NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
TRENTON, NEW JERSEY

FINAL REMEDIAL INVESTIGATION REPORT

REMEDIAL INVESTIGATION/FEASIBILITY STUDY

COMBE FILL SOUTH LANDFILL

VOLUME I

May 1986

LAWLER, MATUSKY & SKELLY ENGINEERS
as Prime Contractor in Association with
R.E. WRIGHT ASSOCIATES, INC.

509369

Project No. 455-102

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CHAPTER 1

INTRODUCTION

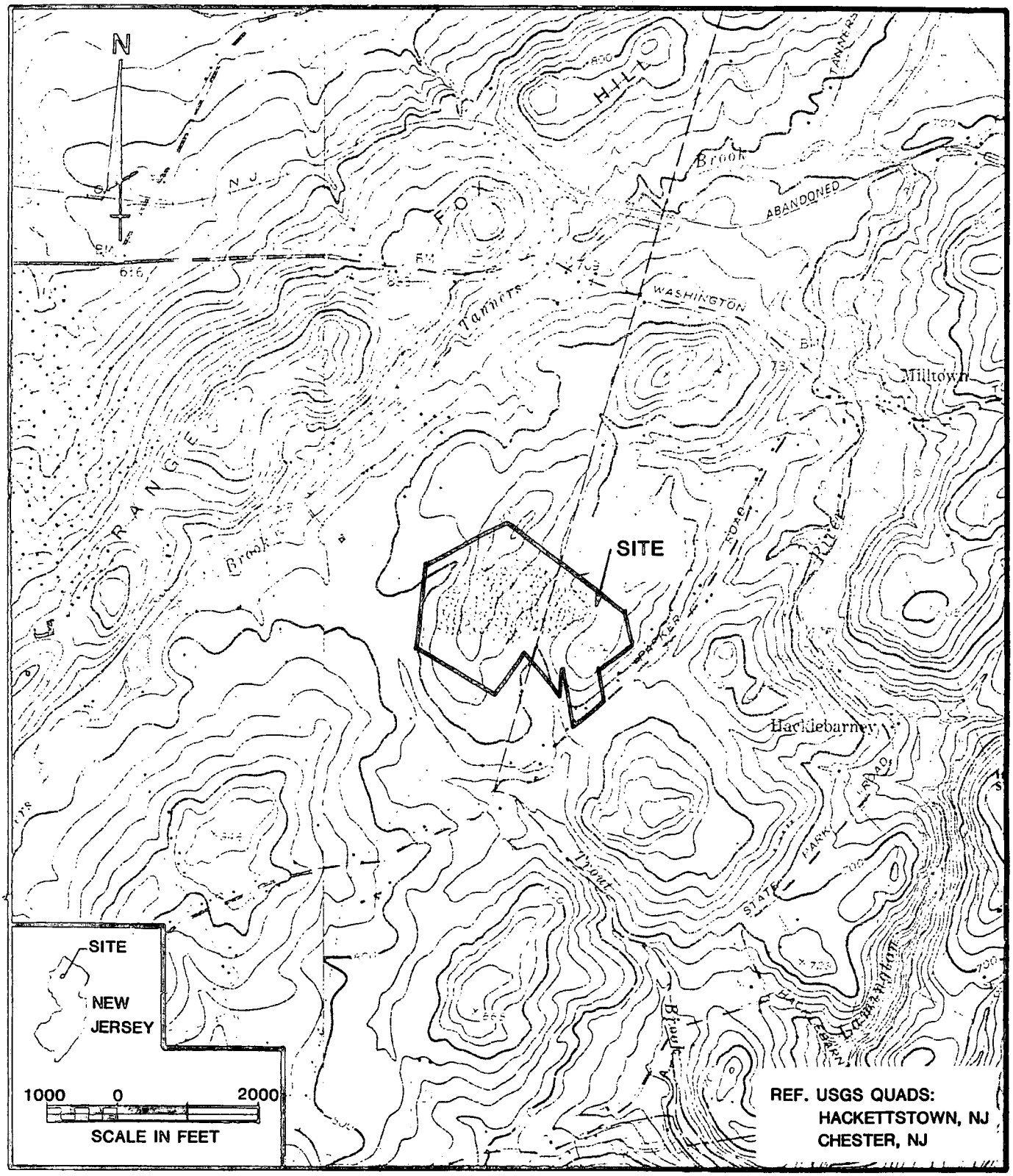
1.1 BACKGROUND

1.1.1 Site Location

The Combe Fill South landfill study site is located in a semirural area of Chester and Washington townships, Morris County, NJ, approximately 20 miles west of Morristown (Figure 1-1). The land parcels currently owned by the Combe Fill Corporation (administered by a trustee-in-bankruptcy) that make up the majority of the site include five contiguous lots of about 115 acres. Of this acreage, 81 are in Chester Township (Block 37, Lots, 15, 16, 16-1, and 16-3) and 34 are in Washington Township (Block 17, Lot 7). The townships' common boundary bisects the site in a northeast-southwest direction (Figure 1-2). The approximate center of the site can be located at 40° 46' 17" north latitude and 74° 44' 29" west longtitude.

A sixth parcel of land about six acres in size (Chester Block 37, Lot 28), also owned by the Combe Fill Corp., is not contiguous with the other parcels. It is not part of this study because no landfilling activities are known or suspected to have occurred there. Properties now belonging to several neighbors of the Combe Fill South landfill, located between the discontiguous smaller parcel and the five larger parcels, were previously owned by the Combe Fill Corp.

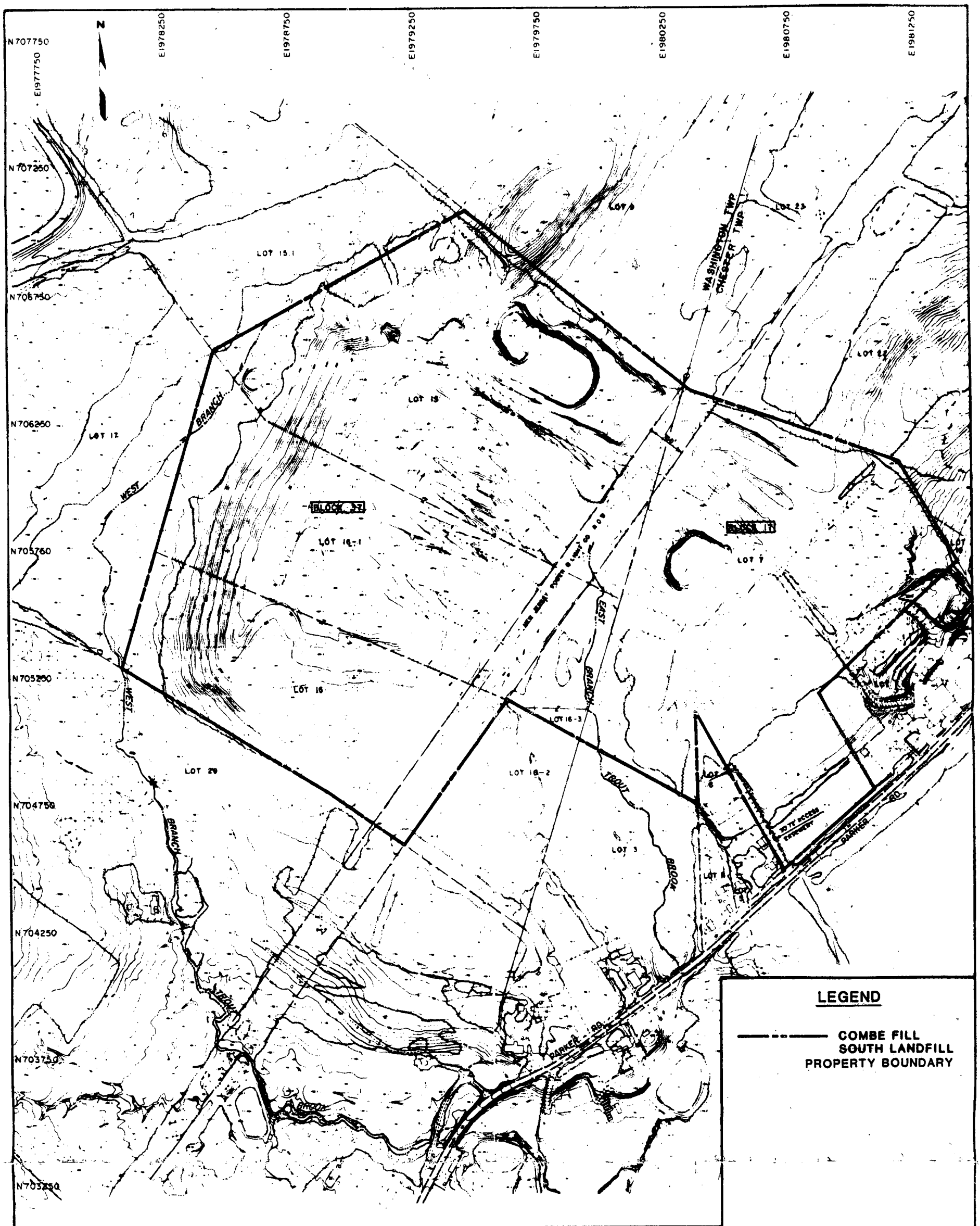
A 2-acre portion of Lot 15.1 (Chester Block 37), located to the northwest of the main body of the Combe Fill South landfill, is also considered to be part of this study because of suspected il-



COMBE FILL SOUTH LANDFILL RI/FS

GENERAL SITE LOCATION MAP

FIGURE 1-1



LEGEND

COMBE FILL SOUTH LANDFILL PROPERTY BOUNDARY

400 0 400

Scale in feet

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SITE LOCATION MAP

FIGURE 1-2

legal landfilling activities on this land. Although illegal landfilling activities were also suspected to have taken place to the south of the site (on Lot 16-2, Block 37 in Chester Township), no direct examination of this parcel was possible because access was denied by the current owner.

1.1.2 Site Description

The inactive landfill site is located off of Parker Road about one mile southwest of the Borough of Chester. It is situated on a local topographic high such that surface waters drain radially from the site (Figure 1-1).

Landfill leachate, groundwater, and surface water runoff from the southwestern portion of the site constitute the headwaters of the East and West Branches of Trout Brook, which flows southeast toward the Lamington (known locally as Black) River. To the southwest of the site near the headwaters of the West Branch of Trout Brook is a hardwood wetland. Much of the wetland that existed on the landfill property had been cleared and possibly used for waste disposal by the landfill operator.

Tanners Brook, located to the west and north about 0.5 mile at its closest point to the landfill, flows northeast to its junction with the Black River. The Black River flows south through Hacklebarney State Park, about 1.5 miles to the southeast of the landfill, to its junction with the Raritan River, about 13 miles from the confluence of Trout Brook and the Black River.

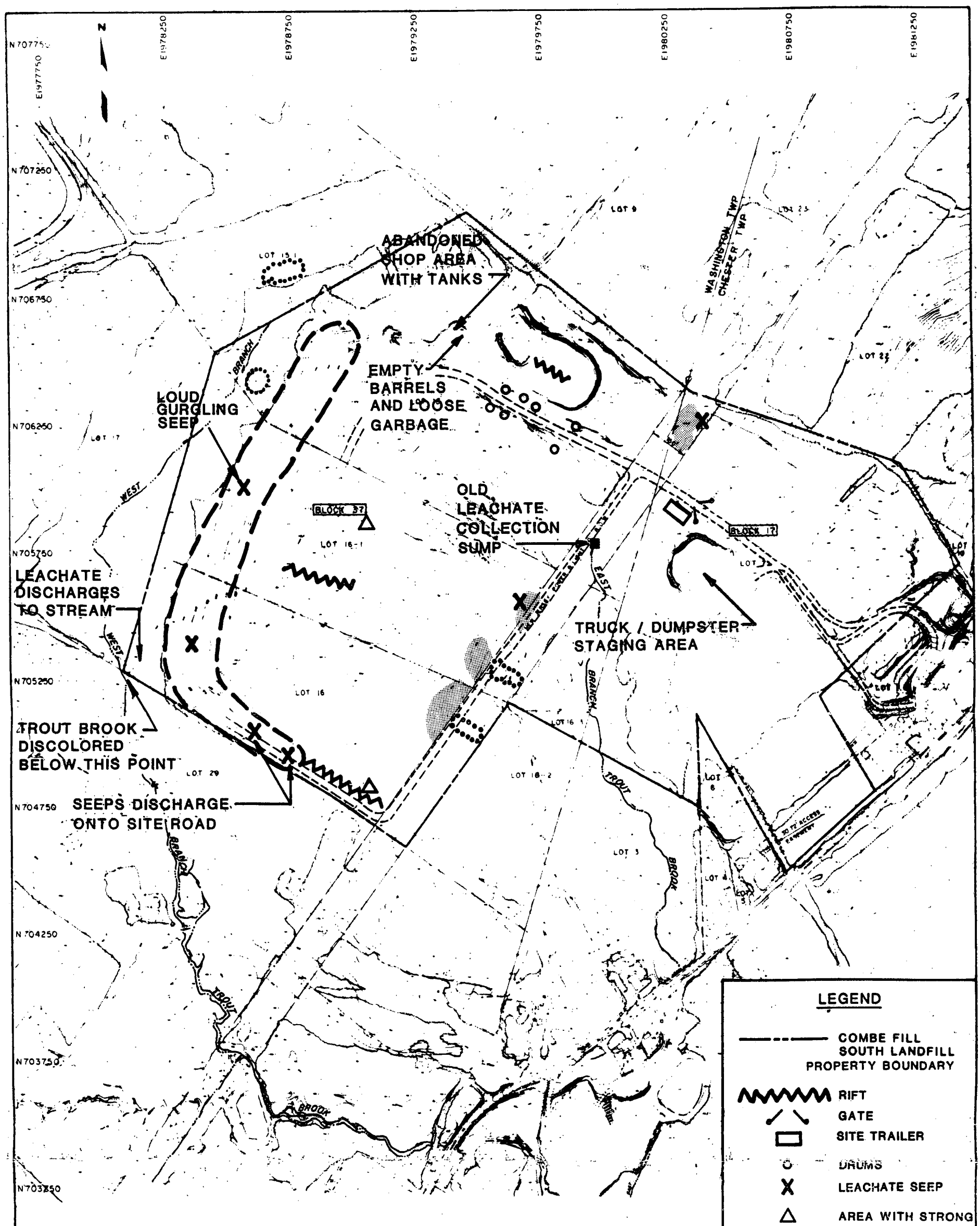
The Combe Fill South landfill lies in the Piedmont Physiographic Province termed "The Highlands" in NJ. Rocks are generally metamorphic and are considered to be Precambrian in age. The bedrock at the site consists of Losee and Byram Gneisses, is highly frac-

tured, and outcrops at two locations in the vicinity of the landfill. Natural unconsolidated deposits above bedrock are often very shallow and consist of Edneyville, Califon, and Parker soils and granitic saprolite. Low permeabilities within the granite bedrock result in high groundwater levels, leaving a major portion of the waste in a saturated condition.

Access to the site is by a dirt road running primarily east-west and passing through property owned by Filiberto Sanitation Co. (Lot 7-2) to Parker Road (Figure 1-3). A locking gate is located about one-third of the way into the site on the dirt road. The study site trailer was located just beyond the gate, to the west, from September 1984 to October 1985. To the south and east of the gate is a truck and dumpster staging area still used by the Filiberto Sanitation Co. A New Jersey Power and Light Co. (NJP&L) 200-ft wide right-of-way running primarily northeast-southwest bisects the site.

To the north of the east-west entrance road are older disposal and borrow areas rising steeply away from the road. The area is punctuated with rifts and leachate seeps flowing north off of the site. To the south of the east-west dirt road lies the newer landfill areas rising more gradually but exceeding the height of the older fill areas. On either side of the dirt road are empty 55-gal drums and loose garbage. At the northern tip of the site the dirt road turns south and disappears within another 600 ft at the top of the newer landfill area. To the north of the bend in the road is an abandoned workshop area strewn with empty rusty tanks, barrels, and large pieces of machinery.

Proceeding south onto the newer landfill areas, the ground descends steeply to the west and south toward what was once a part of the wooded wetland area and is now punctuated by numerous leachate



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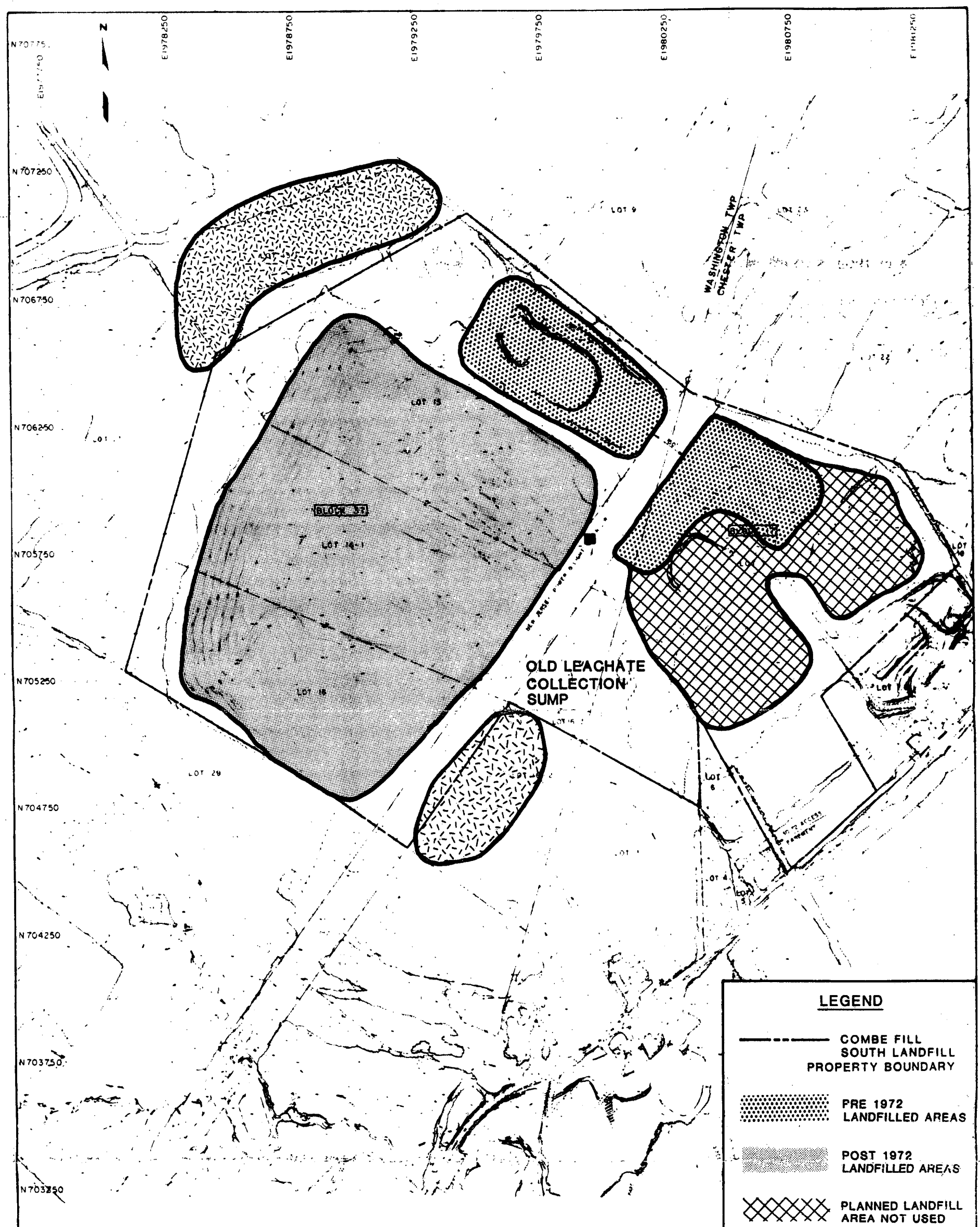
SITE PHYSICAL DESCRIPTION

FIGURE 1-3

seeps that break out onto the surface and enter the intermittently dry stream bed of the West Branch of Trout Brook. Numerous seeps of red, brown, and yellow, some with an oily sheen, occur along the southern dirt access road. Rifts occur along this southern border as well as the top of the fill, and both areas are also marked by strong organic vapors.

Proceeding north on the north-south dirt access road along the powerline right-of-way, numerous swampy areas, pools of standing water, and leachate seeps can be seen along either side of the road. About 400 ft to the south of the intersection of the two dirt roads is an old leachate collection sump that was once used as part of a leachate recycling system at the landfill. Existing cover at the site consists of coarse and permeable local soils and crushed rock. Erosion has occurred in many areas, exposing wastes. Severe erosion has occurred along the eastern, southern, and western slopes of the new fill areas.

