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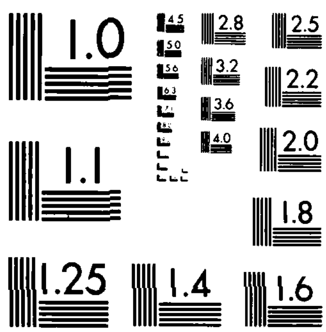

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RESEARCH TRIANGLE INSTITUTE

AD-A158 801

Installation Restoration Program
Phase II - Confirmation/Quantification
Stage 1

for

Seymour Johnson Air Force Base, NC 27531

Prepared for

United States Air Force
Occupational and Environmental Health Laboratory (OEHL)
Brooks Air Force Base, Texas 78235

July 1985

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Phase II - Confirmation/Quantification
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July 1985

Prepared by

Center for Environmental Measurements
Research Triangle Institute
Research Triangle Park, NC 27709

Contract No.
F33615-83-D-4010

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Prepared for

United States Air Force
Occupational and Environmental Health Laboratory (OEHL)
Brooks Air Force Base, Texas 78235

This report has been prepared for the U.S. Air Force by the Research Triangle Institute for the purpose of aiding in the implementation of the Air Force Installation Restoration Program. It is not an endorsement of any product. The views expressed herein are those of the contractor and do *not* necessarily reflect the official views of the publishing agency, the United States Air Force or the Department of Defense.

PREFACE

The primary objectives of this project were to collect and analyze soil and groundwater samples and to perform an initial characterization of the hydrogeochemical regime at potential contamination sites on Seymour Johnson Air Force Base near Goldsboro, North Carolina. This study constituted Phase II of the U.S. Air Force Installation Restoration Program (IRP).

On this project, RTI staff members were responsible for field reconnaissance, arrangement of soil test borings and monitoring-well installations, and classification of the soil samples obtained from the drilling activities. Twenty monitoring wells were installed and developed and in situ measurements of water quality and water levels were obtained. Groundwater samples were collected and analyzed for parameters such as oil and grease, phenol, total organic carbon, total organic halogen, volatile organic compounds, lead, chromium, cadmium, nickel, and nitrate. Selected soil samples were analyzed for parameters such as oil and grease, total organic halogens, phenol, lead, chromium, and pesticides. The hydrogeochemical environment of the study area was characterized based on field observations, published hydrogeologic data, and analyses of the subsurface data. The enclosed report presents the findings of this evaluation.

RTI's supervisor for this project was Dr. William F. Gutknecht and the RTI project leader was Mr. W. Joseph Alexander, both in RTI's Center for Environmental Measurements. Other RTI professional support on the project was received from Mr. John A. Sokash, Ms. C. Jane Holden, and Ms. Susan K. Liddle. RTI's Support Services Group is also acknowledged, specifically Ms. Jan L. Shirley, Ms. Kathleen B. Mohar, Mr. John H. Morey, Jr., and Ms. Elizabeth Kaufman. The well drilling, soil sampling, and surveying for the project were performed by Soil and Material Engineers, Inc.

The field activities were performed between January and May 1984. The first draft report was issued in August 1984 and the second draft report was issued in January 1985. Technical monitors for the project were 1LT Dulcie A. Weisman and Dr. Dee Ann Sanders, Technical Services Division, USAF Occupational Environmental Health Laboratory (USAF OEHL).

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FIGURES

FIGURES (continued)

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EXECUTIVE SUMMARY

A Phase II evaluation has been conducted at the Seymour Johnson Air Force Base under the Department of Defense's Installation Restoration Program (IRP). Eight potential source areas were identified by the Air Force, prior to this evaluation, for further study in the IRP Phase II (Figure 1). The evaluation primarily included the drilling of soil test borings, the installation, development, and sampling of monitoring wells, and the analysis of soil and water samples (Table 1). Also used in the evaluation were published hydrogeologic data, Seymour Johnson AFB documents and IRP Phase I report, field measurements of water quality, multiple water-level measurements, and site observations.

A surficial aquifer was encountered at shallow depths beneath all sites studied on the Base. The surficial aquifer is susceptible to contamination by Base activities because of its shallow occurrence and properties. Groundwater flow in the surficial aquifer is primarily horizontal and discharge occurs into streams and some drainage ditches that practically surround the base. The surficial aquifer is not used for water supply on the Base. Potential users of the surficial aquifer located off the Base would be effectively separated from the Base's shallow groundwater discharges because of the location of the surrounding streams and drainage ditches.

A distinctive clayey stratum forms the base of the surficial aquifer and is thought to represent the upper section of the Black Creek formation. The downward movement of water and contaminants through this clayey stratum is limited because of its stratification and composition.

The permeable sections of the Black Creek formation and underlying Cape Fear formation form a principal aquifer system. This aquifer system is the sole source of water used by the Base and is also used on a regional basis as a significant source of water. The principal aquifer system is partially confined and protected by clay layers in the Black Creek formation.

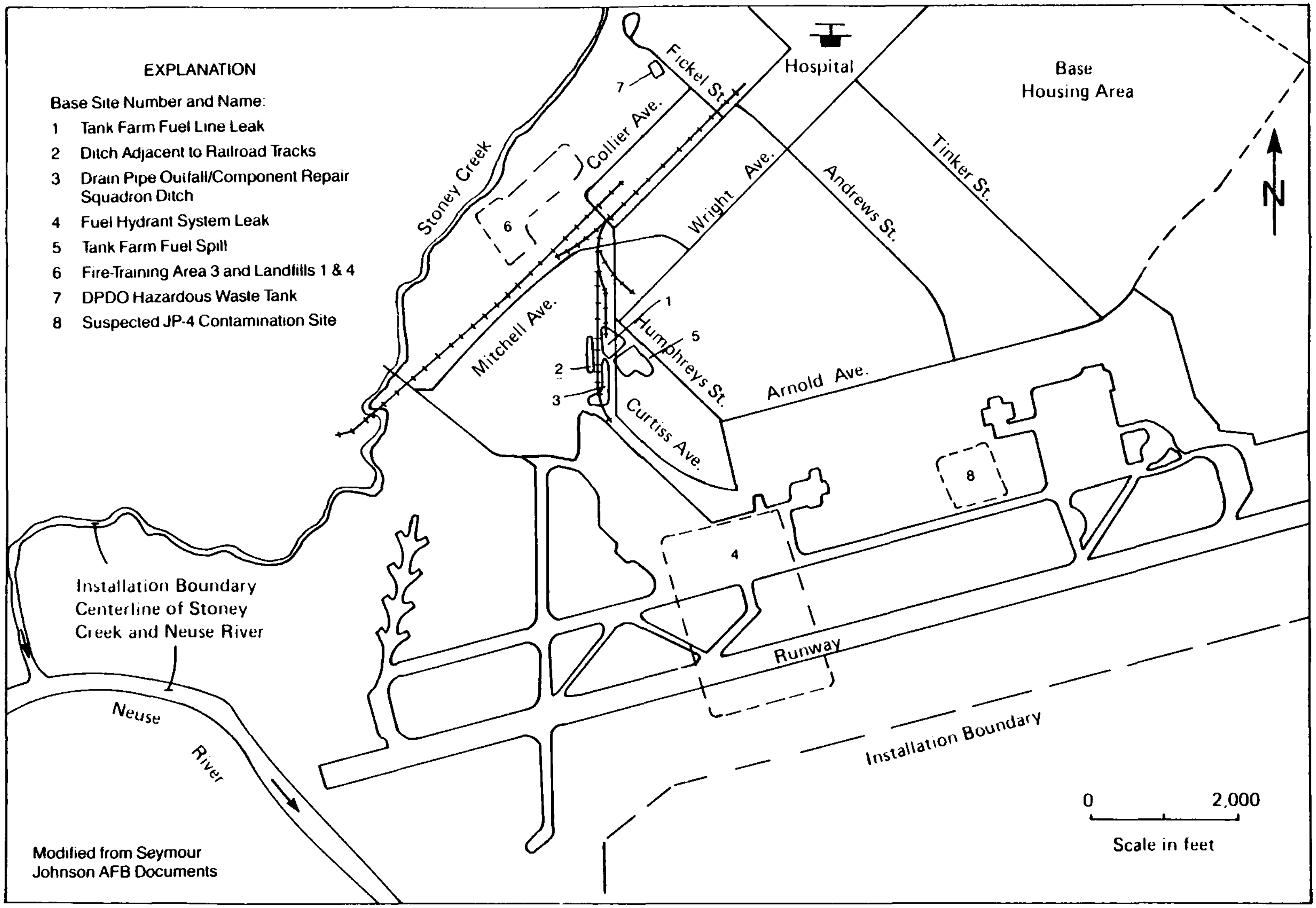


Figure 1. General outline of base sites studied.

TABLE 1. INDEX TO BASE SITES STUDIED

Site number	Site name	Sampling locations	Reference figure number
1	Tank farm fuel line leak	MW-19, MW-20, MW-21, MW-22 MW-23, MW-26	3
2	Ditch adjacent to railroad tracks	MW-25	4
3	Drain pipe outfall/component repair squadron ditch	MW-24	5
4	Fuel hydrant system leak	MW-1, MW-2, MW-3, MW-4, MW-5, MW-6	6
5	Tank farm fuel spill	MW-15, MW-16, MW-17	7
6	Fire-training area 3	MW-11	8
6	Landfill No. 1	MW-12	8
6	Landfill No. 4	MW-13, MW-14, SW-1	8
7	DPDO hazardous waste tank	STB-7, STB-8, STB-9, STB-10	9
8	Suspected JP-4 contamination site	STB-27, STB-28, STB-29, STB-30	10

MW = Monitoring well.
STB = Soil test boring.
SW = Seepage sample.

The analytical results provide a basis for evaluating the sites studied. The most significant sites are those where groundwater contamination has been confirmed in the surficial aquifer as a result of Base activities. These sites include the tank farm fuel line leak (Site 1), the ditch adjacent to the railroad tracks (Site 2), the drain pipe outfall/component repair squadron ditch (Site 3), and landfill number 4 (Site 6). Degradation of groundwater quality has also been inferred at the fuel hydrant system leak (Site 4) and the tank farm fuel spill (Site 5) on the basis of limited water quality analyses. There is potential for groundwater contamination at the fire training area 3 (Site 6) and the Defense Property Disposal Office (DPDO) hazardous waste tank (Site 7). Landfill number 1 (Site 6) and the suspected JP-4 contamination site (Site 8) have a low potential for groundwater contamination and should not require further study.

The groundwater contamination encountered appears to be confined to the surficial aquifer and does not represent a direct adverse impact on groundwater users. The principal aquifer system appears to be protected from direct contamination from Base activities because of the hydrogeologic setting.

The major environmental concern revealed by this evaluation is the potential discharge of contaminated water from the surficial aquifer into ditches, streams, and the Neuse River. Recommendations for further evaluation and preliminary actions are summarized for appropriate sites in Table 2. A more detailed discussion of alternative measures and recommendations is provided in Sections 5 and 6, respectively.

TABLE 2. SUMMARY OF RECOMMENDATIONS FOR BASE SITES

Site number	Site name	Recommendations
1	Tank farm fuel line leak	Install shallow monitoring wells and one deep monitoring well, and analyze groundwater for TOC, TOX, and O&G. Resample and analyze groundwater from wells MW 22 and MW-26. Supplement with same analyses from storm drains. Analyze selected samples for VOC and further quantification by GC/MS. Analyze hydraulic conductivity of surficial aquifer in selected wells.
2	Ditch adjacent to railroad tracks	Install shallow monitoring wells and analyze groundwater for TOC, TOX, and O&G. Supplement with same analyses from surface water features. Analyze selected samples for VOC and further quantification by GC/MS. Analyze hydraulic conductivity of surficial aquifer in selected wells. Monitor and replace existing booms on regular basis.
3	Drain pipe outfall/component repair squadron ditch	Install shallow monitoring wells and analyze groundwater for TOC, TOX, and O&G. Supplement with same analyses from storm drains and surface water features. Analyze selected samples for VOC and further quantification by GC/MS. Analyze hydraulic conductivity of surficial aquifer in selected wells.
4	Fuel hydrant system leak	Resample and analyze groundwater from wells MW-3, MW-4, and MW-6 for TOC and O&G. Supplement with same analyses from drain lines and seepage along southern drainage ditch. Analyze selected samples for VOC and further quantification by GC/MS. Analyze hydraulic conductivity of surficial aquifer in selected wells. Monitor and replace existing booms on regular basis.
5	Tank farm fuel spill	Drill one deep soil test boring to examine the deeper subsurface conditions within the central part of the Base. Install shallow monitoring wells and lysimeters in vicinity of Tank 3414 and analyze water for TOC and O&G. Resample and analyze groundwater from well MW-17. Analyze selected samples for VOC and further quantification by GC/MS
6	Fire training area 3	Install one shallow monitoring well downgradient of well MW-11 and analyze groundwater for TOC, TOX, O&G, and phenol. Analyze sample for VOC and further quantification by GC/MS if TOC is greater than 3 mg/l.
6	Landfill No. 1	No further evaluation or action is recommended at this time.
6	Landfill No. 4	Install shallow monitoring wells in swampy area west of the landfill and analyze groundwater and surface water for TOC, TOX, and phenols. Analyze samples with highest concentrations for nickel, lead, chromium, cadmium, and VOC. Resample and analyze groundwater from well MW 13. Install and sample one shallow upgradient well. Conduct reconaissance geophysical survey to optimize well siting and aid in determination of contaminant extent in the area west of the landfill.
7	DPDO hazardous waste tank	Analyze additional shallow soil samples downslope of site for chromium, lead, mercury, barium, arsenic, manganese, phenols, and TOX. Install one shallow monitoring well southwest of the site and analyze groundwater for same parameters as soil in addition to TOC and O&G. Analyze one surface water sample (seepage in the vicinity of the site or from Stoney Creek) for same parameters as groundwater sample. Analyze selected samples for VOC and further quantification by GC/MS.
8	Suspected JP-4 contamination site	No further evaluation or action is recommended at this time.

TOC Total organic carbon
TOX Total organic halogen
O&G Oil and grease
VOC Volatile organic compounds
GC/MS Gas chromatography/mass spectrometry

SECTION 1

INTRODUCTION

1.1 INSTALLATION RESTORATION PROGRAM

The United States Air Force, due to its primary mission, has long been engaged in a wide variety of operations dealing with toxic and hazardous materials. Federal, State, and local governments have developed strict regulations to require that disposers identify the locations and contents of disposal sites and take action to eliminate the hazards in an environmentally responsible manner. The primary Federal legislation governing disposal of hazardous waste is the Resource Conservation and Recovery Act (RCRA) of 1976, as amended. Under Section 6003 of the Act, Federal agencies are directed to assist the Environmental Protection Agency (EPA) and, under Section 3012, State agencies are required to inventory past disposal sites and make the information available to the requesting agencies. To ensure compliance with these hazardous waste regulations, the Department of Defense (DOD) developed the Installation Restoration Program (IRP). The current DOD IRP policy is contained in Defense Environmental Quality Program Policy Memorandum (DEQPPM) 81-5, dated 11 December 1981 and implemented by Air Force message dated 21 January 1982. DEQPPM 81-5 reissued and amplified all previous directives and memoranda on the Installation Restoration Program. DOD policy is to identify and evaluate past hazardous material disposal and spill sites and to control the migration of hazardous materials from those sites. The IRP will be the basis for response actions on Air Force installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as clarified by Executive Order 12316.

The IRP has four phases, consisting of:

- Phase I - Initial Assessment/Records Search
- Phase II - Confirmation and Quantification

- Phase III - Technology Base Development
- Phase IV - Operations/Remedial Actions.

The Phase I activities at Seymour Johnson Air Force Base (AFB) were completed by Engineering-Science, Inc. The specific goal of Phase I was to identify the potential for environmental contamination from past waste disposal practices at the Base and to assess the potential for contaminant migration. Recommendations for Phase II were included in the Phase I report issued in July 1982.

1.2 PURPOSE AND SCOPE OF THE PHASE II EVALUATION

The Research Triangle Institute (RTI) was directed by the Occupational and Environmental Health Laboratory (OEHL), Brooks Air Force Base, Texas, to review the Phase I report, to conduct a presurvey for Phase II, and to define the best approach to accomplish the requirements of Phase II. After visiting the Base in September 1983, RTI presented plans for Phase II that were accepted by the Air Force under Contract Number F33615-83-D-4010, Order 3.

The overall goals of the Phase II evaluation at Seymour Johnson AFB have been to

1. Determine if environmental contamination has resulted from waste disposal practices;
2. Make recommendations for actions necessary to fully evaluate the magnitude and extent of contamination should contamination be found;
3. Make site-specific recommendations where possible for actions necessary to mitigate adverse environmental effects of existing contamination problems;
4. Suggest potential ways of restoring the environment to as near a normal level as practical;
5. Suggest a future environmental monitoring program to document conditions and future discharges at sites identified.

Research Triangle Institute performed the Phase II evaluation at Seymour Johnson AFB between September 1983 and July 1984. This report summarizes the various activities performed at the Base during that period and presents recommendations for subsequent action.

1.3 LOCATION OF SEYMOUR JOHNSON AIR FORCE BASE

Seymour Johnson AFB is in Wayne County, North Carolina, just southeast of the City of Goldsboro (Figure 2). The Base comprises 3,216 acres of contiguous property, bounded as indicated in Figure 2. In addition, the Air Force owns or has easements on four additional sites totaling 13 acres located in the immediate vicinity of the Seymour Johnson AFB. These sites are primarily used for navigational and communication purposes. The Air Force also owns a 46,604-acre tract of land used as a bombing and gunnery facility in Dare County, North Carolina, approximately 120 miles northeast of the Base.

1.4 HISTORY OF SEYMOUR JOHNSON AIR FORCE BASE

Seymour Johnson AFB was activated in June 1942, when the War Department approved the establishment of a technical training school southeast of Goldsboro. The primary mission was to serve as Headquarters Technical School, Army Air Force. In 1943, additional missions followed, including the Provisional Overseas Replacement Training Center, preparing officers and enlisted men for overseas duty; the 75th Training Wing, providing training for the Army Air Forces; and the 326th Fighter Group, providing training for replacement pilots for the P-47 Thunderbolt. In 1944, basic training of P-47 pilots became the primary mission at Seymour Johnson AFB.

At the end of World War II in Europe, Seymour Johnson AFB was designated a Central Assembly Station for processing and training troops being reassigned throughout the continental United States and the Pacific. This function was discontinued in September 1945, and the Base became an Army Air Force Separation Center.

In May 1946, Seymour Johnson AFB was deactivated, and in 1949 the property was deeded to the City of Goldsboro. Between 1950 and 1953, Piedmont Airlines conducted regular flights into Seymour Johnson Field. Other facilities at the Base were leased to private interests for warehousing, temporary residence for a road circus, light manufacturing, family housing, and special presentations.

At the end of 1952, the City of Goldsboro transferred the Base to the Federal Government, and, shortly thereafter, the U.S. Army Corps of Engineers

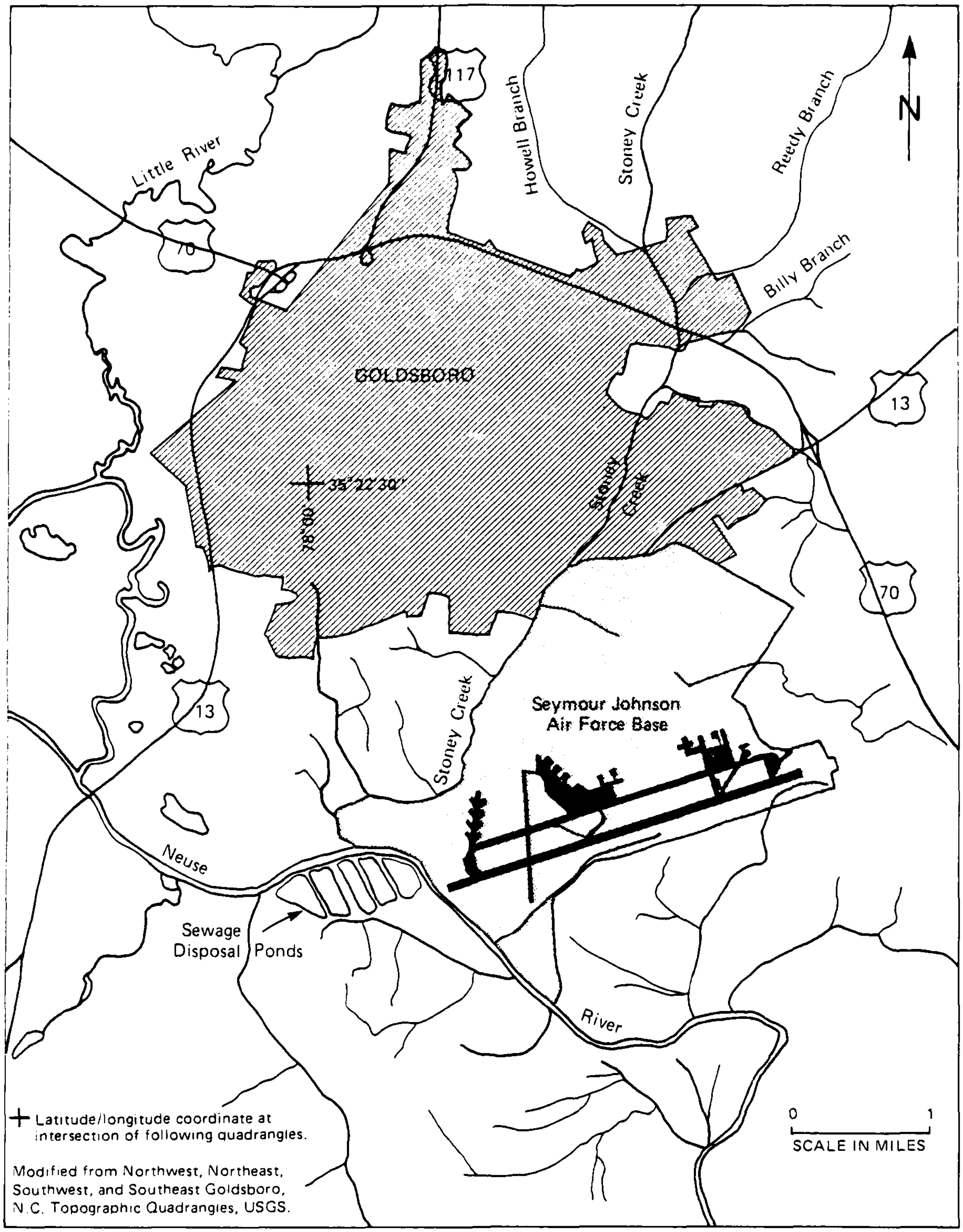


Figure 2. Location of Seymour Johnson Air Force Base.

began construction activities for reopening the Base. In 1956, Seymour Johnson AFB was reactivated as a Tactical Air Command Base, and during the same year, the 83rd Fighter-Day Wing was assigned to the Base. The 83rd Fighter-Day Wing was deactivated in 1957, and the 4th Fighter Group was assigned to the Base as the primary, or host, unit. The 4th Fighter Group was later designated the 4th Tactical Fighter Wing.

A Strategic Air Command unit designated the 4241st Strategic Wing was activated at Seymour Johnson in 1958. Activation of the 911th Refueling Squadron took place in early 1959. The 4241st was redesignated the 68th Bomb Wing in 1963.

1.5 DESCRIPTION AND HISTORY OF SITES STUDIED

Ten priority sites were identified in the Phase I report as potentially containing hazardous material resulting from past activities. These 10 sites were ranked in order of decreasing potential for harm to the environment (Table 3). Also provided in Table 3 is the period of operation at or date of occurrence of each site.

Five of these priority sites identified in the Phase I report were selected for the Phase II assessment and redesignated as Sites 4, 5, and 6 (Table 3). The sites not selected from the Phase I ranking were subsequently determined by the USAF and RTI to be of lower priority, and more emphasis was placed on the sites with greater potential for harm to the environment. The POL area of the Base was therefore further subdivided into Site 1 (tank farm fuel line leak), Site 2 (ditch adjacent to railroad tracks), and Site 3 (drain pipe outfall/component repair squadron ditch). Two sites that were discussed in the Phase I report but were not ranked as priority sites were added to the Phase II assessment. These were Site 7 (DPDO hazardous waste tank) and Site 8 (suspected JP-4 contamination site). The addition of these sites to the Phase II effort was directed by the USAF. An index to the Base sites studied under Phase II, along with associated sampling locations, is provided in Table 1.

1.5.1 Tank Farm Fuel Line Leak (Site 1)

The study area for Site 1 is indicated in Figure 3. The site is immediately west of the POL tank farm. The POL tank farm pump station

TABLE 3. PHASE I PRIORITY RANKING OF POTENTIAL CONTAMINATION SOURCES WITH SITES SELECTED FOR PHASE II ASSESSMENT

Rank	Site name	Period of operation or date of occurrence	Overall total score	Designation of sites selected for Phase II assessment[a]
1	Leakage from fuel hydrant system	Leaks detected 1978	76	Site 4
2	Tank farm fuel spill	November 1980	75	Site 5
3	Landfill No. 4	1970 - present	57	Site 6
4	Fire training area No. 3	1956 - present	56	Site 6
5	Landfill No. 3	1961-1970	51	not selected
6	B-52 crash site	1961	45	not selected
7	Munitions residue burial site	1956 - present	44	not selected
8	Landfill No. 1	1941 - 1946	41	Site 6
8	Landfill No. 2	1956 - 1961	41	not selected
9	Coal pile	1956 - 1972	39	not selected

NOTE: This ranking was performed according to the Hazard Assessment Rating Methodology (HARM) in the Phase I Report (modified from Engineering-Science, Inc., 1982).

[a]Selection by USAF and RTI.

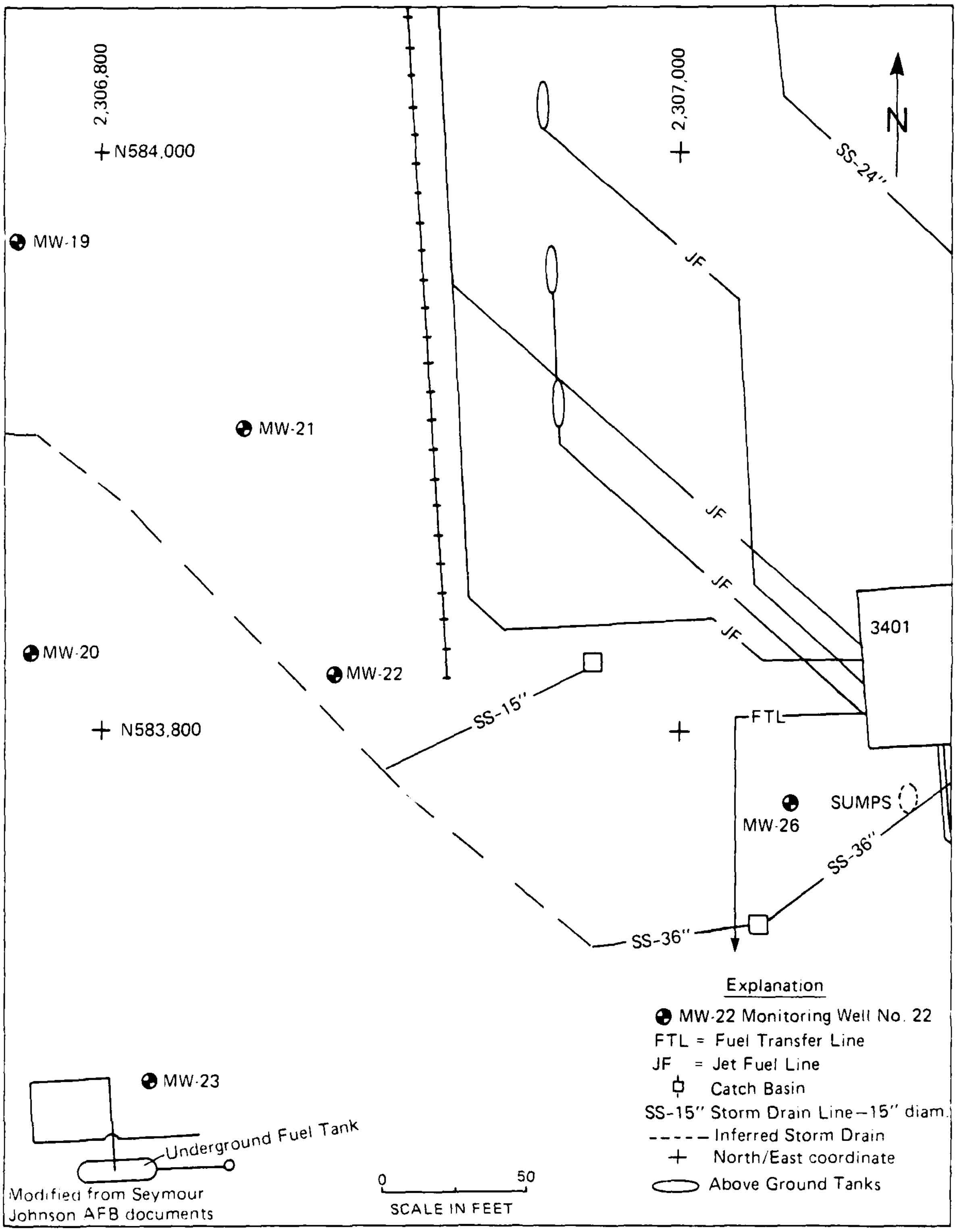


Figure 3. Location of Site 1 (tank farm fuel line leak).

(building 3401) is fed by a variety of underground fuel pipelines (Figure 3). These lines serve as main fuel transfer lines or lead to underground or aboveground storage tanks.

In mid-1981, relatively pure JP-4 began to seep into a small, three foot deep, concrete sump adjacent to the tank farm pump station. Excavation of the immediate area to a 4-foot depth revealed no source for this fuel. Pressure testing of pump station piping indicated no apparent leaks. During backfilling, a 12-inch diameter steel pipe was placed vertically next to the sump to provide a means of recovering JP-4 on a regular basis. The fuel level varies from 1 to 3 feet below the ground surface and, reportedly, fluctuates with rainfall. The average thickness of the fuel layer is 3 to 4 feet.

In an effort to define the extent of potential subsurface migration of petroleum-related products, six shallow monitoring wells were installed at Site 1 (Figure 3). The wells were located in areas that were assumed to be hydraulically downgradient from the fuel lines.

1.5.2 Ditch Adjacent to Railroad Tracks (Site 2)

The location of Site 2 is indicated in Figure 4. The ditch trends roughly north-south and parallels the fence and railroad tracks that bound the western portion of the POL area. The ditch drains approximately 500 feet northward into the main POL area drainage ditch (Figure 4). The north-south trending ditch is shallowest near its origin and is several feet deep at its confluence with the east-west trending drainage ditch. The purpose of the ditch adjacent to the railroad tracks is to intercept petroleum-related products observed in the shallow subsurface.

Seepage that was covered by a dark oily film (assumed to be petroleum-related products) was observed entering both sides of the north-south trending ditch adjacent to the railroad tracks at the time of the Phase II field studies. The flow in the ditch increases to the north as additional seepage enters. Flow was observed in the ditch during each visit to the site and is believed to be associated with groundwater discharge.

In an effort to determine the groundwater quality in the vicinity of Site 2, one shallow monitoring well was installed on the west side of the ditch (Figure 4). Soil samples were collected at 3-foot depth intervals

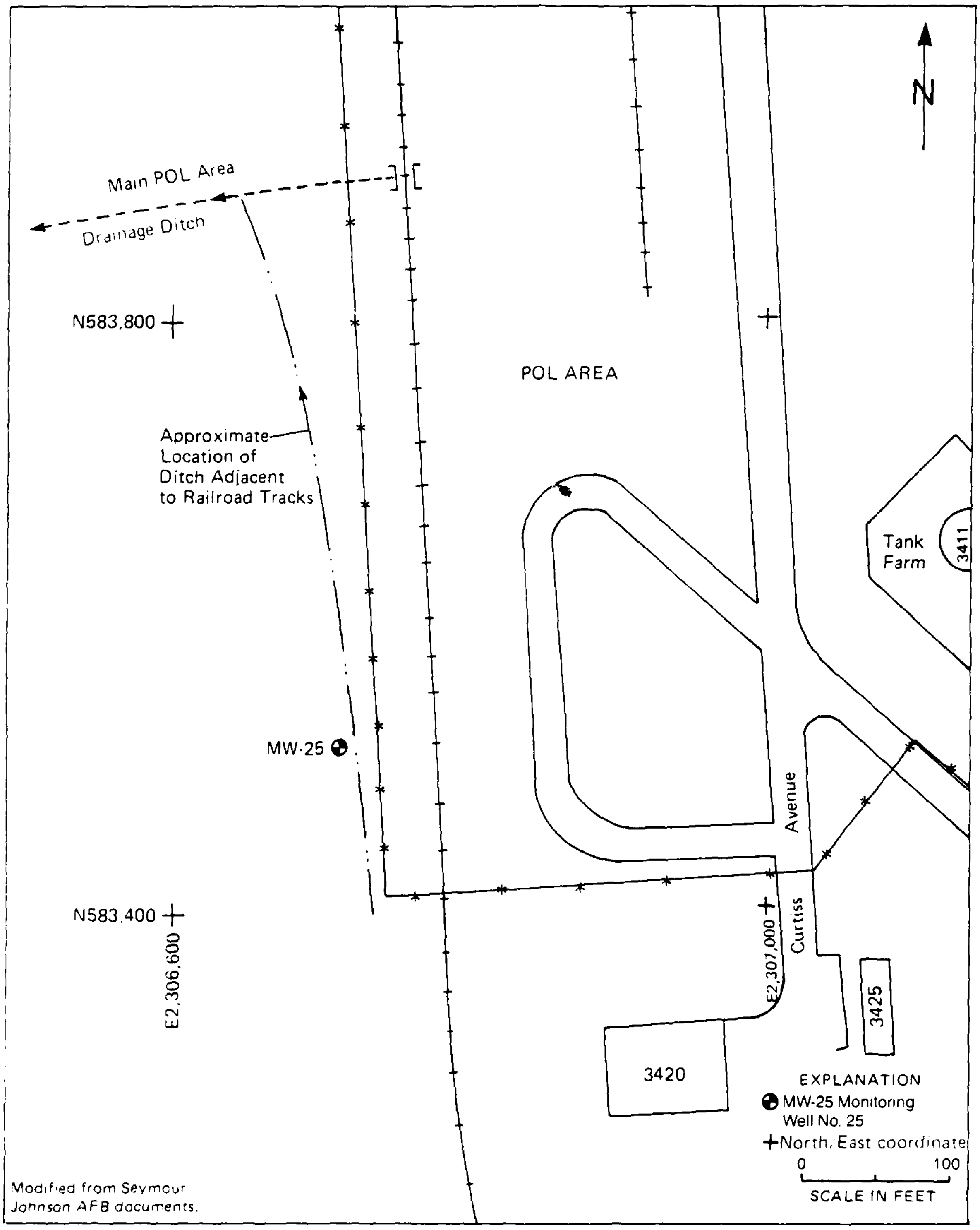


Figure 4. Location of Site 2 (ditch adjacent to railroad tracks).

during drilling. Access problems due to muddy terrain at the time of drilling prevented a well from being installed on the eastern side of the ditch.

1.5.3 Drain Pipe Outfall/Component Repair Squadron Ditch (Site 3)

The location of Site 3 is indicated in Figure 5. A storm drain originating in the POL area drains south parallel to the railroad tracks. This storm drain then drains west where the outfall enters the component repair squadron (CRS) ditch. The CRS ditch flows west and enters Stoney Creek, a tributary to the Neuse River.

The catch basins along the storm drain at Site 3 were noted to have a strong odor (assumed to be petroleum-related products) at the time of the Phase II field studies. The flow within the storm drain appears to increase to the south, even during periods of no rainfall.

In an effort to determine the groundwater quality in the vicinity of Site 3, one shallow monitoring well was installed (Figure 5). The well was installed immediately east of the storm drain line.

1.5.4 Fuel Hydrant System Leak (Site 4)

The location of Site 4 is indicated in Figure 6. The fuel hydrant system is located beneath the aircraft parking apron just south of Base operations and north of taxiways to the main runway. The site is underlain by a system of storm drains described in subsequent sections.

A 10-inch fuel-transfer line supplies JP-4 from the POL tank farm to sixteen 50,000-gallon underground tanks located near the SAC and TAC aircraft parking aprons. Three pumphouses deliver fuel from these tanks to the fuel hydrant network. The entire system has been in use since its construction in 1956. Sections have been repaired or replaced as required.

