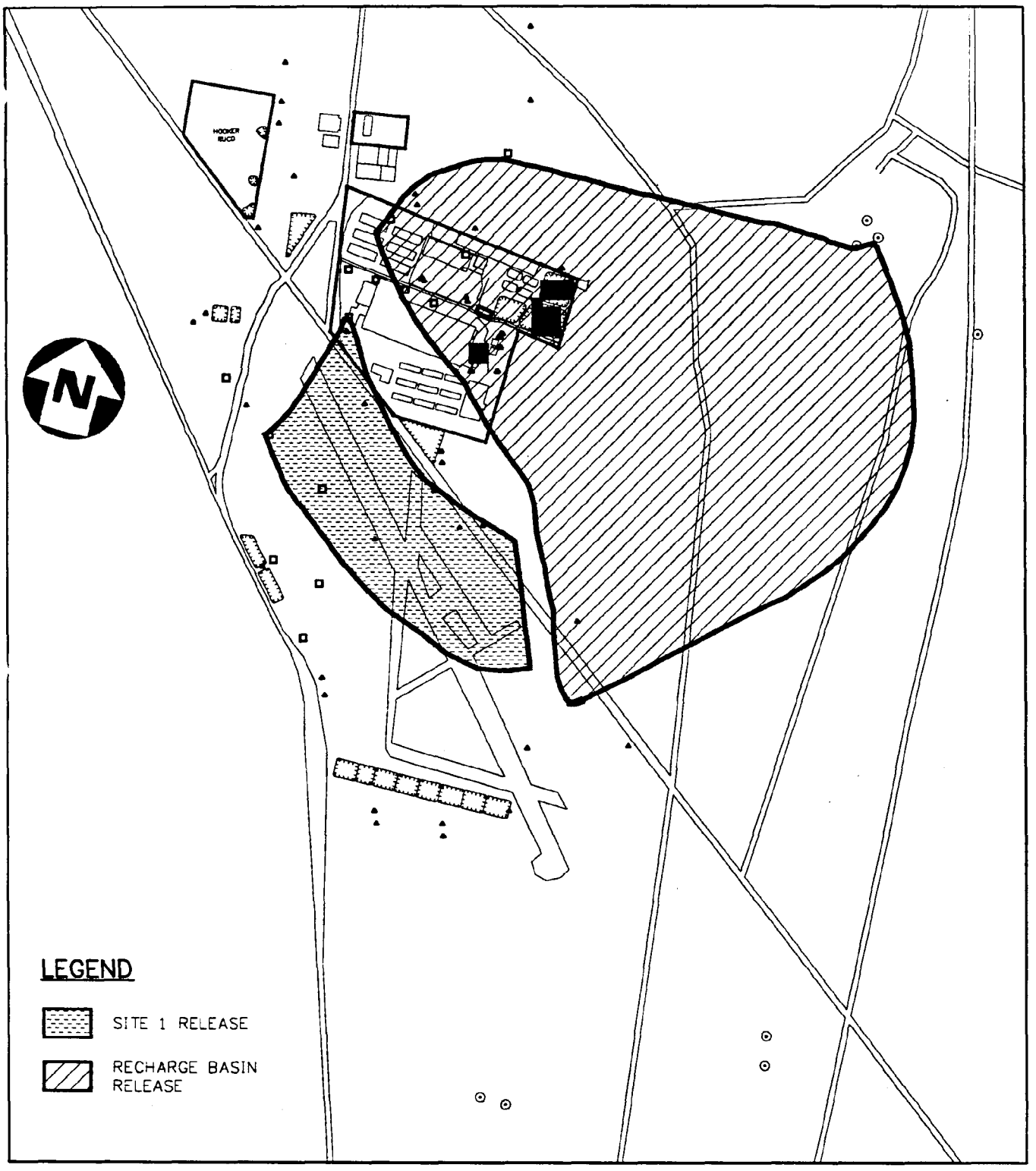


COMBINED PUMPING SCENARIO
PARTICLE LOCATIONS IN LAYER 3
(200-300 FEET)
BETHPAGE NWIRP

FIGURE 5-

HALLIBURTON NUS
Environmental Corporation

ACAD: 1953/OTHER.DWG 07/19/93 MJJ VIEW-AV1 93060405.LAY



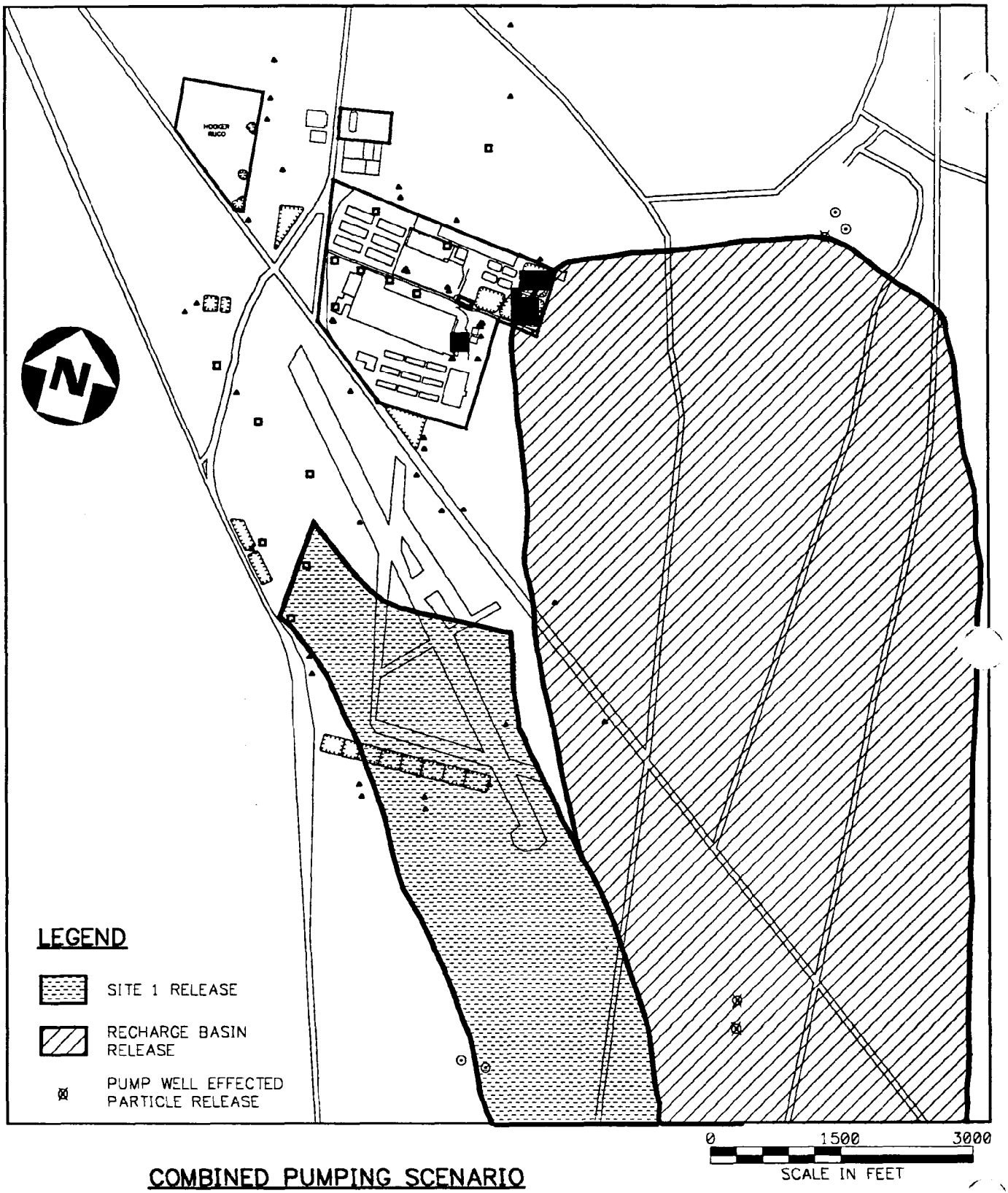
COMBINED PUMPING SCENARIO
PARTICLE LOCATIONS IN LAYER 4
(300 – 450 FEET)
BETHPAGE NWIRP

FIGURE 5-6

HALLIBURTON NUS
Environmental Corporation

NYSDEC 033335

ACAD: 1953/OTHER.DWG 07/19/93 MJJ VIEW-AV1 93060406.LAY



COMBINED PUMPING SCENARIO
PARTICLE LOCATIONS IN LAYER 5
(450 - 673 FEET)
BETHPAGE NWIRP

FIGURE 5-.