Figure 1-4 shows the known and suspected disposal areas on and near the site. The older fill areas were used and partly covered prior to 1972 at which time a certificate of registration was issued to Chester Hills Inc. to operate the landfill. Design/operation drawings, prepared by Elam and Popoff Engineers in July 1971, used as the basis for the landfill registration were used in conjunction with New Jersey Department of Environmental Protection (NJDEP) inspection reports to arrive at the approximate disposal areas depicted in Figure 1-4. Two areas of about 15 acres on the northern border of the site were used as disposal/stockpile areas prior to 1972. Approximately 50 acres west of the powerline were used for landfilling from 1972 until landfill closure in November 1981. About 25 acres on the eastern edge of the property were planned but apparently never used for landfill operations but may have been used for stockpiling of cover soils. Illegal waste disposal is



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APPROXIMATE LANDFILL ACTIVITY AREAS

FIGURE 1-4

suspected to have occurred at two areas outside of the present property boundaries. They include a 9-acre field northwest of the landfill (referred to as the "soybean field" in previous reports), now part of a neighboring horse farm, and a 6-acre open field southeast of the powerline right-of-way along the southern border of the site. Although the northwestern field was investigated as part of this study, the southern field was not because access was denied by the property owner.

1.1.3 Site History

A chronological summary of the history of the Combe Fill South landfill is presented in Appendix AA. This chronology is an update of that originally presented in the Remedial Action Master Plan (RAMP) prepared by NUS Corporation for EPA in December 1983. The site has been operated as a municipal refuse facility since the 1940s. In 1970 and 1971 the landfill was operated by Filiberto Sanitation Inc. a local refuse hauling firm currently located on Parker Road, through which access is obtained to the landfill.

In December 1972 a "Certificate of Registration" by NJDEP was issued to Chester Hills Inc. to operate a sanitary landfill on the site. The certificate was based on a landfill design, prepared in 1971 and submitted by Elam and Popoff Engineering Associates, that approved the site for nonhazardous municipal solid waste. In 1977 two observation wells were installed by Chester Hills Inc. at the request of NJDEP and monitoring for metals, phenols, cyanide, and conventional sanitary constituents began.

In September 1978 the ownership and operation of the landfill were transferred from Chester Hill Inc. to the Combe Fill Corp., who operated the landfill until October 1981, at which time they declared bankruptcy and ceased operation. The landfill remained

open, accepted limited quantities of waste, and underwent some minor reclamation activity (i.e., soil cover) under the auspices of the local health offices and NJDEP. The Combe Fill South landfill officially closed in November 1981, although a bankruptcy hearing was not held until December 1982. The property is currently being held by a trustee-in-bankruptcy.

During the time of the ownership of the property by Chester Hills Inc. and the Combe Fill Corp., about 90 acres of the original property along the western edge of the site were sold, resulting in the current site configuration described previously.

In August 1982 a Mitre Ranking Form for Combe Fill South was submitted by NJDEP to EPA. On 20 December 1982 Combe Fill South was proposed for inclusion on the National Priorities List ("Superfund" sites) and was officially listed on 8 September 1983. The RAMP for the site was prepared in December 1983 and a request-for-proposal was issued by NJDEP for a Remediation Investigation/Feasibility Study (RI/FS) in spring 1984. A contract to conduct the RI/FS was awarded in July 1984. Field investigations and analyses conducted by the contractor as part of the RI/FS that form the basis of this remedial investigation (RI) report began in September 1984 and continued into 1985.

The following sections on the site's waste-related activities and response activities describe how the site's waste disposal activities may relate to possible sources of contamination on the site, and summarize response actions, including sampling and monitoring activities. Originally prepared for the RAMP, these sections have been updated and amended, where appropriate, with additional or more current information.

1.1.3.1 Waste Disposal and Related Activities. The Combe Fill South landfill was approved by NJDEP for the disposal of municipal and industrial wastes, sewage sludge and septic tank wastes, and chemicals and waste oils as part of its certificate of registration. However, little data are available to document either the type or volume of wastes disposed of at the site.

Using the landfill cross sections prepared by Elam and Popoff in 1971 as a guide to waste depths, an approximate waste volume of 4.8 x 10^6 yd^3 can be calculated (i.e., 15 acres of "old" fill areas at 30 ft deep and 50 acres of "new" fill area at 50 ft deep). Records of waste volume received at Combe Fill South were summarized by the Morris County Planning Board in April 1981. This information indicated that between 40,000 to 50,000 yd^3 of waste were received by the landfill monthly from January 1980 to January 1981. This volume increased to almost 70,000 yd^3 in February 1981 and was projected by the County to increase during March and April 1981. Using a monthly average of 45,000 yd^3 of waste, the total volume of waste that would have been received from 1972 through 1981, when the landfill closed, would be 5.4 x 10^6 yd^3. Thus, it is reasonable to assume that at least 4.8 x 10^6 to 5.4 x 10^6 yd^3 of waste are buried at the Combe Fill South landfill.

Correspondence between the NJDEP Solid Waste Administration and Warner-Lambert Company (also identified as Parke Davis) indicates that pharmaceutical products were authorized for disposal at Combe Fill South by NJDEP and had been so disposed about once every two weeks in 1980. One shipment in February 1981 made by Warner-Lambert was, however, not allowed to be disposed at Combe Fill South by NJDEP. This shipment contained 1% saline solution (two skids, each containing 60 cases of dispo-a-vial), forty 30-gal fiber drums of bulk and packaged products of Gelusil (antacid liquid), saline solution, Sorbitol (sugar paste), Tucks ointment (witch hazel and

glycerine), Uticort cream and ointment (base of benizone), and blood G.A.S. (ampules of water with 3% indicator salt). This waste was subsequently deemed nonhazardous by NJDEP, but its eventual disposal site is undocumented.

The only other available information on specific waste generators and products was obtained from the daily log of the Chester Board of Health on Combe Fill South activities and the Combe Fill South correspondence file maintained by Washington Township. These files indicate that several drums (labeled Douglas Engineering) were found on-site in March 1981 and may have contained alcohol or methylene chloride. Also, tea residue sludges and calcium oxide (from Tenco) were received on May 1981, and empty crushed containers of paints and dyes (from Sandoz Inc., a pharmaceutical company) may have also been received in May 1981. Disposal of the tea residues and empty dye containers had apparently been authorized by the New Jersey public utilities commission (PUC) and/or NJDEP. In September 1981 an unmarked 55-gal drum of undetermined content (Chester sanitarian suspected diesel fuel oil) was found in the dumpster area and was found empty in the same area on November 1981.

Local residents maintain that other unauthorized, perhaps hazardous, wastes (a white powder or gel) were disposed in the northwest "soybean " field and southeast field and that dumping of unauthorized wastes occurred after hours at the landfill. There is no documentation or evidence to support these claims of disposal of unauthorized hazardous materials.

The landfill design developed by Elam and Popoff and approved by NJDEP in 1972 specified the trench method of waste disposal. It is believed, though unsubstantiated, that this method was employed in the old fill areas as well. As specified in the accepted design, a

trench was to be dug to competent bedrock or to 5 ft above the seasonal high water table. The trench was first to be backfilled with 2 ft of compacted residual soil if the bedrock was exposed. Several lifts, 3 to 5 ft deep, of compacted refuse and solid waste were then to be deposited in the trench. At the end of each working day 1 ft of residual soil was to be spread over the waste in the trench.

Based on NJDEP inspection reports from 1973 to 1981 numerous operating violations were noted including the absence of an initial residual layer of residual soil to be first placed on the bedrock prior to waste placement and absent or inadequate final daily cover. Other frequent violations included uncontrolled litter, exceeding maximum allowable width of operating face, and excavation of previously deposited waste.

Although not strictly a violation of the design parameters, the inspection reports also noted that excavation and breakup of the saprolite (the broken bedrock layer above competent bedrock) was done as part of trench excavation. Trench excavation commenced in the new fill area in 1972 and advanced to the west and south. Although not specified in the design, NJDEP inspection reports note the addition of lime to neutralize the wastes.

Leachate collection basins to collect surface runoff as well as leachate were included as part of the landfill design and are noted in the NJDEP inspection reports as being located west and south of the landfill. During most years of operation, based on NJDEP and other site inspections, these basins merely overflowed into the headwaters of Trout Brook. However, according to NJDEP and town files, a leachate recycling system was in operation for about three years beginning in July 1973. There are, however, no data or other records indicating the location, design, or method of operation of

this recycling system. The only remnant of the recycling system is the leachate sump in the southern part of the site near the NJP&L right-of-way. Apparently, leachate was channeled to this sump and then pumped to the top of the fill area where it was discharged onto the ground (or perhaps to recharge basins, although none are now in evidence).

The NJDEP inspections often noted odorous leachate seeps (red, brown, black in color) emanating from the western and southern edges of the new fill and overflowing from the leachate basins. Such seeps were first noticed in 1972/1973 and were suspected of causing a fish kill in Trout Brook. Other observations of seeps were continually made during inspection reports until the close of the landfill.

In 1979 runoff from exposed waste was observed to be entering fractures in the bedrock. This apparently resulted from the excavation of unconsolidated overburden and highly fractured bedrock from the trenches to increase waste disposal capacity in the trench. This practice provides a direct pathway for leachate to reach the deep groundwater system, which is the source of potable water for the majority of residents within a 1-mile radius of the site.

In January 1979 sparks from an operating doser ignited aerosol cans of hairspray being disposed of in the trenches, which resulted in explosions of the cans and small fires. Reports are conflicting as to the extent of the fire and explosions, but they were apparently not extensive and put out the same day as the incident occurred.

In late 1980 Combe Fill Corp. began clearing trees in a wetland area located west of the then existing fill. In February 1981 Chester and Washington townships filed an injunction against Combe Fill Corp. seeking to prevent further work in the wetland. A re-

straining order was temporarily issued halting this work but was amended to allow the clearing of the trees but postponed any waste disposal activity in the cleared area. At approximately the same time (January 1981) Combe Fill North landfill closed, resulting in increased truck and waste disposal activities at Combe Fill South.

In March 1981 NJDEP issued an "Order Modifying Registration" that required the suspension of fill operations in the wetlands until revised plans showing use of leachate collections systems, impermeable barriers, and additional monitoring wells was submitted by Combe Fill Corp. (Two monitoring wells had been installed in 1972 and were sampled quarterly as part of a well monitoring program described in subsequent paragraphs.) At the same time EPA issued a citation to Combe Fill Corp. for violation of Section 301(a) of the Clean Water Act (CWA). In March 1981 the courts ruled in response to the initial injunction issued by Chester and Washington townships that:

1. NJDEP designate areas suitable for fill
2. Sediment erosion permits under CWA are not applicable
3. NJDEP appoint an impartial project manager to oversee problems and complaints
4. NJDEP and Combe Fill Corp. decide whether wetland dumping is permissible

Subsequently, NJDEP delineated approximately 34 acres of hard-wood wetlands near the West Branch of Trout Brook. (Most of this wetlands acreage was subsequently sold and is no longer within the property boundary of the present landfill).

In September 1981 NJDEP issued a second "Order Modifying Registration" stating that ground and surface water sampling data indicated that groundwater contamination existed at the landfill and that the

Combe Fill Corp. cease operations when the maximum allowed elevation of the then operational lift was reached and that proper closure and monitoring plans be submitted to the state. Combe Fill Corp. officially declared bankruptcy in October 1981 and ceased operating the landfill. However, the landfill continued to accept waste through November 1981 under the auspices of Chester Township and NJDEP. There are no records to indicate that any final cover or other site reclamation procedures were conducted.

1.1.3.2 Response Actions to Date. Possible leachate problems at the site became evident in 1972 when the New Jersey Division of Fish and Game reported a fish kill in Trout Brook and requested further investigation of the site by NJDEP. Follow-up inspections by NJDEP, local health officials, and interested citizens in early to mid-1973 confirmed the release of leachate to surface and groundwaters in the area. NJDEP and the Townships recommended additional leachate treatment and recycling. Apparently in response to these recommendations, Chester Hills, Inc. installed the leachate collection and recirculation system, which operated from July 1973 to sometime in 1976. Subsequently, NJDEP recommended the installation of four groundwater monitoring wells at the site, two of which were finally installed by the Combe Fill Corp. in 1977.

Starting in January 1977 and continuing approximately every 3-4 months through 1981, these wells and 2 to 3 other wells near the landfill (primarily private wells located at the Filiberto Sanitation Garage and at the Filiberto residence on Parker Road) were sampled and analyzed by Combe Fill Corp. for metals, phenols, cyanide, and conventional sanitary constituents. During this time the designations of the wells changed, rendering some of the data useless because of the unexplained changes in sampling locations (see Appendix C).

Inspections of landfilling operations by the Bureau of Solid Waste of NJDEP were conducted on a semiregular basis every few months from 1972 to 1981, although there are time periods (particularly in the late 1970s) when inspections occurred only once every six months or more. During this time several violations were issued to Combe Fill Corp. for inadequate cover and litter from 1973 to May 1981.

Public concern over the landfill operations began to increase in 1980 and 1981 when Combe Fill Corp. attempted to extend the landfill boundaries. These extensions included realignment of the access road and clearing of trees in the wetland to the west of the fill. The problem was aggravated when Combe Fill North, another Morris County landfill, closed in January 1981 and waste shipments to Combe Fill South increased.

Beginning in 1980, sampling and analyses of groundwaters and leachate at the site, local residential wells, and nearby surface waters were conducted by Chester and Washington townships, NJDEP, and environmental interest groups such as the Upper Raritan Watershed Association (URWA) and Help Avoid a Landfill Tragedy (HALT). Appendix BB provides a complete chronology of these sampling events and the analyses performed on these samples, up to the initiation of the RI/FS project. The sampling and analyses conducted as part of the RI/FS and those conducted by the Combe Fill Corp. are not specified in this chronology.

In January and February 1981 Combe Fill Corp. began clearing portions of the wetland at the head of the West Branch of Trout Brook in preparation for waste disposal. On 3 March 1981, in response to the clearing activities near and in the wetland area of the landfill, Chester and Washington townships brought suit against Combe Fill Corp. in Superior Court to stop this work. Additionally,

numerous complaints were filed with NJDEP from environmental activist groups and township leaders. The presiding judge issued an order suspending the clearing activities in the wetland for two weeks. However, waste materials may have been placed in the wetland area prior to this court order.

On 19 March 1981 NJDEP responded to the operations in the wetland by issuing an "Order Modifying Registration." This order required the immediate suspension of activities in the wetland and required Combe Fill Corp. to submit revised design plans with a method for secure disposal in the wetland. Concurrently, EPA cited Combe Fill Corp. for violation of Section 301 of the CWA, and required an application to the Army Corps of Engineers for a sediment and erosion control (404) permit. The presiding judge's final ruling was given on 25 March 1981.

In March, April, and early May 1981 NJDEP and URWA took water samples from monitoring wells and surface water sources in the landfill area. In May and June 1981, HALT, a local citizen's group, in cooperation with Washington and Chester townships, organized a sampling and analysis program of approximately 90 local residential wells for volatile organic constituents. NJDEP also took additional residential well samples in June 1981.

In July and September 1981 NJDEP conducted tests on water supplies of households on Parker Road, Schoolhouse Lane, and Valley Brook Road. This sampling supplemented Chester Township's private well testing program, which was conducted from January through September 1981.

On 20 August 1981 PUC began hearings on a rate increase requested by Combe Fill Corp. to cover the costs for environmental protection measures and to provide an escrow account for proper closure of the

landfill. No decision was reached on these requests before the landfill closed.

Based on results of the water quality monitoring programs noted above, NJDEP concluded that groundwater contamination existed on-site and may pose a threat to water supplies. As a result, NJDEP issued a second "Order Modifying Registration" on 18 September 1981. This order required Combe Fill Corp. to discontinue waste disposal operations upon completion of the existing lift. On 15 March 1982 NJDEP proposed a permanent water monitoring program for the local area, which was not implemented. In June 1982 NJDEP authorized and evaluated commercially available filter systems being used by several local private wells.

A geologic reconnaissance at the Combe Fill South site was conducted by NJDEP on 29 June. Terrain conductivity surveys were conducted by NJDEP in August 1982 to determine the location and direction of groundwater contamination. The Mitre Ranking Form was submitted by NJDEP to EPA on 12 August 1982, and the site was officially listed on the National Priorities List (of "Superfund" sites) on 8 September 1983.

1.2 NATURE AND EXTENT OF CONTAMINATION

1.2.1 Waste Types/Conditions of Waste

According to a memorandum from Mr. Dave Kaplan of NJDEP to Mr. Haig Kasabach of NJDEP (Appendix D), wastes that were accepted at Combe Fill South Landfill included typical household wastes, industrial wastes, dead animals, sewage sludge, septic tank wastes, chemicals, and waste oils. These wastes were said to be placed in large trenches and covered with crushed rock.

The field investigation verified that the site was poorly covered, primarily with a thin veneer of crushed granitic rock. Numerous empty 55-gallon motor oil drums were scattered across the landfill surface. The majority of wastes encountered during field reconnaissance, drilling operations, and test pit excavations were typical household wastes (garbage bags, paper, appliances, etc.) and nonhazardous industrial wastes (plastic, wire, metal frames, etc.). Refuse encountered during the drilling of well D-6, which penetrated the center of the landfill, appeared to be highly decomposed rubbish. No visibly apparent evidence of hazardous materials at the surface (drums, hazardous liquids, etc.) was uncovered during field operations at Combe Fill South Landfill.

1.2.2 Previous Mitigation Efforts and Their Results

Although extensive monitoring activities (primarily sampling and analysis of groundwater and surface water) have been conducted at or near the site since 1981, little actual physical remediation or mitigation of the sources or pathways of contamination at the site was employed either during the operation of the landfill, or after site closure. Perhaps the most significant action to date was the actual closure of the site as an active landfill.

Physical contact with the waste and its associated soils and leachate is still possible. The existing locking gate and minor rock barricade on the dirt access road only serves to limit normal vehicular traffic into the site. It does little to limit pedestrian traffic or off-the-road vehicular entry. There is no circumferential site barrier nor are any other site security measures employed.

Inspections of the site conducted by NJDEP and the Chester Township Board of Health indicate that soil cover during development of lifts and at the time of site closure were inadequate and little if

any grading of the site was done. Soils used for cover were inadequate both in terms of the depth of material and ability to limit infiltration. Revegetation of the top soil was not undertaken, and vegetation has not been reestablished in many areas, leading to serious erosion, particularly in the steep sloping areas.

Surface runoff and leachate from the site enter local surface waters and the bedrock groundwater aquifer. Leachate collection basins used during the 1970s often served merely as collection points for direct discharge of the leachate/runoff to Trout Brook. During 1973-1976, a leachate recycling system was used that may have pumped the collected leachate back onto the fill where it was allowed to reinfiltrate.

As part of the first "Order Modifying Registration" issued to Combe Fill Corp. in March 1981, revised landfill operating plans were required to include a leachate collection system and impermeable barrier to mitigate leachate flow into the ground and surface water; however, no revised designs were submitted and no remedial actions were taken. In its second "Order Modifying Registration" issued in September 1981, NJDEP required that proper landfill closure plans be submitted, which presumably included such state requirements as adequate cover and a landfill gas collection system for methane control. Again, neither of these actions have been taken and numerous rifts on the site attest to methane gas production and landfill subsidence. Lack of adequate cover has also enabled the continued escape of contaminants into the air above the site, although dust generation and wind erosion are somewhat curtailed by the small amount of cover and vegetation that has been established.

1.3 REMEDIAL INVESTIGATION/FEASIBILITY STUDY

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and its funding mechanism, the Hazardous Substance Response Trust Fund (Superfund), require that federal action taken in response to hazardous substances in the environment be in accordance with the National Contingency Plan (NCP), which was revised in November 1985. This Remedial Investigation/Feasibility Study (RI/FS) being conducted for the Combe Fill South landfill is one in a series of actions in the remedial response process outlined by NCP.

In a RI/FS, field investigations of the suspected hazardous waste site are conducted to obtain information to identify, select, and evaluate remedial action alternatives. The RI emphasizes data collection and site characterization; the FS emphasizes data analysis and evaluation of alternative actions.

1.3.1 Remedial Investigation for Combe Fill South

The major elements of the RI for the Combe Fill South landfill included:

- Development of workplans for the investigation including a Field Sampling Plan (FSP), Quality Assurance Project Management Plan (QAPMP), and Health and Safety Plan (HASP)
- Field investigation including environmental testing, measurement, and sampling on and off the site
- Laboratory analysis of the environmental samples taken during the field investigation
- Data summarization and site characterization based on the field work and laboratory analysis
- Preparation of the remedial investigation report

The following paragraphs summarize the objectives of the field investigation and how and why the actual field measurements and sampling activities were conducted as part of the RI. Detailed discussions of the methodologies and procedures used during the field investigation can be found in the FSP, QAPMP, and HASP and their addenda.

1.3.1.1 Borehole Geophysical Logging. On 15, 16, and 17 April 1985 R.E. Wright Associates, Inc. (REWAI) conducted a borehole geophysical survey of four selected monitoring wells: D-3, D-5, D-6, and D-7. Existing wells DW-2 and DW-4, drilled prior to this study, were scheduled to be logged in order to obtain well construction and stratigraphic information. However, legal access to the wells was not obtained in time to conduct these measurements on the existing wells.