The underground hydrant refueling system has developed leaks on occasion. Since 1978, leaks resulting from cathodic reaction have been detected and repaired in some laterals. The liquid fuels maintenance shop performs (at a minimum) annual pressure tests on the hydrant lines. No pressure loss has been observed; however, during vacuum defueling procedures, metal flakes and other foreign material have appeared in increased amounts in the fuel filters. This material is considered indicative of corrosion in the

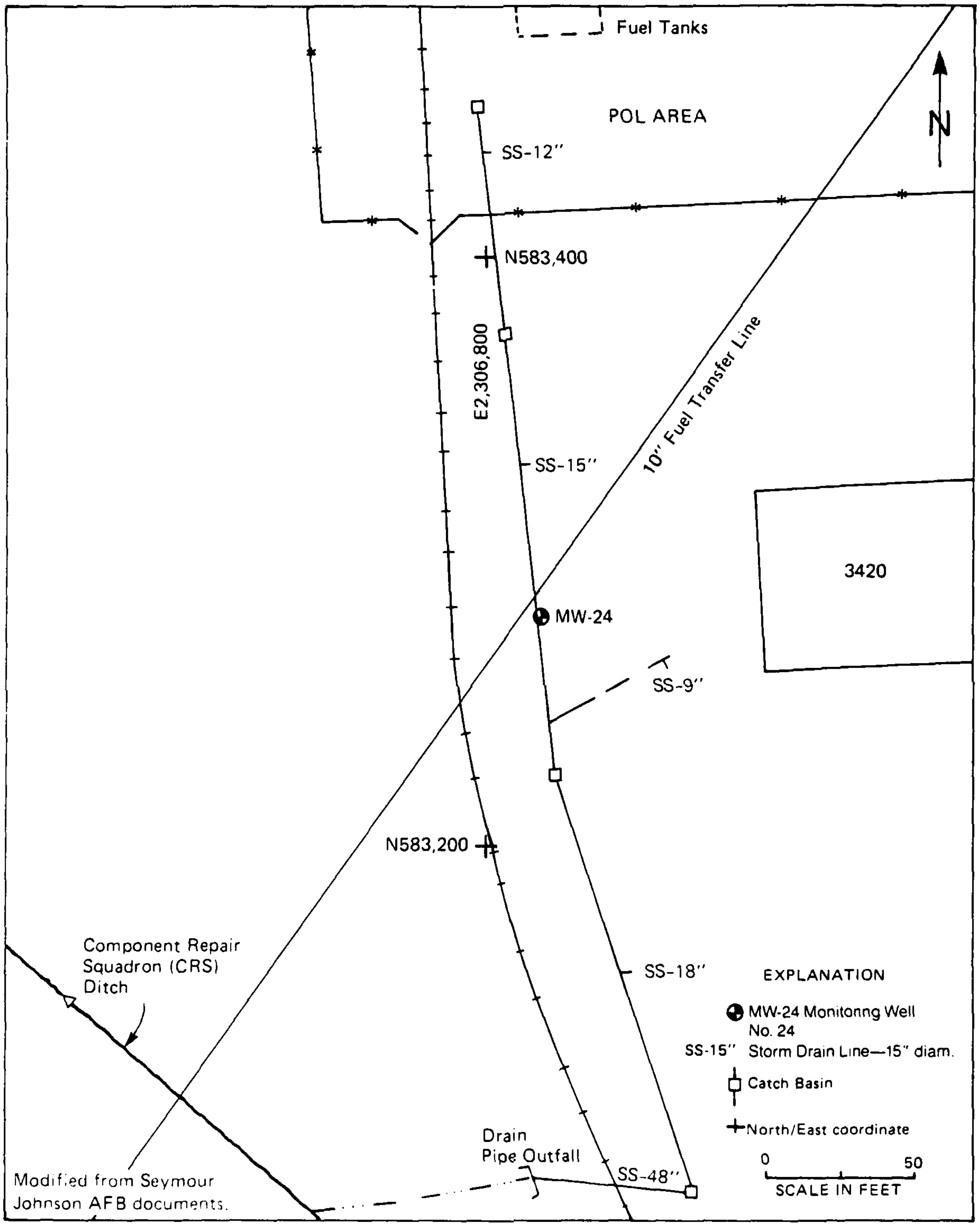


Figure 5. Location of Site 3 (drain pipe outfall/component repair squadron ditch).

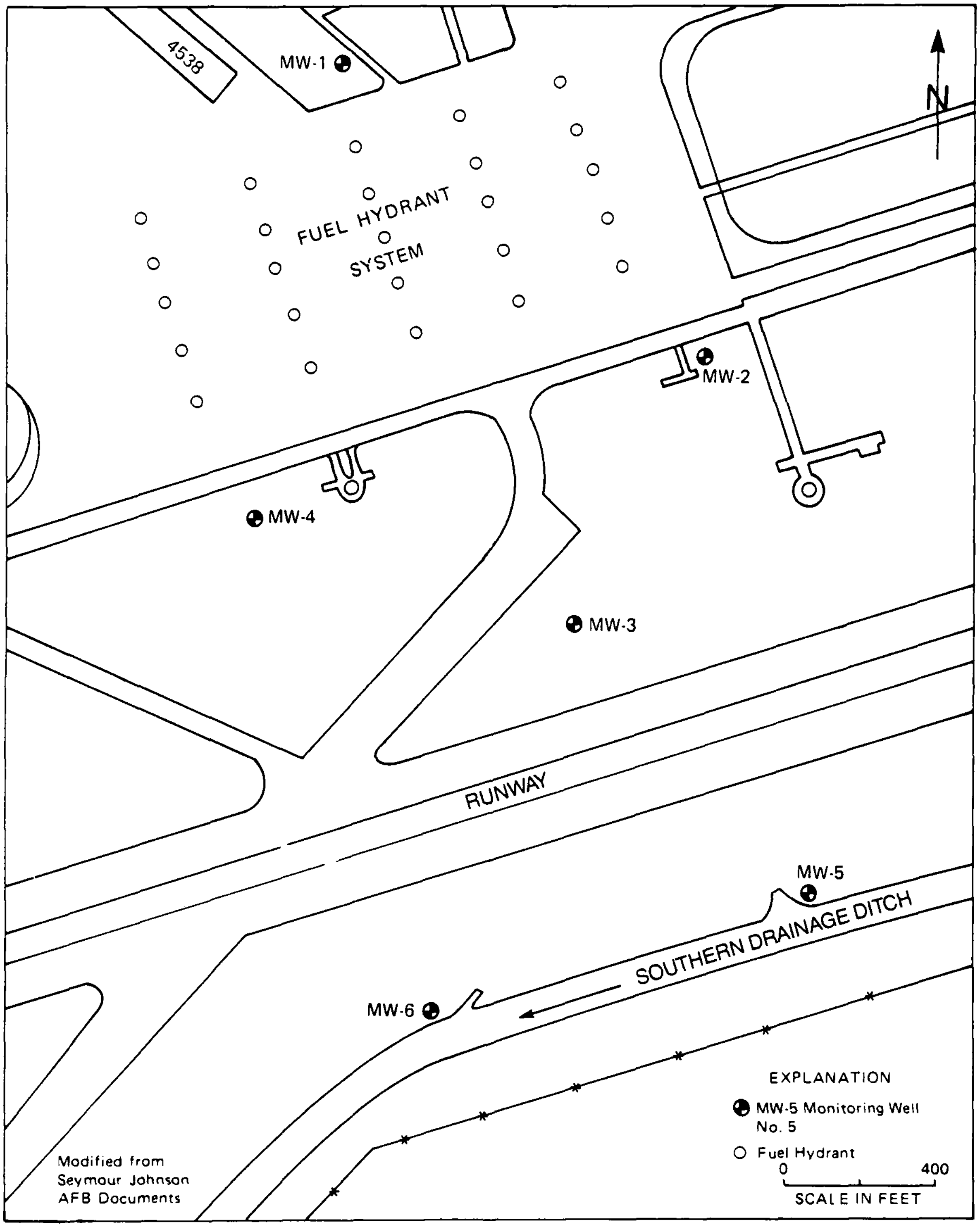


Figure 6. Location of Site 4 (fuel hydrant system leak).

system piping. JP-4 has been observed infiltrating into the storm drain at two manholes on the aircraft parking apron. It is uncertain if the source of the infiltrating fuel is an active leak or a residual that may have developed during a past leak.

So that the potential effects of the fuel hydrant system leak on groundwater resources could be assessed, six monitoring wells were installed at Site 4 (Figure 6). Well MW-1 was intended to serve as an upgradient sampling location.

1.5.5 Tank Farm Fuel Spill (Site 5)

The location of Site 5 is indicated in Figure 7. Most of the JP-4 fuel on Base is stored at the POL tank farm in five aboveground tanks (two 420,000-gallon tanks and three 840,000-gallon tanks). In November 1980, a large fuel spill occurred at the POL tank farm when a valve stem at the base of Tank No. 3414 (also referred to as Tank No. 2) was unbolted while an associated safety valve was still open to the tank. Approximately 400,000 gallons of JP-4 were spilled and an estimated 375,000 gallons of fuel were recovered. The clay dike surrounding the tank did not overflow. After cleanup, test pits were dug in the diked area to a depth of 1 foot, and shallow wells (6 inches diameter, 3 feet deep) were dug. Little or no infiltration into the soil was detected. Rainwater collected within the dike had no significant concentration of oil and grease prior to discharge. The test pits and shallow wells were covered and filled within a few months of the spill date.

Since 1981, rainwater collected within the dike surrounding Tank No. 3414 has shown abnormally high oil and grease concentrations (580 milligrams/liter (mg/l) to 124,000 mg/l). There has been no history of fuel spillage within this dike since the November 1980 spill. No explanation for the high concentration of oil and grease has been recorded.

Three monitoring wells (each about 30 feet deep) were installed in the vicinity of Tank No. 3414 (Figure 7). The wells were set deeper than others on the Base to determine the potential vertical extent of the 1980 spill. The bottoms of each of these wells were still within the clayey sands that separate the surficial aquifer from the principal aquifer (see Section 4.9.1).

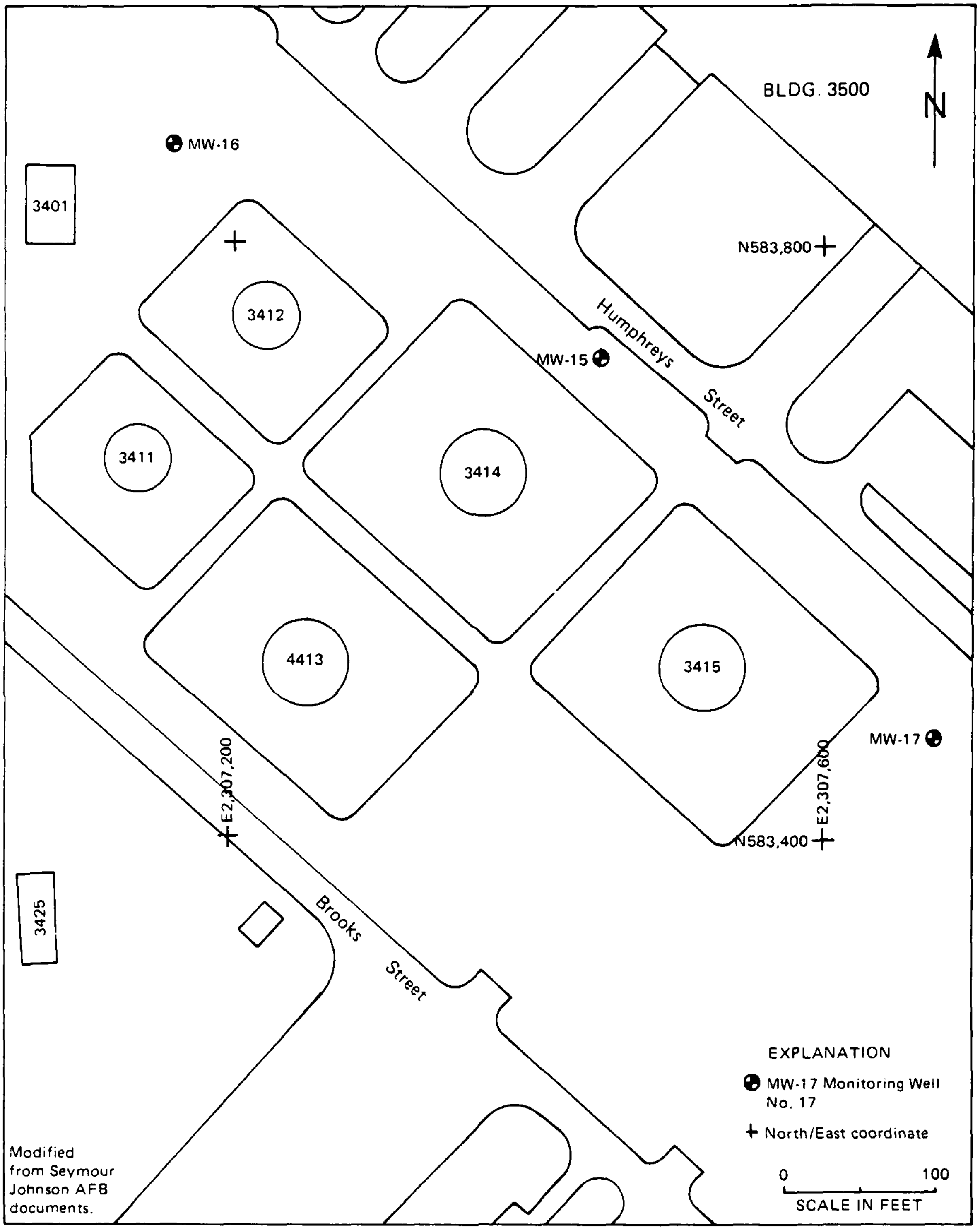


Figure 7. Location of Site 5 (tank farm fuel spill).

1.5.6 Fire Training Area 3 and Landfills 1 and 4 (Site 6)

The location of Site 6 is indicated in Figure 8. The description and history of the three components of Site 6 are discussed in the following subsections.

1.5.6.1 Fire Training Area 3--

The fire department has operated fire protection training areas on Base where fires were ignited and then extinguished. Fire training area 3 has been in operation since late 1958 or early 1959 and is the major permanent fire training area on Base. The facility is located adjacent to a fenced truck yard off an extension to Collier Avenue (Figure 8).

The fire training area is comprised of a diked pit formed on a compacted-soil base. An underdrain system was installed to drain the pit to an underground oil/water separator prior to discharging the water into the storm drainage system. A fuel system was later installed to evenly distribute the fuel within the pit from an adjacent fuel storage tank. Until 1974, the area was used on a monthly basis. From 1974 on, the frequency of training was reduced to quarterly exercises. Between 1956 and the mid-1970's, contaminated fuels and some combustible waste chemicals were burned in the pit. Beginning in 1976, fire training exercises were conducted using only uncontaminated JP-4. Approximately 500 gallons of fuel were used during a typical training exercise. The area was saturated with water prior to the application of fuel. Protein foams and dry chemicals have been used as extinguishing agents from 1956 to the present; AFFF has been used from 1972 to the present; Halon 1211 has been used from 1974 to the present. Residual fuels were burned prior to draining the pit.

One monitoring well (approximately 30 feet deep) was installed northwest of the fire training area to determine the groundwater quality downgradient of the diked pit (Figure 8).

1.5.6.2 Landfill No. 1--

Landfill No. 1 is located northwest of Fire Training Area 3 and southeast of Stoney Creek (Figure 8). The actual layout of the landfill is not known at present. The total area of the site is reportedly about 2.5 acres.

The site was operated during the initial activation of the Base, 1941 through 1946. During this same period, the Base operated a refuse incinera-

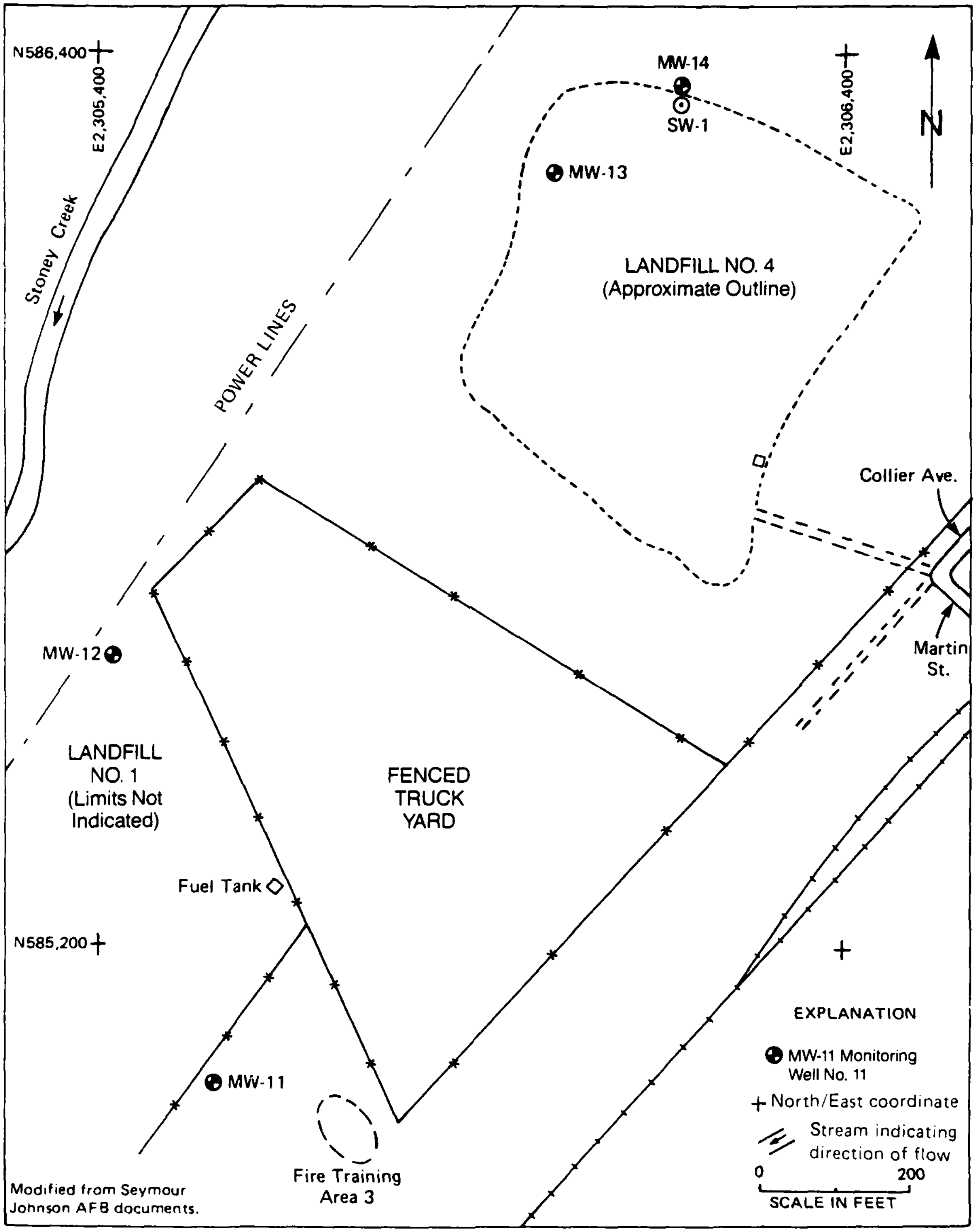


Figure 8. Location of Site 6 (fire training area 3 and landfills 1 and 4).

tor, indicating the landfill only received a portion of the waste and refuse generated at the Base. Ash from the incinerator was likely disposed of in this landfill along with a small quantity of miscellaneous industrial wastes. Refuse suitable for animal feed was sold to local farmers, and scrap metals were salvaged. The landfill is closed, and the majority of the area has an established vegetative cover. In recent years an excavation training program was conducted in the landfill area. These excavations have uncovered remnants of landfill debris.

One monitoring well (MW-12) was installed between the assumed northern limits of the landfill and Stoney Creek. Rubble fill material was encountered during drilling, indicating some extension of the landfill northwest of the vegetated cover area beneath the existing powerlines.

1.5.6.3 Landfill No. 4--

Landfill No. 4 is located between Collier Avenue and Stoney Creek (Figure 8). The total area of the landfill is approximately 8 acres. The landfill operation began in 1970. Landfill No. 4 was utilized through 1978 for the disposal of general refuse generated on the Base with the exception of refuse from the housing area and some miscellaneous industrial chemicals. The landfill was operated in a trench and fill fashion; no burning occurred, and the wastes were covered daily. Trenches were described to have ranged from 6 to 7 feet in depth.

In 1978, the Base established a contract for collection and off-Base disposal of all refuse generated at Seymour Johnson AFB. The only waste disposed of in the landfill from 1978 to the present is rubble from grounds maintenance. Trench and fill procedures were discontinued, and the landfill was filled along a slope.

Leachate has been observed along the northern toe of the landfill. This leachate has been sampled (SW-1), and two monitoring wells have been installed at the landfill (Figure 8).

1.5.7 Defense Property Disposal Office (DPDO) Hazardous Waste Tank (Site 7)

Site 7 is located on the northern section of the Base, just south of Fickel Street (Figure 9). The area is enclosed by a fence but is not paved. No known spills have occurred from the site. There are also no

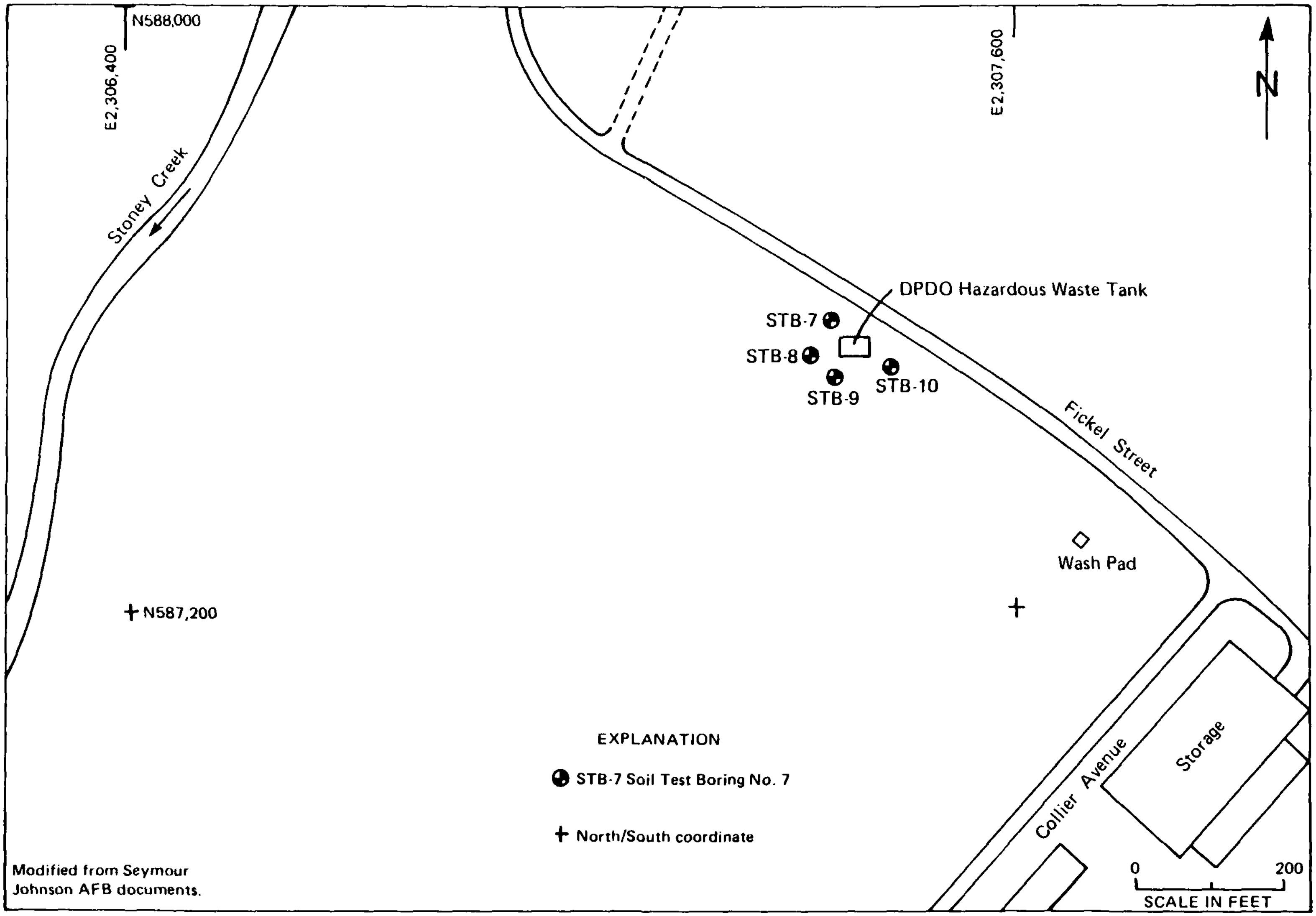


Figure 9. Location of Site 7 (DPDO hazardous waste tank).

obvious indications of spills on the ground surface. Barrels stored at the site have appeared to be intact. An underground storage tank exists at the site and is used to store commingled POL waste products. Pesticides and waste solvents have also been stored at the site.

Four soil test borings were drilled around the site (Figure 9) to depths of about 30 feet. Soil samples were collected for analysis, but no monitoring wells were installed in the borings. The borings were later grouted to the land surface.

1.5.8 Suspected JP-4 Contamination Site (Site 8)

Site 8 is located in the central portion of the Base between the flight line road and Building 4820 (Figure 10). The site is adjacent to a golf course and is used occasionally for troop practice areas. The site was suspected by some of having JP-4 contamination from observations of discolored seepage that migrated to the ground surface during periods of rainfall.

Four soil test borings were drilled at Site 8 to depths of about 15 feet (Figure 10). Soil samples were collected for analysis, but no monitoring wells were installed in the borings. The borings were backfilled with soil and grouted at the land surface.

1.6 ANALYSES PERFORMED AT THE SITES

The water samples collected from the six sites with monitoring wells or leachate sampling were selectively analyzed under the IRP program for:

- pH,
- conductivity,
- temperature,
- oil and grease,
- phenol,
- total organic carbon,
- total organic halogen,
- volatile organic compounds (aromatics and halocarbons),
- lead,
- cadmium,
- chromium,
- nickel, and
- nitrate.

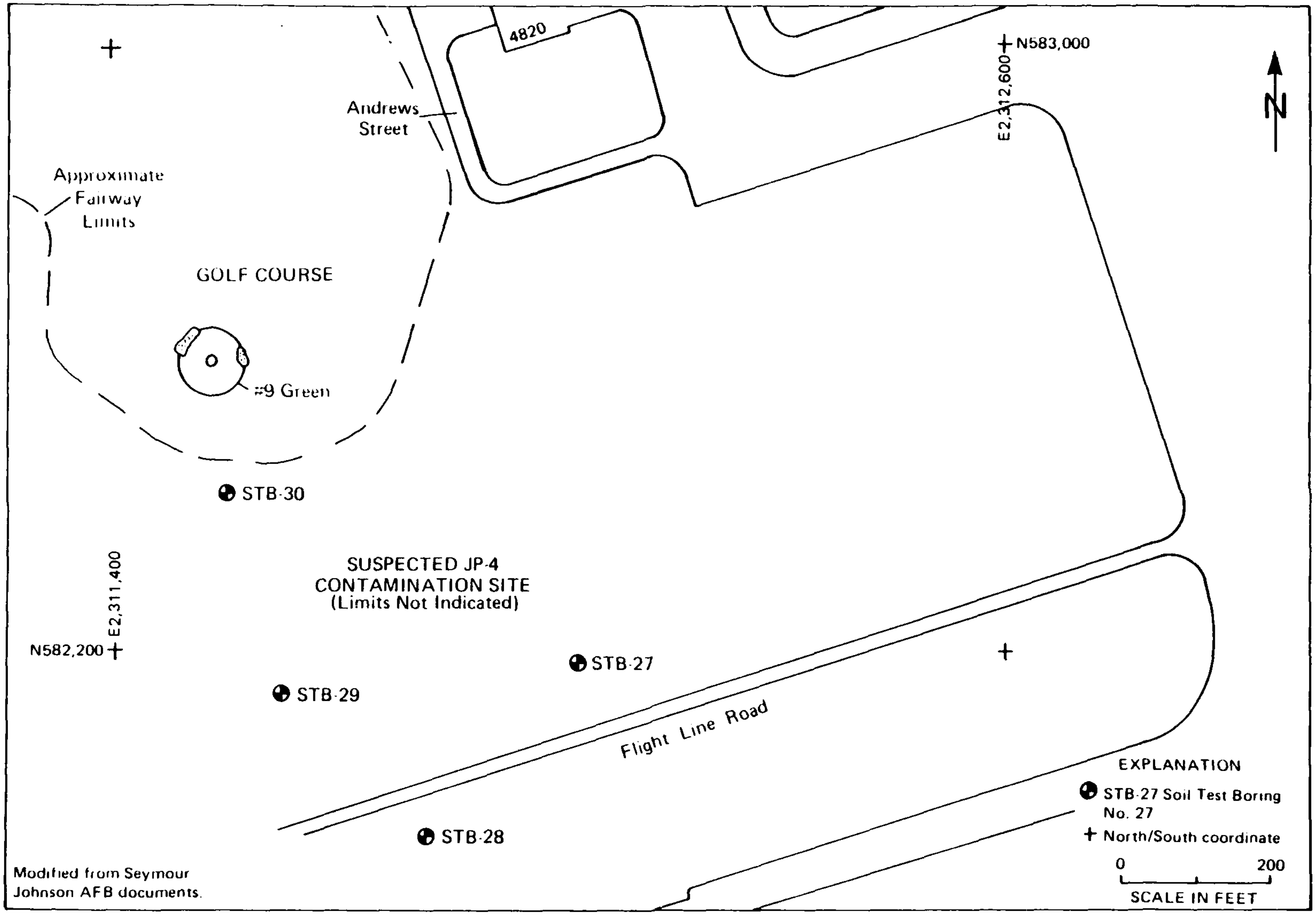


Figure 10. Location of Site 8 (suspected JP-4 contamination site).

The soil samples collected from the two sites with soil test borings were selectively analyzed under the IRP program for:

oil and grease,
total organic halogen,
phenol,
lead,
chromium, and
pesticides.

Supplemental analyses were performed on four groundwater samples by OEHL for:

chemical oxygen demand, and
volatile organic compounds (aromatics and halocarbons).

The analytical procedures used are provided in Appendix A. The results of the analyses are described in Section 4.

1.7 IDENTIFICATION OF FIELD TEAM

The following RTI professionals conducted the Phase II field activities:

W. J. Alexander, hydrogeologist,
W. F. Gutknecht, analytical chemist, and
J. A. Sokash, environmental chemist.

The field activities included site reconnaissances; periodic observations of drilling activities; classification of soil samples; supervision of selected monitoring well installation; in situ measurements of water quality; water level measurements; and development, purging, and sampling of monitoring wells.

The well drilling, soil sampling, and surveying was performed by Soil and Material Engineers, Inc., of Raleigh, North Carolina. The field activities were performed between January and May 1984.

SECTION 2

ENVIRONMENTAL SETTING

2.1 PHYSIOGRAPHY

2.1.1 Location

Seymour Johnson AFB is located in the Atlantic Coastal Plan physiographic province. The North Carolina Coastal Plain has been subdivided into three physiographic regions and the Base is within the middle region (Figure 11). Scarps associated with former high stands of sea level delineate the regions. Major changes in soil conditions, stratigraphy, and geomorphology occur across these subdivisions.

The Piedmont-Coastal Plain boundary is marked by the fall line (Figure 11). The upper Coastal Plain extends east of the fall line to the Coats scarp (Figure 12). The lower Coastal Plain extends from the Surry scarp to the sea (Daniels, Gamble, and Wheeler, 1971).

The middle Coastal Plain is bounded on the west by the Coats scarp and extends eastward to the Surry scarp (Figure 12). The elevation at the toe of the Coats scarp is 275 feet above mean sea level (msl). The elevation at the toe of the Surry scarp is 94 feet above msl. The middle Coastal Plain is an area of generally fluvial sediments, somewhat dissected, but with relatively broad flat areas between the streams. Three seaward sloping terrace plains (Brandywine, Coharie, and Sunderland) exist in the Neuse River basin of the middle Coastal Plain (Figure 12). The Goldsboro area is on the post-Miocene Sunderland surface.

2.1.2 Climate

Precipitation in the Goldsboro area is greatest in July and least in December or January (Pusey, 1960). The mean annual precipitation measured at the Base according to data available from the Detachment 2, 3rd Weather Squadron, is about 50 inches.

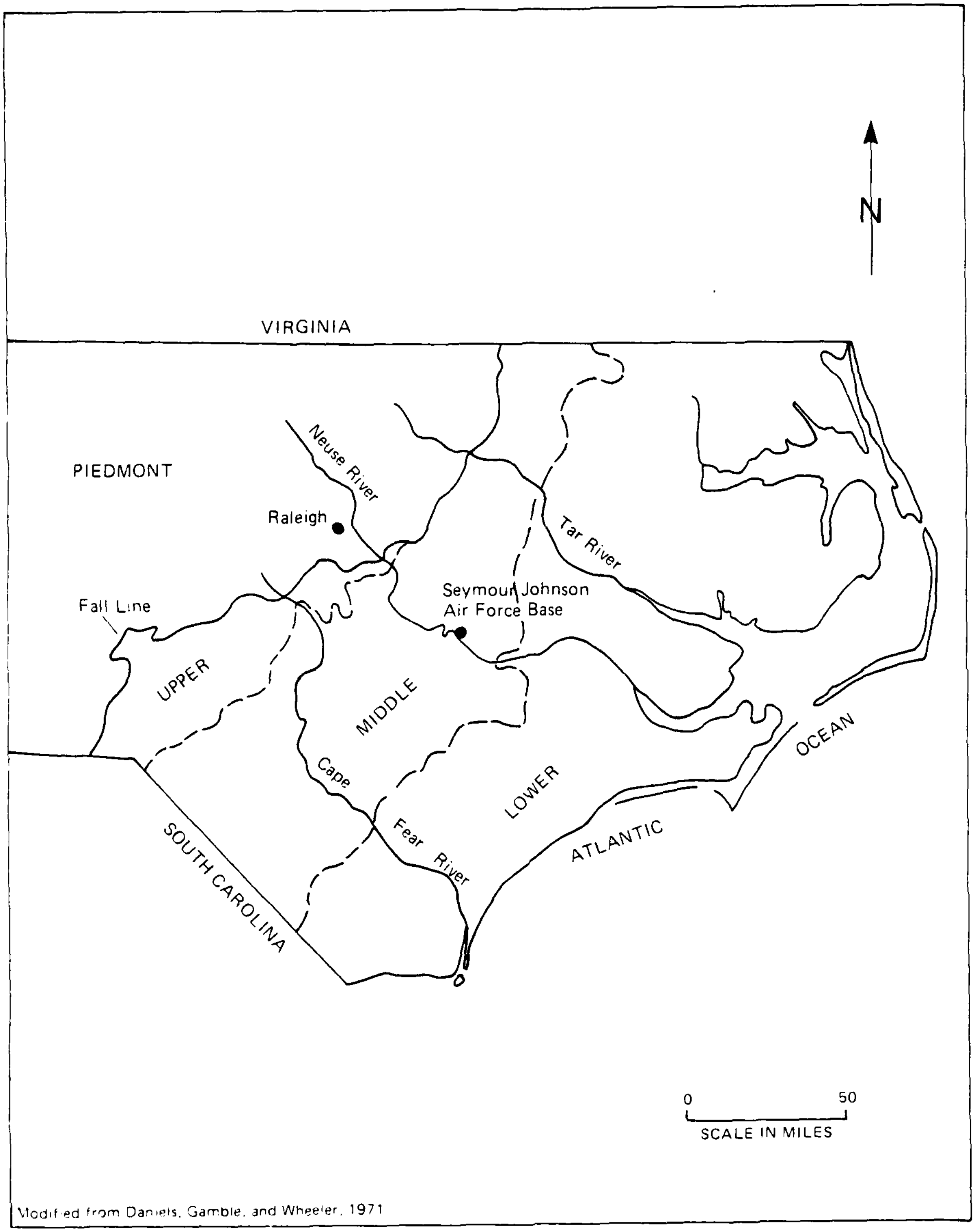


Figure 11. Subdivisions of North Carolina Coastal Plain.

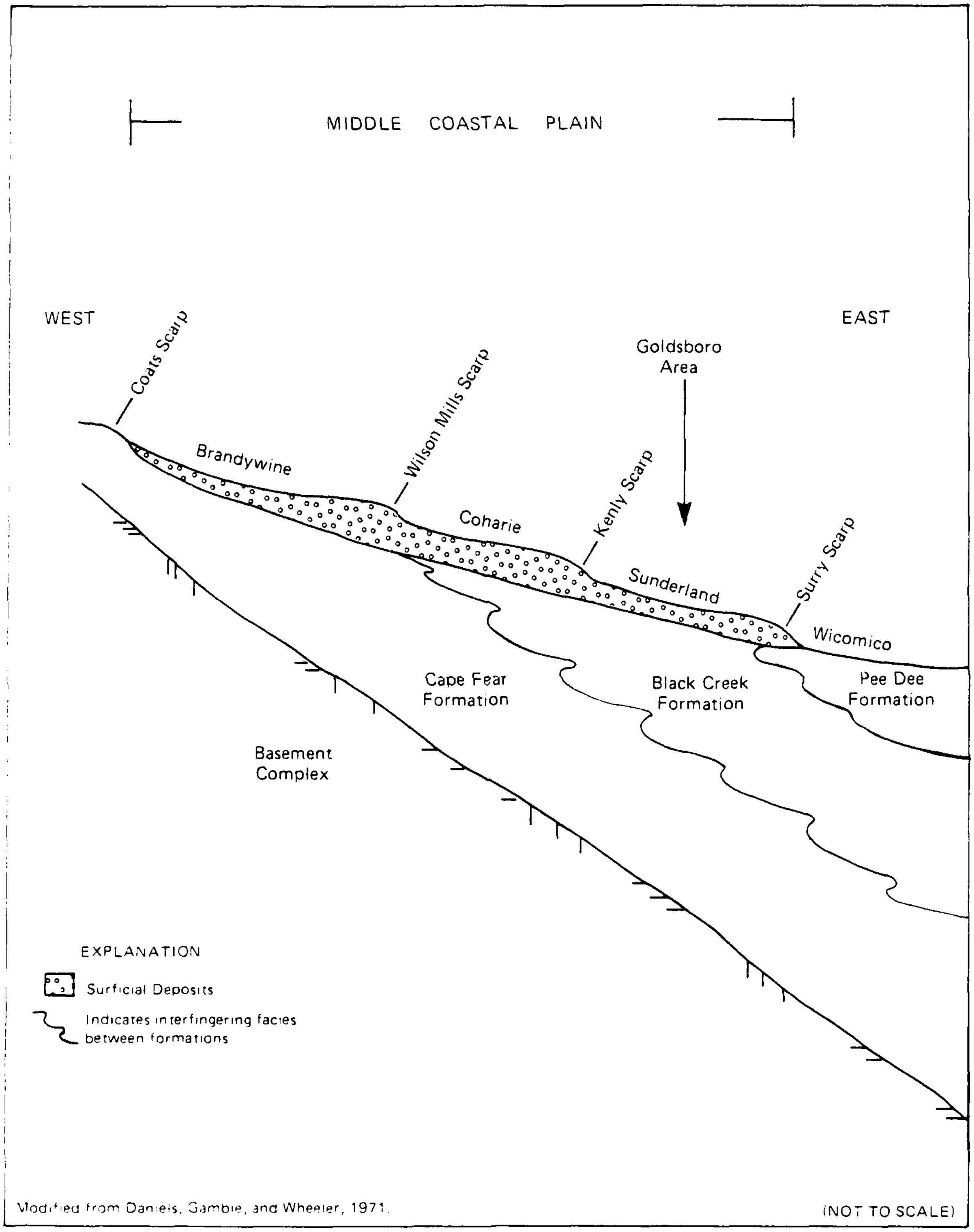


Figure 12. Generalized cross section through the middle Coastal Plain.