HALLIBURTON NUS
Environmental Corporation

TABLE 5-2

SUMMARY OF PARTICLE TRACKING RESULTS
NWIRP BETHPAGE, NEW YORK

Grumman Pumping Conditions	BWD Pumping Conditions	Particle Release Location	No of Particles Released	Percentage of Particles Reaching Each Location					
				Production Well/Recharge	Travel Time (min/max - yrs)	Constant Head Boundary	Travel Time (min/max - yrs)	BWD Wells	Travel Time (min/max - yrs)
Current Conditions	Current Conditions	Site 1	48	100 %	14.8 / 53.5	0%	0	0%	0
		Recharge Basins	96	30%	2.4 / 13.8	70%	20.4 / 55.5	0%	0
		BWD Wells (1)	72	0%	--	100%	1.7 / 21.6	--	--
High	Average	Site 1	48	100%	3.8 / 11.8	0%	--	0%	0
		Recharge Basins	96	73%	0.8 / 40.4	24%	20.7 / 58.2	3%	10.4 / 24.1
		BWD Wells (1)	72	7%	7.4 / 18.6	93%	1.6 / 34.9	--	--
High	High	Site 1	48	100%	4.0 / 11.6	0%	0	0%	0
		Recharge Basins	96	65%	0.8 / 30.3	2%	30.9 / 69.9	33%	7.4 / 49.5
		BWD Wells (1)	72	8%	7.11 / 15.4	92%	1.2 / 26.6	--	--
No Pumping	Average	Site 1	48	0%	0	100%	49.7 / 58.5	0%	0
		Recharge Basins (2)	0	--	--	--	--	--	--
		BWD Wells (1)	72	0%	0	100%	2.8 / 18.8	--	--
No Pumping	High	Site 1	48	0%	0	0%	0	100%	48.8 / 58.0
		Recharge Basins (2)	0	--	--	--	--	--	--
		BWD Wells (1)	72	0%	0	100%	1.7 / 30.9	--	--

(1) Capture zone analysis performed for BWD wells.

(2) Recharge basins inactive during No Pumping conditions.

(min/max - yrs): minimum/maximum time in years for a particle to reach that point.

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Average and high pumping scenarios at the BWD wells were considered for high pumping conditions at Grumman production wells (as shown in Table 5-1). Average BWD well pumping conditions were simulated by pumping at the rate determined from 1991 and 1992 average pumping rate data. The BWD wells were considered to be pumping at 120% of 1991 and 1992 rates, and well BP-09 was considered to be active although it was taken off-line in 1991. These assumptions represent conservative estimates of the current conditions at the BWD wells. High pumping conditions at the BWD wells were also simulated. In this scenario all BWD wells were pumping at their actual (highest) capacity.

Table 5-2 summarizes the final destinations of the particles released from each site during high pumping conditions, and the minimum and maximum travel time of particles from each release site to their final destinations. Figures which illustrate the particle tracking pathlines for the high pumping situations are provided in Appendix F.

Particle Tracking Results and Conclusions - Grumman High Pumping Conditions, BWD Wells at Average Pumping Conditions

- All particles released from Site 1 are captured by PW-14 and PW-05.
- 73% of particles released from the NWIRP recharge basins are captured by the Grumman production wells, 24% reach the south constant head boundary, while 3% of particles reach BP-08 from the NWIRP recharge basins.
- The capture zones for BWD wells BP-07, BP-08 and BP-09 extend primarily into the north constant head boundary. Some particles originate in the vicinity of the NWIRP recharge basins. Three particles (4% of total) move from the north recharge basins to BP-08, while two particles (3% of total) move from northwest of the NWIRP recharge basins to BP-09.

Particle Tracking Results and Conclusions - Grumman High Pumping Conditions, BWD Wells at High Pumping Conditions

- All particle released from Site 1 are captured by PW-14 and PW-05.
- 65% of particles released from the NWIRP recharge basins are captured by Grumman production wells, with 2% reaching the south constant head boundary. BWD well BP-11 receives 19%, BGD-1 receives 7%, BP-08 receives 6% and BP-09 receives 1% of the total particles released.
- The capture zones for BWD wells BP-07, BP-08 and BP-09 extend primarily into the north constant head boundary, although 8% of particles move from the Grumman north recharge basins to BP-08.

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No Pumping Conditions at Grumman Production wells and Recharge basins

No pumping conditions were simulated to determine how contaminants would move if Grumman production wells and recharge basins were inactive, and no pumping activity was occurring at the Grumman site. For this pumping scenario, all Grumman production wells and recharge basins were inactive. Recharge basins on Hooker-Ruco property were considered inactive. Two separate scenarios were considered for past pumpage conditions at the BWD wells during no pumping conditions at the Grumman site (as shown in Table 5-1). Average pumping conditions and high pumping conditions for the BWD wells were simulated. These two pumping conditions for the BWD wells are the same as those used for the high pumping conditions at Grumman production wells and basins.

Table 5-2 summarizes the final destinations of the particles released from each site during no pumping conditions, and the minimum and maximum travel time of particles from each release site to their final destinations. Figures which illustrate the particle tracking pathlines for the no pumping situation are provided in Appendix F.

Particle Tracking Results and Conclusions- No Pumping at Grumman, BWD Wells at Average Pumping Conditions

- Particles released from Site 1 move to the south constant head boundary.
- The capture zone for BWD wells BP-07, BP-08 and BP-09 extends into the north constant head boundary.

Particle Tracking Results and Conclusions - No Pumping at Grumman, BWD Wells at High Pumping Conditions

- 42% of the particles released from Site 1 were captured by BP-10, and 58% were captured by BP-11
- The capture zone for BWD wells BP-07, BP-08 and BP-09 extends into the north constant head boundary.