The geophysical logs recorded gamma ray, resistance, spontaneous potential (SP), caliper, temperature, and density measurements. The SP and density logs were performed in addition to the logging requirements outlined in the FSP. All decontamination and calibration procedures were performed in accordance with the FSP and QAPMP.

The information obtained from the logs was useful in the preparation of Chapter 4 (Hydrogeologic Investigation) of this report. Borehole geophysical logs are presented in Appendix B and further discussion on the results obtained is included in Chapter 4.

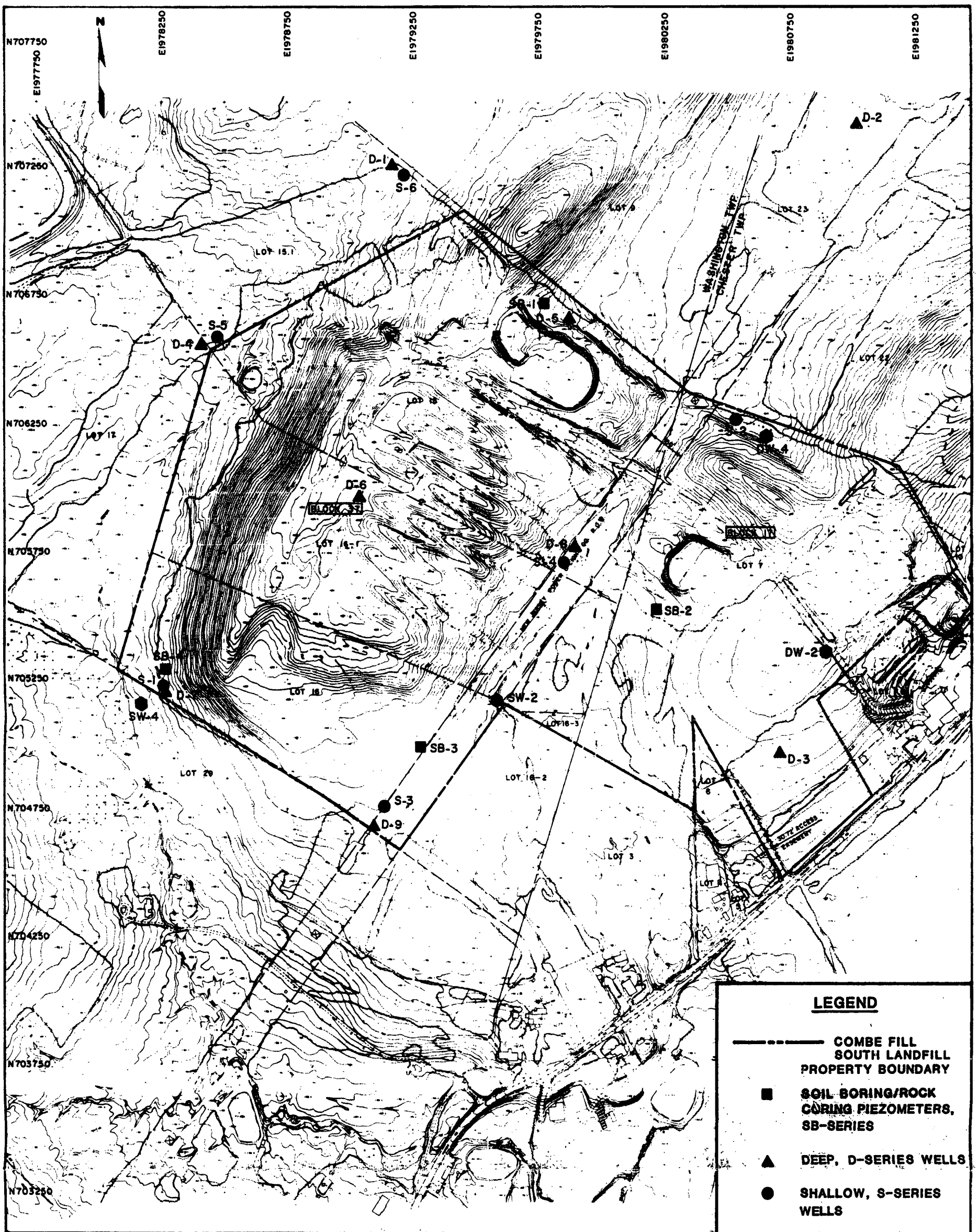
1.3.1.2 Geophysical Survey. Electromagnetic terrain conductivity (EM) and magnetometer (MN) surveys were conducted in and around the Combe Fill South Landfill between 22 and 26 October 1984. The objectives of these surveys were:

- To help identify and define the extent of groundwater contamination
- To delineate potential areas of buried metallic wastes (i.e., drums)

To accomplish these objectives, 314 magnetometer stations were established and measured, and approximately 11,750 ft of EM traverses were conducted. The two surveys identified several anomalous areas, some of which were selected for further testing. Detailed discussion on the methods used and results of these surveys is presented in Chapter 4.

1.3.1.3 Soil Boring/Rock Coring. A portion of the subsurface field investigations at the Combe Fill South site consisted of drilling four soil boring/rock coring holes with subsequent installation of piezometers in these holes. The purpose of these borings (referenced as SB-1, SB-2, SB-3, and SB-4) was to obtain detailed stratigraphic and structural information concerning soils, saprolite, and competent bedrock. Piezometers were constructed in these borings to measure water levels in the unconsolidated soil/saprolite system. Information obtained from the construction and sampling of these wells has been used in the completion of the Chapter 4. The location of all completed soil borings is shown on Figure 1-5, and detailed geologic logs of these soil borings are included in Appendix E.

1.3.1.3.1 Soil Boring/Rock Coring Procedures. All equipment was decontaminated, and personnel protection levels followed during drilling were assigned by the on-site Health and Safety Officer (HSO) in accordance with the approved Health and Safety Plan (HASP). Drilling and construction of SB-series wells followed the procedures outlined in the FSP with the following exceptions:



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LOCATION OF SOIL / ROCK
CORING PIEZOMETERS
AND MONITORING WELLS

FIGURE 1-5

- In soil boring SB-1, the piezometer was set in the cored bedrock interval instead of in the unconsolidated interval as specified in the FSP. This was necessary because groundwater was not encountered in the unconsolidated material. The only difference in construction technique was that a lower bentonite seal was not installed before the screen/riser assembly was placed in the hole and sand packed.

- No soil samples from SB-1 were selected for chemical analysis due to the coarseness of the unconsolidated interval, limited sample recovery, unsaturated conditions, and the absence of positive detection of volatile organics in the interval by the HNU photoionization instrument.

1.3.1.4 Monitoring Wells. A drilling and well construction program was conducted to delineate the horizontal and vertical extent of groundwater contamination surrounding the landfill site. Chemical data available prior to the RI/FS indicated that measurable contamination was present in the groundwater to the north and to the south of the site in both the shallow (unconsolidated) and deep (bedrock) aquifers.

Nine deep (bedrock) monitoring wells and six shallow (unconsolidated) monitoring wells were constructed at the site between mid-November 1984 and the end of January 1985 (Figure 1-5). Geologic logs for these wells are included in Appendix F.

During drilling, access to several of the wells (most notably D-5) was very difficult due to rain, freeze/thaw, and saturated ground conditions. These difficulties prolonged the drilling effort significantly. Data obtained during the construction and sampling of monitoring wells at Combe Fill South landfill is discussed in Chapter 4 of this report.

1.3.1.4.1 Bedrock Monitoring Wells. Nine deep bedrock monitoring wells were drilled and constructed on and adjacent to

the landfill property. The locations of these wells (D-series) are shown on Figure 1-5.

The purpose of the bedrock wells was to monitor groundwater in this portion of the aquifer in all potential flow directions from the site. Specifically, these wells provided the following:

- Definition of the groundwater head distribution in the bedrock aquifer. From this, potential directions of groundwater flow from the site could be established.
- Groundwater quality to evaluate whether known off-site domestic well contamination is a result of chemical migration from the landfill and to assist in the evaluation of appropriate remedial alternatives.
- Pumping and monitoring points for measurement of aquifer properties via pumping tests
- Definition of waste thickness, waste composition, groundwater head potential within the landfill, and groundwater quality immediately beneath and adjacent to the landfill

Construction and development of deep bedrock monitoring wells followed the procedures outlined in the FSP with a few exceptions as noted below.

Originally, the FSP specified that threaded and coupled stainless steel casing was to be welded away from the hole well under construction in a "safe" zone to avoid potential explosive situations. This method proved to be extremely time consuming, costly, and would have provided a finished casing installation less than desirable in terms of strength and straightness. In order to rectify this problem it was decided, with the approval of NJDEP, to weld the casing sections to-

gether directly over the hole. This method expedited the installation of the casing and ensured much straighter and stronger casing joints. The air at the hole was monitored with an explosimeter during welding. No explosion hazards were present during the operation as a result of the change.

The FSP specified that after the 6-in. diameter casing was set, the remainder of the hole would be drilled, developed, and grouted. However, to establish a firm and reliable casing/slurry seat, it became necessary to place the slurry in the casing annulus prior to further drilling below the casing seat. Although the FSP originally called for a pure bentonite slurry, a small amount of portland cement was added to the lower portion of the bentonite slurry mix to solidify the casing seal at the seat. The bentonite/portland slurry was then allowed to set and settle undisturbed overnight prior to further drilling.

Occasionally, an outer length of temporary steel casing had to be used to stabilize the unconsolidated material to allow installation of the 6-in. diameter stainless steel casing. This temporary steel casing was removed after the stainless steel casing and the bentonite/portland slurry had been installed except in well D-6. In well D-6, which was drilled through the middle of the landfill, two outer steel casings of 10-in. and 8-in. diameter were left in the ground to prevent the grout from dispersing into the refuse, which would have left an inadequate seal for the casing. A neat portland cement grout was used rather than bentonite in the annular spaces in well D-6 to provide a more rigid seal in this well, due to the nature of the materials in contact with the casing.

1.3.1.4.2 Shallow Monitoring Wells. Six shallow monitoring wells were constructed in the saturated overburden (unconsolidated material) to allow:

- Determination of the level of contamination in the unconsolidated aquifer
- Determination of vertical head distribution in the unconsolidated aquifer with respect to the deep bedrock system
- Description of the depths, thicknesses, and composition of the unconsolidated material, particularly those zones of low permeability or potential confining layers
- Determination of the depth of saturated materials and competent bedrock
- Sampling of water quality in the upper groundwater

Shallow wells were constructed where preliminary data suggested the occurrence of unconsolidated material. The locations of these shallow (S-series) wells are also shown on Figure 1-5.

Construction and development of S-series wells followed the procedures outlined in Section 3.2.2.3 of the FSP. The only procedural exception to the FSP was that 4-in. stainless steel casing and screen joints were welded together over the hole during installation for reasons discussed above.

The temporary outer steel casing used in setting the 4-in. stainless steel casing in well S-2 became stuck in the hole while attempting to remove it during well construction. It is believed that sand and gravel became compacted around several of the outer casing couplings. Repeated efforts to pull this temporary casing from the hole failed. It was later decided, with NJDEP approval, that since most of the 4-in. stainless

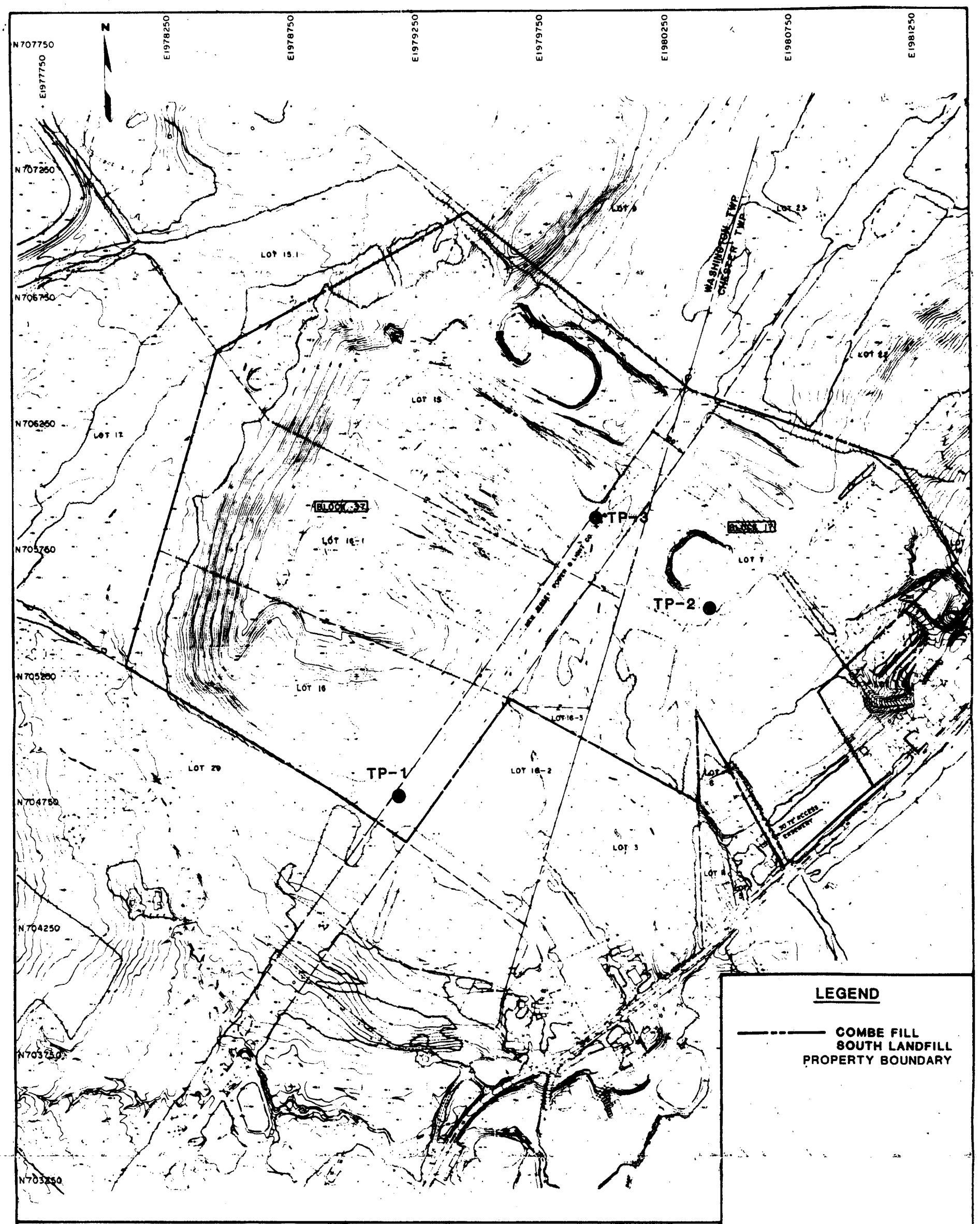
steel screen was exposed to the formation, it would not be necessary to either pull the steel casing or abandon the well. Well S-2 was completed with the temporary steel casing remaining in the hole as shown on the log in Appendix F.

1.3.1.5 Test Pit Investigations. On 27 August 1985, three backhoe test pits were excavated at the Combe Fill South site. The purpose of these pits was to investigate sources of apparent anomalies in the conductivity and electromagnetic surveys, which were conducted in October and November 1984. All test pits excavated at the site were located on or near anomalies discovered by the geophysical surveys. Figure 1-6 shows the test pit locations. The results of test pit investigations are presented in Chapter 4. These pit construction procedures and logs are included in Appendix G.

1.3.1.6 Pumping Tests. A short-term (4-hr) constant-rate pumping test was conducted on shallow well S-3 and each of the nine deep (D-series) wells. The tests were conducted to measure aquifer transmissivity and storativity values. The tests were also performed in an effort to provide insight into directional permeability anomalies between the bedrock aquifer and the saturated shallow aquifer. The results of the tests are discussed in Chapter 4, and data are provided in Appendix P.

The provisions of the FSP were followed during the testing. Approval was obtained from NJDEP to extend the duration of any pumping test up to 24 hours to observe longer term reactions, if necessary. This option was not found to be necessary during this testing, and all tests were limited to the 4-hr maximum.

1.3.1.7 Slug Tests. On 17 and 19 April 1985 shallow monitoring wells S-1, S-2, S-4, S-5, and S-6 were slug tested in order to estimate the hydraulic conductivity of the saprolite. A minimum of



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TEST PIT SAMPLING STATIONS

FIGURE 1-6

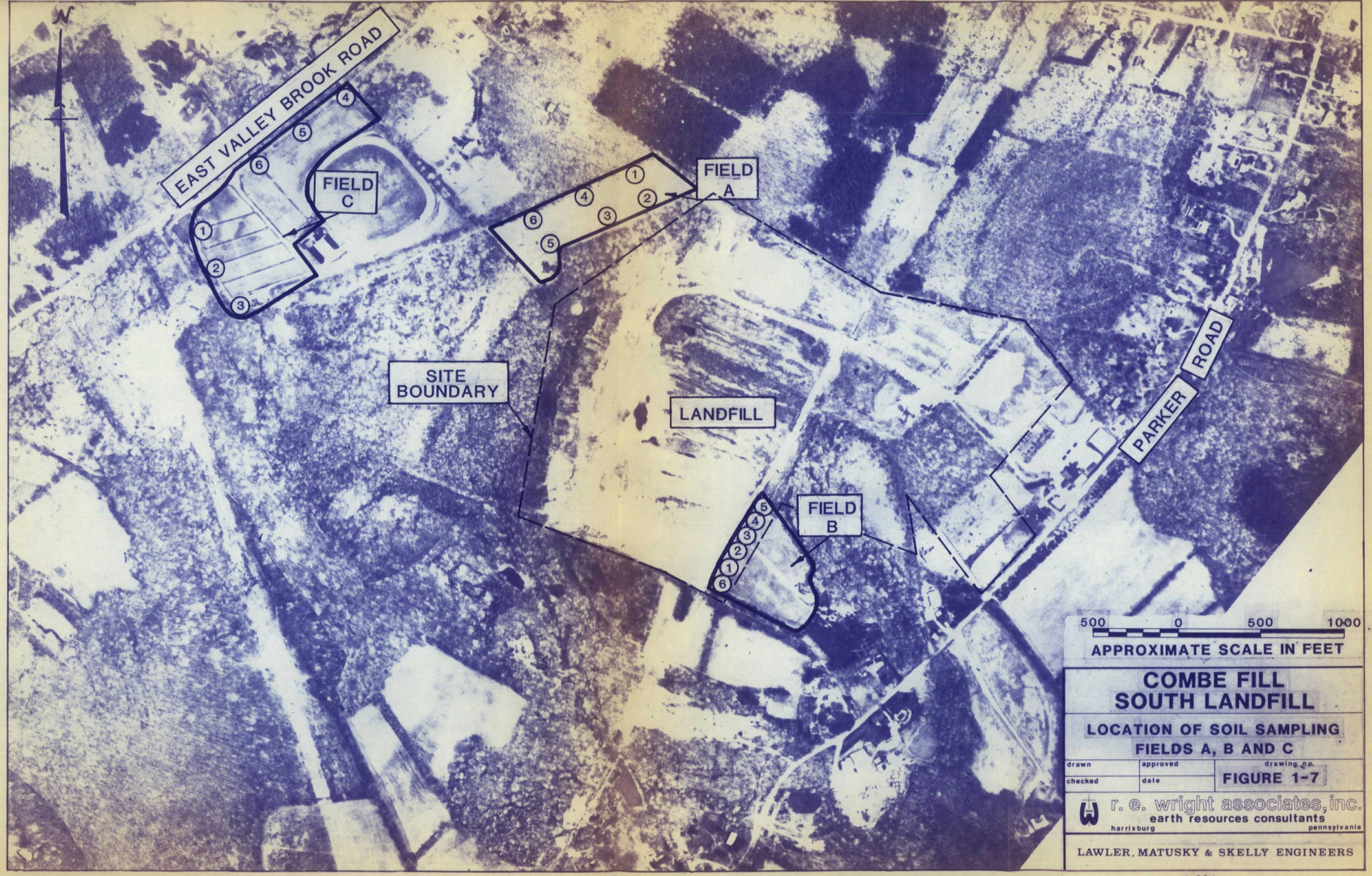
four measurements were made at each well following the slug test specifications of the FSP. The data is provided in Appendix Q, and Chapter 4 discusses the results of the tests.

1.3.1.8 Packer Tests. During the weeks of 18 April and 26 April 1985, static packer tests were conducted on monitoring wells D-1, D-6, D-7, D-8, and D-9 to measure changes in the vertical head gradient of the groundwater. Chapter 4 discusses the results of the packer testing.