2.1.3 Topography and Drainage

Land surface elevations in the Goldsboro area average about 110 feet, msl. At the Base the land surface slopes from about 112 feet above msl along the eastern side to 60 feet above msl along the Neuse River floodplain on the west. The Neuse River is the principal drainage feature at the Base. Drainage from the northern half of the Base enters Stoney Creek, a significant tributary to the Neuse in the Goldsboro area (Figure 2). The centerline of Stoney Creek also serves as an installation boundary along the northwest side of the Base. The southern portion of the Base is drained by a manmade channel that also flows into the Neuse River. Drainage in much of the area surrounding the Base has been augmented by drainage ditches. The area is generally well drained with no normally occurring wetlands.

Sections of the Base are subject to flooding from Stoney Creek and the Neuse River during intense rainfall such as 100-year storm events. Stoney Creek drains an area of nearly 28 square miles at its confluence with the Neuse River. The Neuse River drains an area of some 2,420 square miles, measured from its point of origin to the west installation boundary.

2.2 STRATIGRAPHY AND HYDROGEOLOGY OF THE MIDDLE COASTAL PLAIN

2.2.1 Stratigraphy

The general geology of Wayne County is indicated in Figure 13. In most of the county, sedimentary deposits rest unconformably on a basement complex of pre-Cretaceous rocks. The sedimentary deposits are largely unconsolidated and dip and thicken to the east (Figure 12). Only sedimentary deposits are of interest in this report because the basement complex is not a significant source of groundwater in the area.

Sedimentary deposits that have been identified in this area of the middle Coastal Plain include, in descending order:

Surficial deposits
Yorktown formation
Castle Hayne limestone
Peedee formation
Black Creek formation
Middendorf formation
Cape Fear formation.

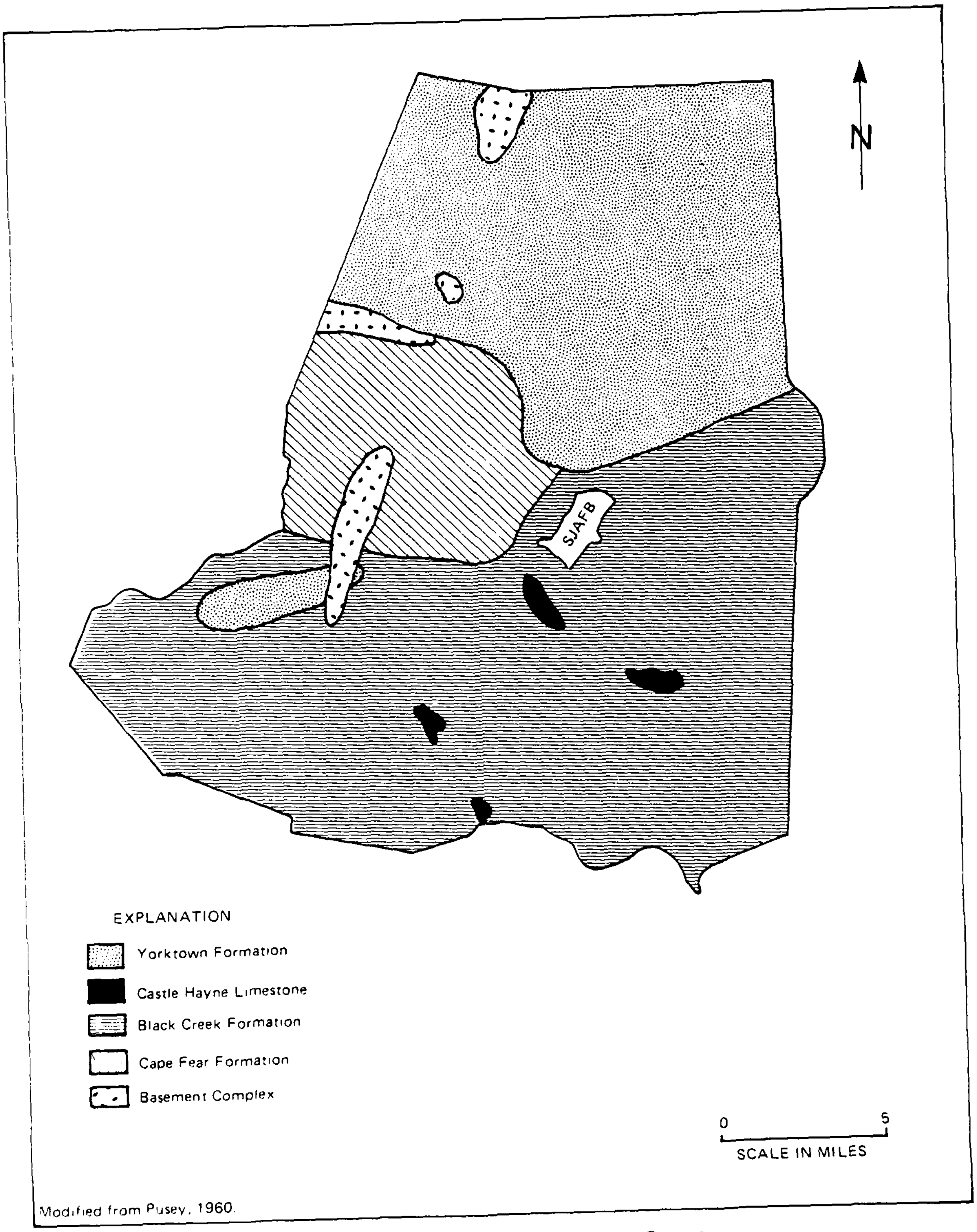


Figure 13. Geologic map of Wayne County.

The lithology and water-bearing properties of these deposits are summarized in Table 4 and discussed in more detail in the following subsection. Of these sedimentary units, only the surficial deposits, the Black Creek formation, and the Cape Fear formation are known to exist beneath Seymour Johnson AFB.

2.2.2 Hydrogeology of Sedimentary Deposits

The following discussions pertaining to the geology and general water-bearing characteristics of the sedimentary deposits are based on information provided in Robinson and Mann (1977), Pusey (1960), Zastrow (1982), Winner (1984), and Daniels, Gamble, and Wheeler, (1971).

2.2.2.1 Surficial Deposits--

In the Goldsboro area, surficial deposits of Holocene and Pliocene ages have been identified by Daniels, Gamble, and Wheeler (1971) as the Sunderland surface and Goldsboro sands, respectively. The deposits are predominantly sands or sandy clays and rest on the disconformable surface of the Black Creek formation. The deposits are typically less than 40 feet thick in Wayne County (Pusey, 1960). Sandy and clayey surficial deposits were identified by this study at Seymour Johnson AFB overlying the darker clays of the Black Creek formation. These deposits are of primary interest for the Phase II evaluation and are further described in Section 4.

Groundwater occurs at shallow depths within the surficial deposits. The deposits supply small yields, typically less than 10 gallons per minute (gal/min) to domestic wells south of the Neuse River (Pusey, 1960). The groundwater in the surficial deposits contains objectionable amounts of iron and is soft and commonly corrosive to metals (Pusey, 1960).

2.2.2.2 Yorktown formation--

The Yorktown formation is composed of massive marine clays interbedded with thin shell beds. The formation occurs in the northern half of the county (Figure 13) and is not significant as a water supply in the context of this evaluation.

TABLE 4. LITHOLOGIC DESCRIPTIONS AND WATER-BEARING PROPERTIES OF GEOLOGIC DEPOSITS OR FORMATIONS IN THE WAYNE COUNTY AREA

System	Series	Geologic deposit or formation	Description of sediments	Aquifer designation and water-bearing properties
Quaternary	Holocene	Goldsboro sand	Gray to brown medium sand; few thin sandy clay lenses or beds	Surficial aquifer--supplies some domestic wells south of Neuse River. Yields typically <10 gal/min
	Pliocene	Sunderland formation	Clay to fine sandy clay to clay loam upper sediment; gradational contact to basal coarse sediments, coarse and and fine gravel basal sediments	Surficial aquifer--supplies some domestic wells south of Neuse River. Yields typically <10 gal/min
Tertiary	Miocene	Yorktown formation	Massive greenish-gray sticky, silty clay loam; sandy loam to loam beds. May be fossiliferous	Supplies some shallow wells (<60 ft deep) in northern Wayne County. Yields rarely <25 gal/min. Not present near Seymour Johnson AFB.
	Eocene	Castle Hayne limestone	Coarse, conglomeratic sandstone cemented by limy matrix grading to marl	Few water supplies developed in Wayne County. Yields <10 gal/min. Not present near Seymour Johnson AFB.
Cretaceous	Upper Cretaceous	Peedee	Gray to greenish-black calcareous, glauconitic clayey silts and fine-grained sands with thin beds of gray calcareous sand and hard sandy limestone	Not significant source of water in Wayne County. Not present near Seymour Johnson AFB
		Black Creek	Gray to greenish montmorillonitic clays and thin beds of gray to white slightly glauconitic sand. Thin beds of hard, sandy limestone containing pyrite, lignite, and possibly collophane	Black Creek aquifer. Used in conjunction with underlying Cape Fear aquifer. Supplies water to wells in southern and southeastern Wayne County. Well depths usually <150 ft. Domestic wells yield <25 gal/min. Used at Seymour Johnson AFB.
		Middendorf	Light-colored, cross-bedded, kaolinitic sands with lenses of white massive kaolin. Lignite and pyrite common. Clays are non-calcareous	Not present in vicinity of Goldsboro
		Cape Fear	Light-colored, poorly sorted quartz sands and montmorillonitic clays with appreciable feldspars crossbedded sands with delineated graded muddy sand-sandy mud couplets fines upward into a structureless mud bed	Cape Fear aquifer. Used in conjunction with overlying Black Creek aquifer. Supplies water to municipal wells in central portion of Wayne County. Yields as high as 375 gal/min. Used at Seymour Johnson AFB
Pre-Cretaceous		Basement	Basement rocks (metamorphic crystalline complex)	Produces low yields from fractures. Not an important source of groundwater in area

Indicates disconformity between deposits or formations.

2.2.2.3 Castle Hayne Limestone--

The Castle Hayne limestone only occurs as isolated outliers of varying lithology in the southern part of Wayne County (Figure 13) and is not significant as a water supply in the context of this evaluation.

2.2.2.4 Peedee Formation--

The Peedee formation is composed of dark gray to green even-textured quartz sand containing glauconite, mica, and clay. The Peedee exposed in the Goldsboro area represents the basal unit of the Peedee and interfingers with the Black Creek formation to the east.

The formation is thin and therefore is not a significant source of groundwater in the Goldsboro area, although it is an important aquifer in the lower Coastal Plain. The formation has not been recognized at the Seymour Johnson AFB. Most wells tapping the Peedee formation in the area are dug or driven wells that yield 10 to 20 gal/min. The water is alkaline, moderately hard, and low in iron.

2.2.2.5 Black Creek Formation--

The Black Creek formation consists of black or dark gray thinly laminated montmorillonitic clay and lenses of sand. It contains abundant mica and lignite, as well as iron sulfides. The lower part of the formation contains minor amounts of glauconite.

The lower part of the Black Creek formation reflects both continental and marine deposition. The upper part of the Black Creek formation was deposited in shallow marine waters. Zastrow (1982) determined the Black Creek to contain fluvial, tidal flat, and estuarine facies. Detailed mapping done by Zastrow (1982) along the Neuse River at Goldsboro indicated that section of the river to be in the tidal flat facies of the Black Creek formation. Zastrow (1982) further divided the tidal flat facies into four subunits: mudflats, transitional flats, sandflats, and tidal channels. The mudflats and tidal channels compose the largest percentage of the outcrops, but transitional flats and sandflats are not uncommon. The lithology and textural parameters of the mudflat subunit showed it to be a laminated mudstone. The mudflat deposits consistently overlie and interfinger with transitional flat and sandflat sediments in the Seymour Johnson

AFB area. Tidal channel scour and fill structures are common on the mudflat subfacies.

The formation thickens from a featheredge along its western margin to about 200 feet at Clinton and probably is as thick as 400 feet near Ivanhoe. Because of its wide extent, shallow depth, and the presence of sand lenses, the Black Creek formation is the source of water for a large number of domestic and municipal wells in the Goldsboro area. Wells tapping the Black Creek aquifer system are commonly developed in conjunction with productive units of the Cape Fear aquifer. The productive units of the Black Creek aquifer are found at depths below 10 feet msl in the Seymour Johnson AFB area. Above these productive zones lies a unit of laminated sand and clay which is interpreted to have a thickness of more than 50 feet beneath the Base. The yield of wells tapping the Black Creek aquifer system ranges from 50 gal/min from small-diameter screened wells to 500 gal/min from large-diameter gravel-packed wells. The average specific capacity of the wells inventoried is about 5 gal/min per foot of drawdown (Pusey, 1960). According to Winner (1984), the transmissivity of the aquifer near the base is 700 $feet^2$/day (ft^2/d).

The water from the Black Creek aquifer is not of uniform chemical quality. Near its outcrop area the aquifer contains water of low pH that is high in iron. The lower part of the aquifer contains slightly alkaline water low in iron in some areas.

2.2.2.6 Middendorf Formation--

The Middendorf consists of poorly indurated quartzitic pale orange sands and lenses of light gray silty clay (Zastrow, 1982). The formation has not been recognized in the vicinity of Seymour Johnson AFB but is present west of Goldsboro. The formation is not significant as a water supply in the context of this evaluation.

2.2.2.7 Cape Fear Formation--

The Cape Fear is comprised of cross-bedded, poorly sorted, immature quartz sands and montmorillonitic clays, with an appreciable feldspar content. Colors are commonly yellowish gray for the sands and light gray for the clays. Intraformational conglomerates of mudstone are common. Low angle cross-bedding is recognized in the sandier units. Graded muddy sand-sandy mud couplets have been identified throughout the unit. The sequence is described as having a disconformity overlain by gravelly sand with megaclasts of quartz and clay pebbles. This grades into a cross-bedded sand which fines upward into a structureless mud bed (Zastrow, 1982). The formation dips southeastward at 12 to 15 feet per mile in the outcrop area and probably attains a thickness of about 250 feet southwest of Wayne County (Pusey, 1960).

The Cape Fear is capable of yielding large supplies of groundwater and is an important aquifer in the Goldsboro area. In other areas, especially where the aquifer is less than 50 feet thick, it is capable of yielding only small to moderate domestic supplies. The transmissivity of the aquifer near the base is 1,200 ft^2/d (Winner, 1984). The thin clay layers separating the aquifer from the overlying Black Creek aquifer have an effective confining thickness of 18 feet and a vertical conductivity of 7×10^{-5} ft/d (Winner, 1984).

The quality of water in the Cape Fear aquifer is not uniform. In the area near the fall zone where water table conditions exist, the water in the Cape Fear has a pH less than 7.0 and contains large amounts of iron. In the areas where artesian conditions exist, the water has a pH greater than 7.0 and is low in iron content (Pusey, 1960).

2.2.3 <u>Groundwater Usage</u>

Municipal and domestic water supplies in most of Wayne County (Figure 14) are obtained from groundwater resources. Goldsboro's municipal water supply is derived from the Neuse River; the Little River is used only for emergency supply (Robison and Mann, 1977). The surficial aquifer is used for small domestic water supplies south of the Neuse River. The surficial aquifer does not appear to be used immediately east or west of the Base. Groundwater usage in 1980 from the Black Creek aquifer was estimated to be 0.64 million gallons per day (Mgal/d) and from the Cape Fear aquifer to be 0.77 Mgal/d (Winner, 1984).

Seymour Johnson AFB derives its water supply from the Black Creek aquifer and the Cape Fear aquifer (Figure 12), herein called the principal

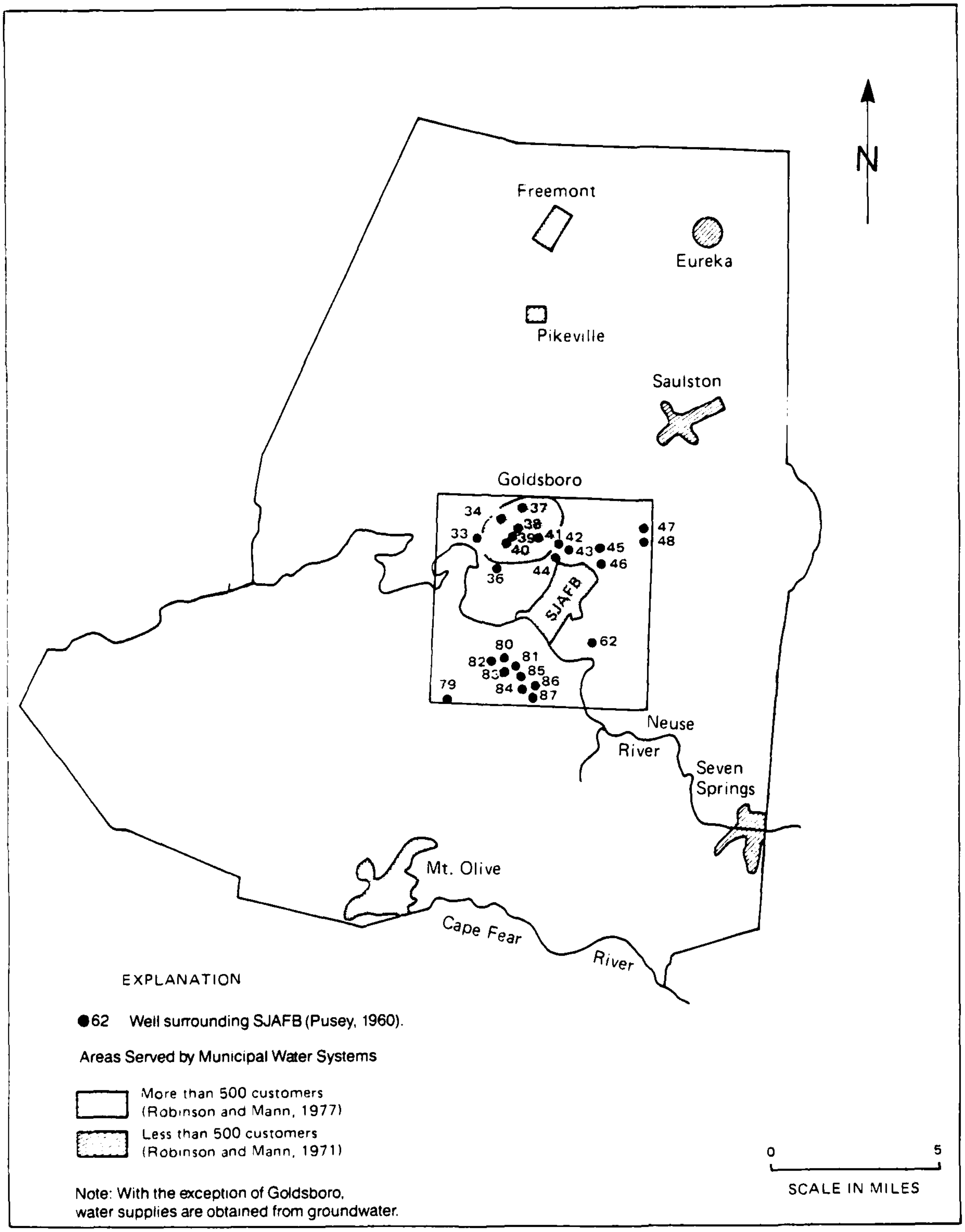


Figure 14. Water usage in Wayne County.

aquifer system. The Base water-supply and service wells are depicted in Figure 15 and data for these wells are provided in Appendix B. Information pertaining to water wells located adjacent to Seymour Johnson AFB is also provided in Appendix B.

2.2.4 Groundwater Flow Conditions

Groundwater flow in the surficial aquifer is influenced by topographic features. Recharge primarily occurs where precipitation infiltrates higher elevations and in areas where permeable deposits are exposed near the land surface. Discharge primarily occurs into wells, streams, and deeper drainage ditches in the area. At Seymour Johnson AFB, the overall direction of flow in the surficial aquifer is interpreted to be from the higher central portion of the Base to the north (into Stoney Creek), to the west (into the Neuse River), and to the south (into the southern drainage ditch). Although the horizontal flow component in the surficial aquifer is dominant, some downward leakage through the clay layers into the underlying aquifers likely occurs. The contribution of recharge from the surficial aquifer at the Base to the principal aquifer system is interpreted to be less significant than other sources of recharge described below. This situation has been well-documented in other areas (Fetter, 1980). Directions of groundwater flow in the surficial aquifer at the Base are described in more detail in Section 4.

The principal aquifer system is primarily recharged in areas where these deeper formations crop out. Major streams that have dissected the surficial deposits may also serve as recharge or discharge areas to the deeper aquifers. Water levels measured in the Base wells reflect changes in the stage of the adjacent Neuse River (Winner, 1984) and indicate hydraulic connections between the river and the principal aquifer system. From a regional perspective, the Goldsboro area is interpreted to be in a discharge area of the principal aquifer system (Winner, 1984). The complex interchange between aquifers and surface water features in the Goldsboro area is dependent on a variety of factors including the specific hydrogeology within a local area, the depth of streams or rivers, and the location and pumping patterns of well fields.

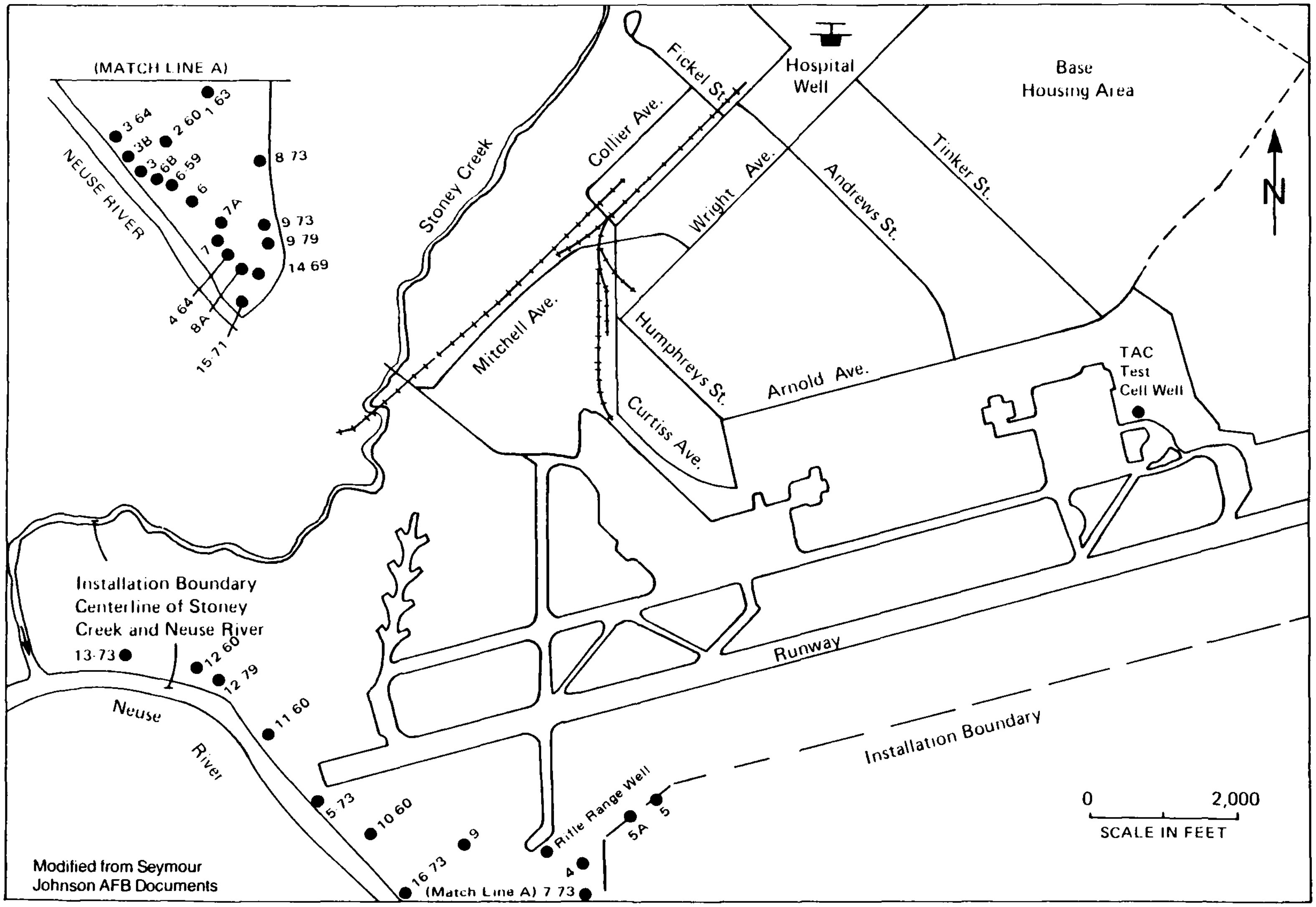


Figure 15. Location of Base water-supply and service wells.

2.2.5 Historic and Potential Groundwater Problems

The information available for this evaluation did not reveal any significant historic groundwater problems in the vicinity of the Base. The iron content of the aquifers is variable and can limit the suitability of groundwater for potable supply and agricultural uses. Adequate supplies of high quality groundwater exist, however, to meet local supply demands in the foreseeable future (Robison and Mann, 1977).

In Coastal Plains settings, such as those found in the Wayne County area, surficial aquifers are commonly susceptible to contamination. Because these aquifers are within a few feet of the land surface, they commonly become contaminated locally from septic systems, surface spills, or waste disposal practices. Principal aquifer systems are generally protected from contamination in areas where significant deposits of clay tend to confine the more permeable deposits used for water supply. Potential groundwater problems could arise in principal aquifers in areas where confining beds are thin or absent and direct hydraulic communications exist with surface sources of contamination.

SECTION 3

DESCRIPTION OF FIELD PROGRAM

3.1 INTRODUCTION

In an effort to define hydrogeologic and water quality conditions beneath the potential contaminant source areas at Seymour Johnson AFB, Research Triangle Institute implemented a drilling, soil sampling, and groundwater monitoring program. A preliminary reconnaissance of the sites was made in late 1983. The drilling activities were conducted between January and February 1984. The monitoring wells were developed in March 1984 and sampled in April 1984. Four wells (representing sites 1, 2, 3, and 5) were resampled in May 1984 for supplemental analyses requested by the State of North Carolina (refer to Section 3.5).

The field program resulted in the installation of a total of 8 shallow soil borings (noncased) and 21 borings that were converted to monitoring wells. Borings and monitoring wells installed at each of the potential contaminant source areas are listed in Table 1. Surveyed locations of borings and monitoring wells are indicated on Figures 3 through 10. Descriptions of subsurface conditions encountered during drilling are presented in Appendix C. Construction and surveying data for the monitoring wells and soil test borings are provided in Appendix D. Details of the field activities are presented in the following subsections.

3.2 DRILLING AND SOIL SAMPLING PROGRAM

Following a preliminary reconnaissance of the sites, locations for monitoring wells and borings were selected. Efforts were made to situate most of the wells next to and/or hydraulically downgradient from the potential contaminant source areas. In some sites, one monitoring well was also located hydraulically upgradient in order to assess the quality of relatively unaffected groundwater. Best estimates were made early in the program as to depths of monitoring wells or borings. Most of the soil test borings and monitoring wells are installed to a depth of 15 feet below land surface. The remaining monitoring wells and soil test borings are installed between 25 and 30 feet below land surface. The combination of shallow and deep monitoring wells allowed for a more complete characterization of the subsurface conditions and provided a means for determining the vertical extent of contamination.

The boreholes were drilled using conventional 6-inch diameter hollow-stem augers with inside diameters of 3.5 inches. Two drilling rigs were used on the project. A truck-mounted rig was used for all boreholes except MW-12, MW-13, MW-14, and MW-25. These boreholes required the use of an all-terrain drilling rig because of site access problems. Auger flights were steam-cleaned prior to drilling at each location to minimize possible cross-contamination between boreholes. Drilling was performed without using any drilling fluids.

Soil samples were collected at 3-foot intervals using an 18-inch long, 2-inch diameter, split-spoon sampler. The sampler was driven into the soils using the weight of a 140-pound hammer. The number of blows required to drive the sampler 12 inches with the hammer falling freely from a height of 30 inches was recorded as the penetration resistance (Appendix C). The split-spoon sampler was washed prior to collecting each soil sample to minimize cross-contamination between sampling intervals. The soil samples were placed in glass jars and sealed. The samples were subsequently refrigerated. The soil samples were classified by RTI (Appendix C), and representative portions were selected for laboratory analysis.

3.3 MONITORING WELL INSTALLATION

With the exception of the 8 soil test borings that were backfilled and/or grouted upon completion, the remaining 21 boreholes were converted to monitoring wells. The monitoring wells were used for water level measurements and groundwater sampling. Permission to install the wells was obtained from the North Carolina Department of Natural Resources and Community Development in January 1984. The monitoring wells consist of 2-inch diameter PVC casing coupled to bottom sections of 0.010-inch wide slotted PVC well screen. Since these wells were emplaced as part of an initial investigation, a PVC construction design was considered adequate. Other well construction materials may be considered for permanent, long-term monitoring. The well assembly was inserted into the hollow-stem auger flights. After the wells were in place, augers were pulled and a gravel packing was carefully emplaced around the well screen. In some cases the sandy formation materials collapsed around the well screen creating a natural sand packing. Sufficient gravel was added in the annular space of the borehole to bring the gravel pack 2 feet above the screened section. A 1-foot thick bentonite plug was then installed and the remaining annular space filled with cement. Construction details for individual wells and depths of soil test borings are provided in Appendix D.

Protective steel well covers were placed over the monitoring wells and seated 2 feet into the cement. The flange at the top of the steel covers was surveyed to the nearest hundredth of a foot above mean sea level. The location of the wells and soil test borings were also surveyed. These survey data are also provided in Appendix D. Water level measurements obtained in the wells are provided in Appendix E.

3.4 MONITORING WELL DEVELOPMENT

The monitoring wells were developed in early March 1984. Data collected during the development activities are provided in Appendix F. Most of the wells were developed by over-pumping techniques using a centrifugal pump. The intake sections to the centrifugal pump were thoroughly cleaned with laboratory soap and water between each monitoring well to minimize cross-contamination. Hand-operated pumps were used as a safety measure in wells where petroleum-related products were suspected of being present. In wells with extremely low yields, a PVC bailer was used for development. The intake section of hoses used in hand pumping as well as bailers were also thoroughly cleaned between wells.

The groundwater discharged from the monitoring wells was retained in 30-gallon containers for volume determination and observation. The groundwater extracted from wells MW-22 and MW-26 was judged to be contaminated on the basis of visual observations and odor and was therefore discharged into an oil-water separator in the POL area. Groundwater from all other wells was discharged on the ground surface in the vicinity of the wells.

The temperature and the specific conductivity of groundwater was measured during well development (Appendix F). Well development was considered complete when the specific conductance was relatively stable and the turbidity of the water significantly decreased. In those wells screened within clayey deposits, the well development commonly required the removal of as many as 50 casing volumes (Appendix F).

Well yields were estimated during the development process. Yields were typically less than 1 or 2 gal/min although a few wells yielded between 10 and 15 gal/min (Appendix F).

3.5 WATER-QUALITY SAMPLING

Following monitoring well development, groundwater samples were collected in April 1984 for water quality analysis. Prior to sampling, water levels were measured in each well (Appendix E). Water level measurements were followed by the evacuation of at least three well casing volumes of water using sampling tubing. Samples were then drawn from the well through 1/4-inch polyethylene tubing attached to a peristaltic pump. The tubing was dedicated for each monitoring well so that cross-contamination would be prevented. The volume of sample collected at each location varied depending on what laboratory analyses were to be performed. Samples requiring filtration prior to analysis were filtered in the field using 0.45-micrometer membrane filters. All sampling equipment was thoroughly washed between sites to avoid cross-contamination. Field measurements of temperature, pH, and specific conductivity were also taken at the time of each sampling. Results of these analyses are presented in Appendix G.

Efforts were made to draw samples from within the midsection of the well screen. The intake section of each tubing was permanently tagged so that consistency could be achieved in future sampling. Samples were then preserved in accordance with laboratory specifications and were kept chilled until delivery to RTI's laboratory. Results of the analyses are provided in Appendix H. Four wells (MW-15, MW-22, MW-24, and MW-25) were resampled in May 1984 for supplemental analyses requested by the State of North Carolina. These wells were selected for the resampling effort so that the extent of contamination in the POL area could be better defined. The State of North Carolina requested the supplemental analyses of water samples from these wells to test for chemical parameters that were beyond the original scope of this study. These parameters and the preferred procedures to be followed in sample collection were outlined in a written communication from the State (Adams, 1984). The analyses were performed by the USAF OEHL. Results of these analyses are provided in Appendix I.

SECTION 4

DISCUSSION OF RESULTS AND SIGNIFICANCE OF FINDINGS

Site-specific descriptions of the hydrogeology and results of soil or water-quality conditions are provided in the following subsections. The significance of these findings is summarized in Subsection 4.9.

4.1 TANK FARM FUEL LINE LEAK (SITE 1)

A description and history of the site was provided in Subsection 1.5.1.

4.1.1 Hydrogeology

The topographic setting of Site 1 is indicated in Figure 16. Site 1 is presently a nearly flat-lying area with some slope to the west. According to the Base topographic and utility maps (originating January 1959), the area was previously drained by a northwest-trending drainage ditch (Figure 16). Storm drains in this area, shown on the 1959 Base topographic and utility map, suggest a hydraulic connection between this localized storm drainage and the filled drainage ditch. This system drains to the northwest.

Six monitoring wells were installed at the site. Two inferred hydrogeologic profiles have been constructed using five of these wells (Figures 17 and 18). Several feet of fill materials have been placed in some areas of Site 1 (Figure 17). Where encountered, these materials consist of black clayey sand with some root material (Appendix C). Silty sands with a wide textural variation underlie the fill, where encountered. The silty sand strata have an average thickness of about 6 feet at the site. The sands are significantly coarser grained with layers of clayey sand at well MW-23 (Figure 18) and may represent a channel deposit within the surficial deposits. The estimated yield of well MW-23 (6 to 8 gal/min) was also significantly higher than in other wells at the site (less than 1 gal/min), indicating a localized geologic feature in the vicinity cf well MW-23.

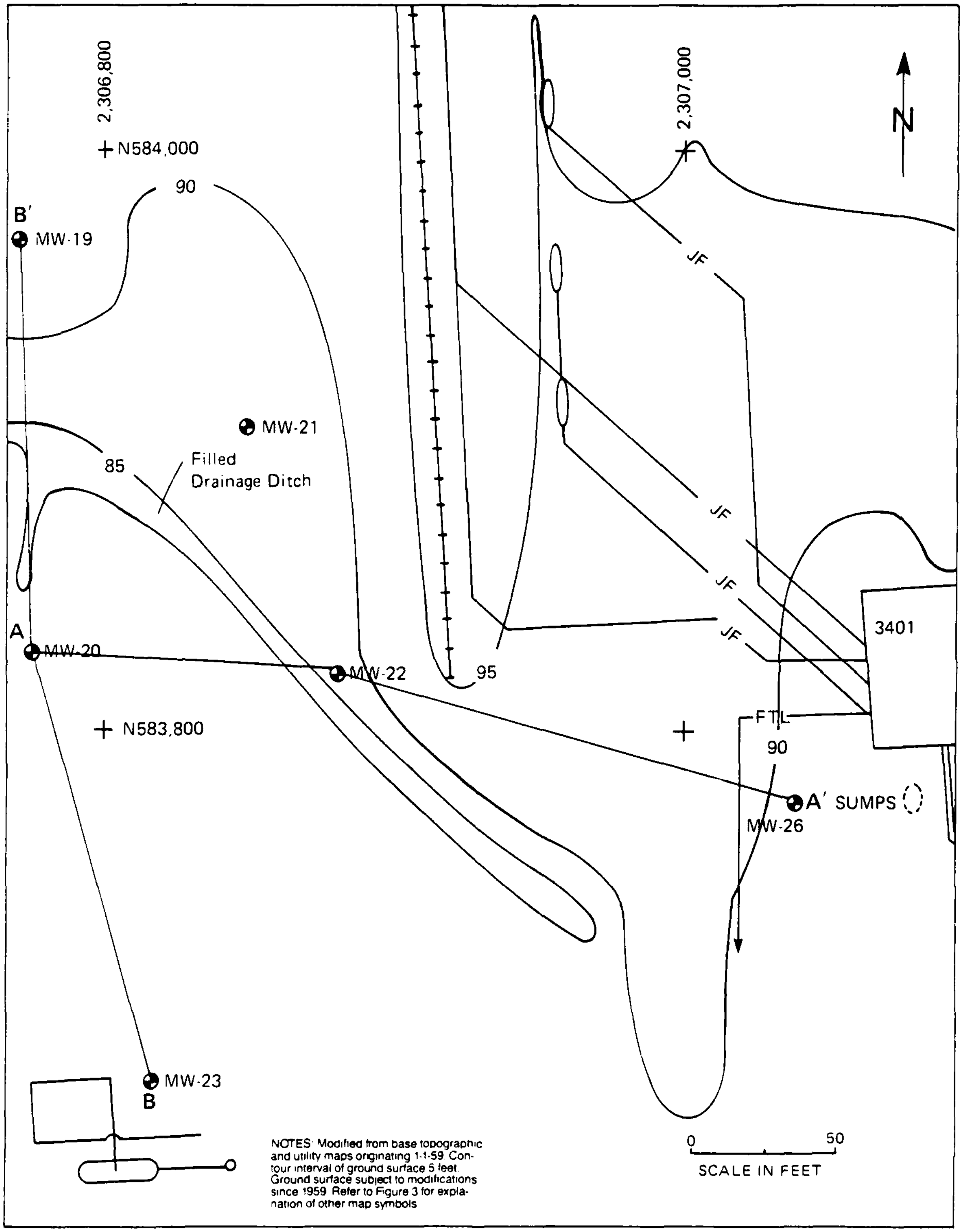


Figure 16. Topographic setting of Site 1 with location of inferred hydrogeologic profiles A-A′ and B-B′.