5.2.8 Comparison of Particle Tracking with Monitoring Well and Production Well Analytical Data

This section will provide a brief comparison of projected (contaminated) particle flow paths (Figures 5-3 through 5-7) with analytical data obtained during the RI (Figures 5-4 and 5-5). Direct comparisons are available for the shallow-, intermediate-, and production well-depth groundwater.

Shallow-depth groundwater projected particle tracks versus measured contaminant distributions can

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be evaluated by overlaying Figure 5-3 with Figure 4-4. With the exception of actual contamination being found north of Plant No. 3 and TCE being detected in GM-13, the maps are almost an exact overlay. The recharge basin water particle tracks of the shallow groundwater versus actual measured contamination overlay is not as good. However, it must be recognized that the particle tracks are projected for the entire depth of the shallow groundwater (50 to 100 feet bgs), whereas the monitoring wells include only depths of approximately 50 to 60 feet. Also, shallow depth groundwater contamination can be strongly influenced by precipitation events. In addition, the particle tracking figures illustrate the potential extent contamination may have traveled under a variety of pumping conditions, not all of which may have existed.

Intermediate-depth groundwater projected particle tracks versus measured contaminant distributions can be evaluating by overlaying Figure 5-4 with Figure 4-5. With the exception of actual contamination being found near Hooker/RUCO Superfund Site and TCE being detected in HN-24I, the maps are again almost an exact overlay. The recharge basin water particle tracks accurately project the contamination found in the residential neighborhood to the east.

Production well-depth groundwater projected particle tracks versus measured contaminant distributions can be evaluated by comparing data in Table 4-8 with Figures 5-6 and 5-7. Based on the particle tracks, Site 1-related contamination may affect Grumman production wells on the NWIRP (PW-14) as well as the downgradient production wells. Recharge basin particle tracks may affect additional NWIRP production wells including PW-10, PW-11, PW-15, as well as upgradient Grumman production well PW-16.

Overall there appears to be a strong correlation between potential particle tracks from Site 1 and the NWIRP recharge basins to observed shallow-, intermediate-, and production well-depth groundwater data. It is also likely that additional sources of contamination may exist.

5.2.9 Sensitivity Analysis

Sensitivity analysis is the process of characterizing the effects of changes in model parameters on the behavior of the calibrated model. Sensitivity analysis for the groundwater flow model included increasing and decreasing aquifer parameters incrementally and comparing the resulting changes in modeled heads to the calibrated values of head. The magnitude of change in heads from the calibrated solution is a measure of the sensitivity of the solution to that particular parameter. Additional discussion of sensitivity analysis procedures and results are presented in Appendix F.

Horizontal hydraulic conductivity values were increased and decreased by 25% and 50% for the sensitivity analysis. Sensitivity analysis results for hydraulic conductivity show that a decrease of 50% results in a significant increase in both mean error and absolute residual, indicating the model results are sensitive to an decrease of greater than 25% of horizontal hydraulic conductivity compared to calibrated values. The model results are not highly sensitive to an increase of up to 50% or a decrease of up to 25% for horizontal hydraulic conductivity. However, while the model results may not be highly

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sensitive to changes in horizontal conductivity of this magnitude, these changes do produce less favorable solutions than the calibrated model.

Vertical hydraulic conductivity values were increased and decreased by 25% and 50% for the sensitivity analysis. Sensitivity analysis results show that the model is sensitive to a decrease of greater than 25% of vertical hydraulic conductivity. The model results are not highly sensitive to an increase of up to 50% and a decrease of up to 25% for vertical hydraulic conductivity. However, while the model results may not be highly sensitive to changes in vertical hydraulic conductivity of this magnitude, these changes do produce less favorable solutions than the calibrated model.

Storage values were increased and decreased by 25% for the sensitivity analysis. Storage values are used by MODFLOW only during transient simulations, therefore the effects of the sensitivity analysis results were determined by comparing the calibrated time-drawdown curves to the sensitivity analysis curves for the pump test #1 simulation. These curves indicate that the model results are sensitive to an increase of greater than 25% of the storage value and that the model is less sensitive to a smaller increase in storage of 25% or less.

Porosity values were increased and decreased by 25% for the sensitivity analysis. Porosity values are not used in the flow model, although they are incorporated into the particle tracking module MODPATH. Changes in porosity will not effect particle flow direction but will effect the travel time of the particle. Results show that there is a direct relationship between the porosity and the travel time of a particle moving through the aquifer. A 25% increase or decrease in porosity results in the same amount of change in the total travel time of a particle through the aquifer.

Recharge values were increased and decreased by 25% and 50% for the sensitivity analysis. Changes in the recharge to the system exhibit a linear relationship to the mean error and absolute residual values, with an equal amounts of mean error increase and absolute residual error increase being incurred regardless of whether recharge is increased or decreased.