1.3.1.9 Water Level Measurements. Water levels were measured in monitoring wells frequently throughout the field effort. In addition, water levels were recorded in accessible domestic wells during the water quality sampling effort. The data had been used to determine the depth and configuration of the water table and estimate the degree of seasonal fluctuation and response to precipitation. The data and analysis are included in Chapter 4.

1.3.1.10 Soil Sampling. To investigate alleged disposal of contaminants within the shallow soil zones in two areas on the site, a hand-augering/soil sampling program was conducted between 20 and 23 August 1985. A third field, designated Field C, was similarly sampled. This field is outside the anticipated area of suspected contamination and is therefore assumed to be representative of local background conditions. Figure 1-7 shows the locations of the hand-augered soil sample areas. All samples were submitted to the laboratory for full chemical analysis.

In each of these fields, holes were hand augered to a depth of approximately 3 ft. A single composite soil sample, representative of both the upper (A) horizon and lower (B) soil horizons, was prepared by compositing samples from each hole in the respective field. In addition, a few discrete samples were collected where


N
EAST VALLEY BROOK ROAD
FIELD C
FIELD A
FIELD B
SITE BOUNDARY
LANDFILL
PARKER ROAD
500 0 500 1000
APPROXIMATE SCALE IN FEET
COMBE FILL
SOUTH LANDFILL
LOCATION OF SOIL SAMPLING
FIELDS A, B AND C
drawn
approved
checked
date
drawing no.
FIGURE 1-7
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anomalous HNU readings or other characteristics indicated potential contamination.

Logs of soils excavated during this sampling process are provided in Appendix J. The results of this soil sampling program are discussed in Chapter 4.

1.3.1.11 Groundwater Quality Measurements. In order to evaluate the nature and extent of the site's groundwater contaminant in both the shallow and deep aquifers, each of the new monitoring wells (nine deep and six shallow) described above were sampled once in late August/early September 1985. Additionally, two of the existing monitoring wells (DW-2 and DW-4) were also sampled at the same time. The two existing shallow wells (SW-2 and SW-4) were not sampled because their construction was inconsistent with NJDEP monitoring well specifications; they were, however, used to measure groundwater levels at the site. Each monitoring well groundwater sample was analyzed for volatile organics, acid and base/neutral extractable organics, pesticides and polychlorinated biphenyls (PCBs), metals, cyanides, and phenols.

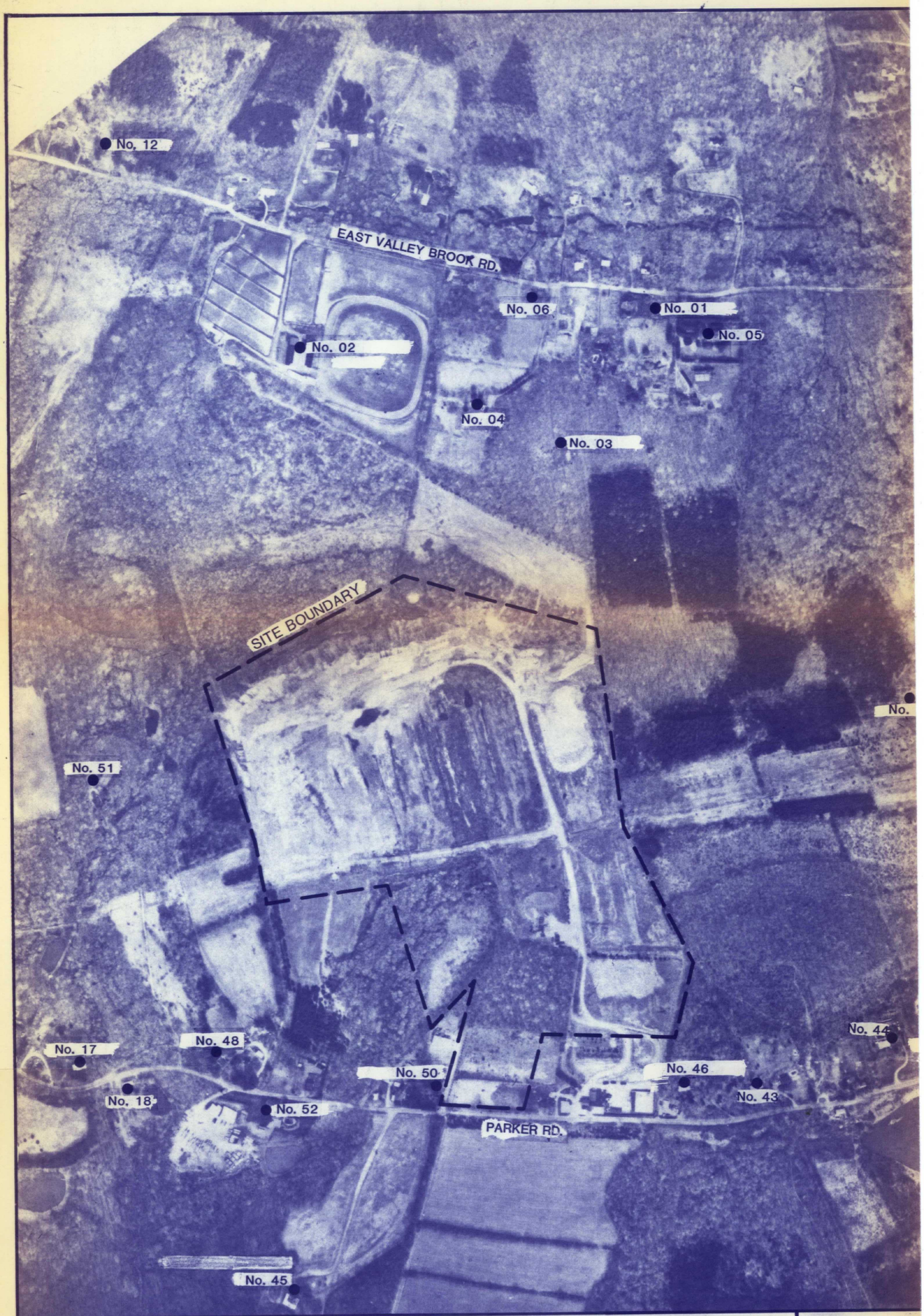
In addition, six deep and two shallow well water samples were analyzed for conventional sanitary constituents that included specific conductance (SPC), nitrate, ammonia, total kjeldahl nitrogen (TKN), total organic carbon (TOC), 5-day biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), hardness, alkalinity, and total and fecal coliform. Although these constituents may not represent a toxic or hazardous problem, they may be environmentally detrimental to surface and groundwater and may therefore also require remedial action.

Gross alpha (α) and beta (β) radioactivity levels were also measured in three deep and two shallow monitoring well samples. These measurements were made to assess whether the above normal radioactivity levels previously measured near the landfill emanated from a naturally occurring source (i.e., monazite, a naturally radioactive rock that is suspected of being indigenous to the area) or a man-made source disposed of in the landfill.

1.3.1.12 Potable Well Investigation. In order to determine whether groundwater drinking water supplies are being impacted by the landfill, one water sample from each of 25 potable water wells was taken in the vicinity of the site. About half of these samples were taken in mid-August 1985 and the other half in late September 1985. These potable well sample locations are shown in Figure 1-8.

Each sample was analyzed for the organic and inorganic constituents described above for the on-site monitoring well samples. In addition, six of the potable water samples were analyzed for the sanitary suite of constituents enumerated previously, and six samples were analyzed for gross alpha and beta radioactivity. These analyses, in combination with previous potable well analyses done prior to this RI work, and the on-site monitoring well data would be used to determine whether contaminants from the landfill are moving into the drinking water aquifer and entering nearby wells.

1.3.1.13 Surface Water Investigation. In order to evaluate the extent and nature of contamination in surface waters and to determine the contribution of the landfill toward this contamination, sampling and analysis of streams on and near the site were conducted in August and October 1985. Figure 1-9 shows the location of these eight surface water sampling sites. Seven of the sites were sampled in August; one (W-2) was sampled in October because there was no flow at this location in August. At each site (except



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LOCATION OF RESIDENTIAL WELL SAMPLES

FIGURE 1-8

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500 0 500 1000 FEET
SCALE APPROX.

LOCATION OF RESIDENTIAL WELL SAMPLES

FIGURE 1-8

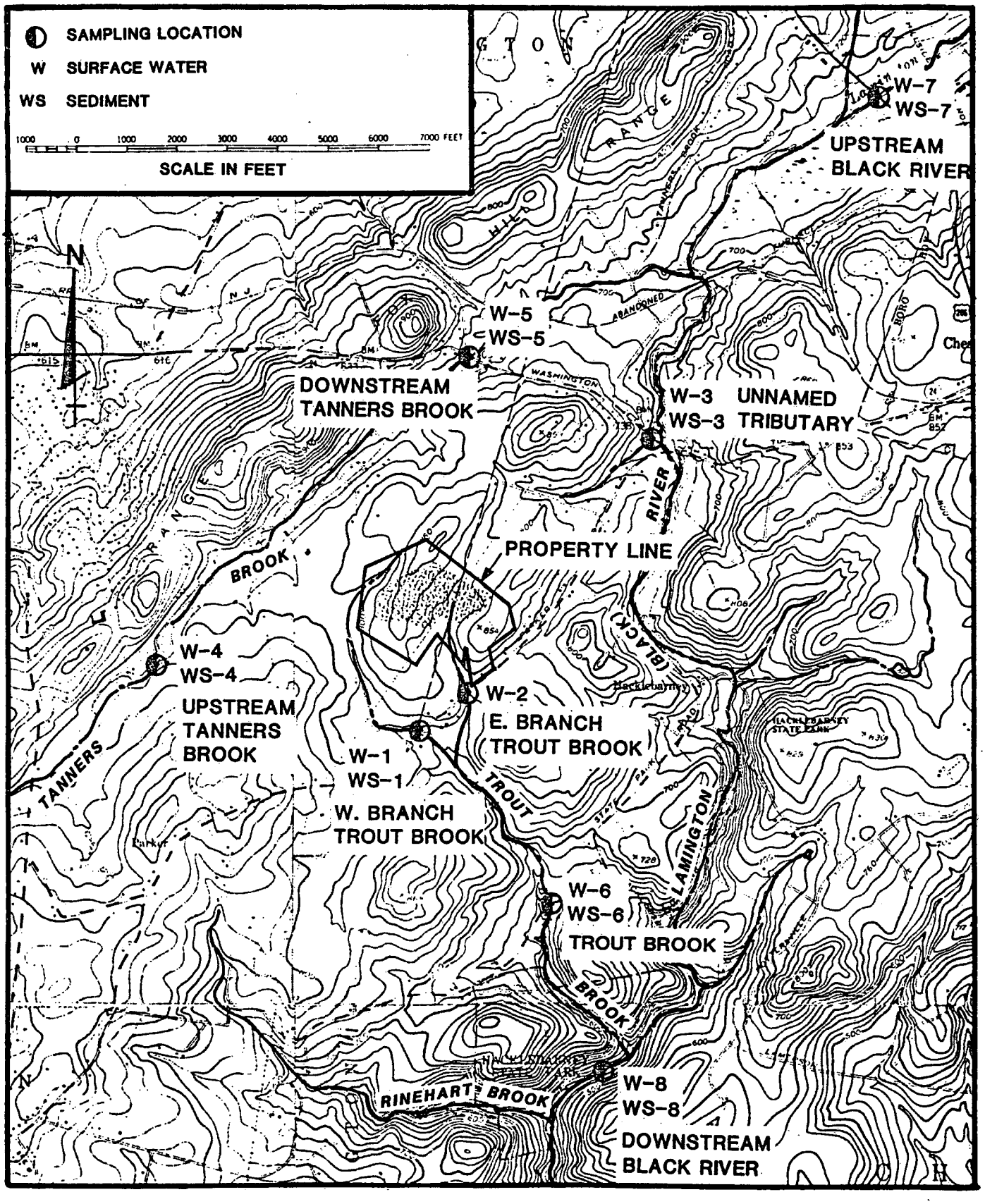


FIGURE 1-9

COMBE FILL SOUTH LANDFILL RI/FS

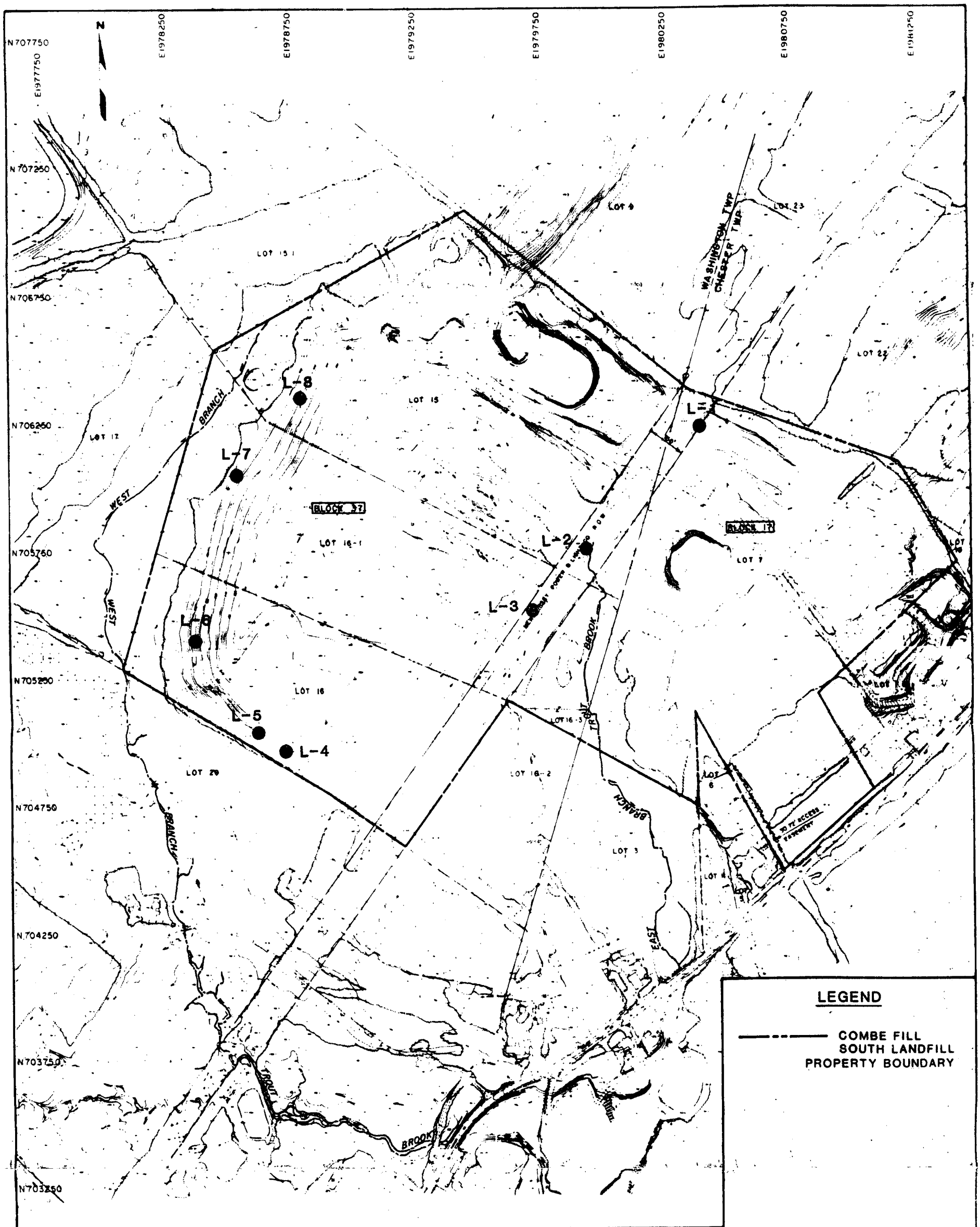
SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

W-2, which was located in a culverted portion of the East Branch of Trout Brook) both a water and sediment sample was taken. Analysis of the water samples provides an indication of the concentration of soluble and suspended contaminants, while analysis of the sediments provides more information on the insoluble constituents that settle out of the water column. A sampling point upstream of the site on the Black River was selected to represent "background" surface water quality. Each of water and sediment samples were analyzed for the organic and inorganic contaminants described previously, and two of the water samples were also analyzed for gross alpha and beta radioactivity.

In addition to the chemical characterization of the local surface water, flow measurements of the east and west branches of Trout Brook were also made. These field flow measurements of Trout Brook and estimates for Tanners Brook and the Black River would be used in conjunction with the measured contaminant concentrations to develop surface water contaminant loading rates and mass balances.

1.3.1.14 Leachate Investigation. Figure 1-10 shows the location of the eight leachate seep sites originally selected based on initial field reconnaissance of the site in summer 1984. Leachate sampling was planned in order to help characterize the nature and extent of contamination being generated by the landfill as a result of dissolution or suspension of chemicals by rainfall infiltrating the landfill. As with the surface water sites, both a water sample and sediment soil sample was to be taken at each location.

In August 1985 an attempt was made to sample the leachate sites; however, low flow rates prevented the complete sampling of all sites. Nevertheless, all the soil-related samples were taken during this survey. In October 1985, after leachate flows had increased because of heavy fall rains, a second survey was con-



LEGEND

COMBE FILL SOUTH LANDFILL PROPERTY BOUNDARY

400 0 400

Scale in feet

Lawler, Matusky & Skelly Engineers
Environmental Science & Engineering Consultants
One Blue Hill Plaza
Pearl River, New York 10965

COMBE FILL SOUTH LANDFILL
REMEDIAL INVESTIGATION/
FEASIBILITY STUDY

r. e. wright associates, inc.
earth resources consultants
harrisburg pennsylvania

LEACHATE SAMPLING STATIONS

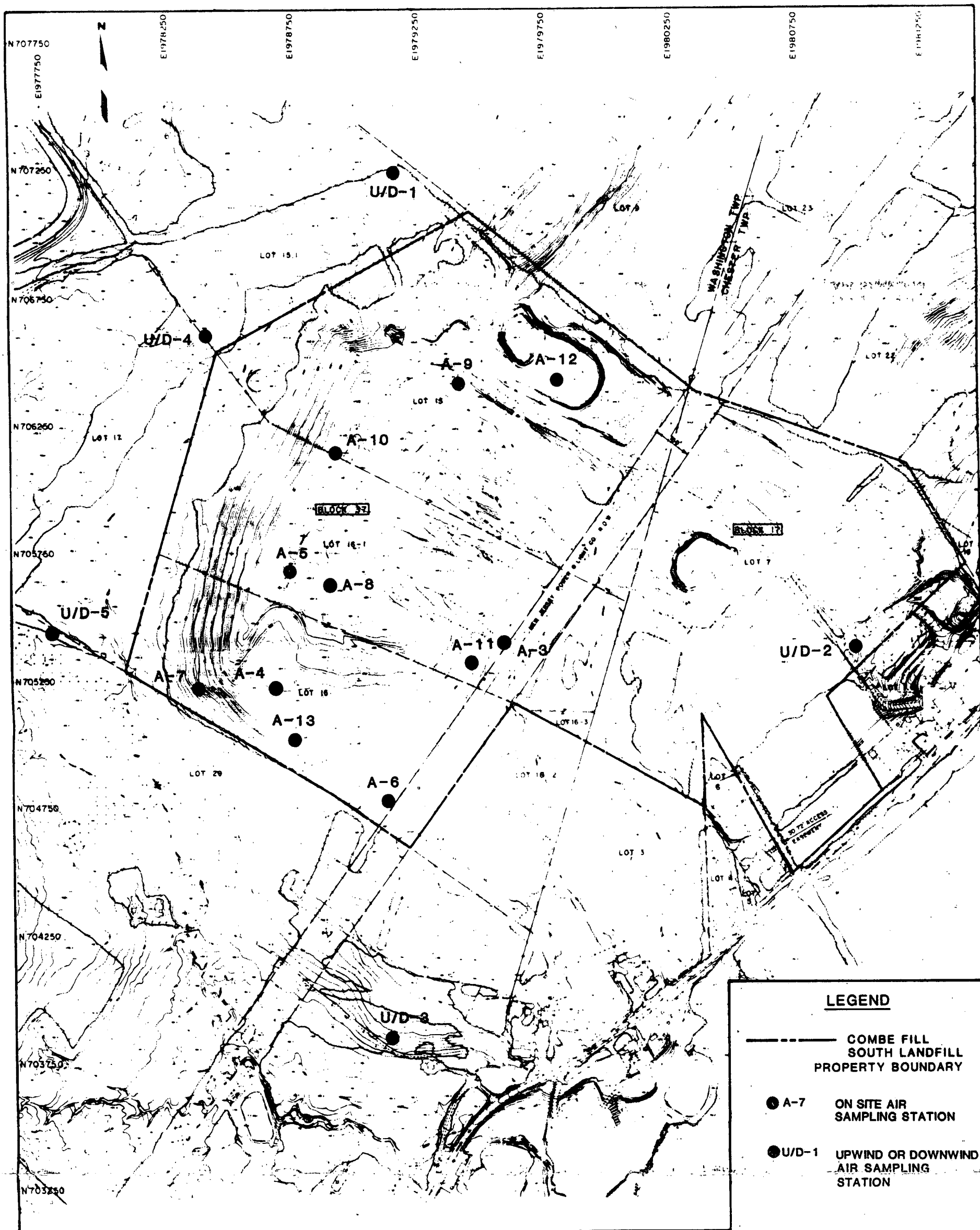
FIGURE 1-10

ducted to collect leachate seep water samples. However, two sites (L-4 and L-5) still did not have sufficient flow for proper water sampling; thus only six of the original eight leachate seeps located have reported seep concentrations.