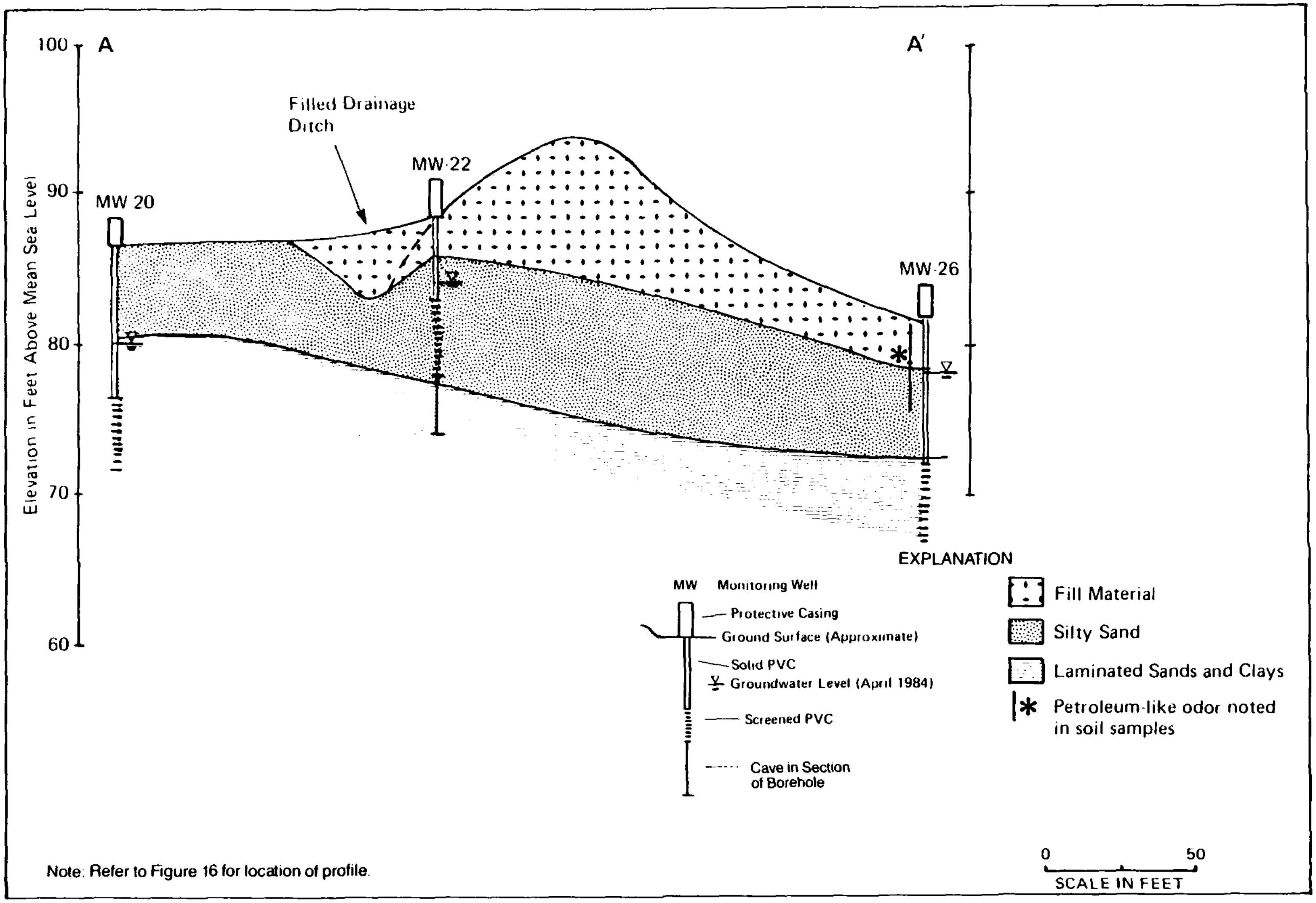


Figure 17. Inferred hydrogeologic profile A-A' (Site 1).

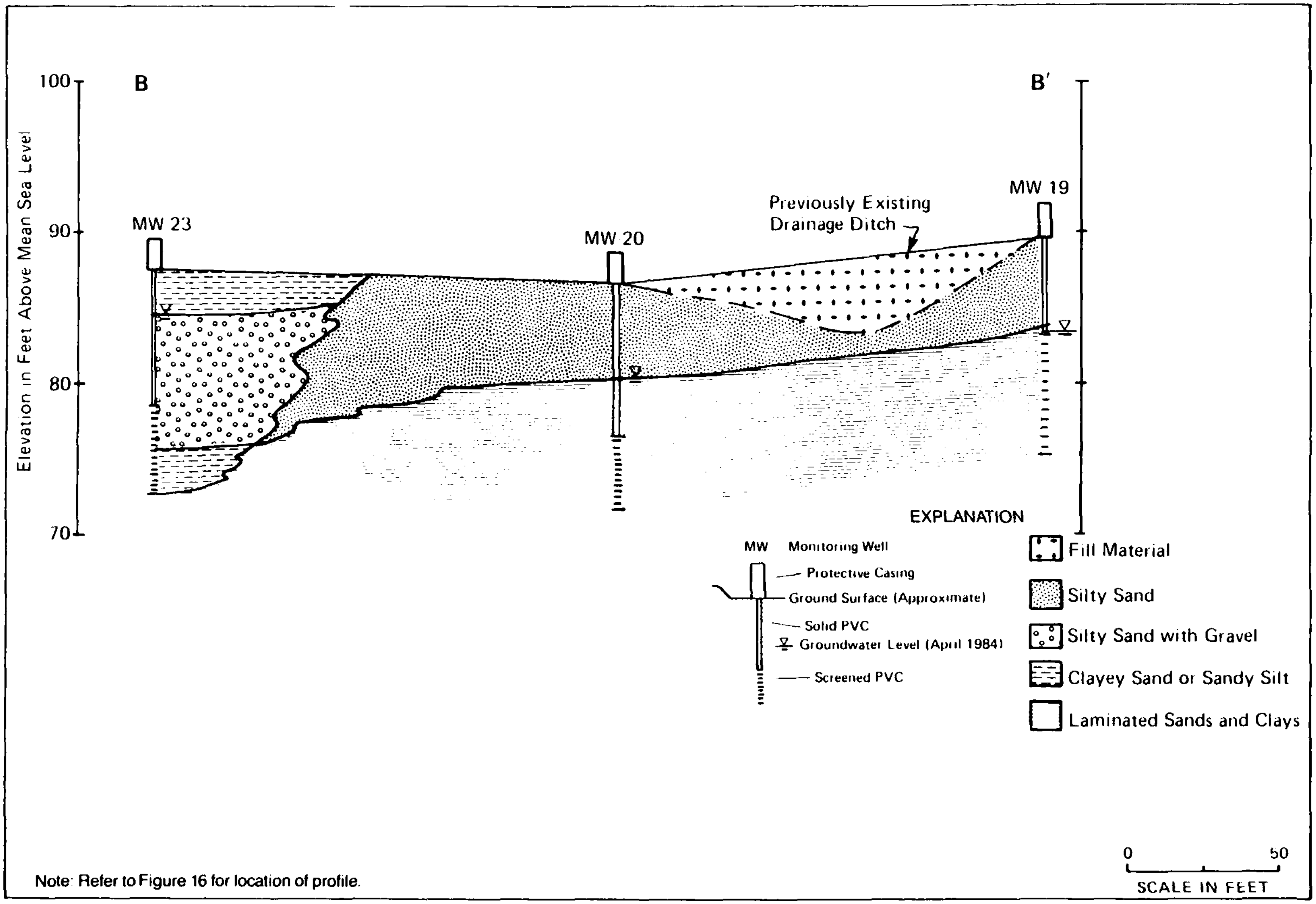


Figure 18. Inferred hydrogeologic profile B-B′ (Site 1).

The silty sands at the site are underlain by a dark gray silty clay laminated with silty fine sand. The clay fractions of the stratum predominate. This stratum, thought to represent the top of the Black Creek formation (refer to Subsection 2.2.2.5), exhibited a consistent lithology where encountered.

The depth to groundwater at Site 1 ranged from about 4 to 7 feet below land surface in early April 1984 (Appendix E). The upper sand strata constitute the surficial aquifer at the site. Wells MW-22 and MW-23 are screened within the upper sand strata and appear to have comparable groundwater elevations (Figure 19). The direction of groundwater flow within the upper sand strata is inferred to be to the west. Some groundwater discharge likely occurs into the main POL area drainage ditch, a portion of which is attributable to storm drain infiltration.

The remaining monitoring wells at Site 1 are partially or fully screened within the Black Creek formation. Groundwater elevations in these wells are typically lower than those screened in the silty sand strata (Figure 19). This may indicate a downward flow component in the Black Creek formation, but additional paired wells would be required to confirm flow components in this heterogeneous material. It is assumed that the principal component of flow in the uppermost aquifer is horizontal. The low groundwater elevation in well MW-26 may be impacted by withdrawal of JP-4 and groundwater from the adjacent sumps (Figure 19).

Groundwater levels declined in wells MW-19, 20, and 21 between February and April 1984. Groundwater levels rose slightly in wells MW-22 and MW-26 over this same time period (Appendix E).

4.1.2 Groundwater Quality

Groundwater quality degradation was apparent in wells MW-22 and MW-26 during well development (refer to observations of discharged groundwater in Appendix F). Groundwater produced from well MW-22 was initially noted to have an unusual deep red-brown coloration that was not noticed in any other groundwater samples on the base. When water collected during the development of well MW-22 was allowed to settle in a clear beaker, it was noted that the red-colored water separated to the bottom of the beaker and was overlain by a chocolate-brown colored water. The groundwater did not have this deep

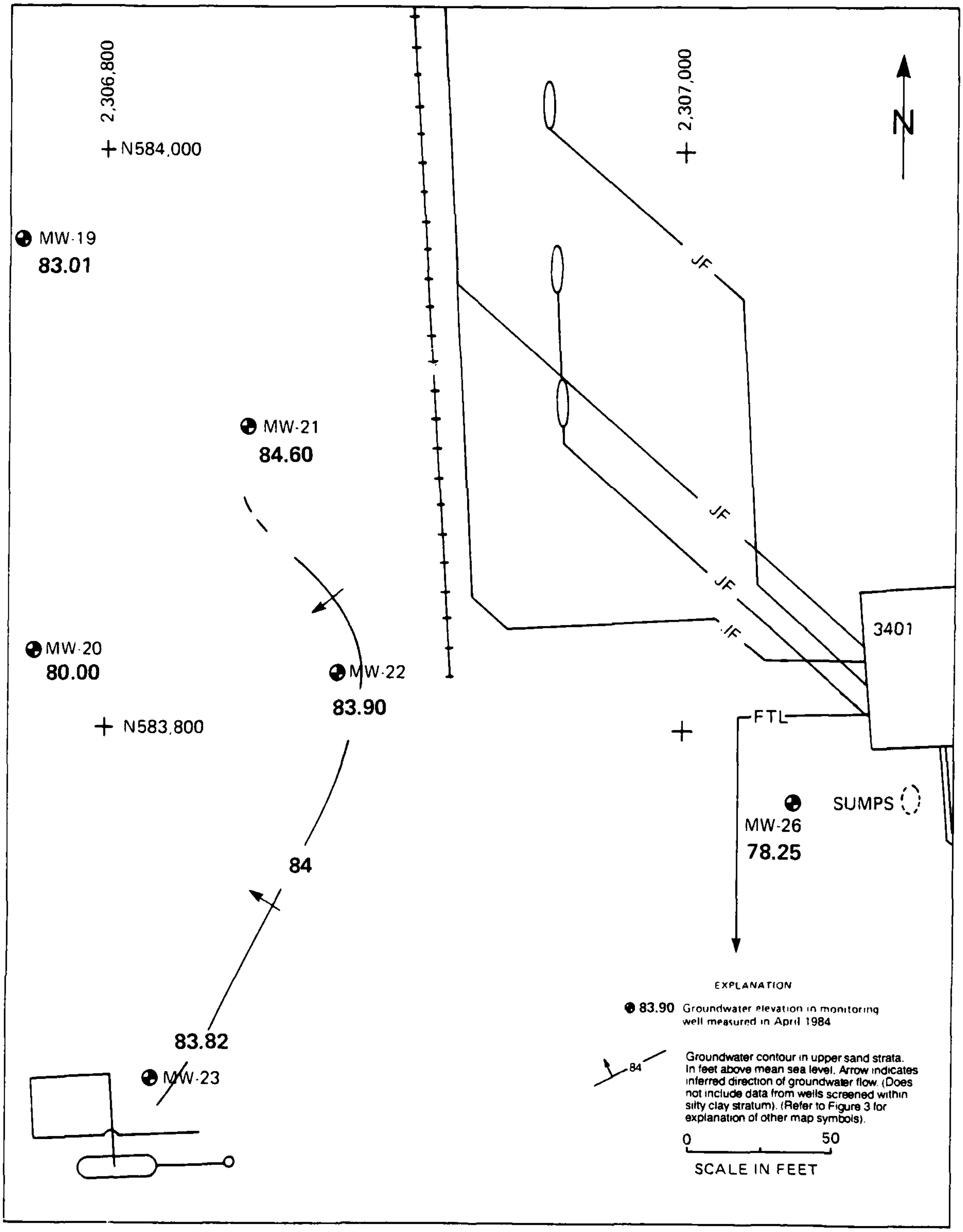


Figure 19. Groundwater elevations at Site 1 with inferred direction of flow in upper sand strata.

red coloration at the time of sampling in May 1984, when the groundwater was noted to have only a pinkish hue. The soil sample collected between 9 and 12 feet in the boring for well MW-22 was also noted to have an unusual dark red-brown coloration that was not observed in any other soil samples collected on Base (Appendix C). Similarly, the fuel-oil-like odor noted in the groundwater samples from MW-26 was also detected in soil samples collected from the ground surface to a depth of 9 feet. It is significant to note that the odor was not detected deeper in MW-26 within the finer grained, clayey deposits of the Black Creek formation.

The results of field measurements conducted on groundwater samples from Site 1 did not reveal any unusual water quality conditions (Appendix G). Specific conductivities ranged from 35 to 87 micromhos per centimeter (μmho/cm) and the pH ranged from 4.45 to 5.70.

The results of the April 1984 water quality analyses for Site 1 are presented in Appendix H, Table H-1. The oil and grease analyzed in well MW-26 (3.21 mg/l) was higher than that measured in the remaining Site 1 wells. The total organic carbon was also elevated (above 3 mg/l) in wells MW-19, MW-22, MW-23, and MW-26. In addition, well MW-26 had measurable concentrations of volatile organic compounds indicative of petroleum-related compounds (Table H-1). Well MW-22 also had elevated concentrations of volatile aromatics and halocarbons in the supplemental analyses conducted for the State in May 1984 by USAF OEHL (Appendix I).

4.1.3 Conclusions

The results of the analyses indicate that petroleum-related products are present in the surficial aquifer in localized areas at Site 1. The actual source of the contamination has not been documented but could be associated with fuel lines or the tank farm spill, both of which are upgradient of the site. Water quality data obtained by the analyses are believed to represent conditions in the surficial aquifer, since the Site 1 wells only partially penetrate the top of the Black Creek Formation. The total extent of the contamination is not known, but it is likely that the petroleum-related products have not extended significantly into the clayey deposits of the Black Creek formation and are following preferred horizontal paths of higher hydraulic conductivity within the aquifer. The surficial aquifer at Site 1 is thought to discharge into drainage ditches west of the POL area railroad tracks where petroleum-related products have been encountered in the surface water. Some contaminant transport to surface water streams may also be attributable to infiltration via storm drains located around Site 1. Additional shallow well points and supplemental water quality analyses would be necessary to quantify the extent and source of contamination.

4.2 DITCH ADJACENT TO RAILROAD TRACKS (SITE 2)

A description and history of the site is provided in Subsection 1.5.2.

4.2.1 Hydrogeology

The topographic setting of Site 2 is indicated in Figure 20 along with the location of an inferred hydrogeologic cross section. The ditch adjacent to the railroad tracks drains to the north into the main POL area drainage ditch. The land surface is a few feet higher east and west of the ditch.

One monitoring well (MW-25) was installed at the site, and an inferred hydrogeologic cross section has been constructed on the basis of data from this well and site observations (Figure 21). The upper 5 feet of soils encountered at the site are silty fine sands (Appendix C). These soils overlie a dark gray silty clay laminated with gray silty fine sand (assumed to represent the top of the Black Creek formation).

Well MW-25 is screened just within the top of the Black Creek formation and had one of the lowest well yields estimated on the Base (significantly less than 1 gal/min). Groundwater was encountered at a depth of only 0.35 feet below land surface in early April 1984 at the site (Appendix E). The drainage ditch adjacent to the railroad tracks appears to intercept groundwater flow from the east and west side based on site observations of seepage. However, this relatively shallow drainage ditch may only intercept the upper portion of groundwater flow in the surficial aquifer. Additional shallow well points would be necessary to define more completely the influence of the drainage ditch on groundwater flow conditions.

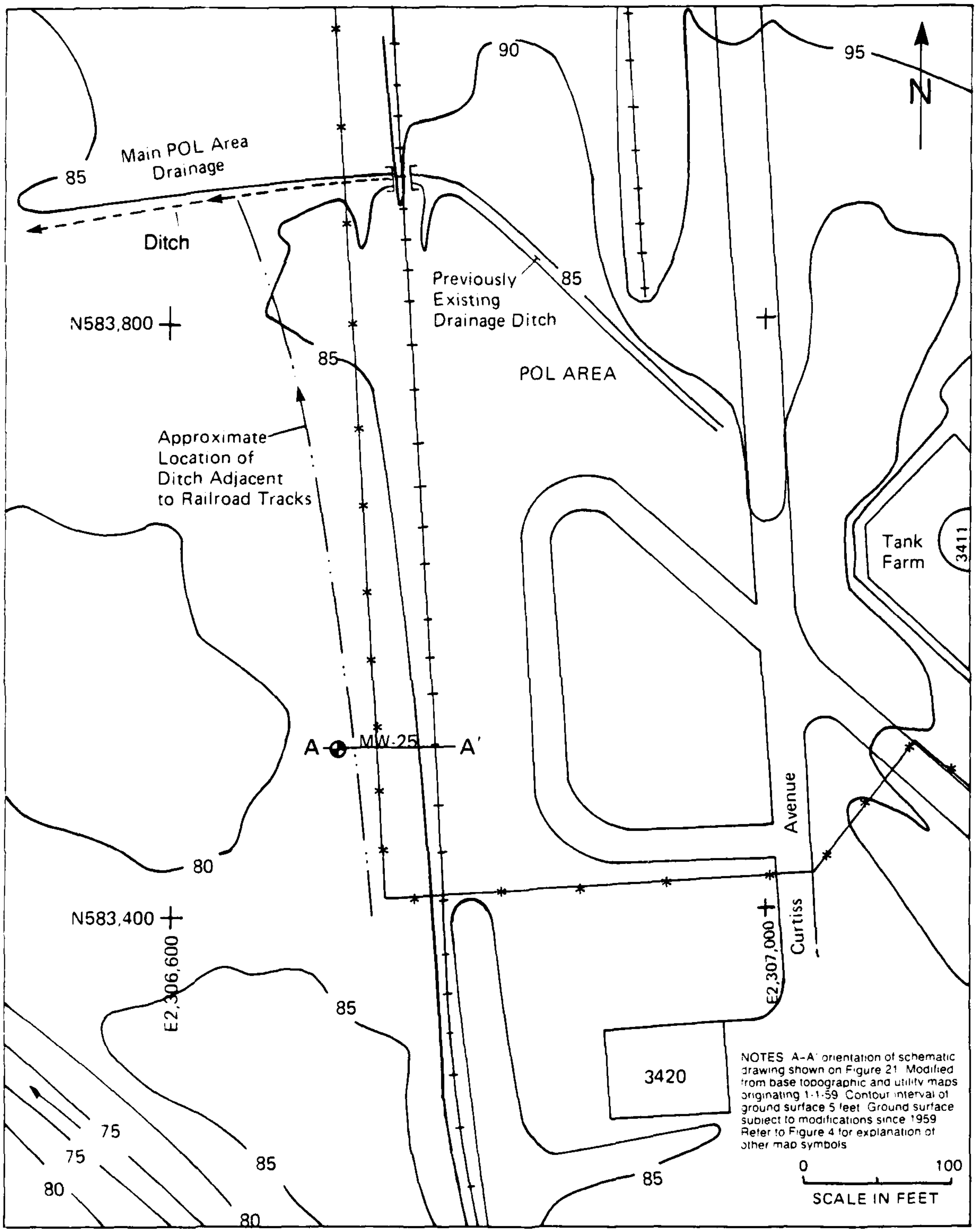


Figure 20. Topographic setting of Site 2.

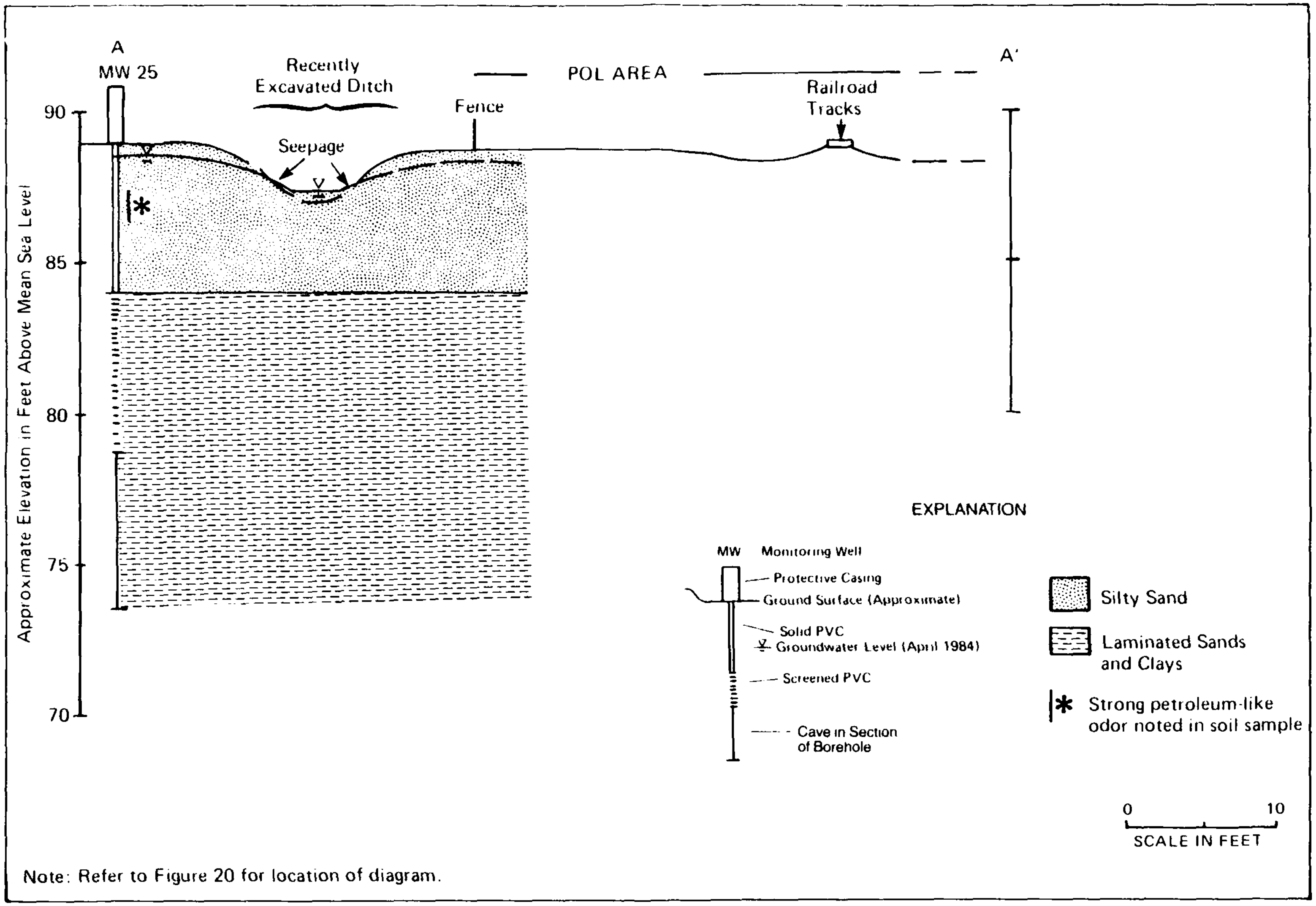


Figure 21. Schematic diagram of subsurface conditions (Site 2).

4.2.2 Groundwater Quality

A strong petroleum-like odor was noted in the soil sample collected between 3 and 5 feet in the boring for MW-25. The seepage entering both sides of the drainage ditch also exhibited a strong petroleum-like odor and a gray, oily film. A specific conductivity between 35 and 38 μmho/cm and a pH of 5.10 was measured in the field on groundwater collected from the well (Appendix G) and did not reveal any unusual water quality conditions.

The results of water quality analyses for Site 2 are presented in Appendix H, Table H-2. The measurements of total organic carbon and oil and grease are below most of the values measured in groundwater samples from Site 1. Total organic halogen was not detected. Volatile organic compounds were detected, however, in the April and May samples (Appendixes H and I, respectively). In addition, the chemical oxygen demand of the groundwater sample collected in May was 25 mg/l. Although the results of these analyses were obtained over two different sampling periods, they are believed to indicate the presence of some petroleum-related compounds in the groundwater.

4.2.3 Conclusions

The results of the analyses indicate that petroleum-related products are present in the surficial aquifer at Site 2 since MW-25 only penetrates the very top of the Black Creek formation. The actual source of the contamination has not been documented, but is probably associated with groundwater discharging from the POL area. The actual extent of the contamination is not known. The drainage ditch is not deep enough to intercept all groundwater flow in the surficial aquifer, and some groundwater contamination could be encountered further west of the ditch. It is unlikely that the petroleum-related products have extended significantly into the clayey deposits of the Black Creek formation. Additional shallow well points and supplemental water quality analyses would be necessary to quantify the extent of contamination.

4.3 DRAIN PIPE OUTFALL/CRS DITCH (SITE 3)

A description and history of the site is provided in Subsection 1.5.3.

4.3.1 Hydrogeology

The topographic setting of Site 3 is indicated in Figure 22 along with the location of an inferred hydrogeologic cross section. The storm drain roughly parallels the east side of the railroad tracks and is in a slightly depressed topographic swale with elevations less than 85 feet above msl. The storm drain originates in the POL area and discharges into the CRS ditch. The CRS ditch is below elevation 75, msl (Figure 22).

One monitoring well (MW-24) was installed at the site immediately east of the storm drain. The schematic diagram has been constructed on the basis of data from this well and site observations (Figure 23). The upper 12 feet of soil at the site consist of multicolored interbedded silty and clayey sands. A gray fine sandy silty clay was encountered below 12 feet and may represent the top of the Black Creek formation.

Groundwater was encountered at a depth of 2.5 feet below land surface at the site in early April 1984. The groundwater level had declined only 0.3 feet since February 1984 (Appendix E). Well MW-24 is screened partially within the silty sand strata and the underlying silty clay stratum (Figure 23). The well had a low yield of less than 1 gal/min (Appendix F). The groundwater elevation appears to be representative of those in the surficial aquifer. Groundwater flow is assumed to be to the south or southwest where discharge is likely to occur into the deep CRS ditch (Figure 23).

4.3.2 Groundwater Quality

A specific conductivity of between 63 and 67 μmho/cm and a pH of 5.45 was measured in the field on groundwater collected from well MW-24 and did not reveal any unusual water quality conditions (Appendix G). The results of the water quality analyses for Site 3 are presented in Appendix H, Table H-3. Significant concentrations of total organic carbon and oil and grease were measured in the groundwater (8.7 and 4.67 mg/l, respectively). Total organic halide was not detected. Volatile organic compounds were detected in the April and May samples (Appendix H and I, respectively). The samples analyzed in May indicate higher concentrations of organic

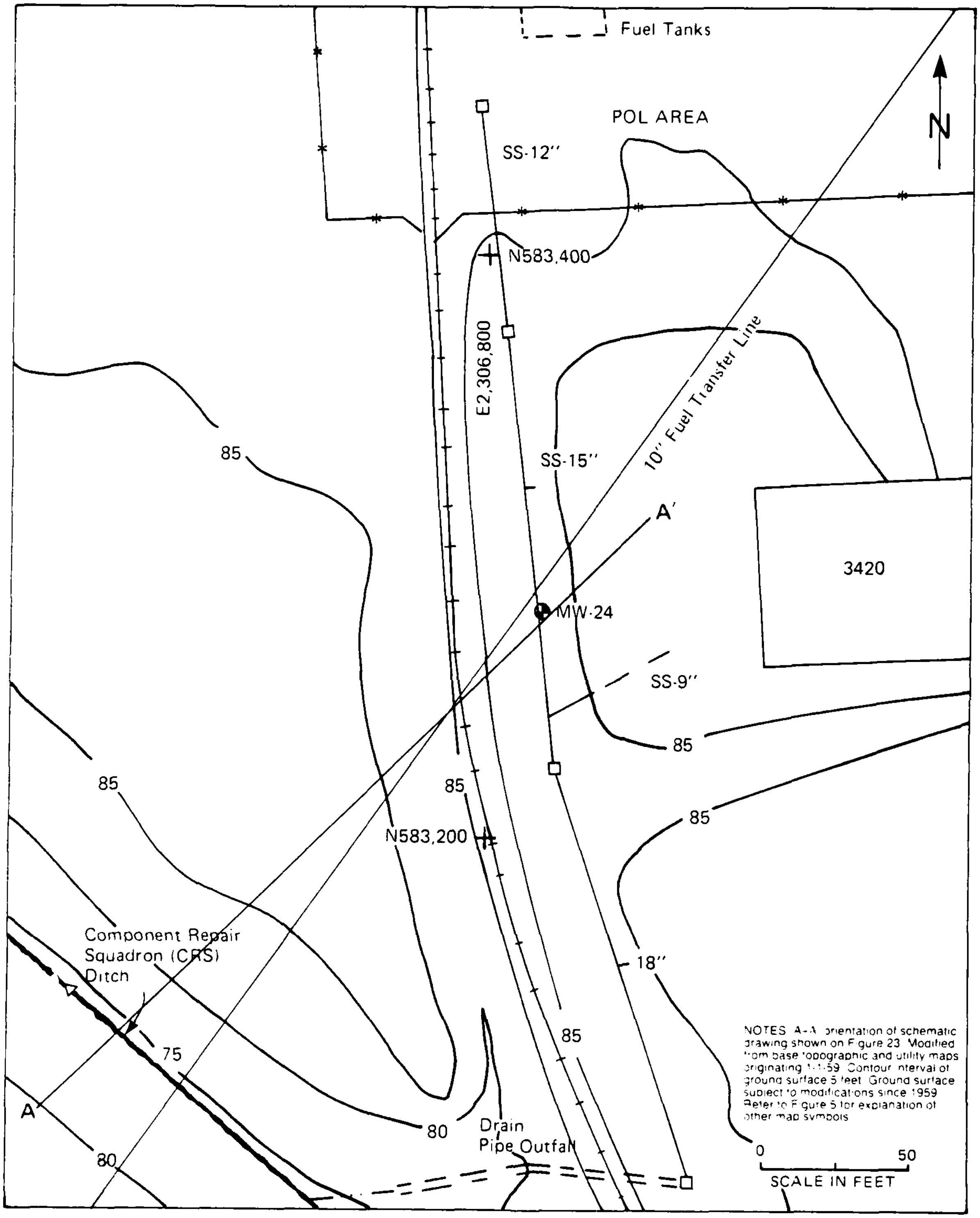


Figure 22. Topographic setting of Site 3.

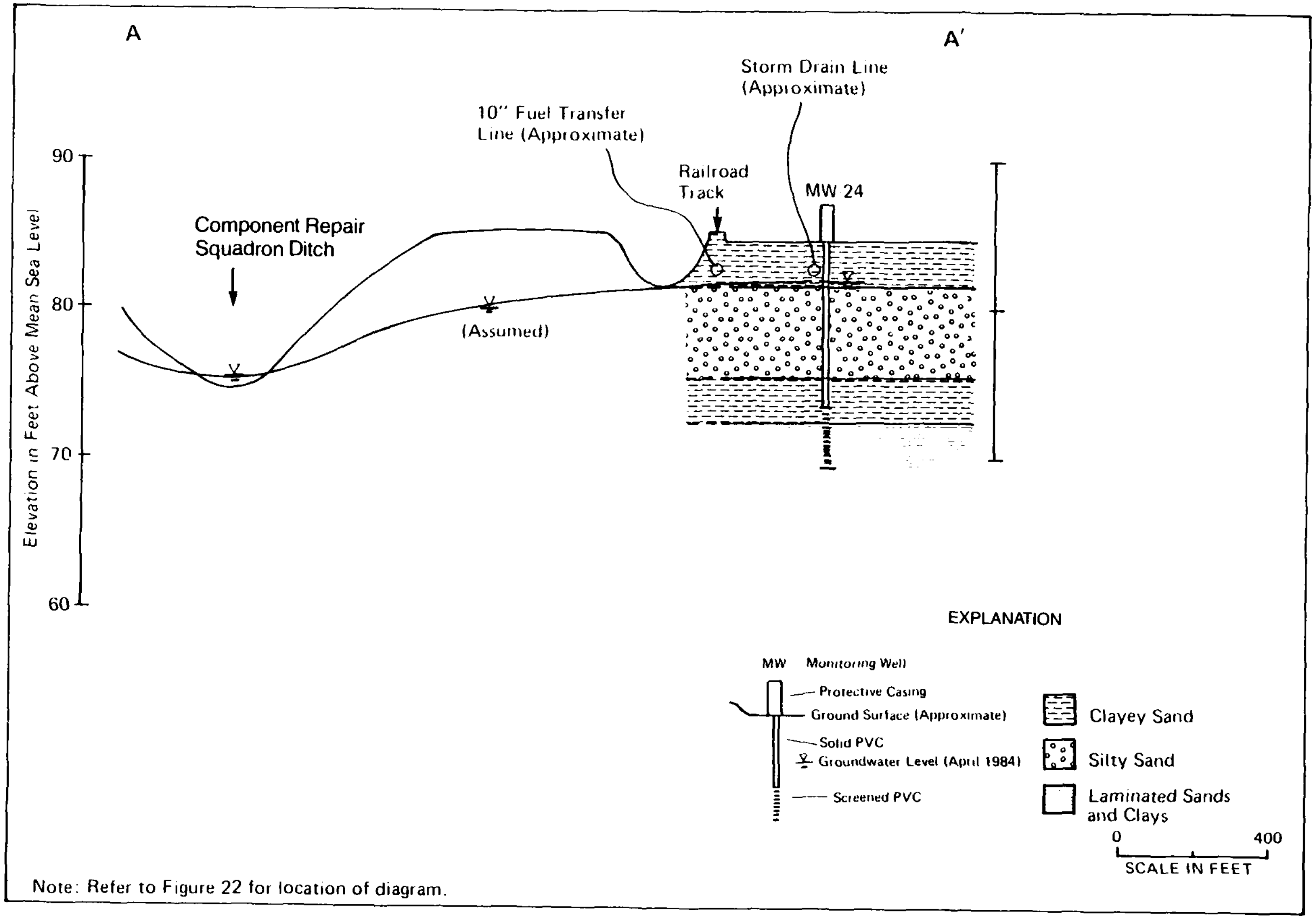


Figure 23. Schematic diagram of subsurface conditions (Site 3).

compounds than in the April samples. The concentrations of organic compounds are generally higher at Site 3 than at other sites studied on the Base and are indicative of petroleum-related compounds in the groundwater.

4.3.3 Conclusions

The results of the analyses indicate that petroleum-related products are present in the surficial aquifer at Site 3. The actual source of the contamination has not been documented but is probably associated with groundwater discharging from the POL area. Some of this contaminated groundwater may be intercepted by the storm drain resulting in more rapid contaminant transport, as strong odors of petroleum-related products have been noted in the catch basins and increasing flows have been observed in this pipe system. Some groundwater contamination may extend west and south of the storm drain, and it is expected ultimately to discharge into the CRS ditch. The primary flow component of groundwater contaminants in this area is expected to be horizontal. Additional shallow well points and supplemental water quality analyses would be necessary to quantify the extent and source of contamination.

4.4 FUEL HYDRANT SYSTEM LEAK (SITE 4)

A description and history of the site is provided in Subsection 1.5.4.

4.4.1 Hydrogeology

The topographic setting of Site 4 is indicated in Figure 24 along with the location of two inferred hydrogeologic profiles. The site generally slopes to the south-southwest, with about 25 feet of relief. Major storm drains present in the area are also indicated on Figure 24. The storm drains discharge into the main southern-drainage ditch.