To determine the effect of more distant boundaries on the capture zone of the eastern BWD wells (BP-07, BP-08, BP-09) the northern constant head boundary conditions in the MODFLOW model were moved 1400 ft to the north, a 40% increase in the distance from the BWD wells to the north constant head boundary. The results of the sensitivity analysis show that under average or high pumping conditions at the BWD wells the capture zone of these wells is not significantly increased if the north constant head boundary is moved 1400 ft north.

5.2.10 Summary of Modeling Results

The computer modeling performed for the NWIRP site accurately simulated water levels in 56 of 61 monitoring wells in the February, 1992 pumping condition and accurately simulated water levels in 55 of 61 monitoring wells in the August, 1992 pumping condition. The wells which fell outside the calibration criteria are in the immediate vicinity of active production wells or recharge basins, which may account for these disparities. Statistical analysis (linear regression and residual contour plots)

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performed on the calibrated steady-state model data indicates a nearly direct correlation in modeled and measured values of head, and that no significant trends exist in the distribution of model error.

Model simulation of pumping test #1 showed very similar results to data measured during the pumping test. A comparison of measured and modeled drawdowns (in the pumping well and the observation wells) shows very close agreement of measured and modeled data. In addition, the time-drawdown curves for modeled and measured data exhibit very similar results. The simulation of pumping test #2 was more difficult because of the small amounts of drawdown produced in the observation wells and due to the size of the model grid-blocks. Model simulations were within 1.0 ft of measured drawdowns for pumping test #2.

During model validation, the model was used to simulate water elevations for two months of data. The model accurately predicted water levels in 59 of 61 monitoring wells in the January, 1992 pumping condition and accurately simulated water levels in 54 of 61 monitoring wells in the August, 1992 pumping condition.

Sensitivity analysis was conducted for all aquifer parameters. Results indicate that the model is not highly sensitive to increases in horizontal or vertical hydraulic conductivity of up to 50% of calibrated values. The model showed significantly increased error if horizontal or vertical hydraulic conductivity were decreased more than 25% from calibrated values. Time-drawdown curves for shallow monitoring wells indicate that the model is sensitive to and increase in storage of 25%. Recharge and porosity exhibit linear (predictable) effects on model output. Sensitivity analysis indicates that moving the north constant head boundary 1400 ft to the north does not have a significant effect on the capture zone of the BWD wells BP-07, BP-08 and BP-09.

Table 5-3 summarizes particle tracking results form Grumman production wells and BWD wells, and when these wells are effected by particle releases. Particle tracking indicates that under current pumping conditions particles released from Site 1 will be captured by Grumman production wells, and BWD wells will not capture particles from the NWIRP recharge basins. Under high pumping (past) conditions at Grumman and average BWD rates, Site 1 particles are captured by Grumman production wells. A small number of particles may effect BWD well BP-08, and to a lesser extent, BWD well BP-09. If Grumman production wells and BWD wells pump at a high rate for sustained periods (as simulated by the steady-state model), all Site 1 particles are captured by Grumman production wells, and 19% of the particles released may move from the NWIRP recharge basins to BWD wells. These pumping conditions may have occurred for short time periods in the past, although the high pumping conditions may not have continued for extended periods of time as simulated in the steady-state model runs. Assuming no Grumman production well or recharge basin activity and average pumping conditions at the BWD wells, Site 1 particles move to the southern constant head boundary, and the capture zone of the BWD wells is not effected by NWIRP recharge basins. Under high BWD well pumping rates, with no Grumman production well or recharge basin activity, particles released from Site 1 are captured by BWD wells BP-10 and BP-11.

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TABLE 5-3

SUMMARY OF FORWARD TRACKING RESULTS
NWIRP BETHPAGE, NEW YORK

Grumman Pumping Rate	BWD Wells Pumping Rate	Particle Release Location	Wells Effected		
			Grumman Production Wells	Eastern BWD Wells (BP-7,BP-8,BP-9)	Southern BWD Wells (BP-10,BP-11)
Current Conditions	Average	Site 1	Y	N	N
		NWIRP Basins	Y	N	N
High Pumping	Average	Site 1	Y	N	N
		NWIRP Basins	Y	S	N
High Pumping	High	Site 1	Y	N	N
		NWIRP Basins	Y	Y	Y
No Pumping	Average	Site 1	N	N	N
No Pumping	High	Site 1	N	N	Y

Y = Well is effected by particles from release source (well captures more than 5% of the total amount of particles released.

S = Well is slightly effected by particles from release source (well captures less than 5% of the total particles released).

N = Well is not effected by particles from release source.