1.3.1.15 Air Investigation. Sampling and laboratory analysis of the air on, upwind, and downwind of the site was conducted in order to evaluate the importance of air as an exposure and migration pathway for contaminants from the landfill. Figure 1-11 shows the on-site sample locations (beginning with prefix A) and the off-site upwind or downwind sites (prefix U/D) that were selected on the basis of wind direction on the day of sampling. The air samples were each collected over an 8-hr day sampling period by passing a specific volume of air through a special absorbent or filter that was analyzed for contaminants.

The sampling was conducted in two phases. During the first phase in July 1984, the gaseous fraction of the air at the landfill site was sampled and analyzed for volatile organic compounds, and the information was used in the development of the site-specific personnel health and safety program. The second phase of the air investigation work was conducted in September 1985 and included sampling and analysis of the air particulates (for semi-volatile organics, metals, and cyanides) as well as additional sampling and analysis of the gaseous fraction of the air for volatile organics.

During on-site field work, daily instrumental air monitoring with a photoionization detection (PID) meter and explosimeter and/or oxygen meter was also conducted as part of the personnel health and safety monitoring program.



LEGEND

——— - - ———	COMBE FILL SOUTH LANDFILL PROPERTY BOUNDARY
● A-7	ON SITE AIR SAMPLING STATION
● U/D-1	UPWIND OR DOWNWIND AIR SAMPLING STATION

400 0 400

Scale in feet

Lawler, Matusky & Skelly Engineers
Environmental Science & Engineering Consultants
One Blue Hill Plaza
Pearl River, New York 10965

COMBE FILL SOUTH LANDFILL
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harrisburg pennsylvania

AIR MONITORING STATIONS

FIGURE 1-11

1.3.2 Feasibility Study for Combe Fill South

The major elements of the FS for the Combe Fill South landfill include:

(1) Identification of remedial response objectives and criteria

(2) Identification and screening of remedial response technologies

(3) Development of remedial alternatives, based on successfully screened technologies

(4) Evaluation of alternatives based on technical, environmental, and cost considerations

(5) Preparation of draft FS

(6) Selection of proposed remedial action alternative and development of conceptual design

(7) Preparation of final FS

These tasks are detailed in the separate feasibility study report being prepared for the landfill.

A treatability study to determine how best to treat waste streams from the site may be conducted as part of either the RI or FS investigation and may be done for the Combe Fill South site.

1.4 OVERVIEW OF REMEDIAL INVESTIGATION REPORT CHAPTERS

This report is divided into the following chapters:

Exec. Summary not included in package

Chapter One: Provides background information about the site including its waste-related activities, sampling events and response actions, nature and extent of contamination, and objectives and activities conducted as part of the RI.

Chapter Two:	Describes the general natural and man-made setting of the site including land use, demographic chacteristics, natural resources and site climatology/meterology.
Chapter Three:	Defines the nature and types of wastes found at the site.
Chapter Four:	Describes the hydrogeology of the site including the geology, stratigraphy, soils, and naturally occurring radioactivity. It characterizes the major aquifers in terms of groundwater flow, magnitude, and direction. The concentration of chemicals found in the rock, soils, and groundwater at and near the site are also summarized.
Chapter Five:	The quality and quantity of leachate and other surface waters and their sediments on and near the site are characterized.
Chapter Six:	The quality of air at and moving off the landfill is described both for gaseous and particulate air fractions.
Chapter Seven:	The radiological characteristics of the site are summarized and the possible sources of the higher than normal background radioactivity are examined.
Chapter Eight:	Site contaminant characteristics and pathways are identified. Populations at risk are identified. Indicator chemicals are selected for evaluation of carcinogenic and non-carcinogenic human health risks. Finally, data needs are identified.
References:	References used in the development of the RI are listed.
Appendices:	Appendices to the RI include such items as boring logs, field test results, calculations, data summaries, monitoring reports, etc.

CHAPTER 2

SITE FEATURES

2.1 DEMOGRAPHY

2.1.1 Population

The Combe Fill South Landfill is situated in a semi-rural area of Morris County, NJ. The 1985 population within five miles of the site numbers about 24,500 based on interpolations of census tract data and estimates prepared by the Morris County Planning Board for 1980, 1984, and 1990. Using these same estimates, the population within a 1-mile radius of the site is about 800. Recent (1984) aerial photography was used to obtain an estimate of the number of houses within a 1/2-mile radius of the site perimeter; assuming three persons per house the resulting 0.5-mile radius population is about 170. Figure 2-1 shows the population areas within 1- and 5-mile radii of the landfill.

2.1.2 Sensitive Populations

Several focal points for individuals that may be sensitive to possible environmental contamination from the site have been identified. Sensitive individuals were assumed to include pre-teen children, the elderly, pregnant women, and hospitalized or convalescent individuals. Table 2-1 lists sensitive population clusters in Chester and Washington townships, and where known, their distance from the landfill and source of drinking water.

2.2 LAND USE AND NATURAL RESOURCES

Land use in the vicinity of the landfill consists primarily of low-density residential (lot sizes are generally more than two acres)

FIGURE 2-1
COMBE FILL SOUTH LANDFILL RI/FS
POPULATION IN VICINITY OF SITE

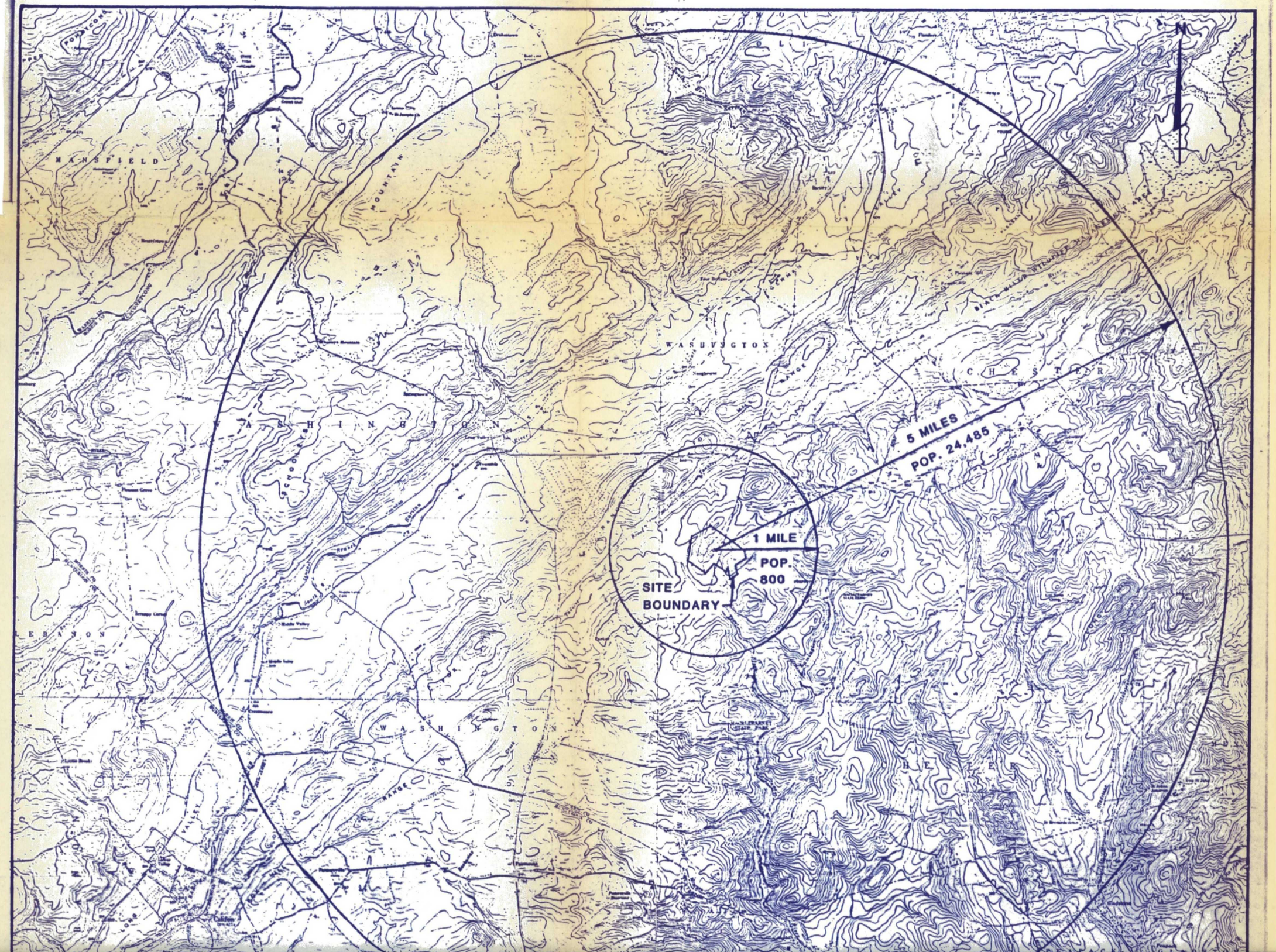

MANSFIELD
WASHINGTON
WASHINGTON
CHESTER
5 MILES
POP. 24,485
1 MILE
POP.
800
SITE
BOUNDARY

TABLE 2-1 (Page 1 of 2)

SITES OF POTENTIALLY SENSITIVE POPULATIONS

Combe Fill South Landfill

FACILITY	TYPE	LOCATION	DISTANCE FROM LANDFILL (mi.)	WATER SERVICE
Early Childhood Development Center	Nursery School	Parker Rd. Chester Twp.	0.53	Public Well
Old Farmers Rd. School	School	Old Farmer Rd. Washington Twp.	1.5	Public Well
West Morris Central High School	School	Bartley Rd. Washington Twp.	2.5	Public Well
Long Valley Middle School	School	West Mill Rd. Washington Twp.	2.6	Public Well
Flock Town Rd. School	School	Flock Town Rd. Washington Twp.	4.3	Public Well
Walter Kossman School	School	Flock Town Rd. Washington Twp.	4.4	Public Well
Liebenzell Mission	Residence for old and young	Pleasant Grove Rd. Washington Twp.		Private Well
Heath Village	Senior housing	Schooleys' Mt. Rd. Washington Twp.		Public Well
Valley Brook Nursery School and Daycare Center	Nursery school, daycare center, swim club	West Valley Bk Rd. Washington Twp.		Private Well
Zion Lutheran Church	Daycare center	Rt. 24-Schooley's Mt. Rd, Washington Twp.		Public Well
Our Lady of the Mt. Church	Daycare center	Rt. 24-Schooley's Mt. Rd, Washington Twp.		Private Well
The Dogwood School	Pre-school/ Kindergarten	Dogwood Rd. Chester Twp.		

TABLE 2-1 (Page 2 of 2)

SITES OF POTENTIALLY SENSITIVE POPULATIONS

Combe Fill South Landfill

FACILITY	TYPE	LOCATION	DISTANCE FROM LANDFILL (mi.)	WATER SERVICE
Westmont Montessori School	Pre-school/ Kindergarten	Rt. 24 Chester Twp.		
Wellkind Neurological Hospital	Hospital	Pleasant Hill Rd. and Flanders Rd. Chester Twp.		
Black River Middle School	School	North Rd. Chester Twp.		
Bragg School	School	Rt. 24 Chester Twp.		
Dickerson School	School	Rt. 513, Rt. 24 Chester Twp.		
Child Study Team	School	Rt. 24 Chester Twp.		
Morris C. Park Commission School	School	Longview Rd. Chester Twp.		
St. Bernards School	School	Ralston Gladstone Rd. Chester Twp.		
Devereux School	School	Pottersville Rd. Chester Twp.		

amidst large parcels of cleared rolling hills. Although some horse husbandry and vegetable, grain, and orchard farming are done in the area, most former farmlands are now unused. A few commercial establishments and a local nursery school are located on Parker Road near the landfill. Remnants of the once-viable iron ore mining industry in the area are in evidence at the Hacklebarney mines just to the south and east of the site. Locally high iron concentrations are also distinctive characteristics of the area soils, surface waters, and groundwaters.

A series of county and state run park segments, including those of the Black River County Park and Hacklebarney State Park, lie to the east and south of the site along the Black River. These parks border both sides of the Black River from approximately the crossing of Rt. 24 to the Hunterdon County border to the south. About 3000 ft of Trout Brook, upstream of its confluence with the Black River, borders or lies within Hacklebarney State Park. This segment of Trout Brook is stocked each spring with trout by NJDEP.

In March 1981, NJDEP delineated about 34 acres of hardwood wetlands on the Combe Fill South property (as originally depicted in Combe Fill Corp.'s 1972 application for registration), which marked the headwaters of the West Branch of Trout Brook. Most of this wetland area (about 20 acres) has been sold and is no longer a part of the Combe Fill South landfill property. The remaining wetland acreage still owned by the Combe Fill Corp. forms the western border of the site along the shore of the West Branch of Trout Brook.

2.3 CLIMATOLOGY

The site has a continental-type climate where winters are controlled by polar continental air masses and summers by tropical air masses. Throughout most of the year the prevailing winds are from

the southwest but during the cooler half of the year (generally from October to April), winds from the northwest are predominant. The average annual temperature is 50°F with an annual maximum of 62°F and an annual minimum of 37°F. The total annual precipitation of 42 in. for the period November 1984 to October 1985 was below the annual normal of 50 in. The average frost-free period is about 146 days and runs from early May to late September/early October. Table 2-2 summarizes the monthly temperature and precipitation data for the area, as measured in Long Valley, about 2 miles to the northwest of the landfill.

2.4 WATER SUPPLY AND WASTEWATER DISPOSAL

2.4.1 Water Supply

In the Township of Chester, 85 residents are currently supplied with potable water by the Peapack-Gladstone Water Department. The residents are served by a 6-8 in. diameter water main on Old Chester Road in the southern portion of the township approximately 3.2 miles from the landfill.

Three hundred residents are currently served by the Chester Water Company in the Borough of Chester. The water is supplied by a single deep well with a current capacity of 0.02 million gallons per day (MGD). The service area is approximately 2.4 miles northeast of the landfill site.

Several areas within Washington Township are supplied with potable water by the Washington Township Municipal Utilities Authority (WTMUA). WTMUA supplys about 5000 residents from 15 low-yielding wells having a combined yield of about 0.6 MGD. The water service area closest to the landfill serves East and West Mill Roads, Fairmont Road, and Mountain Roads located to the west and south of

TABLE 2-2

CLIMATOLOGICAL DATA

Combe Fill South Landfill[a]

	JAN 1985	FEB 1985	MAR 1985	APR 1985	MAY 1985	JUN 1985	JUL 1985	AUG 1985	SEP 1985	OCT 1985	NOV 1984	DEC 1984
Temperature (°F)												
Monthly Maximum	33.1	41.6	53.3	62.4	73.7	75.1	82.2	79.9	74.7	65.5	53.7	47.5
Monthly Minimum	13.3	17.8	25.5	36.4	45.3	50.8	56.6	56.8	50.6	37.9	28.9	27.0
Monthly Average	23.2	29.7	39.4	49.4	59.5	63.0	69.4	68.4	62.7	51.7	41.3	37.3
Monthly Normal Average (1951-80)	26.6	28.2	36.7	48.0	57.4	66.0	70.7	69.2	62.1	51.4	41.3	30.5
Precipitation (in.)												
Total Monthly	1.02	3.27	1.79	1.04	5.81	5.68	5.86	3.77	7.23	1.52	1.77	3.19
Total Monthly Normal (1951-80)	3.86	3.30	4.43	4.33	4.07	3.91	4.68	5.22	4.22	3.92	4.38	4.26

[a]Records for Long Valley, Morris County, NJ

the landfill. There is a 10-12 in. diameter water main from this system approximately 1 mile southwest of the landfill.

The water supply element of the 1982 Morris County Master Plan calls for development of local public water supply wells for Washington Township and the Borough of Chester. The plan indicated that extending the Morris County public water supply system from the Alamatong well field in Randolph Township (to the north) into the Borough of Chester and Washington Township was not cost-effective at that time. The plan estimated that extending the County system into the Borough of Chester alone would require 5.3 miles of water mains at a construction cost of $2.1 million (1982 dollars).

2.4.2 Wastewater Disposal Treatment

A review of information obtained from NJDEP, Division of Water Resources, revealed one publicly owned treatment works (POTW) within 3.2 miles of the Combe Fill South landfill. This treatment plant, the Schooley's Mountain sewage treatment plant (STP), is owned and operated by WTMUA and is located off Sylvan Circle on Fawnridge Drive. The STP has a design flow of 0.5 MGD and is currently treating approximately 0.331 MGD of sewage. The STP services developments in the Schooley's Mountain area west of the South Branch of the Raritan River. Several residential developments within the service area are sewered but are not connected to the treatment system. No sewers exist in the area east of the South Branch of the Raritan River where the Combe Fill South landfill is located.

The STP uses rotary biological contractors to remove organic matter. This is followed by separation of the liquid and sludge in a clarifying bridge. The liquid is discharged to the South Branch of the Raritan River and the sludge is placed in a holding tank where

it undergoes aerobic stabilization. Once stabilized, the sludge is placed in aquatic beds where additional liquid is separated from the sludge and recycled to the head of the plant.

2.5 OTHER POTENTIAL SOURCES OF ENVIRONMENTAL CONTAMINATION

Sixteen potential contributors to groundwater and air contamination in the vicinity of the Combe Fill South landfill are shown in Appendix M. The list includes all industries listed in the Morris County, NJ Industrial Directory that are within 5 miles of the landfill.

There are nine listed potential sources of contamination in Washington Township, five of which are industries in the Cleveland Industrial Park. This industrial park is 2.9 miles south of the Combe Fill South landfill on Parker Road, south of Black River Road. Recent sampling and analysis of the wastewater in the distribution box of the septic system common to this industrial park indicate the presence of priority pollutant volatile organics on the order of 100 ppb. The drinking water wells of several homes near this industrial complex on Black River Road, Pickle Road, Fairmont Road, and Apgar Road have been found to contain elevated concentrations of trichloroethylene and tetrachloroethylene (10-500 ppb). Contamination has been found (at trace levels in other residential wells) as far north of the industrial complex as Flintlock Drive (1.86 miles south of the landfill). Currently, the source of this contamination has not been identified but the site is under investigation.

No additional information is available on any of the other commercial industrial/manufacturing establishments listed in Appendix M. No further attempt has been made at this time to identify the type or nature of any possible contamination from these sources. Other

small local potential sources of contamination such as gas stations, body shops, etc. are not included in this table.

The Combe Fill North landfill, a suspected hazardous waste site, is located in Mt. Olive Township, approximately 7.15 miles from Combe Fill South landfill. A RI/FS is currently being conducted at Combe Fill North. Suspected hazardous wastes disposed at the Combe Fill North landfill have not yet been confirmed by this ongoing study nor has the status of the extent, if any, of air, soil, and water contamination by the landfill.

CHAPTER 3

HAZARDOUS SUBSTANCES INVESTIGATION

3.1 WASTE TYPES/HAZARDOUS SUBSTANCES INVENTORY

Borings and excavations made within the landfill area revealed that the fill appears to be composed of commerical and domestic type wastes consisting of broken glass, paper, discarded appliances, furniture, and other commonly found municipal landfill items. Much of the landfill area has been covered with a thin layer of soil and broken rock. The characterization of other wastes within the fill, which have not been directly probed, remains speculative. There is evidence of post-landfill operation waste disposal in a series of small localized areas of random dumping apparently consisting of household-type refuse. This area is located near the northwest toe of the existing landfill face.

Approximately a dozen 55-gal drums are scattered in the former landfill office area north of well D-6. Most of these drums are labeled "Valvoline" and probably contained motor oil for the operation of landfill equipment and machinery. All the drums have been perforated, and there is no evidence of residual oil from these drums.

Although there may be a variety of hazardous substances present on this site, no obvious hazardous waste or substance was documented, with the exception of the leachate seeps. The inventory and characterization of leachate seeps are discussed in Chapter 5.