Six monitoring wells were installed at Site 4. Well MW-1 was intended to serve as a well upgradient of the fuel hydrant system, and the remaining wells were to serve as downgradient wells. The two parallel hydrogeologic profiles at the site (Figures 25 and 26) are based on subsurface conditions encountered in these wells. The conditions encountered are similar as seen by comparison of the profiles.

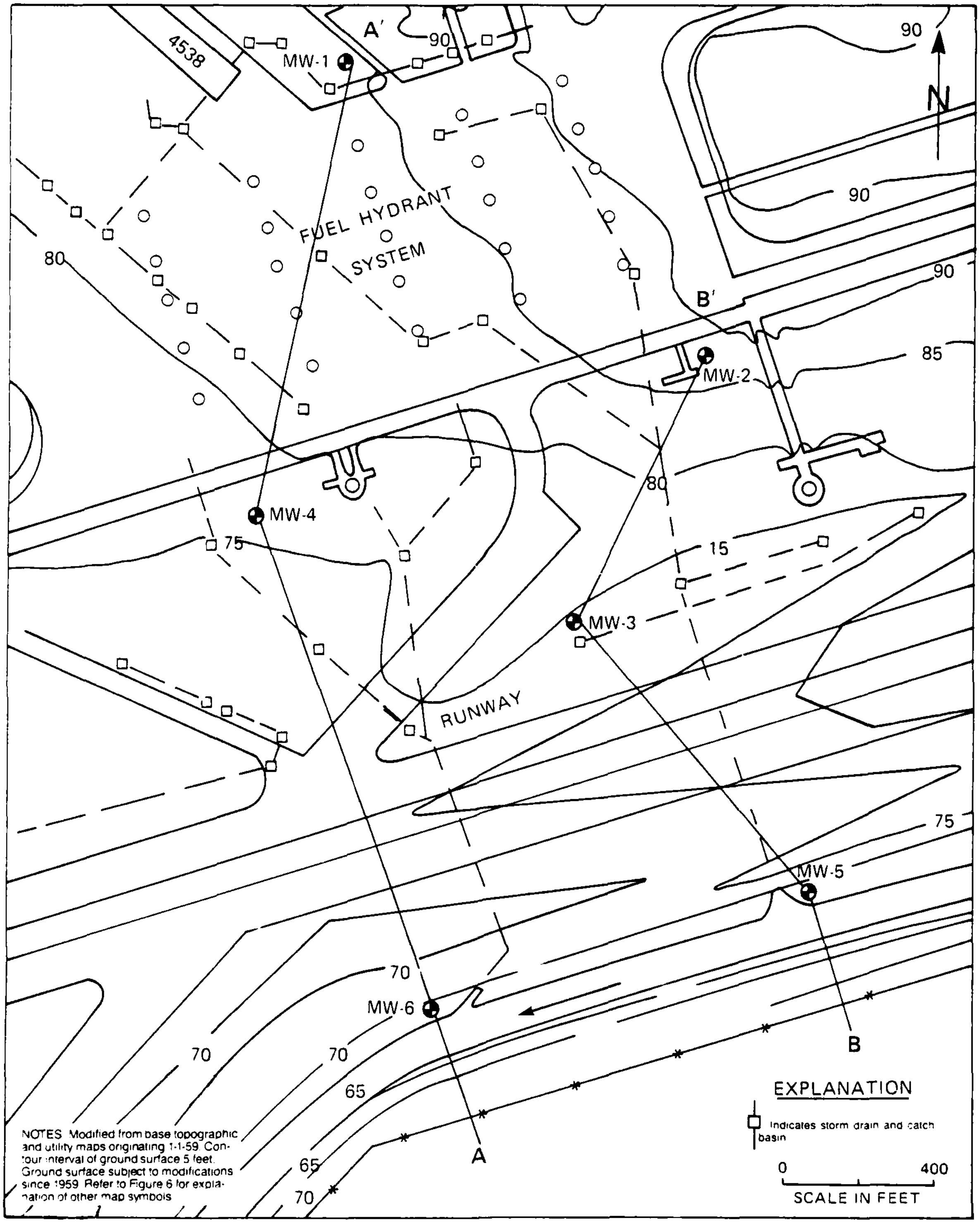
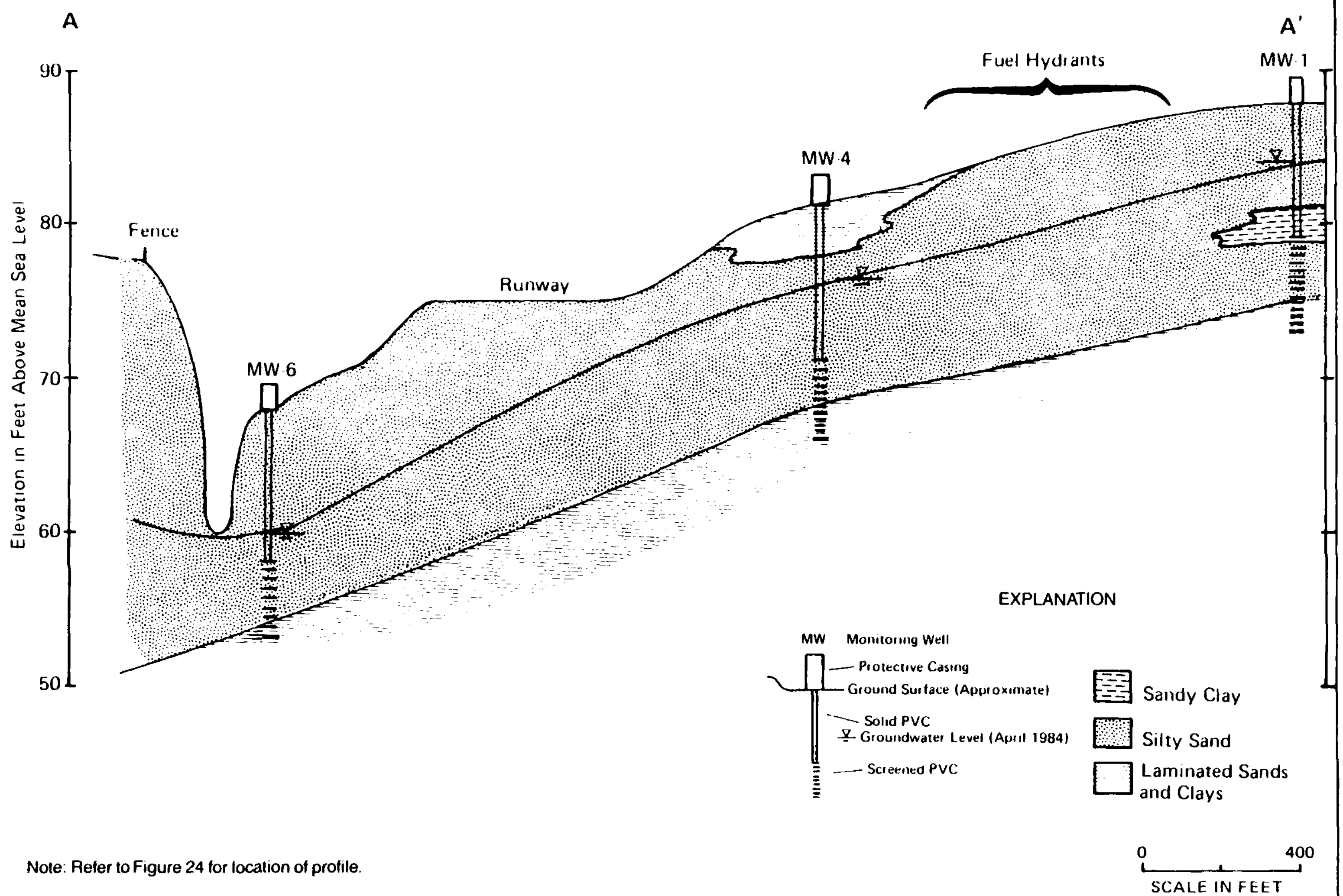


Figure 24. Topographic setting of Site 4 with location of inferred hydrogeologic profiles A-A′ and B-B′.



Note: Refer to Figure 24 for location of profile.

Figure 25. Inferred hydrogeologic profile A-A′ (Site 4).

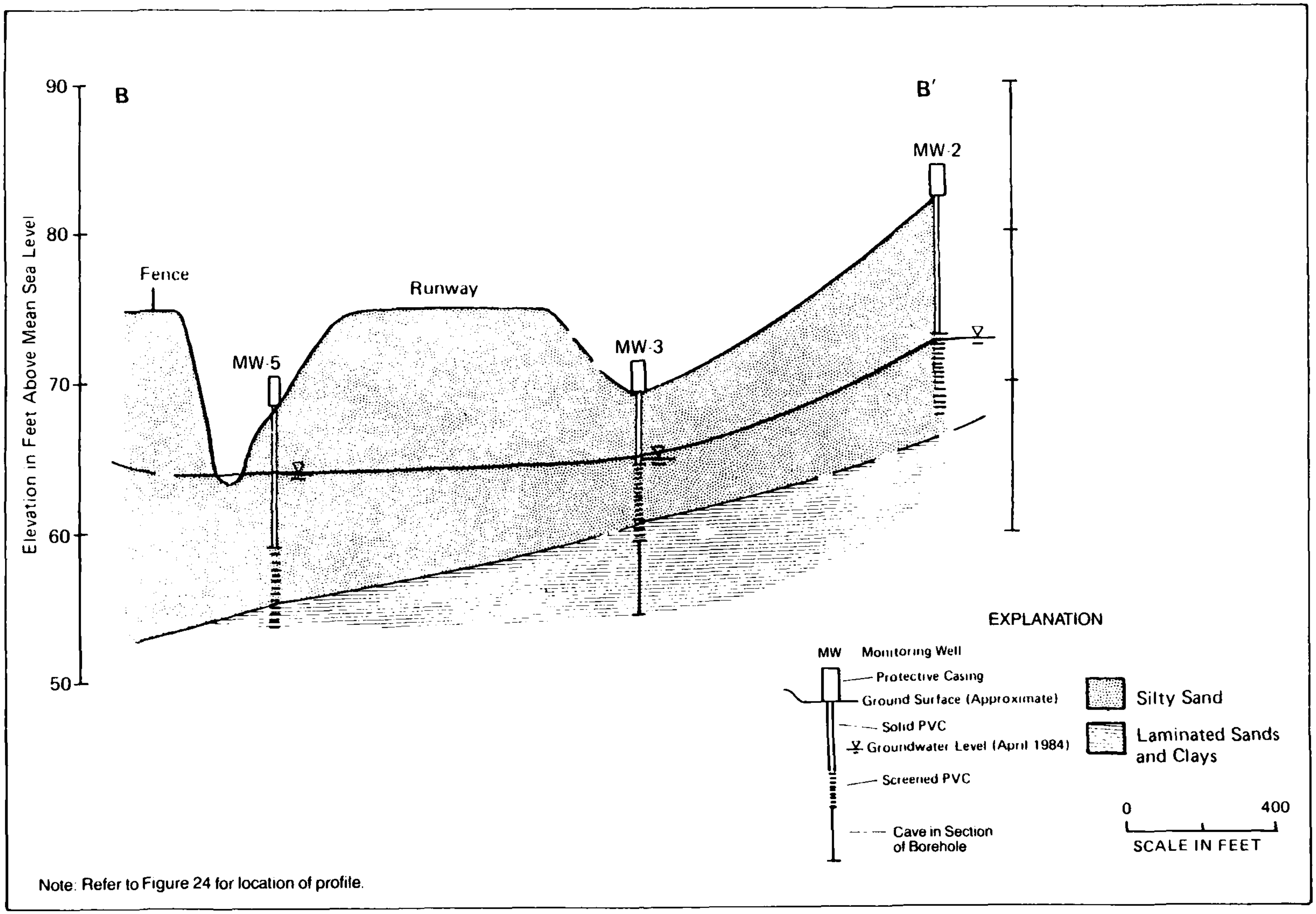


Figure 26. Inferred hydrogeologic profile B-B′ (Site 4).

The upper 10 to 20 feet of sediments beneath the site are predominantly multicolored silty sands with a wide variation in texture. Some localized deposits of silty clay are present within the sand strata. The sand strata are underlain by a dark gray silty clay laminated with gray silty fine sand as observed in borings used for wells MW-1 and MW-3 (Appendix C). This stratum is interpreted to be the top of the Black Creek formation and is believed to exist just beneath the termination depth of well MW-2 (Figure 26). The stratum also exists at wells MW-4, MW-5, and MW-6 but appears to have transitioned into a gray silty fine sand laminated with dark gray silty clay.

Groundwater was encountered at depths of 3.6 to 9.6 feet below land surface of the site in early April 1984. All groundwater levels rose between February and April 1984 (Appendix E). The amount of fluctuation was least in well MW-1 (0.4 feet) and greatest in well MW-6 (1 foot).

The wells at Site 4 are screened within the upper sand strata and have comparable water levels. The April 1984 groundwater elevations were used to prepare a potentiometric surface of the surficial aquifer (Figure 27). Well MW-1 is in a location upgradient of the fuel hydrant system. Groundwater flows to the south where discharge occurs into the main southern drainage ditch (Figure 27). The average hydraulic gradient of the surficial aquifer is fairly flat at Site 4 (about 0.01 foot per foot). The influence (if any) of the storm drains on groundwater flow patterns cannot be ascertained by the wide spacing of these monitoring wells.

4.4.2 Groundwater Quality

The upgradient well was noted to have a higher specific conductance (155 to 170 μmho/cm) and pH (5.95) than the range of values measured in the field for downgradient wells (specific conductance of 39 to 81 μmho/cm) and pH 4.1 to 5.85). No other unusual observations were noted of water quality conditions in the field except a hydrogen-sulfide-like odor of the groundwater in well MW-4 during development (Appendix F).

The results of water quality analysis for Site 4 are provided in Appendix H, Table H-4. The total organic carbon was elevated in wells MW-4 and MW-6 (10.1 and 11.0 mg/l, respectively). The concentration of oil and grease was elevated in wells MW-3 and MW-6 (1.26 and 1.52 mg/l, respectively).

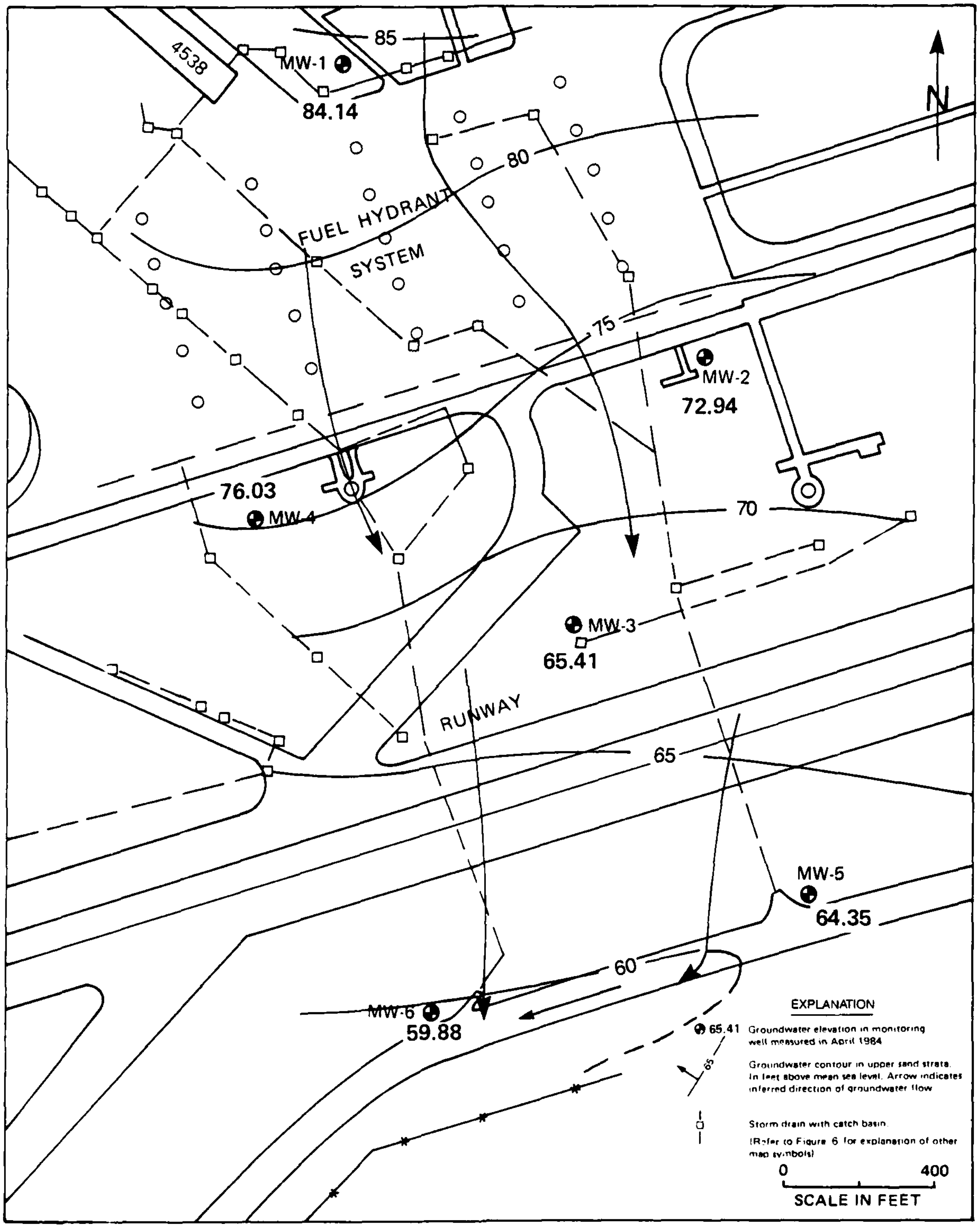


Figure 27. Groundwater elevations at Site 4 with inferred direction of flow in upper sand strata.

4.4.3 Conclusions

A limited number of water quality analyses were performed at Site 4. The results show that wells MW-3, MW-4, and MW-6, which are most directly downgradient of the fuel hydrant system, indicate water quality degradation. This degradation may be associated with petroleum-related products; however, supplemental water quality analyses would be necessary to confirm contamination of the surficial aquifer in this area. Further evaluation of flow in and near the storm drains would be needed to better understand their influence on groundwater flow and contaminant transport.

4.5 TANK FARM FUEL SPILL (SITE 5)

A description and history of the site is provided in Subsection 1.5.5.

4.5.1 Hydrogeology

The general topographic setting of Site 5 is indicated in Figure 28 along with the location of an inferred hydrogeologic profile. The top elevation of the tank farm dikes is around 95 feet above msl, and the site slopes slightly toward the POL yard to the west-southwest.

Three monitoring wells were installed at the site to a depth of about 30 feet. The wells were set relatively deep with respect to others in the monitoring program in an effort to determine if the tank 3414 spill in 1980 resulted in subsurface contamination, and the vertical extent of such contamination. Well MW-17 was intended to serve as an upgradient well. Well MW-15 is adjacent to tank 3414 (Figure 28). The inferred profile (Figure 29) has been constructed through the three wells on the basis of soil descriptions of the auger cuttings by the driller (no soil samples were collected).

The lithology beneath wells MW-15 and MW-17 is similar (Figure 29). About 7 to 10 feet of silty clays overlie 12 to 15 feet of clayey and silty sands. MW-16 differs in that silty sands occur within the upper 10 feet according to the driller's descriptions. These sand strata were encountered in all three monitoring wells and overlie a gray silty clay stratum, probably representing the Black Creek formation. All three wells are screened within the Black Creek formation.

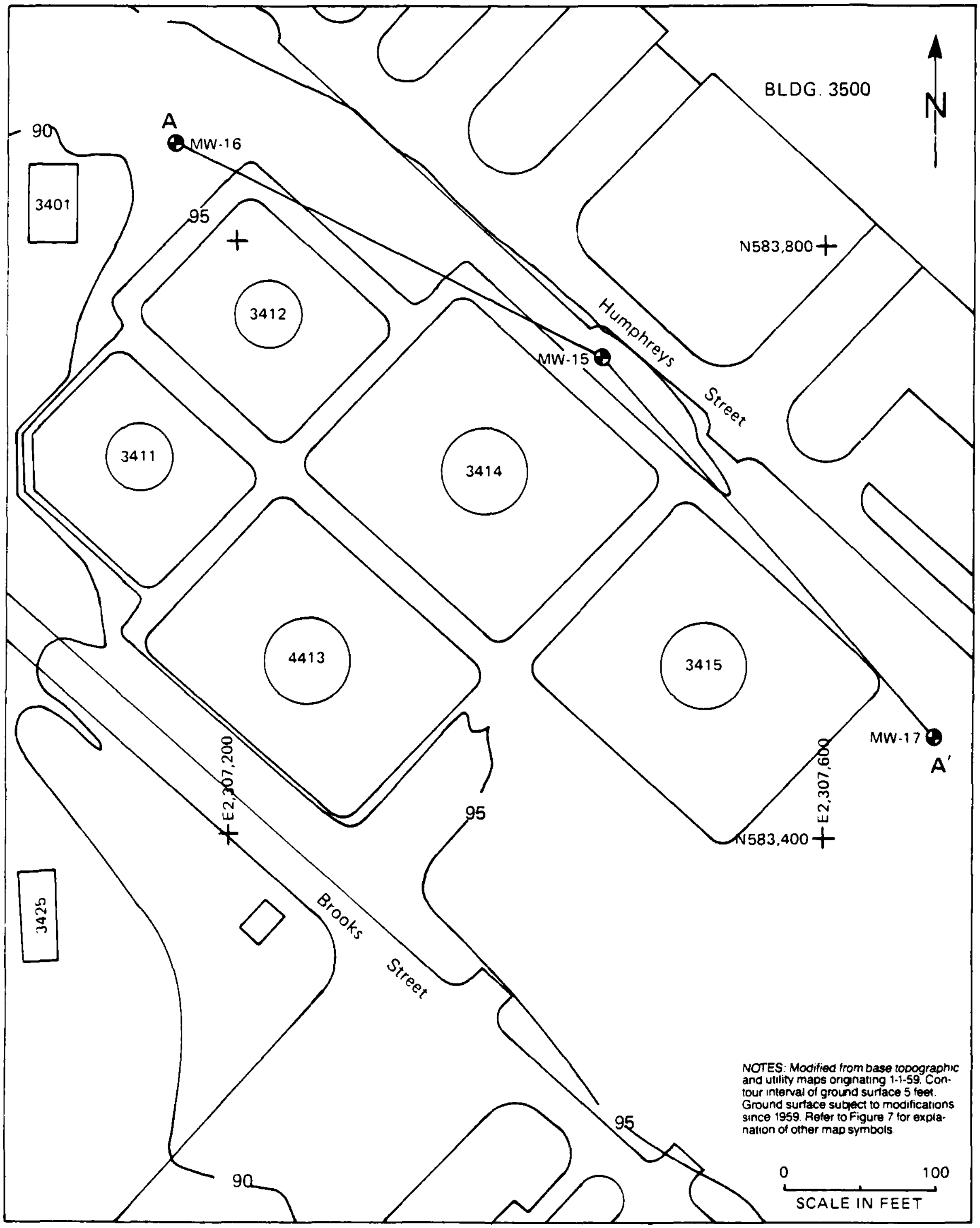
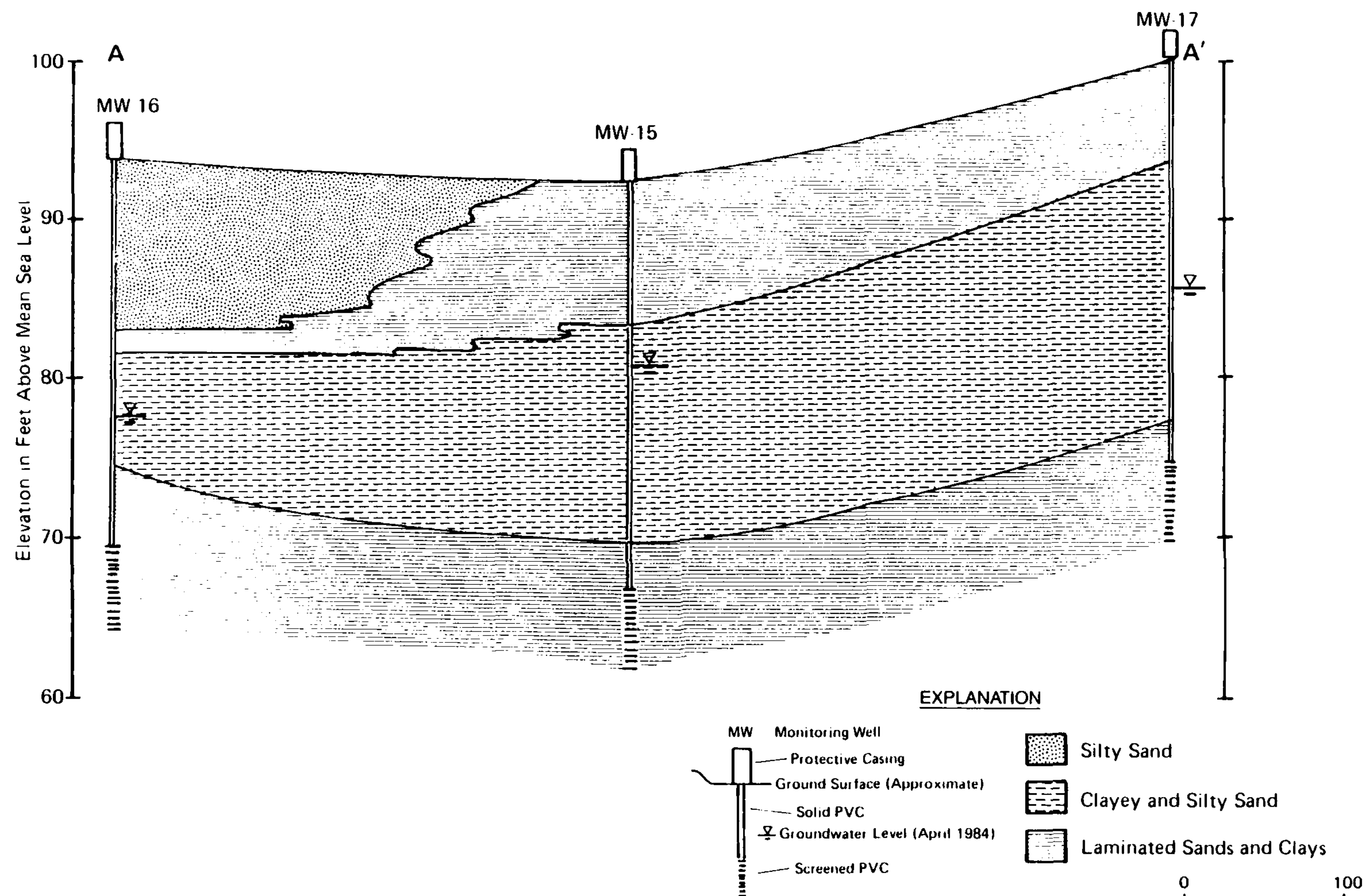


Figure 28. Topographic setting of Site 5 with location of inferred hydrogeologic profile A-A′.



Note: Refer to Figure 28 for location of profile.
Lithology based on observation of auger cuttings by driller.

Figure 29. Inferred hydrogeologic profile A-A′ (Site 5).

Well yields of MW-15 and MW-16 were less than 1 gal/min (Appendix F) and were consistent with wells at other base sites screened within the Black Creek formation. Well MW-17 had the highest yield of the monitoring wells on Base (15 gal/min) and is not representative of wells screened within the upper clayey section of the Black Creek formation. The screened and gravel-packed section of well MW-17 most likely has a direct hydraulic connection with the overlying sand strata or could be in a more permeable zone not detected in the auger cuttings by the driller.

In April 1984, groundwater was encountered at depths of 10.93 to 15.45 feet below the land surface of the site. Water levels had risen 0.4 feet in wells MW-15 and MW-17 since February but had declined 1.75 feet in well MW-16 (Appendix E). Groundwater elevations measured in April 1984 tend to indicate flow from MW-17 toward MW-16 (Figure 29). Higher groundwater elevations may exist within the overlying sand strata, but additional monitoring wells would be needed to assess the different flow components.

4.5.2 Groundwater Quality

Field measurements of groundwater quality and well development did not reveal any unusual water quality conditions. The values of specific conductance and pH measured in April 1984 were consistent in the three monitoring wells (conductivity 53 to 58 μmho and pH 4.5 to 5.1).

The results of water quality analyses for Site 5 are presented in Appendix H, Table H-5. Well MW-15 has an elevated value of oil and grease (3.6 mg/l) but relatively low total organic carbon (1.6 mg/l). These parameters were not detected in well MW-16. Although oils and greases were not detected in well MW-17, the concentration of total organic carbon was slightly elevated above average regional background values (10-15 mg/l) and well above the value seen from well MW-15 (Thomas, personal communication, 1985). As previously indicated, the water level measured within well MW-17 may be indicative of water in the overlying sand strata.

Supplemental water quality analyses of groundwater from well MW-15 performed by USAF OEHL are provided in Appendix I. These results indicate that concentrations of chemical oxygen demand, volatile aromatics, and volatile halocarbons in the groundwater are all below detection limits.

4.5.3 Conclusions

The results of the analyses indicate that petroleum-related products do not appear in the groundwater in significant quantities at the depths measured in wells MW-15 and MW-16. Although oils and greases were detected in water from well MW-15, no volatile organic compounds were detected to confirm the presence of petroleum-related products at that depth. Supplemental analyses of groundwater from well MW-17 would need to be performed to confirm the elevated concentration of total organic carbon measured. Monitoring wells would have to be installed in the silty sand strata to confirm flow components and water quality conditions in this shallower zone.

4.6 FIRE TRAINING AREA 3 AND LANDFILLS 1 AND 4 (SITE 6)

A description and history of the site is provided in Section 1.5.6. The findings of the three components of the site are discussed separately in the following subsections.

4.6.1 Fire Training Area 3

4.6.1.1 Hydrogeology--

The general topographic setting of the fire training area is indicated in Figure 30 along with the location of an inferred hydrogeologic profile. The immediate site area is fairly level but beyond the nearby fence it begins to slope to the northwest toward Stoney Creek.

One monitoring well (MW-11) was installed just northwest of the fire training area. The inferred hydrogeologic profile has been constructed on the basis of data from this well and the well at Landfill No. 1 (Figure 31).

The upper 21 feet of soil beneath the fire training area are predominantly multicolored silty sands with a wide variation in texture. A thin gravel bed was also noted by the driller near a depth of 15 feet (Appendix C). The sand strata are underlain by a gray sandy silty clay that may represent the top of the Black Creek formation.

Well MW-11 is screened just below the sand strata within the Black Creek (Figure 31). The well had one of the lower yields estimated at the Base and was not able to sustain a yield during development (Appendix F).

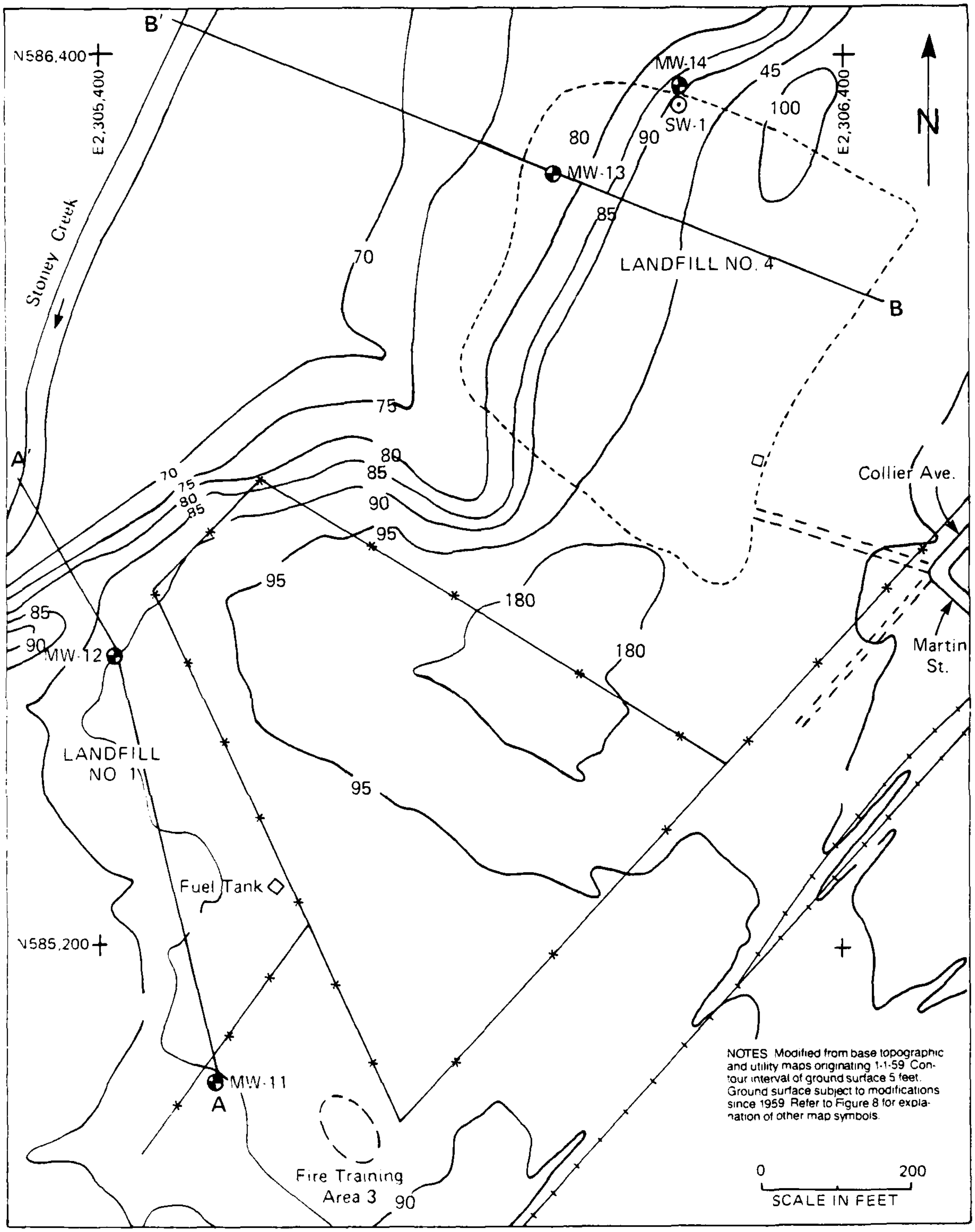
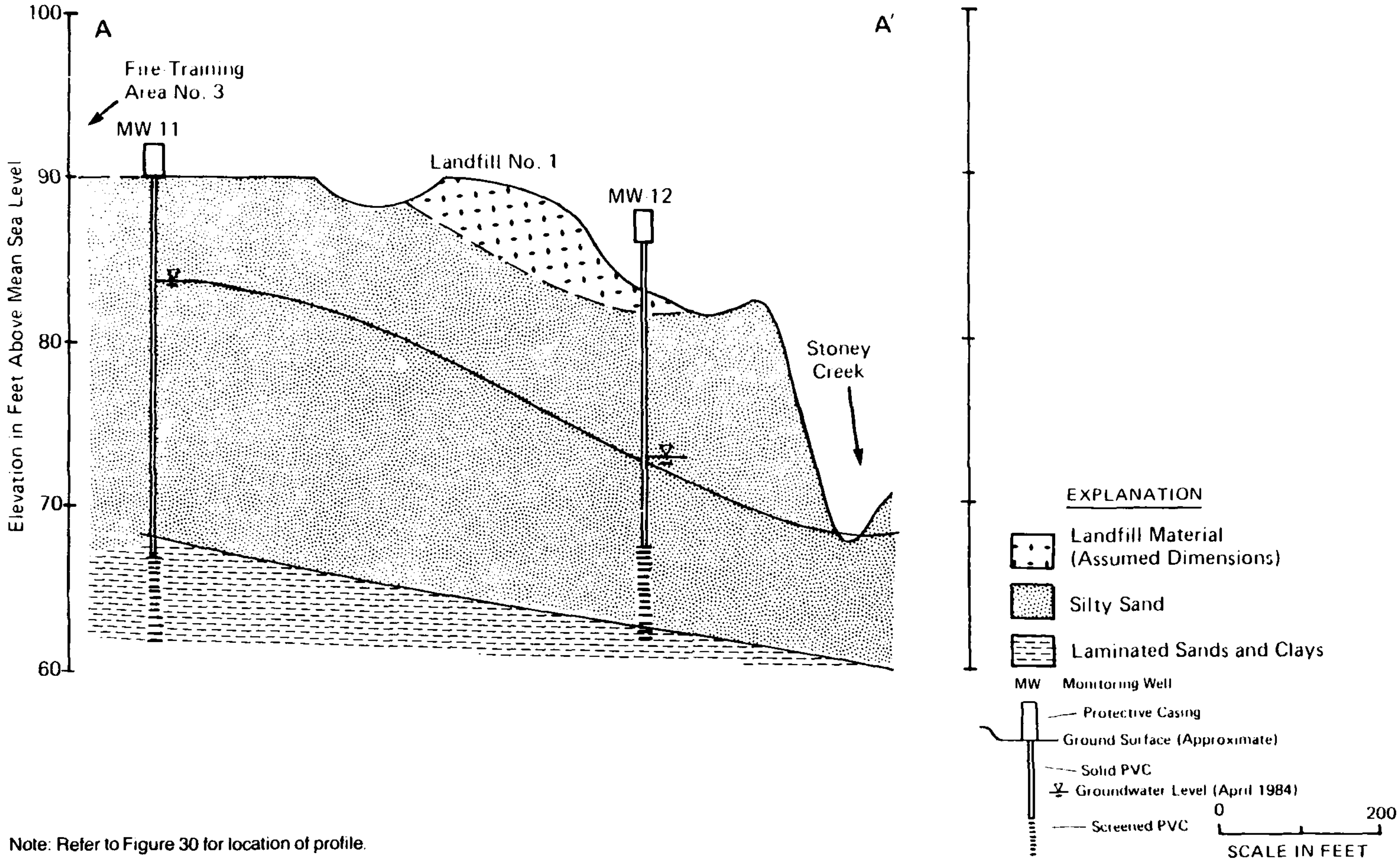


Figure 30. Topographic setting of Site 6 with location of inferred hydrogeologic profile A-A′ and cross section B-B′.