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6

6.0 RISK ASSESSMENT

This section of the report will provide a revised quantitative assessment of the increased cancer risk that results from exposure to polychlorinated biphenyls (PCBs) and other carcinogenic chemicals present in the soils at NWIRP Bethpage. Initial estimates of the risks posed by these chemicals were provided during the Phase 1 Remedial Investigation (RI) report. These estimates were based on select testing of samples for PCBs and pesticides. Results of analyses for soils collected during Phase 2 RI sampling provide a more complete evaluation of the extent and magnitude of the PCB contamination, and therefore, a more comprehensive evaluation of site-related risks. Groundwater analytical results obtained during the Phase 2 RI are very similar to, or lower than, the results obtained during the Phase 1 RI, with only the areal extent of contamination being better defined. As a result, the risk assessment developed during the Phase 1 RI for groundwater is representative of site conditions and will not be revised.

The revised risk assessment uses the same receptors, exposure pathways, and exposure factors that were used during the initial risk assessment. The only change made was a recalculation of representative concentrations for PCBs and corresponding recalculation of cancer risks. For all other chemicals, the representative concentrations used during the Phase 1 RI were used in this assessment.

6.1 SUMMARY OF PREVIOUS RISK ASSESSMENT

During the Phase 1 RI, a total of six surface and four subsurface soil samples (including one background sample) were collected and analyzed for Target Compound List (TCL) pesticides and PCBs, (in addition to the other TCL/TAL parameters). Results from the analyses of the six surface soils were used as the basis for the Phase 1 risk assessment. A minimum of one and maximum of three samples were used to characterize the risks due to exposure to pesticides and PCBs at each of the three sites at NWIRP Bethpage.

Potential receptors identified in the Phase 1 RI are adult employees of the facility and offsite residents. Exposure routes for these receptors include dermal contact and incidental ingestion for employees, and inhalation of site generated fugitive dusts by the offsite residents. Receptor exposure factors and dose estimate input parameters that were employed are identified in U. S. EPA risk assessment guidance or are reasonable and conservative estimates for the given receptors and exposure pathways.

Results of the Phase 1 RI risk assessment indicated that PCB compounds at Sites 1, 2, and 3 were providing a significant contribution to the carcinogenic risk estimates. Phase 2 RI sampling was conducted in order to better define the extent and magnitude of PCB contamination at Sites 1, 2, and 3, and to provide an extended database that can be used to more accurately quantify risks because

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of exposure to PCBs. A total of 7, 8, and 1 additional soil samples were collected from Sites 1, 2, and 3, respectively. Sample locations correspond to the Phase 1 RI sample locations where PCBs were found as tentatively identified compounds (TICs).

6.2 REPRESENTATIVE CONCENTRATIONS

For the Phase 2 RI, representative concentrations were only recalculated for PCB soil data. Testing for other parameters was not conducted on the soils during the Phase 2 RI. Results of analyses for both surface and subsurface soil samples collected during both phases of the RI were used in the calculation of the new representative concentrations for PCBs.

As performed during the Phase 1 RI, the representative concentration that was used for the risk assessment is the sum of the upper 95% confidence limits (UCLs) of the arithmetic mean for individual Aroclors (PCBs). Table 6-1 provides a summary of the representative concentrations for all of the PCBs detected at Sites 1, 2, and 3 for Phase 1 data only, and for Phase 1 and 2 data. A sample calculation for the development of the representative concentration is presented in Appendix K.

6.3 RISK CALCULATION

Carcinogenic risks for the receptors and exposure routes identified in the Phase 1 RI were recalculated based on the revised representative concentrations for PCBs. Noncarcinogenic health effects were not considered for PCBs because no Reference Dose is currently available for this class of compounds. The same exposure input parameters that were used in the Phase 1 RI risk assessment were used for the revised risk calculations.

Calculation of the revised risks were performed using a three step process. Initially, the revised representative concentration obtained from both phases of soil data was divided by the representative concentration obtained during the Phase 1 RI. This calculated value represents the ratio change (increase) of PCBs in site soils based upon the Phase 2 RI data. The value obtained for each exposure route was then used as a scaling factor to revise the Phase 1 RI-calculated PCB risks.

Secondly, the representative concentration scaling factor was multiplied by the appropriate Phase 1 RI PCB cancer risk to obtain a revised estimate of cancer risk for each receptor-exposure route combination. This calculation of carcinogenic risk was performed for all receptor-exposure routes combinations.

Finally, the revised PCB carcinogen risk increase was added to Phase 1 RI total excess carcinogenic risk (adjusted to discount contribution from the Phase 1 RI-calculated PCB risks) to quantify carcinogenic risk change (increase) based upon the additional PCB data. It should be noted that the revised total risk represents the risks based upon all Phase 1 non-PCB data and both phases of data for PCBs.