CHAPTER 4

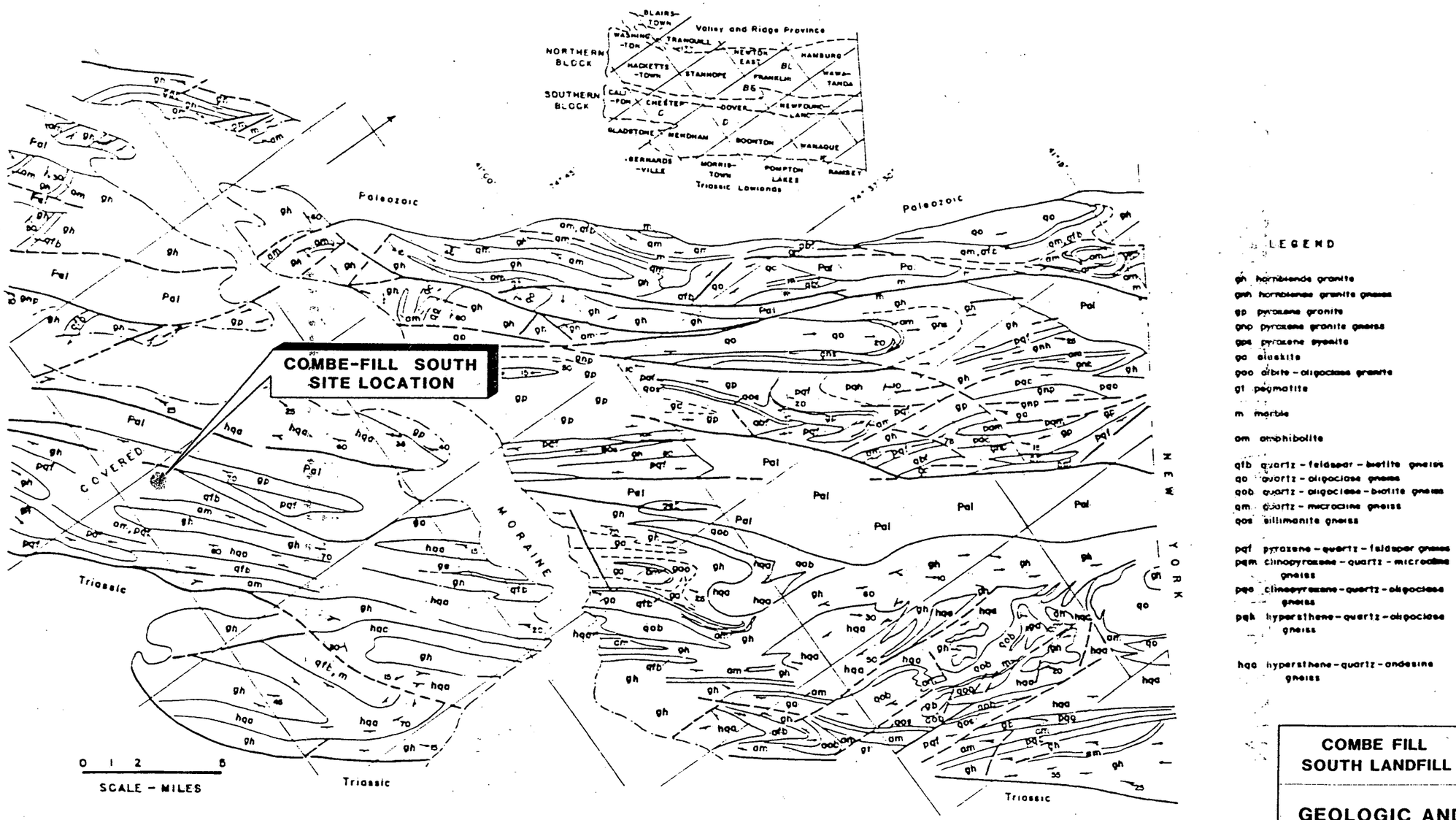
HYDROGEOLOGY

4.1 GEOLOGY AND SOILS

4.1.1 Geologic Structure and Stratigraphy

4.1.1.1 Geologic Structure. Combe Fill South Landfill lies in the Piedmont Physiographic Province. In New Jersey, the region is termed "The Highlands" and consists of a 20-mile wide bank of northeast to southwest trending ridges and valleys extending from the Hudson Highlands of New York to the Reading Prong Region of Pennsylvania. The rocks are generally metamorphic and are considered to be Precambrian in age except in some valleys where Paleozoic sedimentary rocks exist. Topography within the region varies from an elevation of approximately 1000 ft above mean sea level on the ridges to an elevation of 450 ft in the valleys. On the site itself, the topography ranges from 780 ft along the West Branch of Trout Brook to 875 ft at the top of the newer fill area.

The Highlands Region is bounded on the northwest by Paleozoic sedimentary rocks of the Ridge and Valley Physiographic Province. The Ramapo Fault or related geologic faults bound the region to the southeast across which lie the Triassic rocks of the Newark Group. A nearby band of Paleozoic rock bisects the region into northern and southern blocks. The Combe Fill South site lies in the southern block just southeast of this major Paleozoic valley as shown on Figure 4-1. The Precambrian rock units consist predominantly of granites and gneisses, although some marble is present to the northeast, near Franklin, NJ. Paleozoic formations within the region consist of quartzites and limestones.



Precambrian geology of the central and northeastern parts of the New Jersey Highlands. The small inset map gives the names of the seven and one-half minute quadrangles for the area of the larger map; it also gives the locations of places mentioned in the text: Chester (C), Dover (D), Bowling Green Mountain (BG), Beaver Lake (BL) and Wanaque reservoir (W). Note also the identification of the "northern" and "southern" blocks. On the larger map "Pal" represents Paleozoic rocks. Attitudes of foliation and lineation are given by conventional symbols.

COMBE FILL SOUTH LANDFILL	LAWLER, MATUSKY AND SKELLY ENGINEERS
GEOLOGIC AND LOCATION MAP	
drawn / approved / checked / date	drawing no. FIGURE 4 - 1
E. C. Wright associates, inc. earth resources consultants middletown pennsylvania	

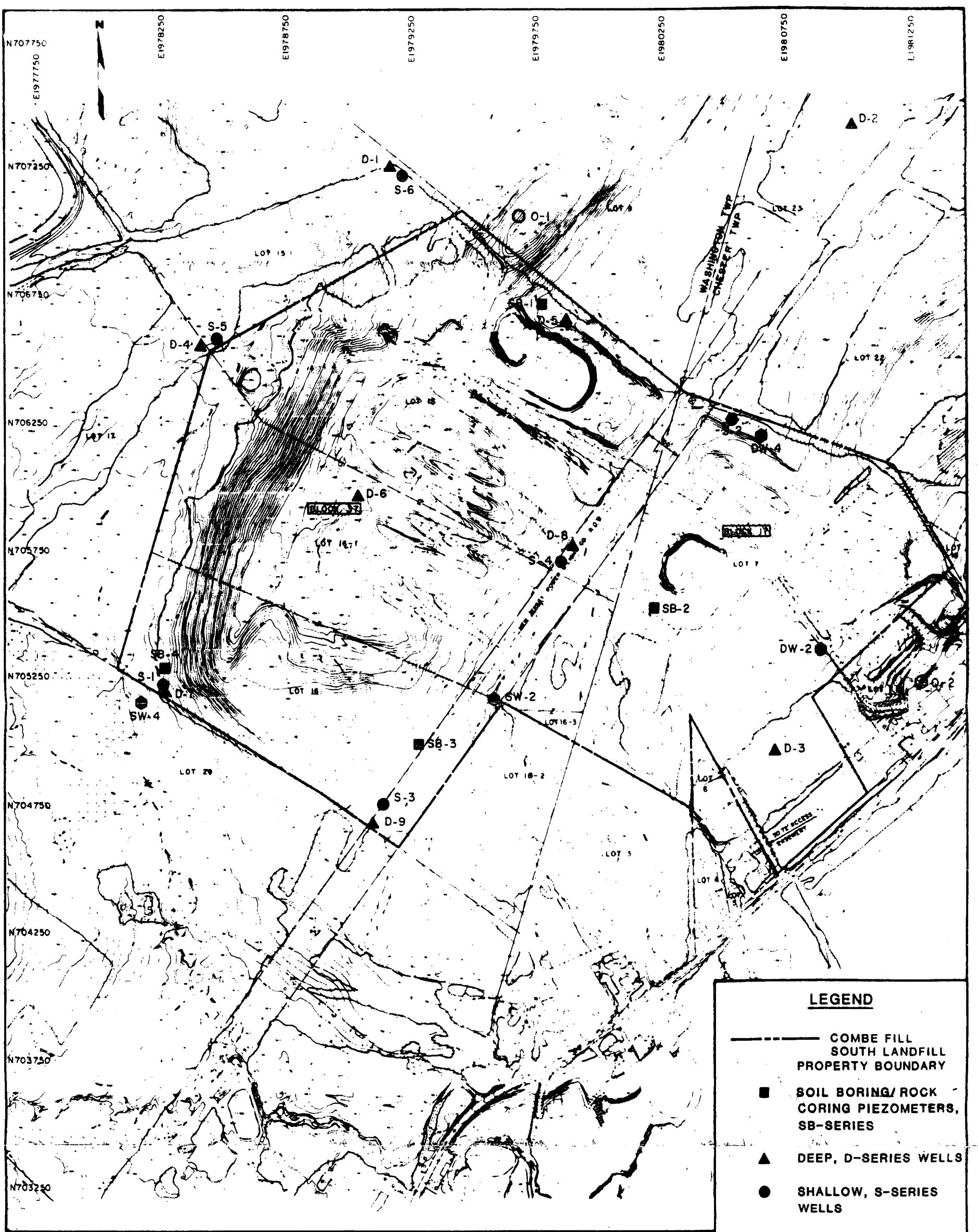
The Precambrian rocks of the Highlands can be considered as basement rock, extending to great depths below ground surface. No other geologic formations of immediate importance to this study exist beneath the basement Precambrian bedrock.

Structurally, the region consists of steep, tight, isoclinal folds that tend to the northeast. The limbs of the folds dip vertically or near vertically. The lineation of minerals constituting the metamorphic rocks tend to closely follow the plunge directions of the fold axes.

The southeast boundary of the region possesses many longitudinal faults that have been interpreted (Smith 1969) as high angle wrench faults; however, some may be reverse faults. This major fault zone is termed the Ramapo Fault. Two other small sets of faults occur in the region. One cluster lies in the Wanaque and New Foundland Quadrangles and strikes north/south. Another set lies within the Hackettstown and Tranquility Quadrangles and strikes east/west. No significant faults lie near the Combe Fill South Landfill.

A structural interpretation of the bedrock at the site was made in 1982 by Mark Germine, Assistant Geologist of NJDEP (see Appendix A). In this field study foliation planes, striking N50°E and dipping 80°E, were located. Foliation planes can be defined as any planar arrangement of textural or structural features. In this case, it would be the occurrence of leafy textured minerals such as mica or biotite. Germine also noted a joint set oriented along this same foliation plane. Joints are planar openings within a rock mass that occur without displacement and commonly occur in parallel sets.

Field examinations conducted by REWAI as part of this RI/FS effort found information agreeing with Germine's. Figure 4-2 shows the



LEGEND

- COMBE FILL SOUTH LANDFILL PROPERTY BOUNDARY
- ■ SOIL BORING/ ROCK CORING PIEZOMETERS, SB-SERIES
- ▲ DEEP, D-SERIES WELLS
- ● SHALLOW, S-SERIES WELLS
- ⬢ EXISTING MONITORING WELLS
- ○ OUTCROP

400 0 400
Scale in feet

Lawler, Matusky & Skelly Engineers
Environmental Science & Engineering Consultants
One Blue Hill Plaza
Pearl River, New York 10965

COMBE FILL SOUTH LANDFILL
REMEDIAL INVESTIGATION/
FEASIBILITY STUDY

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earth resources consultants
Harrisburg Pennsylvania

LOCATION OF BEDROCK OUTCROPS

FIGURE 4-2

locations of two notable outcrops where structural data was acquired. Outcrop O-1, located north of Wells SB-1 and D-5, displays a joint plane striking N52°E and dipping vertically. Joint planes measured at Outcrop O-2 were:

N35°E, vertical
N40°E, vertical
N43°E, vertical

The preceding measurements agree with regional information (Smith 1969).

Three other joint sets, noted in the Germine report, were not confirmed by the RI field investigation. Two of these were a conjugate shear system, consisting of two sets oriented N10°W, vertical, and N45°W, vertical. The third joint set is sheeting, which are joints that occur horizontally and usually lie within the upper 5 to 10 ft of bedrock. Sheeting was reported by Germine in the northeast corner of the landfill.

The landfill lies on the limb of a tight isoclinal fold. The limb has an average trend of N42°E with a vertical to near vertical dip. This vertical trend (N42°E) is the orientation of foliation across the Combe Fill South Landfill.

4.1.1.2 Stratigraphy. Bedrock at the landfill has been mapped (Lewis and Kummel 1910, rev. 1950) as the Losee and Byram Gneisses. The rock units are described as:

Byram Gneiss - Gray, granitoid gneiss composed of microcline, microperthite, quartz, horneblende or pyroxene, and sometimes mica.

Losee Gneiss - White, granitoid gneiss composed of oligoclase, quartz, occasional ortho-

clase, pyroxene, horneblende, and biotite.

The Byram Gneiss underlies most of the landfill, except the very northwest extremity, which is underlain by the Losee Gneiss.

Smith (1969) states that formation names such as Byram Gneiss and Losee Gneiss are too broadly defined and subjective for use as modern terms. He suggests the use of terms conveying mineralogic information. Figure 4-1 illustrates the New Jersey Highlands Region remapped based on mineralogic considerations. The Combe Fill South site lies in the southwestern corner of the Chester Quadrangle in an area mapped as Quartz-Feldspar-Biotite Gneiss. This unit is a heterogeneous group of layered gneisses that have biotite or horneblende as the predominant dark mineral, and oligoclase or perthitic microcline as the dominant feldspar. In his 1982 report (Appendix O), Germine identified the bedrock as a hornblende granite. The data obtained during the drilling program for this RI/FS agrees. The hornblende granite contains quartz, feldspar, and hornblende, with some amphibolite, pyrite, biotite, and pyroxenite. Well logs with geologic descriptions are provided in Appendices F-1 and F-2. The granite was penetrated to a depth of 186 ft without encountering a major change in lithology.

4.1.2 Soil and Unconsolidated Overburden

Three general groups or classes of unconsolidated deposits were encountered during drilling and other intrusive activities at the Combe Fill South Landfill: (1) fill, (2) natural soils, and (3) granitic saprolite. The fill and natural soils were encountered both at the surface and at depth, while the granitic saprolite was only encountered in the subsurface across the site.

4.1.2.1 Fill Material. Fill material at the landfill site consists of a combination of refuse and disturbed earth cover material. The refuse consists of domestic, municipal, commercial, and industrial wastes. The earth cover material was probably removed by excavation from its natural state on-site during landfilling operations, and temporarily stockpiled. It was then redeposited as cover material over refuse at various depth intervals and thicknesses. This material consists primarily of native residual soils, saprolite, and rippable bedrock fragments.

Cover material encountered below grade during drilling consisted primarily of brown to orange-brown, gravelly, sandy silt. Small layers of sand and clay were also present. The sand varied in size from fine to very coarse and consisted of weathered quartz and feldspar particles. Grains were angular to subangular. Granite cobbles and boulders also occurred in varying amounts throughout the landfill. Features distinguishing cover materials from natural soils included an abundance of gravel and cobbles, very poor preferential sorting of grain size, a looser and more chaotic texture and structure in the cover materials, and the common association or intermixing of refuse with the cover material.

Predictably, the thickest fill depths are present on the landfill portion of the property. In most areas, all that appears to exist over the refuse at the surface is a thin (0-5 ft) granitic cobble cover with a sandy base apparently derived from weathering of the cobbles.

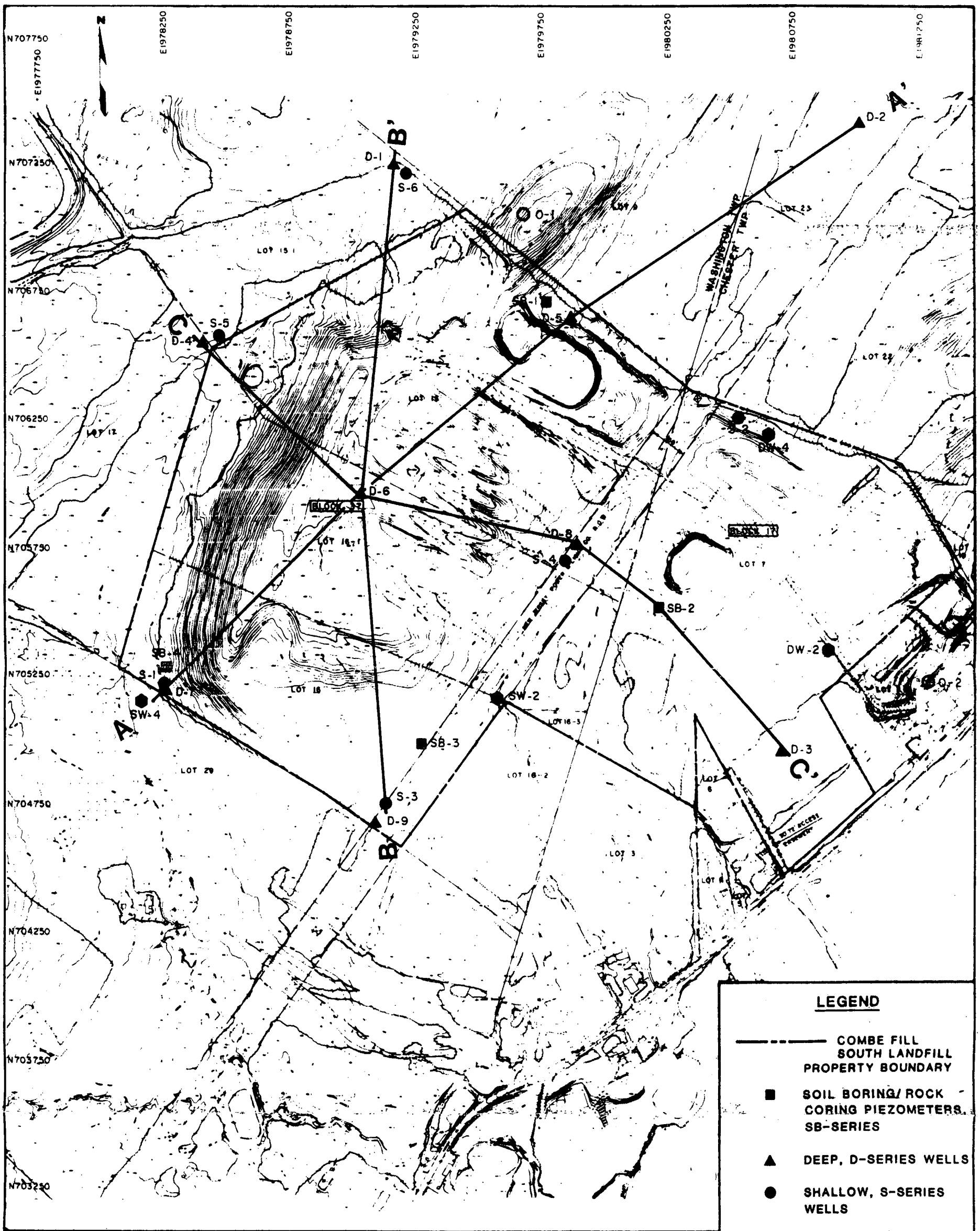
Monitoring well D-6, near the central portion of the landfill, encountered nearly 80 ft of fill, immediately overlying an apparently highly weathered, more competent material assumed to be saprolite, and approximately 18 ft in thickness (Appendix M). This saprolitic material was brown to green-brown in color, is very silty and

sandy, and directly overlies bedrock. A few highly weathered granite fragments were also observed.

It is possible that greater fill thickness exist elsewhere on the landfill; however, the fill thickness encountered in well D-6 probably represents a good overall estimate of maximum fill thickness. The relationship between fill, overlying soils, and underlying materials is shown by cross sections on Plates 1 and 2 in the back pocket of this report. The locations of the cross sections with respect to the site are shown in Figure 4-3. Due to the loss of air and material circulation to the surface while drilling through the fill at well D-6, it was not possible to estimate or confirm the presence or thickness of intermittent cover material within the refuse layers.

4.1.2.1.1 Groundwater in fill. During the drilling of well D-6, numerous voids were encountered in the fill, some measuring several feet thick. These voids provide excellent conduits for fluid flow through the fill. Fluid movement is impeded in the fill where finer materials are more tightly compacted. This was observed in test pit TP-3, where water seeping into the pit was moving through a small sandy zone, but not through a silty-clay area at the same depth. In general, permeability in the fill is nonhomogeneous and anisotropic.

Groundwater saturation of the fill occurs in well D-6, at the southwest corner of the landfill in wells D-7 and S-1, and in soil boring SB-4. Examination of the cross sections (Plates 1 and 2) shows that a large portion of the fill occurs below the groundwater table and is therefore probably saturated. Water was also noticed seeping into test pits TP-2 and TP-3 through the fill material.