Note: Refer to Figure 30 for location of profile.

Figure 31. Inferred hydrogeologic profile A-A′ (Site 6).

Groundwater was encountered at a depth of 5.83 feet below land surface in well MW-11 in early April 1984, a rise of just more than a foot since February 1984. This shallow water level is expected to be comparable with water levels in the overlying sand strata considering the proximity of the well screen to those strata (Figure 31). Groundwater flows from the fire training area where discharge ultimately occurs in Stoney Creek. This relationship is inferred in Figure 31.

4.6.1.2 Groundwater Quality--

Field measurements of groundwater quality and well development did not reveal any unusual water quality conditions (Appendixes F and G). The specific conductance of the groundwater is around 50 µmho/cm and the pH is 5.5. The results of water quality analyses are provided in Appendix H, Table H-6. The concentrations of nitrate (<0.1 mg/l), total organic halogen (<50 µg/l), and phenol (<50 µg/l) from well MW-11 were all below the detection limits. Oil and grease (1.85 mg/l) and total organic carbon (0.6 mg/l) concentrations were above the detection limits, but not unusually elevated above average regional background values (Thomas, personal communication, 1985).

4.6.1.3 Conclusions--

On the basis of the analyses performed, no groundwater contamination was indicated at the depth sampled from well MW-11. An additional downgradient well point screened at the water table would be needed to further substantiate the absence of groundwater contamination resulting from the fire training area.

4.6.2 Landfill No. 1

4.6.2.1 Hydrogeology--

The general topographic setting of the landfill is indicated in Figure 30 along with the location of the same hydrogeologic profile used for the fire training area (Figure 31). The actual dimensions of the landfill are not known at present.

One monitoring well (MW-12) was installed between the assumed northern limits of the landfill and Stoney Creek (Figure 30). A relatively thin scattering of rubble fill material was observed in the vicinity of MW-12.

A topographically depressed area exists just northwest of the well where the northeast-trending power lines are present. Some scattered fill material is also present beneath the power lines. The topography rises further northwest of the power lines before dropping steeply to Stoney Creek (Figure 31).

Approximately 5 feet of brown sandy fill material was encountered at well MW-12. Multicolored sands were encountered between 5 and 20 feet and were occasionally silty. A gray silty fine sand laminated with dark gray silty clay was encountered at a depth of 20 feet and probably represents the top of the Black Creek formation.

Well MW-12 is screened just above the top of the Black Creek formation (Figure 31). The well had an estimated yield (less than 10 gal/min) consistent with the texture of the fine- to medium-grained sands (Appendix F). The depth to groundwater was 9.55 feet below land surface in early April 1984. The direction of groundwater flow is likely to the northwest where discharge occurs into Stoney Creek (Figure 31).

4.6.2.2 Groundwater Quality--

A slightly elevated specific conductance (100 to 142 μmho/cm) was observed in field measurements conducted on groundwater samples (Appendix G) and also during development (Appendix F). A pH of 5.55 was measured in the field.

Results of water quality analyses are provided in Appendix H, Table H-6. Except for a slightly elevated measurement of total organic carbon (3.8 mg/l) there are no other indications of groundwater degradation. The concentrations of total organic halide and phenol are below 50 mg/l and 50 μg/l, respectively.

4.6.2.3 Conclusions--

There are no strong indications of groundwater degradation downgradient of Landfill No. 1 on the basis of the analyses performed. Well MW-12 is considered to be in a representative location and depth with respect to the landfill.

4.6.3 Landfill No. 4

4.6.3.1 Hydrogeology--

The general topographic setting of Landfill No. 4 is indicated in Figure 30 along with the location of an inferred hydrogeologic cross section. The present surface of the landfill is fairly flat with a slope to the northwest. The northwestern limit of the landfill is marked by an abrupt scarp as the landfill extends onto a flat-lying plain near Stoney Creek (Figure 32).

Two monitoring wells (MW-13 and MW-14) were installed at the landfill. One seepage sample (SW-1) was also collected from a leachate migrating from the northern toe of the landfill (Figure 30). The boring used to construct well MW-13 was drilled directly through the landfill material. Fill material consisting of wood fiber, glass, plastic, paper and some clayey, sandy soil was encountered from the land surface to a depth of about 18 feet (Appendix C). The sample from 18 to 20 feet was not recovered but is assumed to be loose saturated sand or gravel near the water table. Silty sands with well-rounded pebbles were encountered to the termination of the boring at 25 feet. Well MW-14, not placed in the landfill, encountered multicolored silty sands and pebbles from land surface to a depth of 5 feet. Gray silty fine sand laminated with dark gray silty clay underlies the sand strata at MW-14 (Figure 32) and is assumed to represent the top of the Black Creek formation.

Well MW-14 is screened within the Black Creek formation, and well MW-13 is screened within the sand strata (Figure 32). The depth to groundwater beneath the land surface varies significantly between wells MW-14 and MW-13 (4.82 and 17.05 feet, respectively) as a function of the thickness of fill encountered. Even though the wells are screened in different lithologies, the groundwater elevations are believed to be generally comparable. Groundwater flow is interpreted to be toward Stoney Creek with low hydraulic gradients (Figure 33). Well yields in both wells are estimated to be less than 1 gal/min (Appendix F).

4.6.3.2 Groundwater Quality--

Field measurements of groundwater quality measured in well MW-14 did not reveal any unusual water quality conditions (Appendixes F and G). The

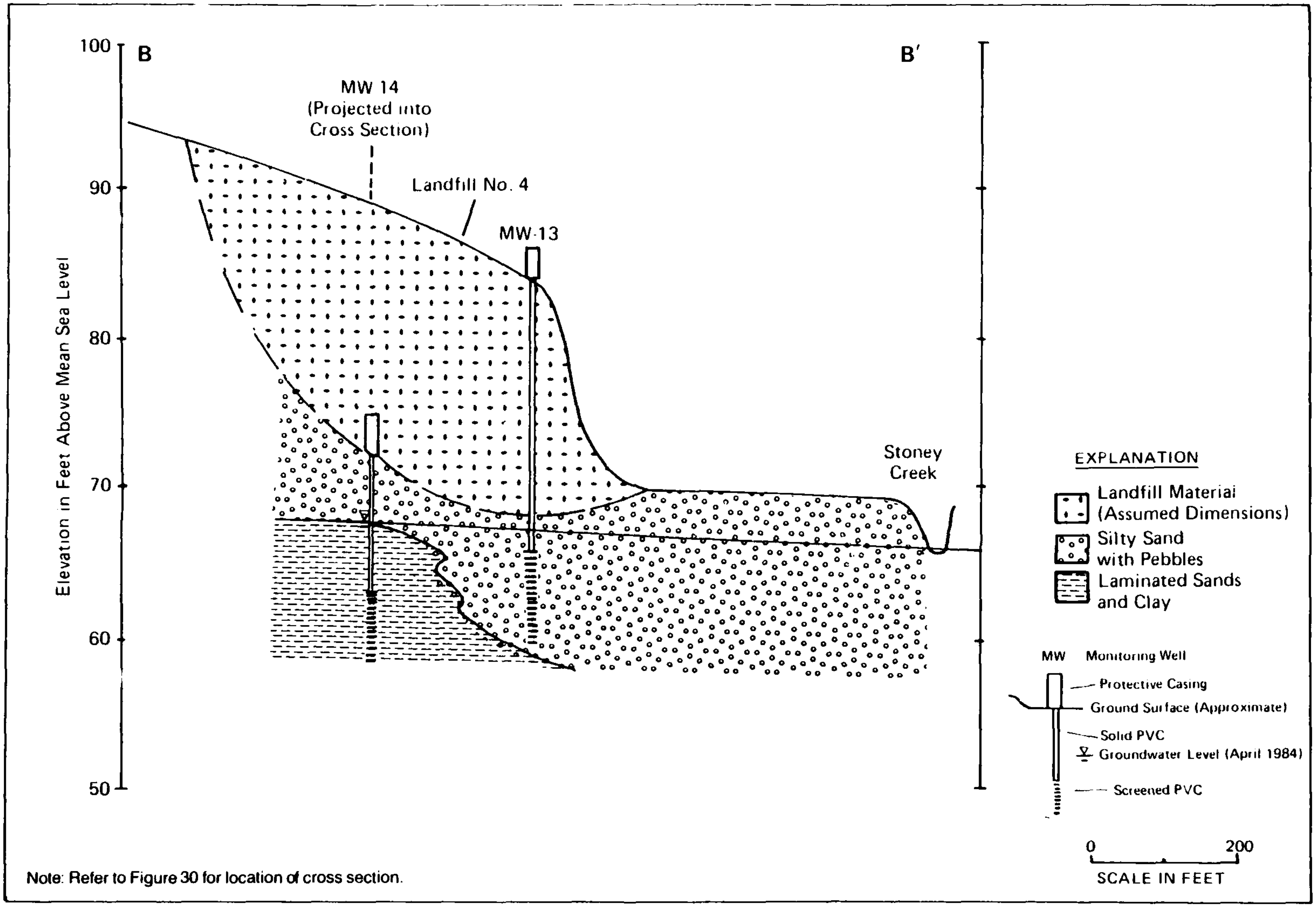


Figure 32. Inferred hydrogeologic cross section B-B′ (Site 6).

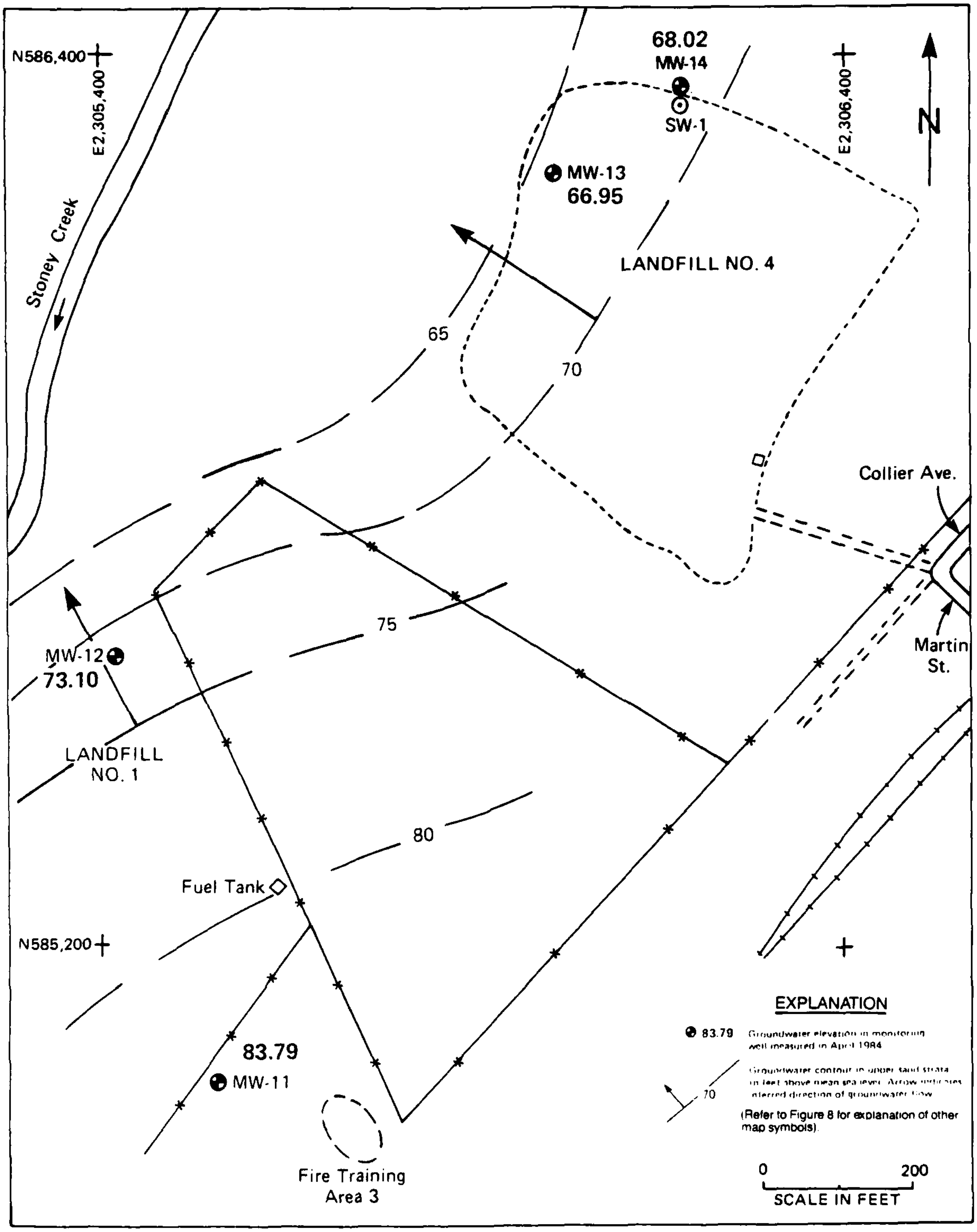


Figure 33. Groundwater elevations at Site 6 with inferred direction of flow in upper sand strata.

specific conductance of the groundwater was typically in the range of 40 to 50 μmho/cm with a pH of 4.95.

Significantly different water quality conditions were noted in the nearby seepage and in well MW-13. The seepage is covered with an oily film and has a conductivity of 1700 μmho/cm, and a pH of 6.45. A marked red-brown stain was noted in the soil surrounding the seepage. Dissolved concentrations of metals in the seepage are also detectable (lead 2.11 μg/l, cadmium 0.52 μg/l, and nickel 37.0 μg/l) although low relative to drinking water standards. Volatile organic compounds were also detected in the seepage (Appendix H, Table H-6).

The groundwater discharged from well MW-13 during development was initially noted to have a high specific conductance (1,900 μmho/cm), a strong hydrogen-sulfide odor, and a dark gray color (Appendix F). Although the specific conductance decreased throughout development, the strong odor and gray color remained. The specific conductance was also high (1,090 μmho/cm) after purging the well water before sampling in April 1984 (Appendix G). The pH of the water is also high (6.20) relative to other groundwater measured at the Base (Appendix G). Significantly high concentrations of total organic carbon (40.9 mg/l), total organic halide (100.9 μg/l) and phenol (184 μg/l) were also measured in the groundwater from well MW-13.

4.6.3.3 Conclusions--

The results of the analyses indicate that the surficial aquifer has been contaminated by Landfill No. 4 activities. The actual extent of the contamination is not known, but it appears to be contained within relatively shallow depths below the natural land surface and above the clayey deposits of the Black Creek formation. Additional shallow monitoring wells and supplemental water quality analyses would be necessary to quantify the extent and impact of contamination.

4.7 DPDO HAZARDOUS WASTE TANK (SITE 7)

A description and history of the site is provided in Subsection 1.5.7.

4.7.1 Subsurface Conditions

The general topographic setting of Site 7 is indicated in Figure 34 along with the location of an inferred hydrogeologic profile. In the

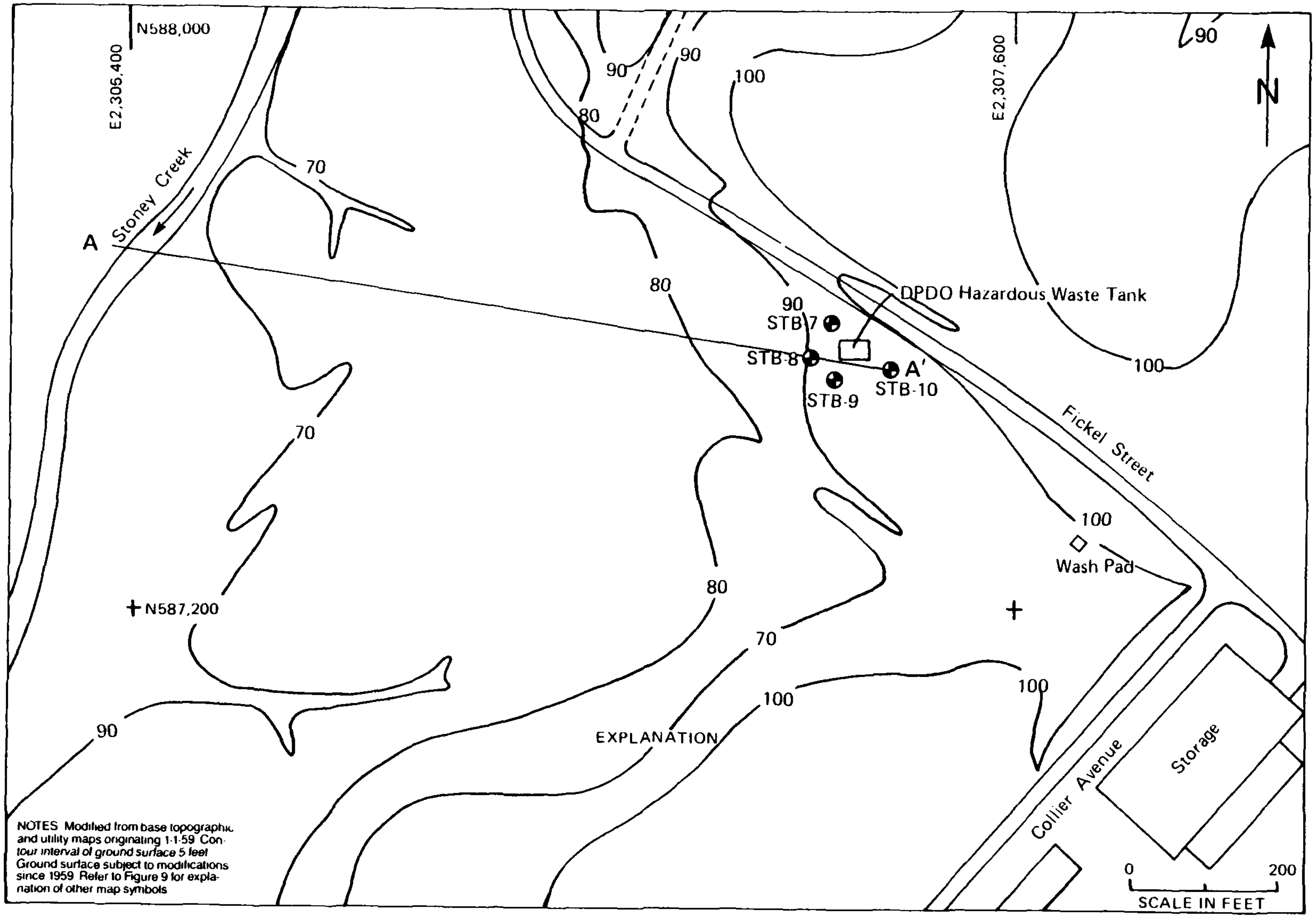


Figure 34. Topographic setting of Site 7 with location of inferred hydrogeologic profile A-A′.

immediate vicinity of the site, the ground surface is relatively flat. Evidence that some of this area has been filled is revealed by the soil test borings drilled at the site. To the southwest, the site area slopes steeply for a few hundred feet and then reaches the wide, flat-lying plain occupied by Stoney Creek (Figure 34).

Four soil test borings were drilled around the site to depths of 30 feet. Soil samples were retained for analysis but no monitoring wells were installed. Boring STB-10 was drilled slightly upgrade of the tank in an area assumed to be out of the direct influence of site activities. The remaining three borings were drilled just downgrade of the site (Figure 34).

Soil test borings STB-8 and STB-10 were used to construct an inferred hydrogeologic profile (Figure 35), which has been extended to Stoney Creek to show the relative topographic setting in the vicinity of the site. Similar lithologies were encountered in the four borings (Appendix C) and are depicted by Figure 35. The upper 3 to 6 feet of material is typically a sandy fill with fragments of rock and wood. A bright yellow substance was noted in the fill material from STB-8. The fill material is underlain by multicolored silty sands that have an average thickness of about 7 feet. Dark gray silty clays laminated with gray silty fine sand underlie the sand strata (Figure 35) and are thought to represent the top of the Black Creek formation.

The depth to groundwater beneath the site is estimated to be about 10 to 14 feet below land surface. Approximate groundwater elevations measured in the boreholes in February 1984 indicate that flow is to the west toward Stoney Creek.

4.7.2 Analysis of Soils

The results of the soil analyses are provided in Appendix H, Table H-7. No pesticides were detected in the soils. In the analyses of lead, chromium, and oil and grease in the soils, the results from boring STB-10 appear to represent background soil conditions (Appendix H, Table H-7). The concentration of lead did not exceed 3 μg/g, chromium did not exceed 7 μg/g, and oil and grease was below detection limits in boring STB-10. Based on these levels, it is apparent that the concentrations of lead and chromium measured

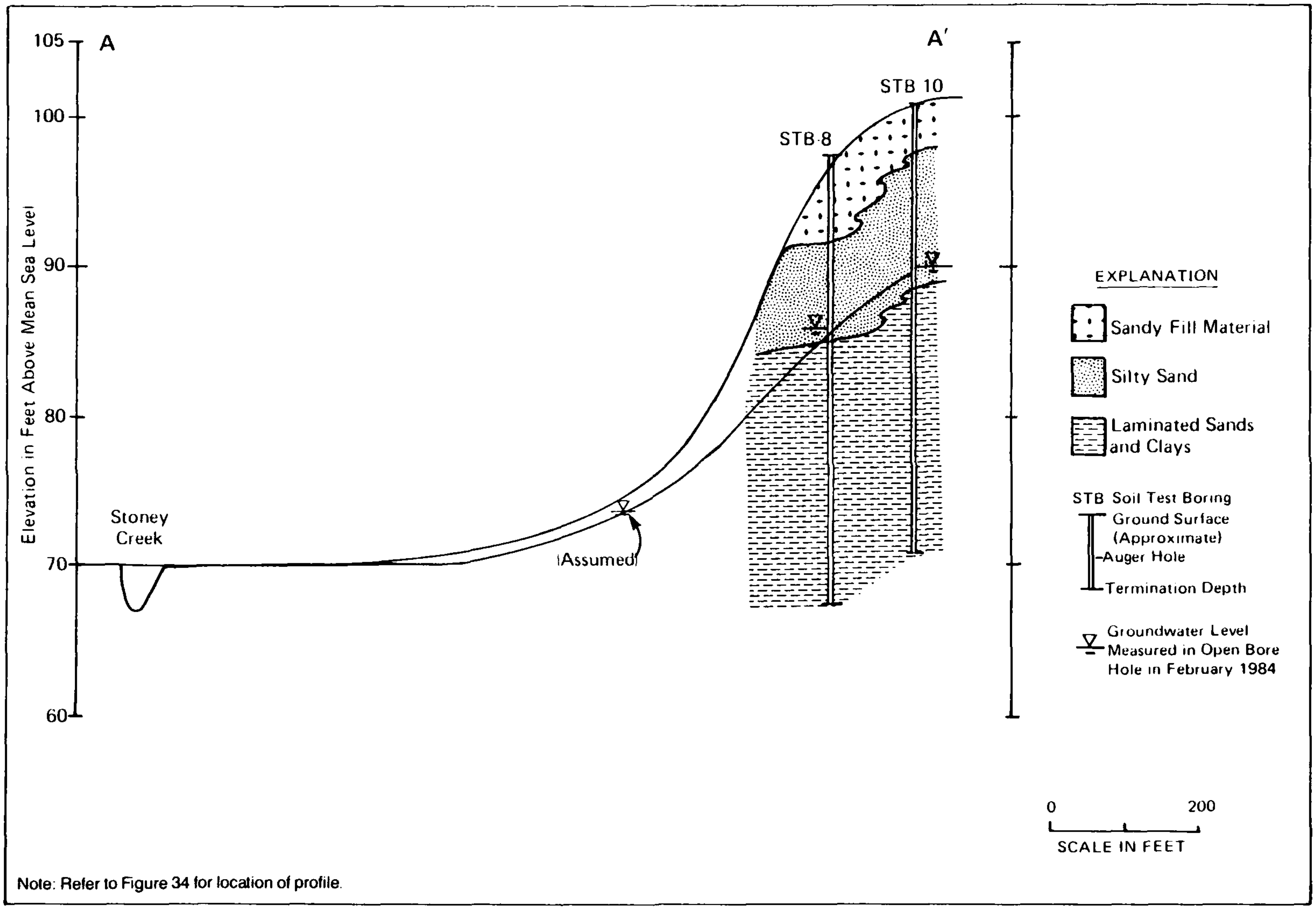


Figure 35. Inferred hydrogeologic profile A-A′ (Site 7).

within the upper 3 feet of soil collected from boring STB-8 (676 and 71 μg/g, respectively) are significantly above background levels. These results may be associated with the yellow substance previously noted that was observed in the fill material at this same depth in boring STB-8. The yellow substance may simply be a local concentration of paint in the fill materials. Some of the metals analyzed in borings STB-7 and STB-9 were also elevated significantly above background levels (Appendix H, Table H-7).

The concentrations of oil and grease measured in the soil samples indicate that the highest values also occurred downgrade of the DPDO tank (Appendix H, Table H-7). The highest concentration of oil and grease (over 9,000 μg/g) was measured in boring STB-9 at a depth of 3 feet.

4.7.3 Conclusions

Pesticides were not detected in the soils at Site 7. Shallow soil contamination by lead, chromium, and oil and grease exists downgrade of the site. The source of the contamination could be associated with the origin of the fill material itself or with disposal practices at the DPDO site. The extent of this contamination is not known, and soil and groundwater sampling with supplemental analyses would be required to determine if significant concentrations of these substances exist in the groundwater.

4.8 SUSPECTED JP-4 CONTAMINATION SITE (SITE 8)

A description and history of the site is provided in Subsection 1.5.8.

4.8.1 Subsurface Conditions

The general topographic setting of Site 8 is indicated in Figure 36 along with the location of an inferred hydrogeologic profile. The site is generally flat-lying with a drainage ditch to the northwest.

Four soil test borings were drilled at the site to depths of about 15 feet. Soil samples were retained for analysis, but no monitoring wells were installed. Soil test borings STB-28, STB-29, and STB-30 were used to construct an inferred profile of subsurface conditions. The subsurface conditions between borings STB 29 and STB 30 are similar (Figure 37). Silty sands overlie a silty clay stratum at an average depth of about 9 feet. This clay stratum may represent the top of the Black Creek forma-

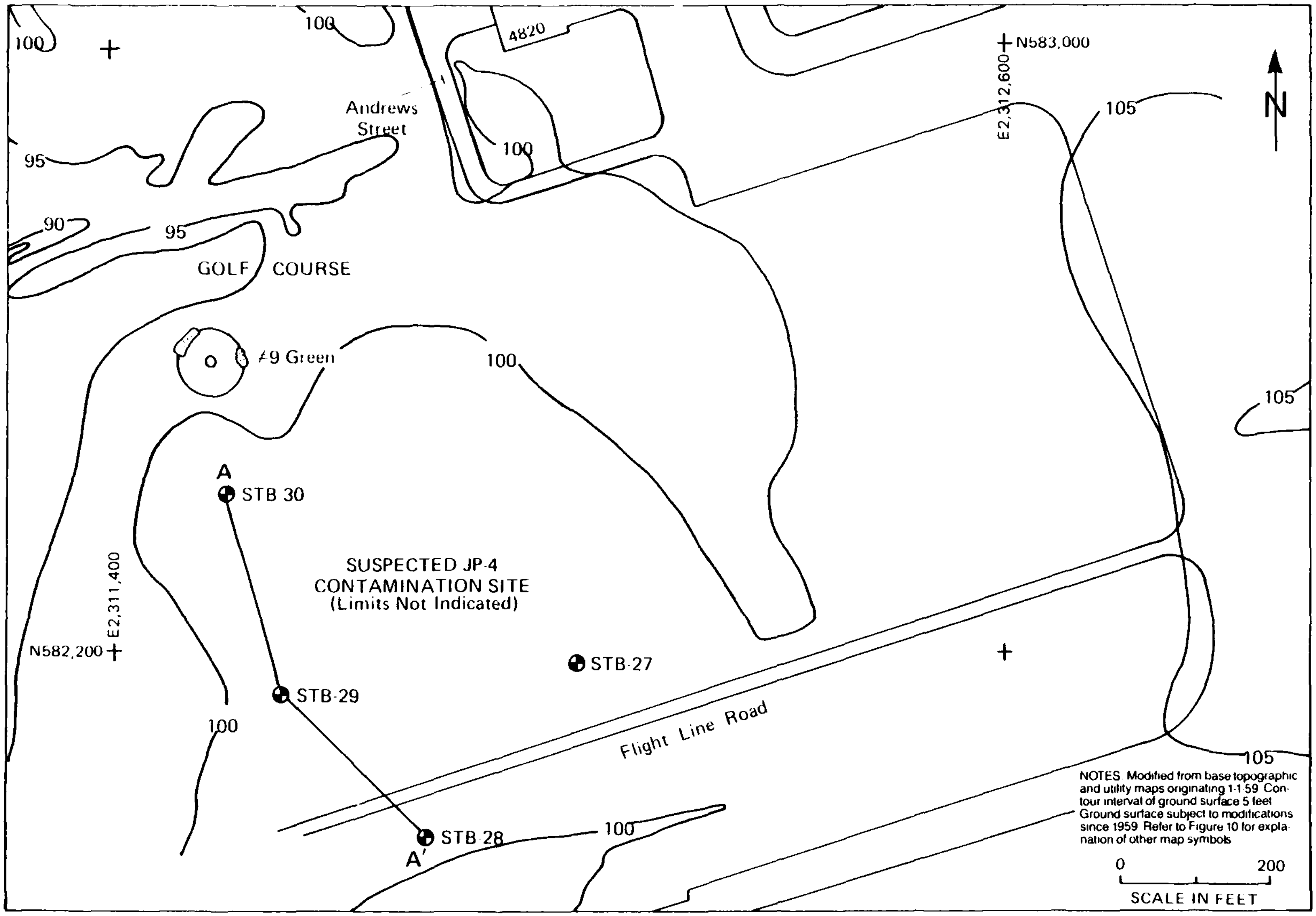
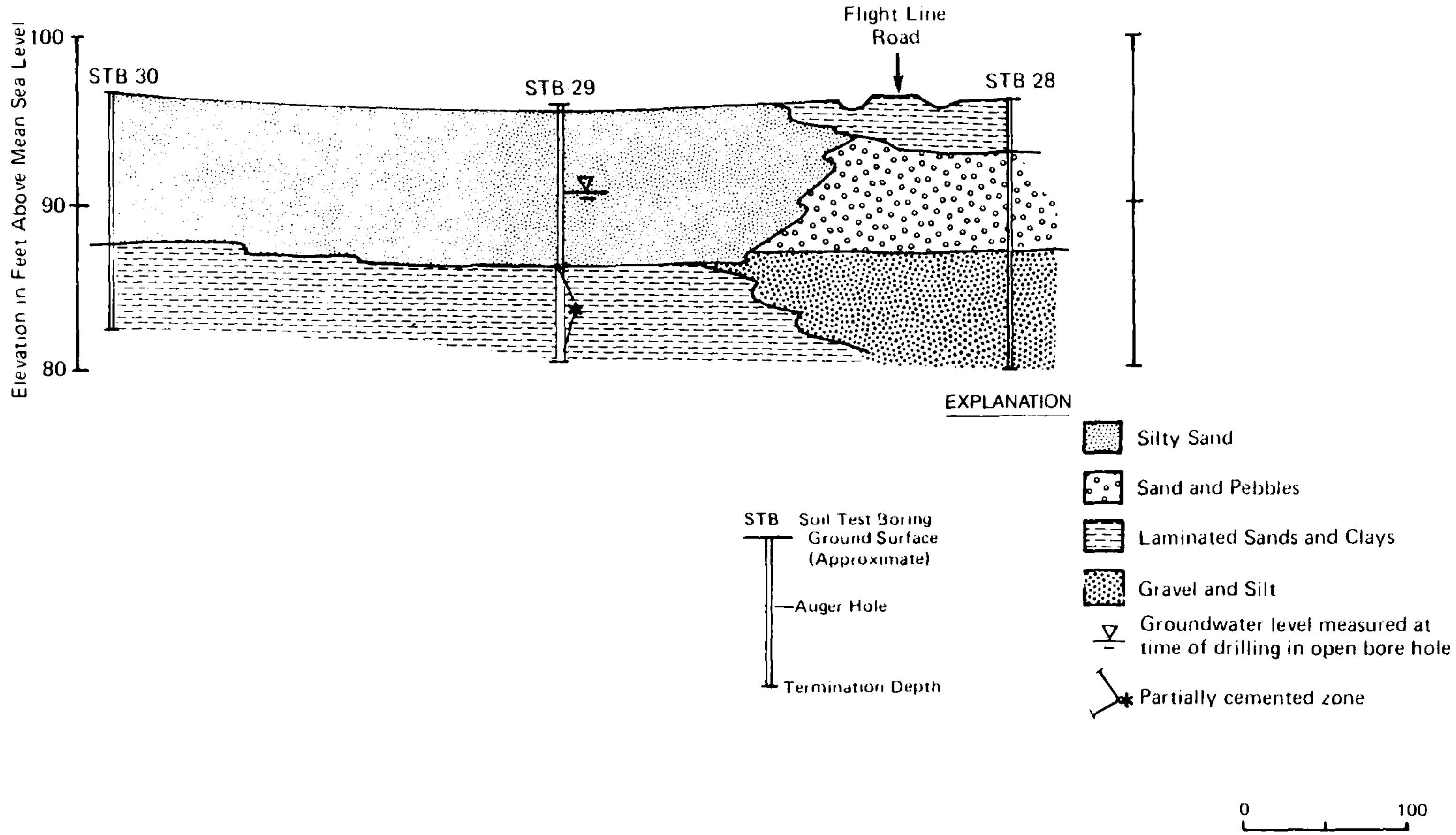


Figure 36. Topographic setting of Site 8 with location of profile A-A′.



Note: Refer to Figure 36 for location of profile.

Figure 37. Inferred hydrogeologic profile A-A′ (Site 8).

tion. On the basis of one groundwater measurement collected at the time of drilling, the water table is estimated to occur at a depth of between 4 and 5 feet below land surface and is within the sand strata. The deposits transition into a gravel-bearing sequence south toward boring STB-28 (Figure 37).

4.8.2 Analysis of Soils

The results of the soil analyses are presented in Appendix H, Table H-8. The samples were only analyzed for oil and grease as a general indicator of the presence of JP-4 fuel. All results were below detection limits.

4.8.3 Conclusions

There is no apparent JP-4 contamination at Site 8 within the depths and areas studied on the basis of oil and grease analyses.

4.9 SIGNIFICANCE OF FINDINGS

The significance of the findings are summarized in the following subsections on the basis of hydrogeology, analytical results, and associated environmental effects.

4.9.1 Hydrogeology

The significant hydrogeological findings are:

- A surficial aquifer was encountered at all sites studied on the Base. The significant findings of the surficial aquifer are that:
  - -- It occurs at a shallow depth and is susceptible to contamination by Base activities.
  - -- It is primarily composed of silty sand but has significant spatial variation in aquifer properties.
  - -- Groundwater flow components are primarily horizontal, with some downward flow likely.
  - -- It primarily discharges into drainage ditches, storm drains, and streams on Base that intersect the water table.
  - -- It is not used on the Base and potential users off the Base would be effectively separated from the Base's shallow groundwater discharges because of the location of surrounding streams and drainage ditches.

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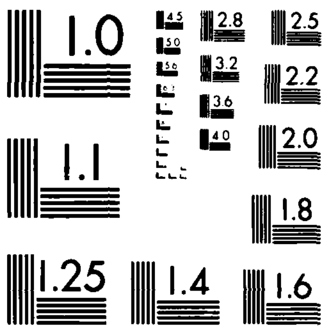

MICROCOPY RESOLUTION TEST CHART

- A clayey stratum exists beneath the surficial aquifer and is thought to represent the upper section of the Black Creek formation. The significant findings of the clayey stratum are that:

  -- It has been identified in most borings beneath the surficial aquifer at all sites.

  -- It appears to serve as an effective base to the surficial aquifer, where encountered, with a predominantly clayey texture.

  -- It is estimated to be several orders of magnitude less permeable than the sands within the overlying surficial aquifer.

  -- Its clayey composition and intense stratification physically retard the downward movement of water (and likely some contaminants).

  -- Its montmorillonitic clayey composition would offer sorption capacity to certain contaminants.

- The Black Creek formation and underlying Cape Fear formation form a principal aquifer system. The significance of this aquifer system is that:

  -- It is the Base's sole source of water.

  -- It is also used on a regional basis as a significant supply of groundwater.

  -- It is hydraulically connected to the Neuse River near the Base's water supply wells.

  -- It may receive some recharge from the overlying surficial aquifer, but most of the recharge is interpreted to be from off-Base sources.

  -- It is partially confined (and largely protected) by the thick clays of the Black Creek formation.

4.9.2 Analytical Results

The analytical results provide a basis for prioritizing the sites studied into four groupings. The highest priority sites (Group 1) are those where groundwater contamination has been confirmed by the analyses, followed by those sites with inferred groundwater quality degradation (Group 2). Of lower priority (Group 3) are those sites where some potential for groundwater contamination exists, followed by those sites where the potential for groundwater contamination appears to be low on the basis of analytical results (Group 4). These groupings have been applied to the sites evaluated in the Phase II program and summarized in Table 5. The groupings provide a basis for selecting and evaluating alternative measures (Section 5) and providing a framework for specific recommendations (Section 6).