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TABLE 6-1

SUMMARY OF REPRESENTATIVE CONCENTRATIONS FOR PCBs IN SOIL
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP BETHPAGE, NEW YORK

Site	PCB Mixture	Representative Concentration (µg/kg)	
		Phase 1 RI Data[1]	Phase 1 and 2 RI Data[2]
1	Aroclor-1242	ND	11,000
	Aroclor-1248	7,900	420,000
	Aroclor-1254	ND	55,000
	Total	7,900	486,000
2	Aroclor-1248	1,900	11,000
	Aroclor-1254	ND	1,900
	Total	1,900	12,900
3	Aroclor-1248	830	470
	Aroclor-1254	530	1,000
	Total	1,360	1,470

ND - Not Detected during Phase 1 sample analysis
(1) - Representative Concentrations are maximum concentrations detected during Phase 1 sample analysis.
(2) - Phase 2 representative concentrations are 95% upper confidence limit of Phase 1 and 2 data.

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A summary of PCB only and total incremental cancer risks is presented in Table 6-2 for both the Phase 1 RI data and data from both phases. A sample calculation of the methodology used to revise PCB and total cancer risk increases is provided in the Appendix K.

6.4 POST INTERIM-REMEDIAL ACTION RISKS

One location in Site 1 that was sampled during the Phase 2 RI contained Aroclor levels in excess of 0.1% by weight (1,300,000 μg/kg of Aroclor-1248 alone). In an interim remedial action, contaminated soils in the vicinity of this sample location were covered and flagged to prevent contact and migration of contaminants.

Since it is likely that the soil in the area of this data point has been addressed on an interim basis, the data point was removed from the Phase 2 RI analytical database and a post-action representative concentration for PCBs of 25.5 mg/kg was developed for all PCBs at Site 1. This representative concentration (4,800 mg/kg) is approximately 5% of the representative concentration that was developed initially for both phases of data at Site 1.

Revised carcinogenic risks calculated for Site 1 using the total PCB representative concentration of 25.5 mg/kg results in carcinogenic risks that are about one-twentieth of the risk that were calculated based on all current soil data. The post-interim remedial action risks are presented in Table 6-3.

6.5 SUMMARY OF REVISED RISK ASSESSMENT

6.5.1 Current Soil Exposures

Table 6-2 provides a summary of the Phase 1 RI-calculated and Phase 2 RI-calculated PCB and total carcinogenic risks. PCB-contributed, and consequently, total cancer risk increase at Site 1 exceeded the CERCLA 10^{-6} lower risk range goal for all receptor-exposure route combinations examined. The CERCLA upper risk range goal of 10^{-4} was exceeded by the PCB risk contribution for onsite worker dermal exposure to soil (2.0×10^{-4}). Onsite worker exposures via incidental ingestion resulted in an increased cancer risk of 7.8×10^{-6} because of PCBs alone. Offsite residential exposure via inhalation of fugitive dusts from Site 1 resulted in an increased cancer risk of 2.7×10^{-6} from PCB exposure.

Total cancer risks for the onsite worker receptor at Site 1 are identical to the calculated PCB risks, indicating over a 99% contribution to total risk by PCBs at Site 1 for this receptor. Offsite receptor total risk (3.3×10^{-6}) from Site 1 is driven by PCBs, accounting for approximately 82% of the total risk.

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TABLE 6-2

REVISED EXCESS CANCER RISK ASSESSMENT SUMMARY
PHASE 2 REMEDIAL INVESTIGATION/FEASIBILITY STUDY
NWIRP BETHPAGE - BETHPAGE, NEW YORK

Receptor	Exposure Route	PCB-Only Risks		Total Risks	
		Phase 1 Data	Phase 1 & 2 Data[1]	Phase 1 Data	Phase 1 & 2 Data
Site 1					
Onsite Worker	Dermal Contact	3.3×10^{-6}	2.0×10^{-4}	4.3×10^{-6}	2.0×10^{-4}
	Ingestion	1.3×10^{-7}	7.8×10^{-6}	1.5×10^{-7}	7.8×10^{-6}
Offsite Resident	Inhalation	4.5×10^{-8}	2.7×10^{-6}	5.9×10^{-7}	3.3×10^{-6}
Site 2					
Onsite Worker	Dermal Contact	7.9×10^{-7}	5.4×10^{-6}	1.7×10^{-6}	6.4×10^{-6}
	Ingestion	3.1×10^{-8}	2.1×10^{-7}	5.3×10^{-8}	2.3×10^{-7}
Offsite Resident	Inhalation	5.7×10^{-9}	3.9×10^{-8}	4.5×10^{-7}	4.8×10^{-7}
Site 3					
Onsite Worker	Dermal Contact	5.6×10^{-7}	6.1×10^{-7}	1.8×10^{-6}	1.8×10^{-6}
	Ingestion	2.2×10^{-8}	2.4×10^{-8}	6.0×10^{-8}	6.2×10^{-8}
Offsite Resident	Inhalation	1.6×10^{-9}	1.7×10^{-9}	3.7×10^{-7}	3.7×10^{-7}

(1) - Increased cancer risk revision calculated as discussed in Section 6.3.