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LOCATIONS OF CROSS SECTIONS
A-A', B-B', AND C-C'

FIGURE 4-3

The monitoring wells and test pits constructed along the haulage road that borders the eastern side of the landfill (wells D-8, S-4, SB-3, S-3 and test pits TP-1 and TP-3) exhibit fill thicknesses ranging from 5 to 10 ft underlain by natural soil. This area is where the natural soil/fill interface is most evident; it occurred within the uppermost 10 ft of unconsolidated material.

4.1.2.2 Natural Soils and Saprolite. The thickest natural unconsolidated deposits, i.e., natural soils and saprolite, occur in the vicinity of wells D-1, D-2, and D-5. Unconsolidated natural soils and saprolite in this area range from 30 to 80 ft in thickness.

It appears that there may have been 40 to 60 ft of soil and saprolite in place over the majority of the landfill before operations began there. This estimate is based upon a comparison between pre- and planned landfilling topography, shown in the original 1971 design plans for Combe Fill South and present landfill topography. The cross sections presented in Plates 1 and 2 show the inferred spatial relationship of the natural soil, saprolite, fill, and bedrock.

As a result of the test drilling, soil sampling, and backhoe test pit work performed during this investigation, an isopach map has been prepared for the site, showing the thicknesses of overburden (unconsolidated deposits, soils, fill and saprolite). This map, shown as Plate 3 and located in the back pocket of this report, indicates that maximum thicknesses of overburden coincide with the highest elevation of the landfill near well D-6. The smallest thicknesses generally occur south of the powerline and in the west-northwest corner of the site, except for the bedrock outcropping just north of SB-1. Substantial natural thicknesses (± 70 ft) of

overburden are present in the northern corner of the site, extending beyond the vicinity of well D-1.

4.1.2.2.1 Natural soils. Most of the natural soil at the site has been disturbed due to the landfilling operations. However, native, undisturbed soils are present adjacent to the site. In a report furnished to Chester and Washington townships by URWA, the following soils were identified and mapped by the Morris County Soil Conservation Service (SCS) at the site.

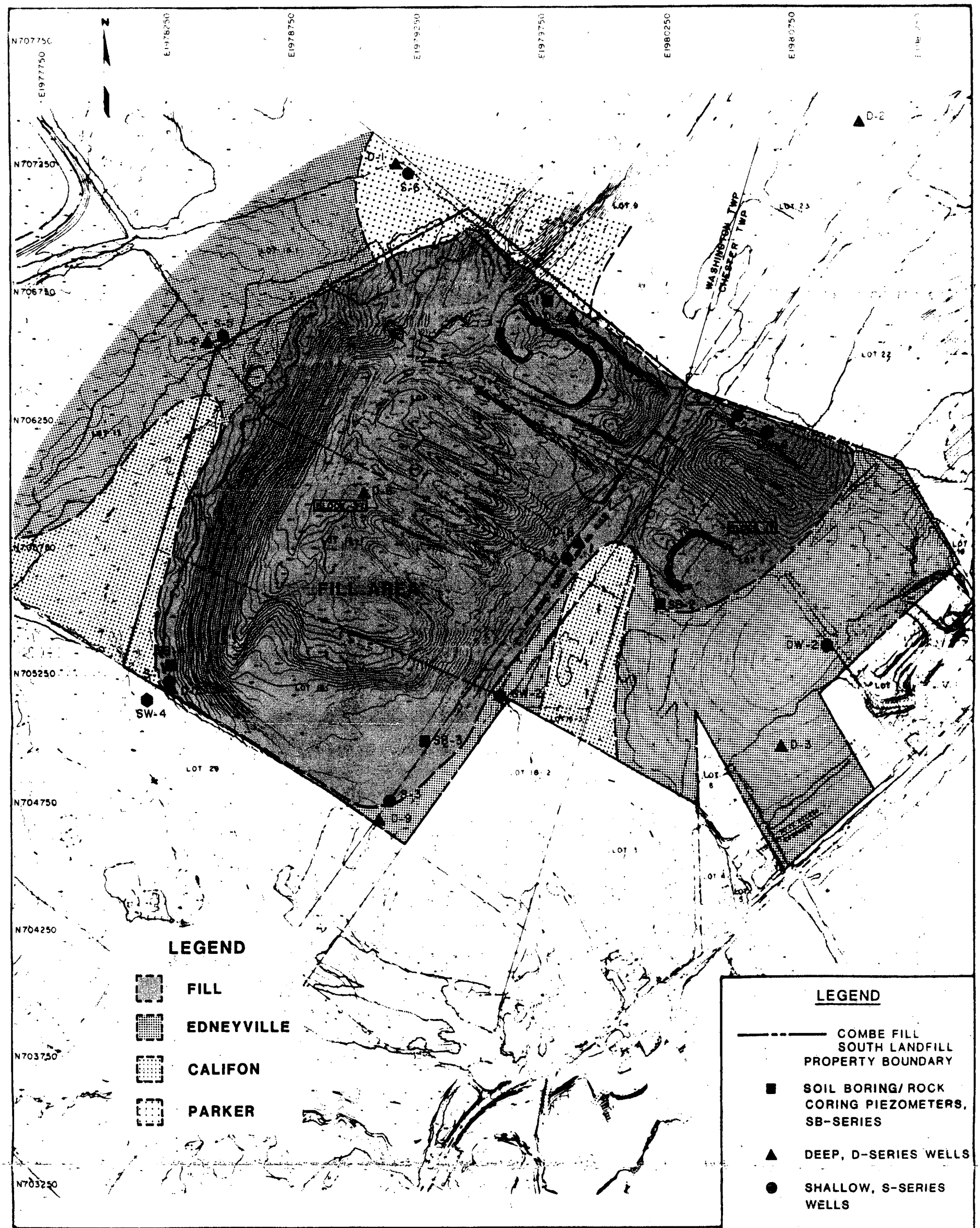
1. Edneyville Series: These soils constitute a major portion of the landfill property and consist of deep, well-drained loamy soils. Much of this soil type has been disturbed during landfilling operations.

2. Califon Series: Califon soils are deep, moderately well- to poorly-drained soils that occur in waterways (East and West Branches of Trout Brook) and wetland areas. A fragipan, a dense compact layer of soil, is generally present in Califon soils at a depth of 9 in.

3. Parker Series: Parker soils are deep, excessively drained, and contain large amounts of gravel and cobbles. They generally occur on the higher, unused portions of the landfill property.

Figure 4-4 is a surficial soils map of the area based upon data acquired during this investigation and from SCS published data.

The Edneyville soils encountered on-site consist primarily of orange-brown to dark brown, slightly sandy, clayey silt to silty, fine- to coarse-grained sand. Overall, finer-grained materials were prevalent. Some granitic gravel, ranging in size from 0.25 to 2 in., also occurred. Most of the sand is subangular quartz with smaller amounts of feldspar and mica. While the Edneyville soils exhibit better sorting than the



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COMBE FILL SOUTH LANDFILL REMEDIAL INVESTIGATION/ FEASIBILITY STUDY

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SURFICIAL SOILS MAP

FIGURE 4-4

overlying fill, sorting can only be classified as fair. These soils also appeared to be more competent and tightly compacted than the landfill cover soils.

Natural soils encountered on the ridge near wells D-1, S-6, D-5 and boring SB-1 belong to the Parker Series. These soils consist of medium brown, yellow-brown, and gray-brown sandy, gravelly silt and clayey silt. Small occasional clay lenses also occur in these soils. Granitic gravel and small-sized cobbles are more prevalent in the Parker soils than the Edneyville soils. Sand is predominantly angular to subangular quartz and feldspar. Smaller quantities of mica and pyrite were also observed. Sorting in Parker soils was poor to fair, and the soil was quite competent and tightly compacted.

Soils observed in soil boring split-spoon samples and hand-augered soil samples were generally very weathered and often extremely hard and dry at the surface. As depth increases, however, these soils become both sandier and somewhat more permeable. Groundwater is present in these soils to the north (well D-2), west (well D-4), and southwest (well D-7) of the site. At all locations investigated, the natural soils grade into an underlying granitic saprolite.

4.1.2.2.2 Granitic saprolite. Saprolite is a soil-like material that is derived from the chemical weathering of either igneous or metamorphic rock. Although commonly soft and soil-like, the material generally retains the parent rock structure.

A highly variable granitic saprolite unit was observed in all borings at Combe Fill South. This saprolite is green-brown to yellow-brown and consists of silt, fine to coarse-grained sand, and many highly weathered granite fragments. These fragments are generally very soft and easily crushable.

During construction of the soil borings, samples were collected for complete sieve analysis and hydrometer testing. These samples provided laboratory confirmation on grain size and range. Generally the grain size curves (Appendix H) are similar for all samples and show 25-40% silt, 15-40% fine sand, 20-35% medium sand, and 0-10% coarse sand and gravel. This wide range of grain sizes is not uncommon in saprolites derived from this parent rock. It should be noted that the 6-8 ft depth interval sample from piezometer SB-4 consisted of both fill material and natural soils, with no saprolite.

Mineralogy of the saprolite shows the sandy grains consisting primarily of angular to subangular quartz and feldspar. Varying amounts of biotite and muscovite mica, hornblende, and amphibole also occur. The gravel-sized material is highly weathered hornblende granite, biotite, and vein quartz. The larger fragments also display minor amounts of pyrite.

In many wells the saprolite appears highly permeable. This is especially true where greater amounts of sand and weathered gravel are present. Wells S-1 and S-5 exhibited relatively high groundwater yields as determined by the yield of displaced water over brief time intervals during air development of the wells. This strongly suggests that the saprolite as a unit is a significant groundwater flow zone on the site. In cases where yields are lower, finer and less permeable materials are present.

With increasing depth in the saprolite, grain size and material competency increase until the saprolite grades into the parent granitic bedrock unit. The drilling log boundaries of these latter units were based upon material competency as well as percentage of fresh rock fragments in the sample. In many

cases, the transitional interface between saprolite and highly weathered granitic bedrock was very gradual.

Saprolite thickness across the site varies from 44 ft in the valley to the northeast of the landfill to approximately 10 ft along the western margin of the landfill. On average, saprolite thickness across the site is about 23 ft. Much of the deepest material excavated prior to landfilling was undoubtedly the granitic saprolite.

The bedrock contour map, shown in Plate 4 and located in the back pocket of this report, illustrates the elevation of the base of the saprolite. Conversely, it shows the elevation of the top of moderately competent bedrock. This map, prepared on the basis of the drilling logs of the new wells and borings, shows that a prominent bedrock crown occurs in the northern part of the site, between wells D-5 and D-1. This feature occurs at a high point of elevation 820 ft above mean sea level (MSL), sloping westward, southward, and eastward to elevations generally ranging from 760 to 770 ft MSL. Otherwise, the bedrock surface is relatively flat, with only moderate slopes. This may be due to the pre-landfilling stripping, ripping, and grading done in preparing the landfill subgrade. Finally, a second but less pronounced bedrock high is present in the southeast corner of the site, occurring at elevation 780 ft, as shown on Plate 4 near wells DW-2 and D-3. The slope of the competent bedrock surface may exert significant control on the movement of groundwater and contaminants, especially in the triangular area between wells D-1, D-5, and D-6.

4.1.2.3 <u>Contamination In Unconsolidated Materials of Soil Borings/ Rock Coring</u>. During drilling and excavation activities at Combe Fill South, HNU, explosimeter, and radiation detector readings were

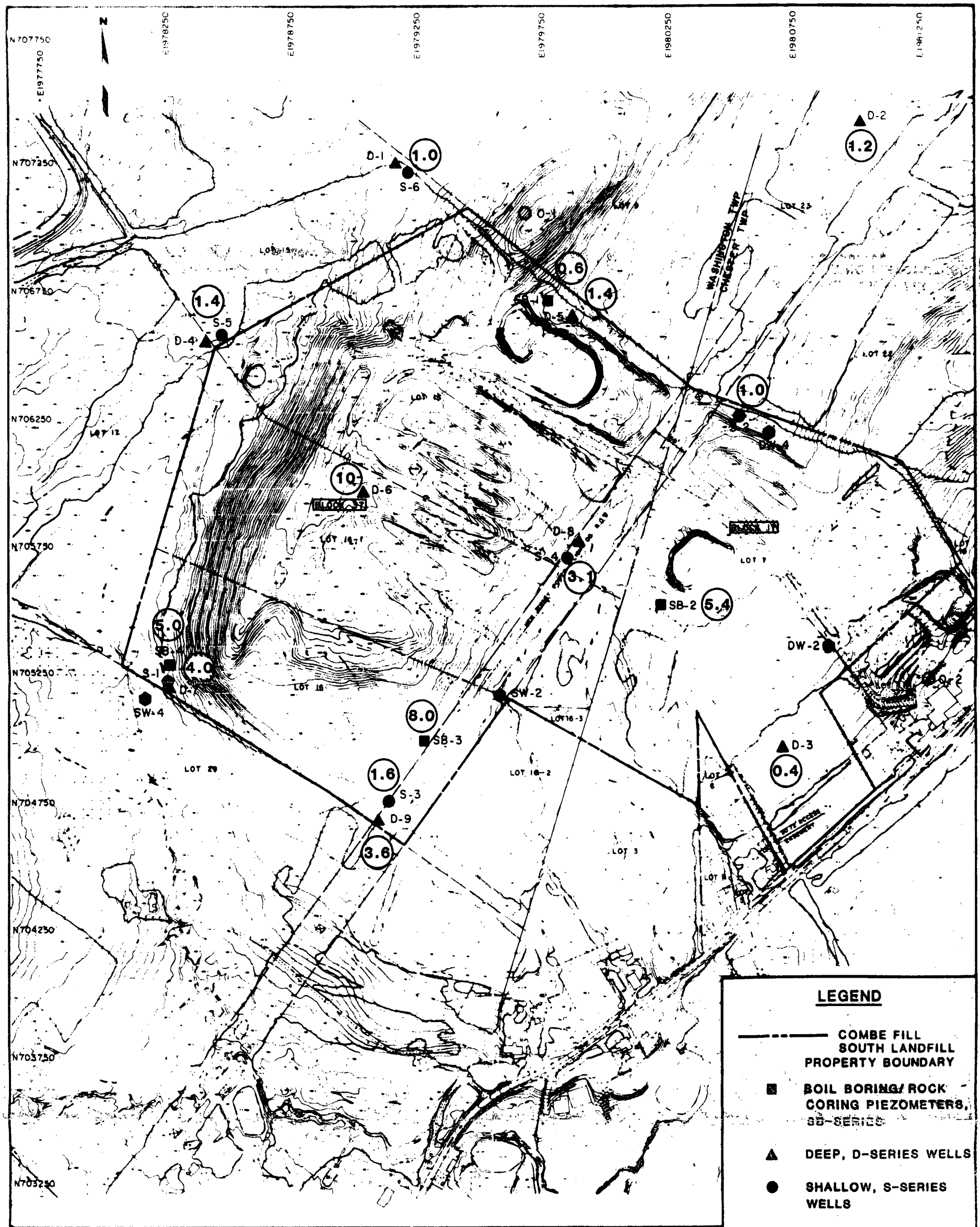
obtained from freshly excavated soils in the manner prescribed in the FSP. In addition, soil samples from selected borings, hand-augered soil sampling sites, and test pits were submitted for laboratory chemical analysis.

4.1.2.3.1 Photoionization detector (HNU) measurements. Photoionization detector readings are included on the geologic logs for monitoring wells and soil borings found in Appendices E and M. These readings suggest at least low level contamination in the soils across the site. Background HNU readings were taken each morning before the start of invasive activities; these readings typically ranged from 0 to 1 ppm and was considered background for the site.

Soils encountered in wells D-1, S-5, and S-6 (Figure 4-5) generally produced the lowest HNU readings of 0 to 1 ppm. The same observation was true for wells D-3 and S-2. HNU readings up to 1.6 ppm were observed in the soils during the drilling of wells S-3 and D-7 at the southeast and southwest corners of the landfill. Similar concentrations were found in wells D-4 and D-5 at the northwestern and northern edges of the landfill.

During the air-rotary drilling of the soils interval of wells S-1, D-9, and S-4 high (up to 4 ppm) HNU measurements were recorded. Predictably, the highest HNU measurements were recorded during drilling of well D-6 located entirely within the fill proper. Readings in excess of 10 ppm were recorded at the surface of D-6 during drilling. No natural soils were encountered in this well, as it penetrated the central portion of the landfill area.

In several of the wells discussed above, HNU readings encountered during drilling of the bedrock zone exceeded those found



LEGEND

- COMBE FILL SOUTH LANDFILL PROPERTY BOUNDARY
- SOIL BORING/ ROCK CORING PIEZOMETERS, SB-SERIES
- DEEP, D-SERIES WELLS
- SHALLOW, S-SERIES WELLS
- EXISTING MONITORING WELLS
- OUTCROP
- (3.6) MAXIMUM PID LEVEL OBSERVED IN SOILS INTERVALS (ppm)

400 0 400
Scale in feet

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MONITORING WELL AND PIEZOMETER LOCATIONS - SHOWING HNU(PID) OBSERVATIONS IN SOILS INTERVALS

FIGURE 4-5

in the soils interval, and were usually associated with water bearing zones and/or minor textural changes in the bedrock. For example, in well D-7, although HNU measurements of up to 0.7 ppm were recorded during penetration of the soils interval, readings of up to 5.8 ppm were noted during the drilling of the bedrock zone. Likewise, although no positive HNU readings were encountered in the soils interval in well D-8, measurements of up to 6.3 ppm were made during bedrock drilling in this well.

Although lower HNU readings were often made in the soils horizon, actual chemical concentrations in the soils, as determined by laboratory analysis, may be the same as those in the bedrock. The increased mobility of contaminants in the fractured bedrock acquifer may partially account for high bedrock HNU readings. The dynamic action of groundwater, aerated by drilling activity, exposes a potentially larger net surface area for the more rapid release of contaminants to the atmosphere and subsequent PID detection as compared to the drilling of soils.

4.1.2.3.2 Chemical analyses. Selected soil samples obtained during soil boring/rock coring activities were submitted to the laboratory for chemical analysis. A summary of the analyses for priority pollutants found in these samples are presented in Table 4-1; additional sample data is provided in Appendix CC. The results of the analyses conducted on samples from piezometers SB-2, SB-3, and SB-4, shown in Figure 4-5, confirm the presence of contaminants in soils at these locations. The geologic logs for these piezometers are included in Appendix E.

Two priority pollutant volatile organic compounds and one base/neutral extractable compound were common to all the soil samples taken from each of the three piezometers. These compounds

TABLE 4-1

PRIORITY POLLUTANT CHEMICAL ANALYSES OF SOIL BORING/ROCK CORING SAMPLES[a]

Combe Fill South Landfill

PARAMETERS	PIEZOMETER SB-2 SAMPLE INTERVAL (ft) 36-38	42-48	PIEZOMETER SB-3 SAMPLE INTERVAL (ft) 12-14	28-30	PIEZOMETER SB-4 SAMPLE INTERVAL (ft) 14-16	22-44
DATE SAMPLED	11/21/84	11/21/84	11/15/84	11/15/84	11/27/84	11/27/84
VOLATILES, ppb						
Carbon tetrachloride	ND	ND	ND	350	ND	ND
Chloroform	558	658	ND	530	5995	5595
Methylene chloride	3324	3864	ND	515	ND	ND
Tetrachloroethylene	ND	ND	805	ND	1395	ND
Toluene	395	495	955	465	2995	ND
ACID/PHENOLICS, ppb						
Pentachlorophenol	ND	BM @ 825	BM @ 825	BM @ 825	BM @ 825	ND
Phenol	ND	ND	BM @ 825	ND	ND	ND
BASE/NEUTRALS, ppb						
Butyl benzylphthalate	350	ND	ND	ND	ND	ND
Diethylphthalate	BM @ 330	ND	ND	ND	ND	ND
Di-n-buylphthalate	500	720	6000	450	560	570
Phenanthrene	Bm @ 330	ND	ND	ND	ND	ND
PESTICIDES/PCBs, ppb	ND	ND	ND	ND	ND	ND
METALS, ppm						
Arsenic	2.6	2.6	2.9	2.4	ND	ND
Cadmium	1.1	4.7	3.7	2.4	1.1	3.4
Chromium	ND	ND	ND	5.9	ND	ND
Copper	3.9	120.0	56.0	31.0	20.0	71.0
Nickel	ND	5.0	ND	ND	6.4	14.0
Zinc	16.0	61.0	91.0	ND	13.0	38.0
MISCELLANEOUS, ppb						
Cyanides	ND	ND	ND	ND	ND	ND
Phenols	ND	ND	ND	ND	ND	ND

BM = Below method detection limit.
ND = Not detected.

[a]Data have been adjusted to reflect contamination in QA/QC field and trip blank samples (see Appendix CC).

were chloroform, toluene, and di-n-butyl phthalate. Chloroform at concentrations from 530 to 5995 ppb, is most prevalent in piezometer SB-4 at the southwest corner of the landfill. The soils in this piezometer also had the highest levels of toluene, i.e., 2995 ppb. As shown on Figure 4-5, HNU field observations of soils at SB-4 indicated volatile organic concentrations of 5 ppm.