4.9.3 Associated Environmental Effects

The groundwater contamination encountered in the Group 1 sites, as well as the inferred groundwater degradation in the Group 2 sites, appears to be confined to the surficial aquifer. Since the surficial aquifer is not used on or immediately downgradient of the Base, the contamination does not represent a direct adverse impact on groundwater users. The major environmental concern is the discharge of contaminated water from the surficial aquifer into ditches, streams, and the Neuse River. Aside from degrading the quality of surface water, the shallow occurrence of petroleum-related products represents a potential fire hazard and potential exposure problems to those working in the more significantly affected areas. These concerns have already been recognized by the Base, and surface water booms have been emplaced and warning signs have been posted. In addition, a fairly comprehensive monitoring program for surface water has been implemented by the Base.

The surficial aquifer does overlie an important aquifer system used as the sole source of water by the Base and as a significant source of water to the population in the surrounding area. This principal aquifer system appears to be protected by the thick clayey composition of the top of the Black Creek formation, and no adverse impacts to the aquifer have been identified by this evaluation. However, alternative measures considered for the Base should recognize that some recharge to the principal aquifer may occur by slow downward leakage from the surficial aquifer and from the Neuse River.

TABLE 5. PRIORITIZING OF SITES WITH RESPECT TO SIGNIFICANCE OF ANALYTICAL RESULTS

Group 1--Sites where groundwater contamination has been confirmed	
Site 1	Tank farm fuel line leak
Site 2	Ditch adjacent to railroad tracks
Site 3	Drain pipe outfall/component repair squadron ditch
Site 6	Landfill No. 4
Group 2--Sites where groundwater quality degradation has been inferred	
Site 4	Fuel hydrant system leak
Site 5	Tank farm fuel spill
Group 3--Sites with potential for groundwater contamination	
Site 6	Fire-training area 3
Site 7	DPDO hazardous waste tank
Group 4--Sites with low potential for groundwater contamination	
Site 6	Landfill No. 1
Site 8	Suspected JP-4 contamination site

SECTION 5

ALTERNATIVE MEASURES

This section of the report provides available options for monitoring and further evaluation of the site conditions. Specific recommendations are provided for the individual sites studied in Section 6. The actual extent and source of groundwater contamination or degradation encountered by this evaluation cannot be determined on the basis of available data. The extent and source of contamination need to be defined before effective remedial actions can be implemented.

Alternative measures at the site could include any of the following:

- Monitor the existing site wells in the POL area for supplemental organic parameters to aid in the determination of source areas.
- Install and monitor additional shallow wells at Group 1 and 2 sites to further determine the extent of groundwater contamination or degradation, respectively.
- Coordinate the efforts of the Base's stream monitoring program with future groundwater sampling and analysis to provide a more comprehensive evaluation of site conditions and surface water/groundwater interactions.
- Supplement the Base's stream monitoring program with sampling stations near Group 1 sites identified by this program.
- Collect and analyze additional soil samples at Group 3 sites to further determine the potential for groundwater degradation.
- Obtain updated surveying data at Group 1 sites to further evaluate surface water/groundwater interactions and to provide a current base for designing remedial alternatives.
- Assist in the siting of supplemental shallow monitoring wells using geophysical techniques to delineate the lateral extent of highly conductive groundwater contaminants.

- Conduct hydraulic conductivity measurements in the surficial aquifer at Group 1 and 2 sites to allow for a preliminary estimate of the potential rate of contaminant transport.

- Install and monitor lysimeters at sites where contamination of the unsaturated zone is suspected.

SECTION 6

RECOMMENDATIONS

The sites studied as a part of this Phase II evaluation were previously prioritized with respect to the significance of analytical findings (Table 5). The recommendations for the sites are categorized by the grouping discussed in Section 4.9.2. A summary of the recommendations involving supplemental evaluation is provided in Table 6.

6.1 GROUP 1 (SITES WHERE GROUNDWATER CONTAMINATION HAS BEEN CONFIRMED)

This group includes Sites 1, 2, 3, and 6 (Table 5). Because of the similar recommendations and significance of findings for Sites 1, 2, and 3, these sites are discussed collectively as a larger site referred to as the POL-area site. Information obtained from Site 5 may also apply to the POL area but is not included here since contamination has not been confirmed at Site 5.

6.1.1 POL-Area Site (Sites 1, 2, and 3)

The proximity of Site 5 to the POL area should allow information obtained from the proposed deep soil test boring near the tank farm to be applied to the POL area as well. One deep monitoring well, screened in the topmost productive sand layer within the Black Creek formation, should be installed to confirm whether the overlying clayey deposits provide adequate protection to the deeper aquifer system.

Additional monitoring wells should be installed within the fenced portion of the POL yard, near the drainage ditches west and southwest of the POL-area site, and in the lightly forested area west of the ditch that parallels the railroad tracks. One well should be installed in the vicinity of building 3500 to serve as an upgradient well. The actual number of wells to be installed should be based on field observations of subsurface conditions, but a total of 10 shallow wells are recommended (Table 6). It

TABLE 6 RECOMMENDATIONS INVOLVING SUPPLEMENTAL EVALUATION AND ANALYSIS

Site No	Number of samples	Subsurface monitoring	Analysis of subsurface samples	Surface monitoring	Analysis of surface samples	Other considerations
1, 2, 3 (POL area)	17 Total 13 groundwater 4 surface water	9 new shallow wells. Locate in POL yard, near drainage ditches, and in area west of ditch parallel to railroad tracks.	9 O&G 9 TOC 9 TOX 4 GC/MS (on highest TOC)	· 1 sample from drainage ditch west of site 1 · 2 samples from storm drain catch basins · 1 sample from drain pipe outfall at Site 3	4 O&G 4 TOC 4 TOX 1 GC/MS (on highest TOC)	· Conduct hydraulic conductivity tests in selected wells · Remeasure water levels in existing wells and compare with water levels in new wells · Measure pH and conductivity on all water samples
		1 new shallow upgradient well near Building 3500	1 O&G 1 TOC 1 TOX			
		1 new deep well in the topmost productive sand layer of the Black Creek formation	1 O&G 1 TOC 1 TOX 1 GC/MS (if TOC >3 mg/l)			
		2 existing wells. Resample wells MW-22 and MW-26	2 O&G 2 TOC 2 TOX 1 VOC (MW-22)			
4 (fuel hydrant system leak)	11 Total 3 groundwater 8 surface water	3 existing wells. Resample wells MW-3, MW-4, and MW-6	3 O&G 3 TOC 1 GC/MS (on highest TOC)	· 4 samples from selected storm drain catch basins or outfalls · 4 samples from seepage along southern drainage ditch	8 O&G 8 TOC 1 GC/MS (on highest TOC)	· Perform supplemental topographic surveying · Conduct hydraulic conductivity tests in selected wells · Remeasure water levels in wells. Determine depths of storm drains and compare elevations with groundwater measurements · Measure pH and conductivity on all water samples
5 (tank farm fuel spill)	6 Total 3 groundwater 3 unsaturated	2 new shallow wells in vicinity of tank No. 3414 3 pressure vacuum lysimeters in vicinity of tank No. 3414	5 O&G 5 TOC 1 GC/MS (on highest TOC)	--	-	· Measure water levels in existing and new wells and interpret ground water flow · One deep (100-150 feet) soil test boring near MW-17 to determine the locations of productive sand zones within the Black Creek formation
		1 existing well. Resample well MW-17	1 O&G 1 TOC			· Measure pH and conductivity on all water samples

(continued)

TABLE 6 (continued)

Site No.	Number of samples	Subsurface monitoring	Analysis of subsurface samples	Surface monitoring	Analysis of surface samples	Other considerations
6 (fire training area 3)	1 Total (Groundwater)	1 new shallow well downgradient of MW-11	1 O&G 1 TOC 1 TOX 1 Phenol 1 GC/MS (if TOC >3 mg/l)	--	--	· Evaluate findings with respect to new upgradient well near landfill No. 4. · Measure pH and conductivity of groundwater
6 (landfill No. 4)	10 Total 8 groundwater 2 surface water	6 new shallow wells in swampy area west of landfill	6 TOC 6 TOX 6 Phenols 3 Ni, Pb, Cr, Cd (on highest TOC) 1 GC/MS (on highest TOC)	2 surface water samples in vicinity of landfill.	2 TOC 2 TOX 2 phenols 2 Ni, Pb, Cr, Cd	· Conduct hydraulic conductivity tests in selected wells. · Preliminary geophysical survey to optimize well siting and determine extent of contamination
		1 existing well. Resample well MW-13.	1 O&G 1 TOC 1 TOX 1 Phenol 1 GC/MS			· Measure pH and conductivity of all water samples. · Perform supplemental topographic surveying.
		1 new shallow upgradient well near Collier Avenue.	1 O&G 1 TOC 1 TOX 1 Phenol 1 Ni, Pb, Cr, Cd			
6 (landfill No. 1)	--	--	--	--	--	· No further sampling or monitoring recommended.
7 (Drbo Tank)	2 Total 1 groundwater 1 surface water	1 shallow monitoring well. Located southwest of site.	1 O&G 1 TOC 1 TOX 1 Phenol 1 Cr, Pb, Hg, Ba, As, Mn 1 GC/MS (If TOC >3 mg/l)	1 surface water sample (seepage in vicinity of site or Stoney Creek)	1 O&G 1 TOC 1 TOX 1 Phenol 1 Cr, Pb, Hg, Ba, As, Mn 1 GC/MS (If TOC >3 mg/l)	· Measure pH and conductivity of all water samples
		5 shallow hand auger borings downslope of site	5 Cr, Pb, Hg, Ba, As, Mn 5 Phenol 5 TOX			
8	--	--	--	--	--	· No further sampling or monitoring recommended.

may be cost effective to install the wells (less than 10 feet in depth) by hand-auger techniques. The wells should be carefully installed so that the water table is in the screened section of the well. These wells should terminate within the silty sand strata and not extend into the Black Creek formation. The wells should be developed and sampled in accordance with procedures described in this report. Water-level data collected from the new monitoring wells at the POL-area site should be used to prepare a detailed potentiometric surface map of the surficial aquifer. Water-level data from selected existing monitoring wells should be compared to data from the new wells. If a hydraulic connection between the new and the selected existing wells is apparent, data from those existing wells should be included in the potentiometric map. These data should aid in the interpretation of groundwater/surface water interactions and potential upgradient source areas. Supplemental topographic surveying of the new monitoring stations and significant drainage features should be performed.

The groundwater collected from the additional monitoring wells should initially be analyzed for total organic carbon, total organic halogen, and oil and grease as an indicator of the extent of petroleum-related products in the surficial aquifer. These findings could indicate the need for supplemental shallow wells until the horizontal extent of the contamination is documented. In order to aid in the identification of the source area(s), selected groundwater samples will likely require further quantification by gas chromatography/mass spectrometry (GC/MS).

The hydraulic conductivity of the upper aquifer should be analyzed by means of a slug test for several of the monitoring wells in the POL area. The results of such a test would enable a preliminary analysis of the potential rate of contaminant transport from this area.

The groundwater sampling program at the POL-area site should be supplemented with data collected from storm drains, drainage ditches, and other significant surface water features near the site (Table 6). The booms that are presently in place in the existing drainage ditches should be monitored regularly and replaced as necessary to provide a more effective control of potential contaminants migrating by surface water.

6.1.2 Landfill No. 4 (Site 6)

Additional monitoring wells should be installed in the swampy area west of the landfill. A preliminary geophysical survey to optimize well siting may be useful to determine the extent of contaminant migration in this area. This area will probably require well installation by hand-auger techniques because of inaccessibility to vehicles. Approximately six shallow wells (less than 10 feet deep) are recommended for the western portion of the site. One well should also be placed in the vicinity of Collier Avenue to serve as an upgradient well. The wells should be installed carefully and water-level data collected from the new and existing wells should be used to construct a detailed potentiometric surface map of the surficial aquifer. Supplemental topographic surveying of the new monitoring stations, significant surface water features, and the limits of the landfill should be performed.

The groundwater collected from these wells should initially be analyzed for total organic carbon, total organic halogen, and phenols. Those samples with the highest concentrations of these parameters should be reanalyzed for nickel, lead, chromium, and cadmium. Those higher concentration samples should also be quantified for organic compounds by GC/MS analysis. The findings could indicate the need for supplemental wells until the horizontal extent of contamination is documented. Well MW-13 should be resampled and analyzed for oil and grease, total organic carbon, total organic halogen, and phenol for comparison with existing data. The sample from well MW-13 should be further quantified by GC/MS analysis. The groundwater sampling and analysis should be supplemented with data collected from surface water just downstream of the landfill and analyzed for the parameters indicated in Table 6.

6.2 GROUP 2 (SITES WHERE GROUNDWATER QUALITY DEGRADATION HAS BEEN INFERRED)

6.2.1 Fuel Hydrant System Leak (Site 4)

No additional monitoring wells are recommended at this site at this time. Groundwater samples collected from wells MW-3, MW-4, and MW-6 should be periodically reanalyzed for oil and grease and total organic carbon. If elevated concentrations are indicated by these analyses, then a GC/MS analysis should be performed to quantify the volatile organic compounds.

The groundwater samples should be supplemented with samples from selected drain lines and seepage along the north side of the southern drainage ditch (Table 6). These samples should also be analyzed for oil and grease and total organic carbon. The sample with the highest concentrations of these parameters should be analyzed by a GC/MS analysis to quantify the volatile organic compounds. The booms that are presently in place in the southern drainage ditch should be monitored regularly and replaced as necessary to provide a more effective control of potential contaminants migrating by surface water.

Water levels in all of the existing wells should be remeasured and compared to water-level data from the new wells. Measurements of the depths of storm drains should be made and compared with groundwater elevations to better determine their influence on groundwater flow.

6.2.2 Tank Farm Fuel Spill (Site 5)

One deep soil test boring (100-150 feet deep) into the Black Creek formation is recommended in the vicinity of well MW-17. Geophysical logging of the borehole should be performed to determine the locations of significant sand layers and the thickness of the laminated sand and clay unit. Information obtained from this boring will be used to determine the appropriate depths for the additional shallow monitoring wells recommended for Site 5 and for the deeper well proposed for the POL area.

Two monitoring wells are recommended in the vicinity of tank no. 3414. These wells should terminate at depths of less than 20 feet and be screened within the surficial aquifer. The two wells should be surveyed and water-level data collected from the wells should be combined with that obtained for the POL-area site in order to aid in the detailed interpretation of groundwater flow in this area. Samples withdrawn from these wells should be analyzed for oil and grease and total organic carbon. If elevated concentrations are indicated by these analyses, then a GC/MS analysis should be performed to quantify the volatile organic compounds. Well MW-17 should be resampled and analyzed for oil and grease and total organic carbon for comparison with existing data. Water levels should be measured in existing and new wells to enhance the interpretation of the direction of groundwater flow.

Some monitoring of the unsaturated zone should be conducted at Site 5 to quantify the occurrence and extent of shallow soil contamination within the diked area surrounding tank No. 3414. The water extracted from the pressure vacuum lysimeters should be analyzed for the same parameters for which the groundwater is analyzed (Table 6).

6.3 GROUP 3 (SITES WITH POTENTIAL FOR GROUNDWATER DEGRADATION)

6.3.1 Fire Training Area 3 (Site 6)

One supplemental monitoring well should be installed downgradient of well MW-11 and screened to a depth of not more than 20 feet below the land surface. Background water quality conditions for this area could be obtained from the upgradient well recommended for the Landfill No. 4 area. The groundwater sample obtained from the supplemental well should be analyzed for oil and grease, total organic carbon, total organic halogen, and phenol. If elevated concentrations are indicated by these analyses, then a GC/MS analysis should be performed to quantify the volatile organic compounds.

6.3.2 DPDO Hazardous Waste Tank (Site 7)

Additional shallow soil samples should be collected in the fill materials in the area downslope from the site (Table 6). This sampling effort could probably be accomplished by hand-auger techniques to depths not exceeding 6 feet. The soil samples should be analyzed for chromium, lead, mercury, barium, arsenic, manganese, phenol, and total organic halogen. One shallow monitoring well (less than 20 feet deep) should be installed just southwest of the site. Groundwater collected from the well should be analyzed for the same parameters as the soils in addition to oil and grease and total organic carbon. A surface water sample should be collected from seepage in the vicinity of the site or from Stoney Creek and analyzed for the same parameters as the groundwater sample. If elevated concentrations are indicated by these water analyses, then a GC/MS analysis should be performed to quantify the volatile organic compounds. An extraction method such as the EPA EP Toxicity test is recommended for the metals analysis. The results of such a test would yield information concerning metal ions that could be freed by organic acids and therefore easily transported by the groundwater.

6.4 GROUP 4 (SITES WITH LOW POTENTIAL FOR GROUNDWATER DEGRADATION)

There are no strong indications of groundwater contamination downgradient of Landfill No. 1 and no oil and grease was detected in the soil samples from the suspected JP-4 contamination area. Therefore, no further sampling or monitoring is recommended for Landfill No. 1 (Site 6) and the suspected JP-4 contamination area (Site 8).

SECTION 7

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APPENDIX A

ANALYTICAL PROCEDURES UTILIZED IN WATER
AND SOIL SAMPLE ANALYSES

APPENDIX A

ANALYTICAL PROCEDURES UTILIZED IN WATER AND SOIL SAMPLE ANALYSES

The groundwater, soil, and leachate samples collected from Seymour Johnson Air Force Base were analyzed by RTI for all or some of a variety of parameters. Included were pH, specific conductivity, oil and grease, total organic carbon (TOC), total organic halide (TOX), nitrate, metals, phenol, pesticides, and selected volatile organic compounds. The 31 priority pollutants analyzed during the volatile organic compound analysis are:

- Acrolein
- Acrylonitrile
- Benzene
- Bis(Chloromethyl)ether
- Bromodichloromethane
- Bromoform
- Bromomethane
- Carbon tetrachloride
- Chlorobenzene
- Chloroethane
- 2-chloroethyl vinyl ether
- Chloroform
- Chloromethane
- Dibromochloromethane
- Dichlorodifluoromethane
- 1,1-Dichloroethane
- 1,2-Dichloroethane
- 1,1-Dichloroethylene
- trans-1,2-Dichloroethylene
- 1,2-Dichloropropane
- 1,3-Dichloropropene
- Ethylbenzene
- Methylene chloride
- 1,1,2,2-Tetrachloroethane
- 1,1,2,2-Tetrachloroethene
- Toluene
- 1,1,1-Trichloroethane
- 1,1,2-Trichloroethane
- Trichloroethylene
- Trichlorofluoromethane
- Vinyl chloride

The procedures used for the analyses of these parameters are presented below. The detection limits for these procedures are provided in Table A-1.

1. pH--The pH of each groundwater sample collected was measured in the field at the time of collection. The field measurements were obtained using a Fisher Model 107 pH meter with electrode. The measurements were made at ambient groundwater temperature and Fisher pH standards were used for calibration. Quality controls included special care to avoid contamination and regular recalibration.

2. Specific Conductivity--The specific conductivity of each groundwater sample was measured in the field using a YSI conductivity meter (Model 33). The temperature of the groundwater was also read on this meter. Quality control included using special care to avoid contamination, and regular recalibration.
3. Total Organic Carbon (TOC)--The total organic carbon was determined with an Oceanography International Model 0524C Total Organic Carbon Analyzer equipped with a Horiba Model PIR 2000 infrared analyzer. The samples were digested (oxidized) with potassium persulfate in a sealed ampule. The CO_2 resulting from oxidation of the organic species was then released and measured using the infrared analyzer. A quality control measure used was the oxidation of different volumes of the water samples in order to optimize the CO_2 measurement.
4. Total Organic Halogen (TOX)--The TOX measurements for the groundwater samples were determined using a Dohrmann Model DX-20 total organic analyzer. The procedure involves collection of the halocarbons on a bed of sorbent carbon and then thermal oxidation of the bed to produce chloride which is measured colorimetrically. A blank was run with each set of four samples, and the instrument was calibrated with a standard of 2,3,5-trichlorophenol before each sample run.
5. Anions--The only anion determined was nitrate. This species was determined using a Dionex System Model 14 ion chromatograph. This system separates the anions using high-performance ion-exchange chromatography and measures them using a conductometric detector. Quality control measures performed included regular recalibration and analysis of quality assurance check samples provided by the EPA. The EPA standard used for the quality assurance check performed on May 14-15, 1984, had a reported nitrate ion concentration of 0.487 mg/l. The observed concentration during analysis was 0.496 mg/l, yielding an analytical error of 1.8 percent.

6. Metals--The metals included lead, cadmium, chromium, and nickel. The water samples were analyzed directly; the soil samples were digested in aqua regia and the resultant solution was analyzed. All the metals were analyzed using flameless atomization atomic absorption spectrometry. A Perkin-Elmer Model 601 spectrometer was used and all procedures were taken from the EPA's water and waste water analysis manual. Quality control measures included regular recalibration and analysis of quality assurance samples from the National Bureau of Standards. The results of quality control tests using NBS 1643a (trace elements in water) standard were:

Metal	Expected concentration (μg/l)	Observed concentration (μg/l)
Lead	27 ± 2	25.6
Cadium	10 ± 1	10.5
Chromium	17 ± 2	15.5
Nickel	55 ± 3	53.5

7. Phenol--Phenol was determined in the groundwater samples using EPA Method 420.1. In the procedure, phenolic materials are reacted with 4-aminoantipyrine in the presence of potassium ferricyanide at a pH of 10 to form a stable reddish-brown colored antipyrine dye. The amount of color produced is a function of the concentration of phenolic material. Laboratory-prepared quality assurance samples were analyzed regularly.

8. Volatile Organic Compounds--Samples were analyzed for volatile organic compounds using gas chromatography/mass spectrometry. The apparatus and procedures used for analysis were in accordance with EPA Method 624. Quality control procedures included thorough calibration and manual review of data generated by the instrument computer systems.

9. Oil and Grease--The oil and grease was determined using EPA Method 413.2. The method involves extraction in Freon 113 and measurement of the intensity of an infrared absorption peak from 3,200 cm^{-1} to 2,700 cm^{-1} for this extract. A mixture of n-hexa-

decane, isooctane, and chlorobenzene is used as a standard. The groundwater and soil samples were extracted in a similar manner.

Quality control procedures included repeated tests of blank samples (Freon 113) and the following standards: 4 mg/100 ml, 20 mg/100 ml, 40 mg/100 ml, and 80 mg/100 ml. A spike recovery test was performed on groundwater from MW-23 after the initial sample analysis revealed no discernible peaks. The sample aliquot of MW-23 was spiked with a stock standard solution containing 20.4 mg/50 ml. Analysis of the spiked aliquot yielded an 85 percent recovery. A similar spike recovery test was performed on the extracted soil sample collected from the 27-foot depth interval of STB-7. Analysis of that spiked extract yielded an 89 percent recovery.

10. Pesticides--The pesticides in the soil samples were analyzed using extraction and a gas chromatography method on the resultant extracts. The apparatus and procedures used for analysis were in accordance with EPA Method 608 modified for soil analysis.

TABLE A-1. DETECTION LIMITS FOR ANALYTES DETERMINED IN SAMPLES

Analyte	Estimated detection limit (water)	(soil)
Oil and grease	0.4 mg/l	
pH	±0.03 pH	
Conductivity	±3%	
TOC	0.5 mg/l	
TOX	50 μg/l	
Phenol	0.05 mg/l	
Nitrate	0.1 mg/l	
Chromium	0.5 μg/l	50 μg/g
Lead	0.5 μg/l	50 μg/g
Cadmium	0.5 μg/l	
Nickel	0.5 μg/l	
Benzene	0.5 μg/l	
Toluene	0.5 μg/l	
Ethylbenzene	0.5 μg/l	
Chloroform	0.05 μg/l	
Chloroethane	0.10 μg/l	
Methylene chloride	0.10 μg/l	
1,2-Dichloroethane	0.5 μg/l	
trans-1,2-Dichloroethylene	0.5 μg/l	
Chlorobenzene	0.1 μg/l	
1,1-Dichloroethane	0.5 μg/l	
Pesticide Compounds		
Aldrin	-	0.03 (μg/g)
p,p'-DDD	-	0.03 (μg/g)
p,p'-DDE	-	0.03 (μg/g)
p,p'-DDT	-	0.03 (μg/g)
Dieldrin	-	0.03 (μg/g)

(continued)

TABLE A-1 (continued)

Analyte	Estimated detection limit (water)	(soil)
Endrin	-	0.02 (μg/g)
Heptachlor	-	0.03 (μg/g)
Heptachlor epoxide	-	0.03 (μg/g)
Lindane	-	0.02 (μg/g)
Methoxychlor	-	0.03 (μg/g)
Diazinon	-	0.03 (μg/g)
Malathion	-	0.03 (μg/g)
Parathion	-	0.03 (μg/g)
2,4-D	-	0.05 (μg/g)
2,4,5-T	-	0.05 (μg/g)

APPENDIX B

INFORMATION PERTAINING TO WATER WELLS LOCATED WITHIN AND ADJACENT TO THE BASE

Table B-1. Records of Wells Drilled in the Vicinity of Seymour Johnson AFB

Table B-2. Data for Base Water Supply and Service Wells

TABLE B-1. RECORDS OF WELLS DRILLED IN VICINITY OF SEYMOUR JOHNSON AFB

Well No.	Owner	Depth (ft)	Diameter (in)	Depth of casing (ft)	Water level (ft)	Yield (gal/ min)
33	N.C. Hide Co.	246	8	--	--	105
34	Jack Wright	75	6	71	-18	15
35	Dewey Bros.	49	6	25	-25	--
36	ESSO Station E974	98	6	--	--	--
37	Goldsboro Iron and Metal Co.	246	6	141	--	105
38	Edwards' Young Mens Shop	100	6	97	--	15
39	Heilig and Myers	127	6	125	-33	56
40	Pepsi Cola Bottling Co.	100	6	90	--	30
41	B. C. Allen	99	4	31	--	10
42	Ben R. Lewis	86	4	82	-35	15
43	Charles E. Croom	65	4	61	-4	10
44	Dr. W. Trachtenburg	55	4	51	-20	12
45	State Highway Maintenance yard	113	6	108	--	18
46	E. H. Robbins	207	6	202	-45	60
47	Paul Best	90	6	85	-15	20
48	Central School	101	6	96	--	30
62	County Homes	228	8	174	-20	150
79	Brogden School	77	6	73	-34	15
80	Berry Mitchell	103	4	101	--	5
81	Zeb. Mitchell	70	4	68	--	10
82	Zeb. Mitchell	70	4	68	--	--
83	Herbert Mitchell	68	4	66	--	8
84	Herbert Mitchell	81	4	79	--	8
85	W. P. Hatsell	74	4	72	--	8
86	W. P. Hatsell	69	4	67	--	10
87	J. A. Strader	85	4	83	--	8

-- = Data not available.

NOTES: Modified after Pusey (1960).
Refer to Figure 14 for location of wells.
(Except for #33, which is in slate, all wells are in sand.

TABLE B-2 DATA FOR BASE WATER SUPPLY AND SERVICE WELLS

Base well No.	USGS well No.	Drilling contractor	Year drilled	Total depth (ft)	Cased depth (ft)	Screened intervals (ft)	Approximate elevation of static water level (ft above msl)	Pump setting (ft)	Pump capacity (gal/min)	Usage
1-63	Wa-133	--	1973[a]	157	--	75-95;152-157	36	70	250[b]	Inactive
2-60	Wa-134	Carolina Well & Pump	1967[a]	113	79	79-113	35	80	240[b]	Standby
3-64	Wa-135	--	1964	134.5	--	58-73;85-90;123-128	31	50	300	Standby
4-64	Wa-122	Sydnor Hydrodynamics	1960	195	47	47-52;59-64;175-195	36	96	300	Active
5-73	Wa-123	Sydnor Hydrodynamics	1973	114	48	48-68;74-84	24	92	180	Active
6-59		Heater Well Company	1959	110	110	46-50;60-64;73-85	32	75	250	Standby
7-73	Wa-124	Sydnor Hydrodynamics	1973	122	122	62-92	61	90	150	Inactive
8-73	Wa-125	Sydnor Hydrodynamics	1973	124	58	58-78;84-94	56	102	200	Active
9-73	Wa-126	Sydnor Hydrodynamics	1973	115	48	48-58;62-72;75-85	50	42	180	Inactive
9-79		Heater Well Company	1979	113	110	70-95	24	--	150	Active
10-60	Wa-127	Sydnor Hydrodynamics	1959	140	142	110-140	25	112	200	Active
11-60	Wa-128	Sydnor Hydrodynamics	1959	140	70	70-100	17	70	200	Active
12-60		--	1959	158	--	102.05-107.5; 117.5-127.5; 72.5-82.5;92.5-97.5	50	--	200	Dismantled
12-79		Heater Well Company	1979	113	113	78-98	31	--	150	Active
13-73	Wa-129	Sydnor Hydrodynamics	1973	120	70	70-90	26	115	160	Active
14-69	Wa-130	Carolina Well & Pump	1969	186	48	48-63;73-93; 177.5-182.5	42	92	155	Active
14-82		Skipper Well Drilling	1982	190	--	42-82; 180-185	20	104	150	Active
15-71	Wa-133	Sydnor Hydrodynamics	1971	112	45	45-55;65-75	44	102	200	Active
16-73	Wa-132	Sydnor Hydrodynamics	1973	118	56	56-67;72-88	38	102	130	Active
TAC Test Cell Well Building 10328		Sydnor Hydrodynamics	1971	190	178	94-99;104-109; 114-119;148-153; 158-163;168-173	17	105	50	Service
Hospital Well		(No data on file)								Emergency
Rifle Range Well		(No data on file)								Local
Wells 3, 3B, 5, 5A, 6B, 7, 7A, 8A, and 9		(No data on file)								Dismantled

msl = mean sea level.

-- = Data not available.

[a]Date of reconstruction.

[b]Original pump capacity before reconstruction.

NOTE: Modifed from Robison and Mann (1977) and Seymour Johnson AFB documents.

APPENDIX C

LITHOLOGIC DESCRIPTIONS OF SOIL SAMPLES
COLLECTED DURING THE DRILLING PROGRAM

MONITORING WELL: MW-1
(Fuel Hydrant System Leak)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Gray-brown silty fine to medium SAND	3
3-6	Light gray silty fine SAND	19
6-9	Light gray fine sandy silty CLAY	7
9-12	Orange-brown silty medium to fine SAND	8
12-15	Dark gray silty CLAY laminated with gray silty fine SAND	18

Notes: Boring drilled on 1-13-84.
Boring terminated at 15 feet and monitoring well installed.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

MONITORING WELL: MW-2
(Fuel Hydrant System Leak)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Tan and brown slightly silty fine SAND	55
3-6	Brown and orange slightly silty fine to medium SAND	29
6-9	Red-brown slightly silty fine to coarse SAND with some gravel	24
9-12	Gray clayey medium to coarse SAND	12
12-15	Tan slightly silty fine to medium SAND	11

Notes: Boring drilled on 1-12-84.
Boring terminated at 15 feet and monitoring well installed.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

MONITORING WELL: MW-3
(Fuel Hydrant System Leak)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Tan silty fine SAND	27
3-6	Tan slightly silty fine to coarse SAND	25
6-9	Gray silty fine to medium SAND	10
9-12	Dark gray silty CLAY laminated with gray silty fine SAND	14
12-15	Dark gray silty CLAY laminated with gray silty fine SAND	15

Notes: Boring drilled on 1-12-84.
Boring terminated at 15 feet and monitoring well installed.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

MONITORING WELL: MW-4
(Fuel Hydrant System Leak)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Brown and tan fine to medium sandy CLAY	21
3-6	Dark brown silty fine to medium SAND with some peat material	52
6-9	Brown slightly silty coarse to fine SAND	20
9-12	Tan slightly silty coarse to fine SAND	15
12-15	Gray silty fine SAND laminated with dark gray silty CLAY	36

Notes: Boring drilled on 1-12-84.
Boring terminated at 15 feet and monitoring well installed.

[a] The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

MONITORING WELL: MW-5
(Fuel Hydrant System Leak)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Tan fine sandy SILT	8
3-6	Tan silty fine SAND	12
6-9	Tan silty fine SAND	8
9-12	Gray silty fine SAND	18
12-15	Gray silty fine SAND laminated with dark gray silty CLAY	40

Notes: Boring drilled on 1-11-84.
Boring terminated at 15 feet and monitoring well installed.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

MONITORING WELL: MW-6
(Fuel Hydrant System Leak)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Tan and brown slightly silty fine to medium SAND	19
3-6	Tan slightly silty fine to medium SAND	14
6-9	Gray silty fine SAND	14
9-12	Gray silty fine SAND	19
12-15	Gray silty fine SAND laminated with dark gray silty CLAY	28

Notes: Boring drilled on 1-11-84.
Boring terminated at 15 feet and monitoring well installed.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

SOIL TEST BORING: STB-7
(DPDO Hazardous Waste Tank)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Gray fine to medium SAND with pebbles and wood fragments (fill)	11
3-6	Gray fine to medium SAND with pebbles and wood fragments (fill)	8
6-9	Tan very silty fine SAND	15
9-12	Tan-orange silty clayey fine SAND	15
12-15	Tan and yellow fine sandy SILT	5
15-18	Dark gray silty CLAY laminated with gray silty fine SAND	24
18-21	Dark gray silty CLAY laminated with gray silty fine SAND	26
21-24	Gray silty fine SAND laminated with dark gray silty CLAY	33
24-27	Gray silty fine SAND laminated with dark gray silty CLAY	39
27-30	Gray silty fine SAND laminated with dark gray silty CLAY	45

Notes: Boring drilled on 1-17-84.
Boring terminated at 30 feet and grouted to land surface.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches

SOIL TEST BORING: STB-8
(DPDO Hazardous Waste Tank)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Gray fine to coarse SAND with pebbles and yellow material (fill)	5
3-6	Gray fine to coarse SAND with pebbles and yellow material (fill)	3
6-9	Tan silty medium to fine SAND	3
9-12	Tan silty coarse to fine SAND	7
12-15	Tan and orange laminated slightly sandy silty CLAY	12
15-18	Gray silty fine SAND laminated with dark gray silty CLAY	36
18-21	Gray silty fine SAND laminated with dark gray silty CLAY	19
21-24	Gray silty fine SAND laminated with dark gray silty CLAY	27
24-27	Tan and orange silty fine SAND laminated with silty CLAY	24
27-30	Gray silty fine SAND laminated with dark gray silty CLAY	44

Notes: Boring drilled on 1-17-84.
Boring terminated at 30 feet and grouted to land surface.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

SOIL TEST BORING: STB-9
(DPDO Hazardous Waste Tank)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Black and tan fine to coarse SAND with rock fragments (fill)	4
3-6	Black and tan fine to coarse SAND with rock fragments (fill)	46
6-9	Dark gray and tan laminated silty fine to medium SAND	9
9-12	Dark gray and tan laminated silty fine to medium SAND	7
12-15	Dark gray silty CLAY laminated with gray silty fine SAND	30
15-18	Dark gray silty CLAY laminated with gray silty fine SAND	35
18-21	Gray silty fine SAND laminated with dark gray silty CLAY	31
21-24	Gray silty fine SAND laminated with dark gray silty CLAY	33
24-27	Gray silty fine SAND laminated with dark gray silty CLAY	37
27-30	Gray silty fine SAND laminated with dark gray silty CLAY	43

Notes: Boring drilled on 1-17-84.
Boring terminated at 30 feet and grouted to land surface.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

SOIL TEST BORING: STB-10
(DPDO Hazardous Waste Tank)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Tan clayey coarse to medium SAND with gravel (possible fill)	15
3-6	Tan silty medium to fine SAND	32
6-9	Tan silty fine SAND	14
9-12	Orange-tan silty fine SAND	5
12-15	Dark gray silty CLAY laminated with gray silty fine SAND	25
15-18	Dark gray silty CLAY laminated with gray silty fine SAND	23
18-21	Dark gray silty CLAY laminated with gray silty fine SAND	21
21-24	Dark gray silty CLAY laminated with gray silty fine SAND	21
24-27	Dark gray silty CLAY laminated with gray silty fine SAND	25
27-30	Gray silty fine SAND laminated with dark gray silty CLAY	21

Notes: Boring drilled on 1-17-84.
Boring terminated at 30 feet and grouted to land surface.

[a] The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

MONITORING WELL: MW-11
(Fire Training Area 3)

Depth interval (feet)	Description of subsurface conditions[a]
0.0-1.0	Brown silty fine to medium SAND
1.0-2.5	Brown-tan silty fine to medium SAND
2.5-6.5	Brown silty fine to coarse SAND
6.5-7.5	Orange-brown silty clayey fine to coarse SAND
7.5-10.5	Brown silty clayey fine to coarse SAND
10.5-20.0	Tan-brown silty fine to coarse SAND
(Thin gravel bed noted at 15.0 feet)	
20.0-21.0	Orange silty fine to coarse SAND
21.0-30.0	Gray fine sandy silty CLAY

Notes: Boring drilled on 1-21-84.
Boring terminated at 30 feet and monitoring well installed.

[a]Based on visual observation of auger cuttings by driller.

MONITORING WELL: MW-12
(Landfill Number 1)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-5	Brown fine to medium SAND (fill)	16
5-8	Tan medium to fine SAND	22
8-10	Tan and red medium to fine SAND	22
10-13	Tan and red laminated SILT and fine SAND	8
13-15	Tan silty fine to medium SAND	21
15-18	Tan fine to medium SAND	63
18-20	Tan slightly silty fine SAND	25
20-23	Gray silty fine SAND laminated with dark gray silty CLAY	24

Notes: Boring drilled on 2-29-84.
Boring terminated at 23 feet and monitoring well installed.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

MONITORING WELL: MW-13
(Landfill Number 4)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Dark brown clayey SAND with root material (fill)	14
3-5	Brown clayey SAND with glass and paper (fill)	9
5-8	Brown sandy CLAY with plastic and paper (fill)	50/4[b]
8-10	Brown sandy CLAY with wood fiber and plastic (fill)	24
10-13	Brown and black clayey SAND with wood fiber and plastic (fill)	30
13-15	Brown wood fiber and plastic with some clayey SAND (fill)	16
15-18	Brown wood fiber and plastic with some clayey SAND (fill)	50/6[c]
18-20	(No sample recovery)	9
20-23	Tan-gray silty fine to medium SAND with some roots	16
23-25.5	Tan-gray silty fine to coarse SAND with some well-rounded pebbles	10

Notes: Boring drilled on 2-28-84.
Boring terminated at 25.5 feet and monitoring well installed.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

[b]Indicates 50 blows required to drive soil sampler 4 inches.