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At Site 2, only dermal exposure by the onsite worker receptor resulted in a cancer risk increase greater than 10^{-6}, namely, 5.4×10^{-6} for PCBs, and 6.4×10^{-6} for the total cancer risk. Offsite residents are noted to have a total cancer risk increase of 4.8×10^{-7} due to fugitive dust inhalation from Site 2 soils. PCB exposure accounted for less than a 10% contribution to the total cancer risk for the offsite receptor at Site 2.

For Site 3, PCB-related increases in cancer risks were less than 10^{-6}. However, cumulative incremental cancer risk was noted to exceed 10^{-6} for the onsite worker dermal exposure scenario. Again, offsite residential exposure resulted in a total increased cancer risk of less than 10^{-6} (3.7×10^{-7}).

Under the residential exposure scenario (inhalation of fugitive dusts) for current soil, the total cancer risk increase that may be attributable to Sites 1, 2, and 3 is noted to be 4.1×10^{-6}, which is within the CERCLA risk range of 10^{-6} to 10^{-4}. Exposure to PCBs from soils at sites 1, 2, and 3 accounts for approximately 66% of the total cancer risk for offsite resident receptors.

6.5.2 Post-Interim Remedial Activity Soil Exposures

Interim remedial activities resulting in the isolation of the most PCB-contaminated soil at Site 1 allows for the calculation of the future carcinogenic risks for the identified receptors. Using the same methodology as previously described, carcinogenic risks that are presented in Table 6-3 were calculated. Isolation of the high level PCB contamination at Site 1 results in total risk for the onsite worker to decrease from 2.0×10^{-4} to 1.1×10^{-5} for dermal contact and from 7.8×10^{-6} to 4.1×10^{-7} for accidental ingestion. For offsite residents, inhalation risks decreased from 3.3×10^{-6} to 6.8×10^{-7}.

Revised increased cancer risks in excess of 10^{-6} that are attributable to PCBs only are noted for onsite workers at Sites 1 and 2. At Site 1, PCB contributed cancer risk increases to adult workers of 9.8×10^{-6} and 3.9×10^{-7} are calculated for the dermal contact and incidental ingestion exposure routes, respectively. At Site 2, the PCB-attributable increased cancer risk of 5.4×10^{-6} is noted for the dermal contact exposure route for onsite workers only. All PCB-contributed cancer risks at Site 3 are less than 10^{-6}.

Total cancer risk increases are noted to exceed 10^{-6} at all three sites for dermal exposure by onsite workers. At Site 1, about 90% of the total cancer risk increase noted for the onsite worker receptor results from PCBs. At Site 2, the PCB-contributed cancer risk increase is approximately 84% of the total risk calculated for the onsite worker dermal exposure.

Total cancer risk increases for each of the sites provide an individual risk less than 10^{-6} for offsite residents, however, when added together, the sum total cancer risk increase for offsite residents marginally exceeds the lower risk range goal at 1.5×10^{-6}. PCBs contribute about 10% (a total of 1.7×10^{-7}) to the total risk from all three sites for the residential receptor.

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TABLE 6-3

REVISED EXCESS CANCER RISK ASSESSMENT SUMMARY
POST-INTERIM REMEDIAL ACTION
NWIRP BETHPAGE, NEW YORK

Receptor	Exposure Route	Polychlorinated Biphenyl Risk		Total Risk	
		Phase 1 Data	Phase 1 & 2 Data[1]	Phase 1 Data	Phase 1 & 2 Data
Site 1					
Onsite Worker	Dermal Contact	3.3×10^{-6}	9.8×10^{-6}	4.3×10^{-6}	1.1×10^{-5}
	Ingestion	1.3×10^{-7}	3.9×10^{-7}	1.5×10^{-7}	4.1×10^{-7}
Offsite Resident	Inhalation	4.5×10^{-8}	1.3×10^{-7}	5.9×10^{-7}	6.8×10^{-7}
Site 2					
Onsite Worker	Dermal Contact	7.9×10^{-7}	5.4×10^{-6}	1.7×10^{-6}	6.4×10^{-6}
	Ingestion	3.1×10^{-8}	2.1×10^{-7}	5.3×10^{-8}	2.3×10^{-7}
Offsite Resident	Inhalation	5.7×10^{-9}	3.9×10^{-8}	4.5×10^{-7}	4.8×10^{-7}
Site 3					
Onsite Worker	Dermal Contact	5.6×10^{-7}	6.1×10^{-7}	1.8×10^{-6}	1.8×10^{-6}
	Ingestion	2.2×10^{-8}	2.4×10^{-8}	6.0×10^{-8}	6.2×10^{-8}
Offsite Resident	Inhalation	1.6×10^{-9}	1.7×10^{-9}	3.7×10^{-7}	3.7×10^{-7}

(1) Increased cancer risk revision calculated as discussed in Section 6.3.

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