[c]Indicates 50 blows required to drive soil sampler 6 inches.

MONITORING WELL: MW-14
(Landfill Number 4)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Tan silty medium to fine SAND	7
3-5	Gray and orange silty coarse to fine SAND with some root material and pebbles	11
5-8	Gray silty fine SAND laminated with dark gray clayey SILT	25
8-10	Gray silty fine SAND laminated with dark gray clayey SILT	22
10-13	Gray silty coarse to fine SAND	36
13-15.5	Gray silty fine SAND laminated with dark gray silty CLAY	22

Notes: Boring drilled on 2-24-84.
Boring terminated at 15.5 feet and monitoring well installed.

[a] The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

MONITORING WELL: MW-15
(Tank Farm Fuel Spill)

Depth interval (feet)	Description of subsurface conditions[a]
0.0-0.5	Brown silty fine to medium SAND
0.5-6.5	Tan-brown fine to medium sandy silty CLAY
6.5-7.0	Brown-red fine to medium sandy silty CLAY
7.0-8.5	Orange fine to coarse sandy silty CLAY
8.5-17.5	Tan-yellow slightly clayey silty fine to coarse SAND
(Thin gravel bed noted at 13.5 feet)	
17.5-22.5	Yellow-red silty fine to medium SAND
22.5-30.0	Gray fine sandy silty CLAY

Notes: Boring drilled on 1-27-84.
Boring terminated at 30 feed and monitoring well installed.

[a]Based on observation of auger cuttings by driller.

MONITORING WELL: MW-16
(Tank Farm Fuel Spill)

Depth interval (feet)	Description of subsurface conditions[a]
0.0-1.0	Tan-brown fine to medium sandy slightly silty CLAY (Topsoil)
1.0-2.5	Gray silty fine to medium SAND
2.5-5.0	Dark gray silty fine to medium SAND
6.5-8.0	Tan-gray slightly clayey silty fine SAND
8.0-9.5	Gray-brown fine to medium sandy silty CLAY
9.5-19.0	Orange silty fine to medium SAND
(Thin gravel bed noted at 13.5 feet)	
19.0-20.0	Gray slightly clayey silty fine SAND
20.0-30.0	Gray fine sandy silty CLAY

Notes: Boring drilled on 1-19-84.
Boring terminated at 30 feet and monitoring well installed.

[a]Based on observation of auger cuttings by driller.

MONITORING WELL: MW-17
(Tank Farm Fuel Spill)

Depth interval (feet)	Description of subsurface conditions[a]
0.0-1.0	Yellow-brown slightly clayey silty fine to medium SAND
1.0-2.5	Orange fine to medium sandy silty CLAY
2.5-6.5	Brown fine to medium sandy silty CLAY
6.5-8.5	Yellow-orange silty clayey fine to medium SAND
8.5-17.0	Brown-orange slightly clayey silty fine to medium SAND
17.0-22.5	Yellow-orange silty fine to coarse SAND
22.5-30.0	Gray fine sandy silty CLAY

Notes: Boring drilled on 1-27-84.
Boring terminated at 30 feet and monitoring well installed.

[a]Based on observation of auger cuttings by driller.

MONITORING WELL: MW-18
(Not Drilled)

MONITORING WELL: MW-19
(Tank Farm Fuel Line Leak)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Tan and dark gray silty fine to coarse SAND with some gravel	12
3-6	Dark gray silty fine to medium SAND with root material	18
6-9	Dark gray silty CLAY laminated with gray silty fine SAND	13
9-12	Dark gray silty CLAY laminated with gray silty fine SAND	17
12-15	Dark gray silty CLAY laminated with gray silty fine SAND	18

Notes: Boring drilled on 1-25-84.
Boring terminated at 15 feet and monitoring well installed.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

MONITORING WELL: MW-20
(Tank Farm Fuel Line Leak)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Brown silty fine to medium SAND	3
3-6	Light brown silty fine to medium SAND	27
6-9	Dark gray silty CLAY laminated with gray silty fine SAND	14
9-12	Dark gray silty CLAY laminated with gray silty fine SAND	16
12-15	Dark gray silty CLAY laminated with gray silty fine SAND	18

Notes: Boring drilled on 1-26-84.
Boring terminated at 15 feet and monitoring well installed.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

MONITORING WELL: MW-21
(Tank Farm Fuel Line Leak)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Gray medium to coarse SAND	14
3-6	Tan-gray clayey fine to coarse SAND with gravel	15
6-9	Gray silty fine SAND laminated with dark gray silty CLAY	22
9-12	Gray silty fine SAND laminated with dark gray silty CLAY	26
12-15	Dark gray silty CLAY laminated with gray silty fine SAND	23

Notes: Boring drilled on 1-25-84.
Boring terminated at 15 feet and

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

MONITORING WELL: MW-22
(Tank Farm Fuel Line Leak)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Black clayey fine to coarse sand with some root material (fill)	3
3-6	WOOD fibers with some clayey fine to medium sand	39
6-9	White-tan silty fine SAND	31
9-12	Dark red-brown silty fine SAND with some gravel	24
12-15	Dark gray silty CLAY laminated with gray silty fine sand	16

Notes: Boring drilled on 1-23-84.
Boring terminated at 15 feet and monitoring well installed.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

MONITORING WELL: MW-23
(Tank Farm Fuel Line Leak)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Dark gray clayey medium to fine SAND	10
3-6	Dark gray fine sandy SILT	5
6-9	Tan silty medium to fine SAND with some gravel	25
9-12	White and tan silty fine to medium SAND with gravel	32
12-15	Orange and tan fine sandy SILT	7

Notes: Boring drilled on 1-26-84.
Boring terminated at 15 feet and monitoring well installed.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

MONITORING WELL: MW-24
(Drain Pipe Outfall/CRS[a] Ditch)

Depth interval (feet)	Description of subsurface conditions[b]	Penetration resistance[c] (blows per foot)
0-3	Brown slightly clayey silty fine to medium SAND	17
3-6	Dark brown silty fine to medium SAND	22
6-9	Light gray silty fine to coarse SAND	3
9-12	Tan-gray slightly clayey silty fine to coarse SAND	12
12-15	Gray fine sandy silty CLAY	17

Notes: Boring drilled on 1-26-84.
Boring terminated at 15 feet and monitoring well installed.

[a]Denotes component repair squadron.

[b]Based on observation of soil samples by driller.

[c]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

MONITORING WELL: MW-25
(Ditch Adjacent to Railroad Tracks)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Tan slightly silty fine SAND	22
3-5	Tan silty fine SAND with strong petroleum-like odor	12
5-8	Dark gray silty CLAY laminated with gray silty fine SAND	3
8-10	Dark gray silty CLAY laminated with gray silty fine SAND	10
10-12	Dark gray silty CLAY laminated with gray silty fine SAND	17
12-15	Dark gray silty CLAY laminated with gray silty fine SAND	15

Notes: Boring drilled on 2-22-84.
Boring terminated at 15.5 feet and monitoring well installed.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

MONITORING WELL: MW-26
(Tank Farm Fuel Line Leak)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Black silty and clayey coarse to fine SAND (fill) with petroleum-like odor	4
3-6	Tan silty fine to medium SAND with petroleum-like odor	32
6-9	Light tan and orange silty fine to medium SAND with petroleum-like odor	11
9-12	Gray silty fine SAND laminated with dark gray silty CLAY	16
12-15	Dark gray silty CLAY laminated with gray silty fine SAND	22

Notes: Boring drilled on 1-19-84.
Boring terminated at 15 feet and monitoring well installed.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

SOIL TEST BORING: STB-27
(Suspected JP-4 Contamination Site)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Tan silty fine to medium SAND	9
3-6	Tan-orange with some gray silty fine to medium SAND	32
6-9	Tan coarse to medium SAND with some well-rounded pebbles	24
9-12	Alternating olive-gray with brown silty CLAY	4
12-15	Gray CLAY	50/3[b]

Notes: Boring drilled on 1-13-84.
Boring terminated at 15 feet, backfilled with soil, and grouted at land surface.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

[b]Indicates 50 blows required to drive soil sampler 3 inches.

SOIL TEST BORING: STB-28
(Suspected JP-4 Contamination Site)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Gray and red-brown sandy silty CLAY	28
3-6	Red-brown silty medium to fine SAND with some well-rounded pebbles	31
6-9	Tan silty medium to fine SAND with some well-rounded pebbles	34
9-12	Tan and brown fine sandy SILT	5
12-15	Well-rounded quartz GRAVEL in a matrix of sandy SILT	45

Notes: Boring drilled on 1-13-84.
Boring terminated at 15 feet, backfilled with soil, and grouted at land surface.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

SOIL TEST BORING: STB-29
(Suspected JP-4 Contamination Site)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Tan and gray very silty fine to medium SAND	5
3-6	Tan and gray with red-brown very silty fine to medium SAND	30
6-9	Alternating olive-gray with brown silty CLAY	11
9-12	Dark gray CLAY (partially cemented)	32
12-14.8	Gray silty fine SAND (cemented)	88/9[b]

Notes: Boring drilled on 1-16-84.
Boring terminated at 14.8 feet, backfilled with soil, and grouted at land surface.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

[b]Indicates 88 blows required to drive soil sampler 9 inches.

SOIL TEST BORING: STB-30
(Suspected JP-4 Contamination Site)

Depth interval (feet)	Description of subsurface conditions	Penetration resistance[a] (blows per foot)
0-3	Tan silty fine SAND	8
3-6	Tan and gray with red-brown silty coarse to fine SAND	37
6-9	Tan and red silty fine to coarse SAND with some gravel	21
9-12	Tan and brown silty CLAY	21
12-14.1	Dark gray silty CLAY	50/1[b]

Notes: Boring drilled on 1-16-84.
Boring terminated at 14.1 feet, backfilled with soil, and grouted at land surface.

[a]The number of blows required to drive a standard soil sampler 12 inches into the ground using a weight of 140 pounds falling freely from a height of 30 inches.

[b]Indicates 50 blows required to drive soil sampler 1 inch.

APPENDIX D

GENERAL CONSTRUCTION AND SURVEYING DATA FOR MONITORING WELLS AND SOIL TEST BORINGS INSTALLED ON BASE

TABLE D-1. GENERAL CONSTRUCTION AND SURVEYING DATA FOR MONITORING WELLS AND SOIL TEST BORINGS INSTALLED ON BASE

Monitoring well (MW) or soil test boring (STB) number	Depth of well or boring below land surface (ft)	Stick up of outer well casing[a] above land surface (ft)	Screened interval of well below land surface (ft)	Elevation at top of outer well casing[a] or land surface of STB (ft above msl)	Horizontal coordinates of well or STB[b]
MW-1	13.6	1.9	8.6 - 13.6	89.64	N 581,644 E 2,308,544
MW-2	14.3	2.0	9.3 - 14.3	84.54	N 580,852 E 2,309,527
MW-3	10.1	2.6	5.1 - 10.1	72.26	N 580,140 E 2,309,183
MW-4	14.9	2.1	9.9 - 14.9	83.18	N 580,378 E 2,308,293
MW-5	14.5	1.9	9.5 - 14.5	70.20	N 579,398 E 2,309,763
MW-6	14.8	1.5	9.8 - 14.8	69.48	N 579,059 E 2,308,716
STB-7	30.0	NA	NA	99.32	N 587,575 E 2,307,352
STB-8	30.0	NA	NA	97.43	N 587,534 E 2,307,319
STB-9	30.0	NA	NA	98.35	N 587,501 E 2,307,352
STB-10	30.0	NA	NA	101.12	N 587,517 E 2,307,425

(continued)

TABLE D-1 (continued)

Monitoring well (MW) or soil test boring (STB) number	Depth of well or boring below land surface (ft)	Stick up of outer well casing[a] above land surface (ft)	Screened interval of well below land surface (ft)	Elevation at top of outer well casing[a] or land surface of STB (ft above msl)	Horizontal coordinates of well or STB[b]
MW-11	27.8	2.0	22.8 - 27.8	91.62	N 585,019 E 2,305,557
MW-12	20.5	3.2	15.5 - 20.5	85.85	N 585,589 E 2,305,419
MW-13	23.7	2.0	18.7 - 23.7	86.00	N 586,245 E 2,306,010
MW-14	14.7	2.1	9.7 - 14.7	74.94	N 586,355 E 2,306,184
MW-15	29.6	1.9	24.6 - 29.6	93.45	N 583,725 E 2,307,444
MW-16	29.5	2.1	24.5 - 29.5	96.03	N 583,866 E 2,307,160
MW-17	29.8	1.9	24.8 - 29.8	101.87	N 583,464 E 2,307,673
MW-18	--	--	(Not drilled)	--	---
MW-19	14.8	1.7	9.8 - 14.8	91.61	N 583,971 E 2,306,772
MW-20	15.1	1.9	10.1 - 15.1	88.65	N 583,838 E 2,306,776
MW-21	14.8	1.9	9.8 - 14.8	90.65	N 583,908 E 2,306,850

(continued)

TABLE D-1 (continued)

Monitoring well (MW) or soil test boring (STB) number	Depth of well or boring below land surface (ft)	Stick up of outer well casing[a] above land surface (ft)	Screened interval of well below land surface (ft)	Elevation at top of outer well casing[a] or land surface of STB (ft above msl)	Horizontal coordinates of well or STB[b]
MW-22	11.1	2.1	6.1 - 11.1	91.11	N 583,821 E 2,306,881
MW-23	14.4	2.0	9.4 - 14.4	89.82	N 583,680 E 2,306,816
MW-24	15.1	2.1	10.1 - 15.1	86.74	N 583,279 E 2,306,819
MW-25	10.2	2.0	5.2 - 10.2	91.00	N 583,515 E 2,306,711
MW-26	14.5	1.8	9.5 - 14.5	83.91	N 583,782 E 2,307,039
STB-27	13.8	NA	NA	c	c
STB-28	15.0	NA	NA	96.17	N 581,960 E 2,311,815
STB-29	14.8	NA	NA	95.36	N 582,153 E 2,311,623
STB-30	14.1	NA	NA	96.79	N 582,416 E 2,311,552

NA = Not applicable.

msl = Mean sea level.

[a]Used for measuring point.

[b]Referenced to base grid system.

[c]Not located by surveyor.

APPENDIX E

WATER LEVEL DATA FOR WELLS INSTALLED ON BASE

TABLE E-1. WATER LEVEL DATA FOR WELLS INSTALLED ON BASE

Well number	Late February 1984: Depth of water below ground surface (ft)	Late February 1984: Elevation of groundwater (ft above msl)	Early April 1984: Depth of water below ground surface (ft)	Early April 1984: Elevation of groundwater (ft above msl)
MW-1	4.00	83.74	3.60	84.14
MW-2	10.34	72.20	9.60	72.94
MW-3	5.04	64.62	4.25	65.41
MW-4	5.64	75.44	5.05	76.03
MW-5	4.57	63.73	3.95	64.35
MW-6	9.12	58.86	8.10	59.88
MW-11	7.05	82.57	5.83	83.79
MW-12	a	a	9.55	73.10
MW-13	a	a	17.05	66.95
MW-14	a	a	4.82	68.02
MW-15	11.29	80.26	10.93	80.62
MW-16	13.70	80.23	15.45	78.48
MW-17	14.76	85.21	14.35	85.62
MW-19	4.33	85.58	6.90	83.01
MW-20	6.34	80.41	6.75	80.00
MW-21	3.31	85.44	4.15	84.60
MW-22	5.17	83.84	5.11	83.90
MW-23	4.23	83.59	4.00	83.82
MW-24	2.16	82.48	2.46	82.18
MW-25	a	a	0.35	88.65
MW-26	3.90	78.21	3.86	78.25

msl = Mean sea level.

[a]No groundwater reading obtained during well installation.

APPENDIX F

RESULTS OF WELL DEVELOPMENT

TABLE F-1. RESULTS OF WELL DEVELOPMENT

Well number (and date)	Temperature (° C)	Specific conductivity (µmho/cm)	Cumulative volume extracted (gal.)	Approximate casing volume (gal.)	Estimated well yield (gal/min)	Observations of discharged groundwater (and method of development)
MW-1 (3-6-84)	15	135	--			Initially turbid, sandy-colored water with very fine sand. Transition to fairly clear, light tan water with very little fine sand.
	16	170	10			
	16	190	15			
	15	190	25			
	19	180	30			
	14	170	40			
	15	190	70			
	14	170	75	2	<1	(Centrifugal pump)
MW-2 (3-7-84)	10	52	--			Initially brown, flocculent-silty water with some sand. Transition to tan color with trace of fine sand. Final transition to clear water with no fine sand or silt.
	13	55	5			
	14	60	10			
	14	60	13			
	14	62	15			
	17	66	18			
	15	60	24			
	15	62	29			
	16	62	37			
	16	62	41			
	15	60	49	1	<1	(Centrifugal pump)
MW-3 (3-7-84)	10	50	--			Initially very dark gray water with some very fine sand. Transition to medium to light gray color with decreasing sand content. Final transition to clear water with only trace of fine sand.
	13	50	5			
	13	40	10			
	13	40	13			
	12	32	15			
	13	35	17			
	13	35	20			
	13	37	22			
	13	37	28			
	13	37	30	1	<1	(Centrifugal pump)

(continued)

TABLE F-1 (continued)

Well number (and date)	Temperature (° C)	Specific conductivity (µmho/cm)	Cumulative volume extracted (gal.)	Approximate casing volume (gal.)	Estimated well yield (gal/min)	Observations of discharged groundwater (and method of development)
MW-4	9	65	--			Hydrogen sulfide odor of water throughout development. Initially dark gray, silty water. Transition to tan color with trace of fine sand and silt. Final transition to very light tan with only trace of fine sand.
	12	61	10			
	12	60	15			
	14	65	30			
	13	61	35			
	13	60	45			
	12	58	60			
	12	60	77			
	13	61	82			
	12	58	97			
	12	60	112	2	2	(Centrifugal pump)
MW-5 (3-7-84)	10	40	--			Initially dark gray water with fine sand. Transition to very light gray to clear color. Final transition to clear water with only trace of fine sand.
	13	38	10			
	15	40	15			
	16	40	25			
	15	40	30			
	15	40	40			
	15	40	45			
	15	40	50	2	2	(Centrifugal pump)
MW-6 (3-7-84)	13	82	3			Initially dark gray to medium gray water with fine sand. Transition to clear water with only trace of fine sand.
	14	82	5			
	14	82	8			
	14	82	20			
	14	81	25			
	14	85	30			
	13	85	33			
	13	82	38	1	2	(Centrifugal pump)

(continued)

TABLE F-1 (continued)

Well number (and date)	Temperature (° C)	Specific conductivity (μmho/cm)	Cumulative volume extracted (gal.)	Approximate casing volume (gal.)	Estimated well yield (gal/min)	Observations of discharged groundwater (and method of development)
MW-11 (3-5-84)	15	120	--			Initially dark gray color transitioning to light gray.
	20	80	8			
	19	60	16			
	17	50	23			
	17	52	28			
	17	52	33	3	<1	(Initially centrifugal pump, changed to PVC bailer)
MW-12 (3-6-84)	15	230	30			Initially tan water with fine sand. Transition to clear water with only trace of fine sand.
	14	110	40			
	14	110	60			
	14	108	90			
	15	100	120	2	<10	(Centrifugal pump)
MW-13 (3-5-84)	16	1900	--			Strong hydrogen sulfide odor of water throughout development. Initially dark gray color. Remained gray throughout development.
	17	1025	5			
	17	800	10			
	17	680	15			
	19	260	25			
	18	230	30			
	18	210	40	1	<1	(Centrifugal pump)
MW-14 (3-5-84)	16	100	--			Initially dark gray color. Transition to very light gray color.
	17	55	5			
	17	50	10			
	15	50	13			
	13	45	15			
	12	45	17			
	12	40	19	1	<1	(PVC bailer)

(continued)

TABLE F-1 (continued)

Well number (and date)	Temperature (° C)	Specific conductivity (μmho/cm)	Cumulative volume extracted (gal.)	Approximate casing volume (gal.)	Estimated well yield (gal/min)	Observations of discharged groundwater (and method of development)
MW-15 (3-14-84)	22	89	5			Initially dark brown water with fine sand. Transition to light brown and finally clear with only trace of fine sand.
	23	78	11			
	22	80	22			
	22	80	27			
	22	79	30			
	21	78	33			
	22	79	46			
	--	--	56	3	<1	(Centrifugal pump)
MW-16 (3-14-84)	20	52	24			Initially dark gray water with high content of fine sand. Transition to medium gray and finally clear with only trace of fine sand.
	19	52	29			
	22	52	37			
	22	55	38			
	17	58	43			
	22	60	51			
	23	57	58			
	22	52	75			
	21	52	83			
	24	58	89			
	25	60	92	3	<1	(Centrifugal pump)
MW-17 (3-12-84)	16	58	5			Initially dark brown to light tan water. Transition to clear water with no indication of fine sand.
	18	50	20			
	19	51	37			
	21	55	69			
	19	52	101			
	19	53	128			
	21	55	160			
	19	55	192			
	19	55	224	2	15	(Centrifugal pump)

(continued)

TABLE F-1 (continued)

Well number (and date	Temperature (° C)	Specific conductivity (μmho/cm)	Cumulative volume extracted (gal.)	Approximate casing volume (gal.)	Estimated well yield (gal/min)	Observations of discharged groundwater (and method of development)
MW-19 (3-8-84)	13	73	4			Initially some hydrogen sulfide odor. Water brown and dark gray with high content of fine sand. Transition to light tan then clear with only trace of fine sand.
	14	72	11			
	17	73	15			
	17	72	18			
	17	75	20			
	19	78	24			
	18	78	28			
	19	82	43			
	16	79	46			
	17	79	48	2	<1	(Centrifugal pump)
MW-20	20	30	6			Initially dark gray and turbid water. Transition to medium gray.
	27	40	12			
	16	35	18			
	18	35	19	1	<1	(Centrifugal pump)
MW-21 (3-8-84)	17	52	10			Initially very turbid and dark gray color. Transition to medium and light gray color. Final transition to clear water with only a trace of fine sand.
	17	45	14			
	17	45	16			
	17	46	17			
	16	45	20			
	16	45	24			
	19	47	26			
	21	45	31			
	18	45	33			
	20	48	36	2	<1	(Centrifugal pump)
MW-22 (3-14-84)	--	--	45	1	<1	Well produces red-colored groundwater. Some separation initially between brown color (top) and red color (bottom). Fine sand contained in water. Discharged water was disposed of in oil/water separator in base POL area. (Hand-operated pump)

(continued)

TABLE F-1 (continued)

Well number (and date)	Temperature (° C)	Specific conductivity (μmho/cm)	Cumulative volume extracted (gal.)	Approximate casing volume (gal.)	Estimated well yield (gal/min)	Observations of discharged groundwater (and method of development)
MW-23 (3-8-84)	14	58	25			Initially tan-brown water with fine sand and hydrogen sulfide odor. Transition to tan-yellow color and no indication of fine sand.
	14	60	32			
	14	60	89			
	14	60	121			
	14	60	153			
	14	57	185			
	14	60	217			
	14	60	249	2	6-8	(Centrifugal pump)
MW-24 (3-12-84)	21	75	5			Initially dark brown water with slight hydrogen sulfide odor. Transition to light tan then clear with only a trace of fine sand.
	19	53	8			
	19	53	11			
	19	58	15			
	19	60	18			
	19	61	20			
	19	61	24			
	19	62	26			
	18	63	32	2	<1	(Centrifugal pump)
MW-25 (3-12 and 3-14, 1984)	15	53	5			Initially dark gray water. Transition to fairly clear water but still turbid.
	13	38	10			
	16	42	14			
	15	35	18	<2	<1	(PVC bailer)
MW-26 (3-12-84)	--	--	68	11		Well produces groundwater with fuel-oil like odor. Initially light brown to tan and foamy. Transition to light tan then clear but with fuel-oil like odor and trace of fine sand. Discharged water was disposed of in oil/water separator in Base POL area. (Hand-operated pump)

APPENDIX G

RESULTS OF FIELD MEASUREMENTS CONDUCTED
ON GROUNDWATER SAMPLES

TABLE G-1. RESULTS OF FIELD MEASUREMENTS CONDUCTED ON GROUNDWATER SAMPLES

Well number	Specific conductivity (μmho)		pH (standard) units)	Temperature (° C)	
	March 5-14, 1984	April 3-9, 1984	April 3-9, 1984	March 5-14, 1984	April 3-9, 1984
MW-1	170	155	5.95	14	11
MW-2	60	55	4.75	15	13
MW-3	37	41	4.25	13	12
MW-4	60	58	5.40	12	12
MW-5	40	40	5.85	15	13
MW-6	82	80	4.10	13	12
MW-11	52	50	5.50	17	18
MW-12	100	142	5.55	15	15
MW-13	210	1090	6.20	18	18
MW-14	40	52	4.95	12	20
MW-15	79	55	5.10	22	19
MW-16	60	53	4.80	25	18
MW-17	55	58	4.50	19	21
MW-19	79	70	4.55	17	14
MW-20	35	40	4.85	18	18
MW-21	48	51	4.45	20	15
MW-22	--	87	5.70	--	16
MW-23	60	63	5.55	14	18
MW-24	63	67	5.45	18	13
MW-25	35	38	5.10	15	14
MW-26	--	48	4.80	--	16
SW-1[a]	--	1700	6.45	--	17

[a]Denotes seepage sample from landfill no. 4.

APPENDIX H

RESULTS OF WATER AND SOIL ANALYSES

TABLE H-1. RESULTS OF GROUNDWATER ANALYSES
(Tank Farm Fuel Line Leak)

Monitoring well number	Sampling date (1984)	Oil and grease (mg/l)	Total organic carbon (mg/l)	Total organic halogen (μg/l)
MW-19	4-5	1.48	3.0	BDL
MW-20	4-5	1.20	1.6	BDL
MW-21	4-5	0.83	0.7	BDL
MW-22	4-6	BDL	8.2	BDL
MW-23	4-5	BDL	5.4	BDL
MW-26	4-6	3.21	3.8	BDL

---Volatile organic compounds[a] (μg/l)---

Monitoring well number	Benzene	Ethyl-benzene	trans-1,2-Dichloro-ethylene	Toluene	Methylene chloride	1,2-Dichloro-ethane	1,1,1-Tri-chloroethane
MW-26	15	BDL	BDL	12	BDL	48	11

[a]All samples undergoing volatile organic compound analysis were scanned for the 31 priority pollutants delineated in EPA Method 624 (refer to Appendix A). Those compounds that were consistently below the detection limits in all of the samples tested are not listed.

BDL = Below detection limits (refer to Table A-1).

TABLE H-2. RESULTS OF GROUNDWATER ANALYSES
(Ditch Adjacent to Railroad Tracks)

Monitoring well number	Sampling date (1984)	Oil and grease (mg/l)	Total organic carbon (mg/l)	Total organic halogen (µg/l)
MW-25	4-5	BDL	0.8	BDL

---Volatile organic compounds[a] (µg/l)---

Monitoring well number	Benzene	Ethyl-benzene	trans-1,2-Dichloro-ethylene	Toluene	Methylene chloride	1,2-Dichloro-ethane	1,1,1-Tri-chloroethane
MW-25	15	BDL	BDL	25	BDL	BDL	BDL

[a]All samples undergoing volatile organic compound analysis were scanned for the 31 priority pollutants delineated in EPA Method 624 (refer to Appendix A). Those compounds that were consistently below the detection limits in all of the samples tested are not listed.

BDL = Below detection limits (refer to Table A-1).

TABLE H-3. RESULTS OF GROUNDWATER ANALYSES
(Drain Pipe Outfall/CRS[a] Ditch)

Monitoring well number	Sampling date (1984)	Oil and grease (mg/l)	Total organic carbon (mg/l)	Total organic halogen (μg/l)
MW-24	4-5	4.67	8.7	BDL

---Volatile organic compounds[b] (μg/l)---

Monitoring well number	Benzene	Ethyl-benzene	trans-1,2-Dichloro-ethylene	Toluene	Methylene chloride	1,2-Dichloro-ethane	1,1,1-Tri-chloroethane
MW-24	95	45	BDL	180	17	BDL	BDL

[a]Denotes component repair squadron.

[b]All samples undergoing volatile organic compound analysis were scanned for the 31 priority pollutants delineated in EPA Method 624 (refer to Appendix A). Those compounds that were consistently below the detection limits in all of the samples tested are not listed.

BDL = Below detection limits (refer to Table A-1).

TABLE H-4. RESULTS OF GROUNDWATER ANALYSES
(Fuel Hydrant System Leak)

Monitoring well number	Sampling date (1984)	Oil and grease (mg/l)	Total organic carbon (mg/l)
MW-1	4-9	BDL	5.5
MW-2	4-9	0.94	0.7
MW-3	4-9	1.26	1.3
MW-4	4-9	0.94	10.1
MW-5	4-9	BDL	1.7
MW-6	4-9	1.52	11.0

BDL = Below detection limits (refer to Table A-1).

TABLE H-5. RESULTS OF GROUNDWATER ANALYSES
(Tank Farm Fuel Spill)

Monitoring well number	Sampling date (1984)	Oil and grease (mg/l)	Total organic carbon (mg/l)
MW-15	4-6	3.60	1.6
MW-16	4-6	BDL	BDL
MW-17	4-6	BDL	17.7

BDL = Below detection limits (refer to Table A-1).

TABLE H-6. RESULTS OF GROUNDWATER AND SEEPAGE WATER ANALYSES
(Fire Training Area 3 and Landfills 1 and 4)

Monitoring well number	Sampling date (1984)	Nitrate (mg/l)	Oil and grease (mg/l)	Total organic carbon (mg/l)	Total organic halogen (µg/l)	Phenol (µg/l)
MW-11	4-4	BDL	1.85	0.6	BDL	BDL
MW-12	4-3	--	--	3.8	BDL	BDL
MW-13	4-3	--	--	40.9	100.9	184
MW-14	4-4	--	--	1.0	BDL	BDL

Sampling location	Sampling date (1984)	Lead (µg/l)	Cadmium (µg/l)	Chromium (µg/l)	Nickel (µg/l)
SW-1	4-4				
Dissolved (field filtered)		2.11	0.52	BDL	37.0
Total (not filtered)		5.01	0.75	2.31	26.9

---Volatile organic compounds[a] (µg/l)---

Sampling location	Benzene	Ethyl-benzene	trans-1,2-Dichloro-ethylene	Toluene	Methylene chloride	1,2-Dichloro-ethane	1,1,1-Tri-chloroethane
SW-1	30	30	19	50	BDL	BDL	BDL

[a] All samples undergoing volatile organic compound analysis were scanned for the 31 priority pollutants delineated in EPA Method 624 (refer to Appendix A). Those compounds that were consistently below the detection limits in all of the samples tested are not listed.

-- = Not analyzed.

BDL = Below detection limits (refer to Table A-1).

TABLE H-7. RESULTS OF SOIL ANALYSIS
(DPDO HAZARDOUS WASTE TANK)

Soil test boring number	Sample depth (ft)	Date drilled (1984)	Oil and grease (μg/g)	Lead (μg/g)	Chromium (μg/g)	Pesticides[a] (μg/g)
STB-7	3	1-17	63.9	2.3	3.0	BDL
	9		BDL	3.0	7.5	BDL
	15		BDL	2.5	9.7	BDL
	21		BDL	3.3	7.3	BDL
	27		BDL	BDL	4.6	BDL
STB-8	3	1-17	243.3	676.0	71.0	BDL
	9		BDL	BDL	2.5	BDL
	15		BDL	6.8	3.1	BDL
	21		BDL	0.8	8.2	BDL
	27		BDL	3.5	7.4	BDL
STB-9	3	1-17	9,074.0	0.6	6.8	BDL
	9		BDL	2.6	2.9	BDL
	15		BDL	2.4	10.2	BDL
	21		BDL	1.1	7.8	BDL
	27		BDL	9.5	3.0	BDL
STB-10	3	1-17	BDL	0.9	3.1	BDL
	9		BDL	0.9	4.2	BDL
	15		BDL	1.6	6.4	BDL
	21		BDL	1.8	6.7	BDL
	27		BDL	2.3	5.9	BDL

[a]Refer to Table A-1 for the list of pesticide compounds.

BDL = Below detection limits (refer to Table A-1).

TABLE H-8. RESULTS OF SOIL ANALYSES
(Suspected JP-4 Contamination Site)

Soil test boring number	Sample depth (ft)	Date drilled (1984)	Oil and grease (μg/g)
STB-27	6	1-13	BDL
	9		BDL
STB-28	9	1-13	BDL
	12		BDL
STB-29	9	1-16	BDL
	12		BDL
STB-30	9	1-16	BDL
	12		BDL

BDL = Below detection limits (refer to Table A-1).

APPENDIX I

RESULTS OF SUPPLEMENTAL GROUNDWATER ANALYSES IN POL AREA

TABLE I-1. RESULTS OF CHEMICAL OXYGEN DEMAND

Monitoring well number	Base sample number	Chemical oxygen demand (mg/l)
MW-15	840076	BDL
MW-22	840071	BDL
MW-24	840066	40
MW-25	840061	25

NOTE: Samples collected on May 3, 1984, by RTI and analyzed by OEHL-Brooks.

BDL = Below detection limits (BDL = <10 mg/l for chemical oxygen demand).

TABLE I-2. RESULTS OF VOLATILE AROMATICS

Monitoring well No: OEHL sample No: Base sample No:		MW-25 25710 GN840062	MW-25 25711 GN840063	MW-24 25714 GN840067	MW-24 25715 GN840068	MW-22 25718 GN840072	MW-22 25719 GN840073	MW-15 25722 GN840077	MW-15 25723 GN840078
	Detection limit (μg/l)	Results, μg/l							
Benzene	1.0	23	24	205	153	19	11	BDL	BDL
Chlorobenzene	1.0	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichlorobenzene	2.0	BDL	BDL	237	173	134	96	BDL	BDL
1,3-Dichlorobenzene	2.0	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,4-Dichlorobenzene	2.0	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Ethylbenzene	1.0	1.9	1.9	410	314	10	4.5	BDL	BDL
Toluene	1.0	BDL	BDL	317	220	BDL	BDL	BDL	BDL

BDL = Below detection limits indicated.

NOTES: Samples obtained on May 3, 1984, by RTI and analyzed by OEHL-Brooks.
Methodology: EPA Method 602.

PART I-3: RESULTS OF VOLATILE HALOCARBONS

Monitoring well No: OEHL sample No: Base sample No:	Detection limit (μg/l)	MW-25 25712 GN840064	MW-25 25713 GN840065	MW-24 15716 GN840069	MW-24 25717 GN840070	MW-22 25720 GN840074	MW-22 25721 GN840075	MW-15 25724 GN840079	MW-15 25725 GN840080
		Results, μg/l							
Bromodichloromethane	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Bromoform	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Bromomethane	1.0	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Carbon tetrachloride	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chlorobenzene	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chloroethane	0.5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
2-Chloroethyl vinyl ether	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chloroform	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chloromethane	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Dibromochloromethane	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichlorobenzene	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,3-Dichlorobenzene	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,4-Dichlorobenzene	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Dichlorodifluoromethane	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1-Dichloroethane	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichloroethane	0.2	0.7	1.0	BDL	BDL	0.6	0.8	BDL	BDL
1,1-Dichloroethene	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
trans-1,3-Dichloroethene	0.1	BDL	BDL	BDL	BDL	1.1	1.3	BDL	BDL
1,2-Dichloropropane	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
cis-1,3-Dichloropropene	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
trans-1,3-Dichloropropene	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Methylene chloride	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,2,2-Tetrachloroethane	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Tetrachloroethylene	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,1-Trichloroethane	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,2-Trichloroethane	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Trichloroethylene	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Trichlorofluoromethane	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Vinyl chloride	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

BDL = Below detection limits indicated.

NOTES: Samples obtained on May 3, 1984, by RTI and analyzed by OEHL-Brooks.
Methodology: EPA Method 601.

APPENDIX J

GLOSSARY OF ACRONYMS

APPENDIX J

GLOSSARY OF ACRONYMS

AFB	=	Air Force Base
CERCLA	=	Comprehensive Environmental Response, Compensation, and Liability Act
CRS	=	Component Repair Squadron
DEQPPM	=	Defense Environmental Quality Program Policy Memorandum
DOD	=	Department of Defense
DPDO	=	Defense Property Disposal Office
EP Toxicity	=	EPA Extraction Procedure Toxicity
EPA	=	Environmental Protection Agency
GC/MS	=	Gas chromatography/mass spectrometry
HARM	=	Hazard Assessment Rating Methodology
IRP	=	Installation Restoration Program
JP-4	=	jet propulsion (fuel) -4
MW	=	Monitoring well
O&G	=	Oil and grease
OEHL	=	Occupational and Environmental Health Laboratory
POL	=	Petroleum, oils, and lubricants
PVC	=	Polyvinyl chloride
RCRA	=	Resource Conservation and Recovery Act
RTI	=	Research Triangle Institute
SAC	=	Strategic Air Command
STB	=	Soil test boring
SW	=	Surface water
TAC	=	Tactical Air Command
TOC	=	Total organic carbon
TOX	=	Total organic halogen
USGS	=	United States Geological Survey
VOC	=	Volatile organic compounds

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