The highest concentrations (3864 ppb) of methylene chloride were encountered in piezometer SB-2, which is located near the eastern edge of the landfill. Chloroform, at 658 ppb, and toluene at 495 ppb were also found in soils taken from SB-2. Field HNU readings reached 5.4 ppm in the saprolite SB-2.

Di-n-butyl phthalate was found in each of the three piezometers. The highest concentration of 6000 ppb was in soils from piezometer SB-3, located in the landfill proper. HNU measurements at this site were recorded as high as 8 ppm. Concentrations of di-n-butyl phthalate in piezometers SB-2 and SB-4 ranged between 500 and 720 ppb.

HNU readings reported for the soil borings are measured differently than those reported for air-rotary drilling. The soil removed by the soil borings is scanned while the sample remains in the split-spoon in a basically undisturbed state, thus probably providing the most reliable field scan of relative contamination.

On the other hand, soils removed during air-rotary drilling activities are unavoidably subjected to air injection prior to HNU (PID) monitoring. Volatile organic concentrations that may have been present within these soil horizons may be substan-

tially depleted by the air stripping activity, thus resulting in lower HNU measurements.

In addition to the compounds noted above, carbon tetrachloride (350 ppb) and tetrachloroethylene (805 ppb) were found in soils taken from piezometer SB-3. Tetrachloroethylene, at a concentration of 1395 ppb, was also measured in SB-4.

Butyl benzylphthalate was found in piezometer SB-2 at a concentration of 350 ppb. Other than the di-n-butyl phthalate previously discussed, this was the only other base/neutral priority pollutant found in measurable quantities in any piezometer.

No phenols, pesticides, or cyanides were found in measurable quantities in any of the samples. However, a number of metals were measured including arsenic, cadmium, copper, nickel, and zinc. The most predominant metals were copper and zinc with maximum concentrations of 120 and 91 ppm, respectively.

The QA/QC sample data associated with these soil/rock samples is presented in Table CC-1 of Appendix CC. Chloroform (<22 ppb) and methylene chloride (<95 ppb) were found in the trip and/or field blanks taken during the soil boring/rock coring program. Toluene and tetrachloroethylene were also detected, but at very low levels (<BM). These levels of contamination found in the QA/QC field and trip blanks are minor in comparison to the total quantities of these chemicals detected in the site samples. Nevertheless, the data summarized in Table 4-1 have been adjusted to reflect the occurrence of these field and trip blank contaminants.

Of the three piezometers installed, SB-3 shows the greatest variety and number of chemical compounds (both quantified prior-

ity pollutants as shown in Table 4-1 and tentatively identified compounds shown in Table CC-1 of Appendix CC) and is indicative of the general landfill refuse materials on-site. Individual contaminant peaks such as those for chloroform in SB-4 may reflect the local deposition of specific wastes such as the hospital refuse described in Chapter 1.

4.1.3 Geophysical Investigations

4.1.3.1 Terrain Conductivity Survey

4.1.3.1.1 Method. Conductivity measurements were made around the perimeter of the site and along the access road on the landfill with a Geonics EM 31 terrain conductivity meter (Plate 5 in the back pocket of this report). Readings were taken every 25 ft for a total of 11,750 ft. Measurement of parallel lines outside the boundary of the site, as indicated in the FSP, was not possible due to dense underbrush.

4.1.3.1.2 Electromagnetic theory and limitations. The Geonics EM 31 terrain conductivity meter utilizes a small transmitter coil placed near the ground. An alternating current at audio frequencies (9.8 kH) is passed through the coil, creating a time-varying magnetic field around the coil. The magnetic field induces an electrical current in the ground called an eddy current. Because of the induced electrical current, the soils create a secondary magnetic field. The secondary magnetic field (from the soils) and the primary magnetic field (from the transmitter coil) are both sensed by a receiver coil. The ratio of the secondary magnetic field, relative to the primary magnetic field, is used to determine the conductivity of the soils. Units of conductivity measurements are millimhos/meter, the reciprocal of resistivity measurements.

There are a number of factors that can contribute to the magnitude of the measured conductivity values. Subsurface conditions such as porosity, permeability, temperature, moisture content, and the presence or absence of electrolytes and colloids affect the conductivity measurements of the soil. External environmental factors, such as pipelines, power lines, railroad tracks, and similar interferences influence the magnetic fields and therefore influence the measured conductivities. The resulting conductivity measurements are a complex function of all of these conditions, referred to as apparent conductivity.

The orientation of the transmitter coils (dipoles) either horizontally or vertically define the depths affecting the survey. The survey in this area was conducted with vertical dipoles that discriminate against materials in the first meter of soil and effectively measure to a depth of 6 m. In contrast, measurements from horizontal dipoles are dominated by surface and near surface objects present in the upper 2 m of soil.

4.1.3.1.3 RI investigation results. The terrain conductivity survey was substantially completed around the perimeter of the landfill proper, as shown in Plate 5. Measurements within the landfill would have been adversely affected by the inevitable presence of buried metals, rendering the data virtually useless. The objective of the perimeter survey was to locate conductivity anomalies that would indicate the presence of contaminated soils, contaminated groundwater, or buried wastes. The only traverse which showed major anomalies was the northeast/southwest traverse, located along the NJP&L Co. power lines.

Along this traverse, there were three distinct areas of anomalously high conductivity (Figure 4-6). Near the southwest end of this traverse, a discrete anomaly was apparent, shown as Area G on Plate 5. This anomaly has the appearance of being a groundwater contamination plume because of its smooth shape and wide breadth. Near the center of the traverse line was a second area of moderately high conductivity. The configuration of conductivity (Figure 4-6) would indicate an area with relatively shallow, localized leachate seeps. The third EM anomalous area occurred at the northeast end of the traverse line extending from Area H to the northeast where a large area of generally high conductivity and several highly conductive peaks were present. Like the second anomaly, this conductivity pattern, as shown on Figure 4-6, typifies an area of shallow leachate seepage.

4.1.3.1.4 Previous Electromagnetic Survey. In August 1982 an electromagnetic survey was conducted by NJDEP at the Combe Fill South landfill. A report on the results of this survey is included as Appendix K.

It appears that the NJDEP conducted this survey using a Geonics EM-34 terrain conductivity meter, or similar instrument. This instrument, however, is not specified in their report, and the assumption of its use is based on the depth (approximately 45 ft) of conductivity measurements noted in the introductory statements of their report. In light of the findings of the EM survey conducted during this RI/FS, two significant observations reached by NJDEP in 1982 are relevant.

- The report states that "An increase of terrain conductivity with increasing depth was noted on the immediate perimeter of the landfill. Since no leachate seeps were noted, there is evidence that the conductive water associated

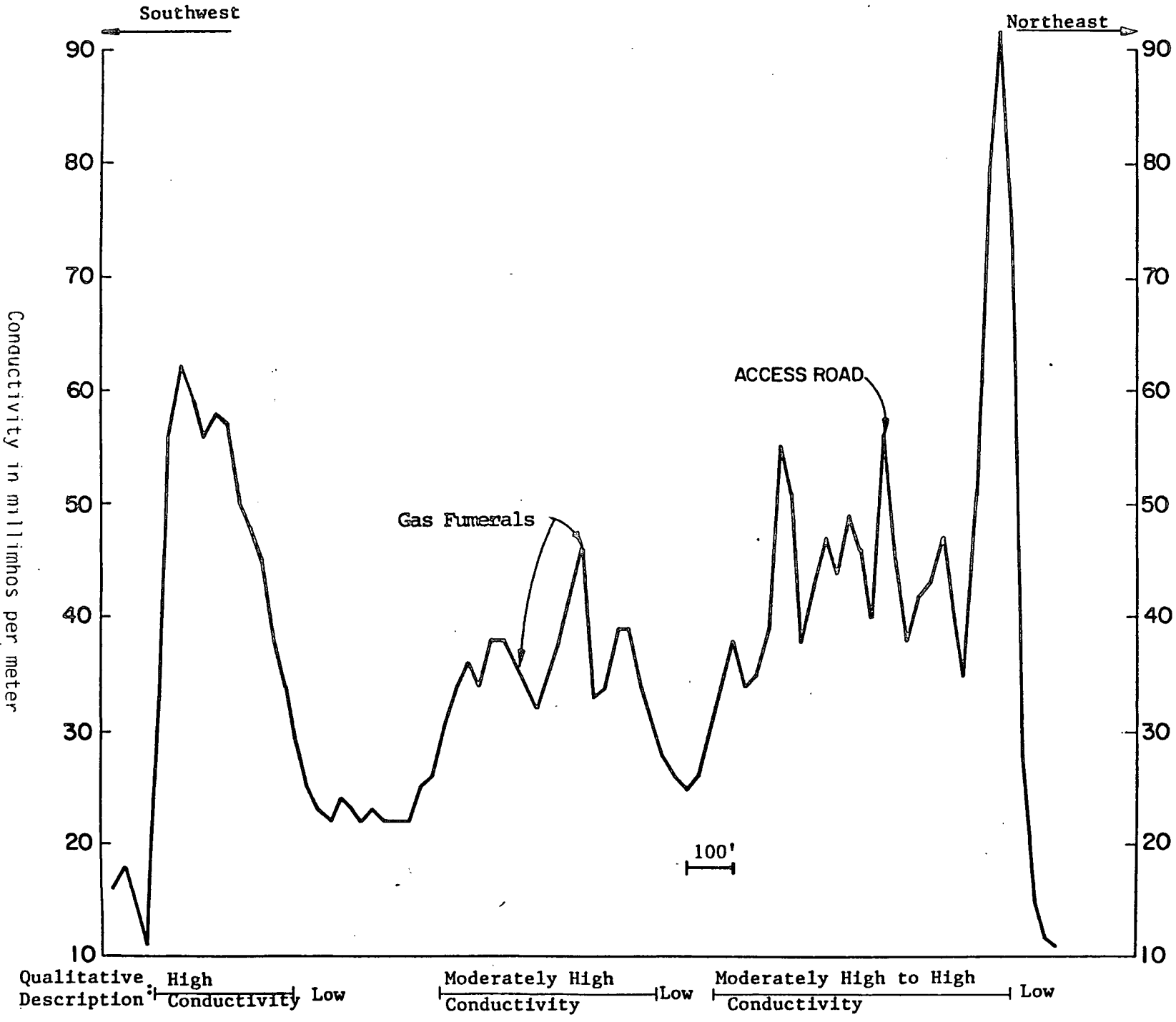


FIGURE 4-6

Graph of electromagnetic values parallel to the New Jersey Power and Light Company right-of-way, adjacent to the eastern border of Combe-Fill South Landfill.

with leachate is present deep within the rock formation."

- The EM observations made during the RI indicated slightly elevated conductivity in the southwest corner of the landfill (near monitoring well D-7); however, this conductivity was not significantly above background levels to warrant additional investigation. The EM survey conducted during the RI/FS was performed with a Geonics EM-31 conductivity meter that has a much shallower range than the EM-34 apparently used during the 1982 NJDEP survey. Assuming that the 1982 survey measured elevated conductivity at greater depths, there may be a deeper zone of leachate flow present in the area below the depth limitation of the RI/FS electromagnetic survey (15-18 ft). It is possible that NJDEP's deeper leachate observations were caused by contaminant migration along the bedrock surface; bedrock in this area occurred at a depth of 37 ft in well D-7. This finding would correlate well with the capabilities of the NJDEP survey instrument.

- The 1982 NJDEP report also states that elevated terrain conductivity readings were found between "Monitoring well 4 (DW-4) and the (New Jersey Power and Light Company) power lines," near the northeast corner of the landfill. Increased conductivity with increasing depth was also noted in this area. However, the NJDEP report stated that interferences by electromagnetic interaction of the power lines with the well casing in the area of the survey could have caused the readings. Nevertheless, the possiblity of highly conductive groundwater in this area was not dismissed.

  Observations made during the EM survey conducted for this RI/FS do not indicate anomalous readings in the vicinity of DW-4, except near the power lines immediately downgradient from DW-4. Leachate seeps were noted and sampled in this power line area during the RI/FS investigation; therefore, the electromagnetic conductivity measurements obtained at this location during the RI/FS are reasonable. Furthermore, the detection of leachate at

greater depths farther upgradient (i.e., east of the power lines) as suggested in the NJDEP report would be in accordance with changes in topography and the depth to groundwater in that area.

4.1.3.2 Magnetometer Survey

4.1.3.2.1 Method. Twenty-one north-south magnetometer traverses were made across the landfill site. The separation between each of these parallel traverses was 150 ft, with measurements made at 25-ft intervals along each traverse. Each traverse line was perpendicular to an east-west baseline shown on Plate 5. Measurements were made with a Scintrex MP-2 proton magnetometer. The field notes made during this survey are presented in Appendix M.

4.1.3.2.2 Magnetometer theory and limitations. The function of the proton magnetometer is based upon the concept of magnetic resonance, the magnetometer measures the relative strengths of local magnetic fields. Assuming the earth's magnetic field is relatively constant, an interpretation of the magnetic properties of the shallow subsurface can be made. At the landfill the magnetic materials can include steel cans, metallic wastes and scrap, metal drums, appliances, and automobiles. Variations in the local magnetic field are therefore largely dependent on the variablility of magnetic materials in the shallow subsurface.

There are several indirect magnetic field changes that usually affect the measured magnetic fields. Diurnal variations, caused by the relative position of the sun and the moon, have a variable effect throughout the day. Typically, the magnitude of these variations is on the order of 50-100 gammas at the latitude of this survey. At the scale of this work, however,

the potential error due to these diurnal fluctuations is negligible.

Magnetic storms, usually caused by solar flares, may affect the data significantly. In this case, however, data from the USGS National Geophysical Data Center, obtained from a stationary magnetometer in Fredricksburg, VA, indicate no effects from magnetic storms.

4.1.3.2.3 Results. Due to the large variance in values recorded across the survey, the relative intensities over the area of interest were adequate to define metallic material. Magnetic intensities on the order of 55,000 to 56,000 gammas were registered for the majority of the area. A low intensity anomaly of 53,000 to 54,000 gammas was encountered along the entire northwest perimeter of the landfill. Within the landfill proper, the normal magnetic intensity was just over 56,000 gammas. This value is consistent with magnetic intensities that are attributable to normal household refuse present throughout the landfill mass. Areas where the magnetic intensities ranged from 57,000 to more than 58,000 gammas are shown on Plate 5.

Seven anomalous areas, labeled A through G, are identified on Plate 5 and are discussed below:

- Anomalies A and B. Centrally located on the Combe Fill South site, these anomalies represent the deepest metallic bodies in the landfill. The magnetic source producing anomaly A is approximately 40 ft below ground surface, based upon depth estimates made using Peters (1949) slope method for calculating the depth to vertical anomalies. A similar calculation indicates that the magnetic source at anomaly B is approximately 47 ft deep. The maximum predicted error for these values would

be 8 and 10 ft, respectively, i.e., the magnetic source may be closer to the ground surface.

- Anomaly C. Also located in the fill area, anomaly C appears to be caused by magnetic materials that are estimated to be buried at a depth of less than 10 ft. By far, this area had the highest values in the survey area, which is indicative of the relative proximity of the source to the surface.

- Anomalies D and E. Located in the fill area near the landfill entrance gate, magnetic wastes appeared to be buried at depths of 30 to 35 ft at both these sites with an error estimate of 6 ft.

- Anomaly F. Centralized in the landfill area are visible topographic ridges containing magnetic materials buried between 8 and 13 ft deep with an estimated error of less than 5 ft. The ridge-like forms probably reflect the cut and fill trenching technique often used to place landfill refuse. Area F actually consists of a group of anomalous areas as shown on Plate 5.

- Anomaly G. Located near the southeast corner of the landfill area, the source of this anomaly is estimated to be 14 ft deep. The depth range error associated with this estimate is 5 ft. The southern extent of this anomaly is not well defined because the power lines dominate the measurement of the magnetic field.

4.1.3.3 Surface Geophysical Data Integration and Summation. Caution must be used in defining the source of anomalies that are recognized with the geophysical measurements made as a part of this investigation. High values of terrain conductivity from the EM survey suggest the presence of electrolytes, such as acids, salts, metals, or other conductive contaminants, in the subsurface. When these measurements are combined with the magnetometer data, the presence of buried drums, in addition to electrolytes or other chemical conditions, may be established. Magnetic anomalies alone would indicate magnetic metallic wastes without necessarily confirming the presence of conductive electrolytes such as inorganic leachate. Conductivity anomalies alone are often subjective and

dependent on interpretive experience. The combination of the two geophysical measurements allows reasonable interpretation of the anomalies discovered.

The specific nature or origin of materials at magnetic anomalies A and B is not definable; however, the data suggest an amalgamation of magnetic materials (metal) buried deep in the landfill.

The source material at anomaly C appears to be very shallow, and further investigation may be warranted to determine the exact nature of this anomaly prior to final remedial design. Due to potential safety hazards excavation in the fill itself was not done during this investigation. The magnetic anomaly and the terrain conductivity profile parallel to the power lines suggested conductive metallic material, possibly buried metal drums, occurring near the surface at Anomaly C.

Anomalies D and E are buried too deep for detection by the terrain conductivity meter; as such, these anomalies can only be recognized as metallic concentrations. A test pit (TP-2) was excavated at anomaly E. Results obtained by this excavation are discussed in Section 4.1.5. A test pit was not excavated at anomaly D because the area is in the fill area.

Shallow magnetic readings and a moderately high soil conductivity may be coincident with the leachate observed at the soil surface in anomaly area F. This area may warrant further investigation prior to final remedial design.

Anomaly G is similar to anomaly F, except that no leachate was observed at anomaly G. The terrain conductivity and magnetic surveys at anomaly G suggest the presence of inorganic chemical wastes and metal. Although a test pit was excavated in this area (TP-1), no

buried drums or wastes of suspicious nature were found in the excavation. A discussion of the results of the excavation is included in Section 4.1.4.

4.1.3.4 Borehole Geophysical Logging. Wells D-3, D-5, D-6, and D-7 were selected for borehole geophysical logging. A series of six logs were run that included temperature, caliper, gamma ray, spontaneous potential (SP)-resistance, and density.

4.1.3.4.1 Description of borehole geophysical logs. A gamma ray log measures the amount of gamma radiation emanating from materials forming the walls of a borehole. Gamma rays are forms of electromagnetic energy emitted during radioactive decay. Clay minerals generally contain higher percentages of potassium, thorium, and uranium and their radioactive isotopes and therefore emit higher levels of gamma radiation than non-clays. For example, shales, especially those of marine origin, show a relatively high degree of gamma radiation whereas sandstones show lower levels of gamma radiation. By measuring the variations in gamma counts, the gamma ray log can be used to determine borehole lithological characteristics and their variation with depth. The results of the gamma logging of the wells are also presented in Chapter 7 as part of the discussion on site radioactivity.

The resistance log measures the electrical resistance of the borehole fluid and the pore fluids present in the surrounding borehole walls. Because of this, the log is sensitive to weathered, washed out areas and fractures along the borehole wall. This log is a useful tool in locating water bearing and weathered zones. The SP (spontaneous potential) log measures the relative electrical potentials caused by the rock and borehole fluid contact. When the resistance and SP logs are used

in conjunction they can detect zones of higher porosity. Higher porosity is indicated when the traces of the two logs diverge or spread apart.

The caliper log generally utilizes three mechanical arms to physically measure well diameter. Fractures, faults, weathered zones, water bearing zones, and casings can often be detected by use of a caliper log.

The temperature log measures the temperature of the fluids within the borehole. It shows the vertical thermal gradient in a well and any anomalies caused by groundwater flow within the borehole. The average geothermal gradient measured at the Combe Fill South site increases with increased depth at a rate of approximately 1°F per 100 ft and is considered normal for such stratigraphy. Where the measured rate of temperature increase in a water-filled boring is less than this rate, downward groundwater flow typically occurs. Conversely, upward groundwater flow generally occurs when the measured rate of temperature increase with depth exceeds the rate of 1°F/100 ft. This log may also be used to determine temperature variations caused by decaying refuse outside the casing of a well drilled through a landfill.

For the density log, a sealed gamma ray emitting source is used to bombard the borehole wall with gamma rays. Gamma rays returning to the detector are then counted, averaged over a period of time, and recorded as counts per second. The counts per second are inversely proportional, semilogarithmically, to the density of the material measured. Therefore, fewer gamma counts per second indicate a greater relative density in the borehole wall, and lower gamma counts correspond to higher density materials; higher gamma counts correspond to lower density

materials. Data from the density log can be extrapolated to also interpret material porosity: lower density materials are typically high in porosity and, conversely, higher density materials are low in porosity. The density log, combined with the other logs described above, helps to define the location of permeable and porous water bearing zones.

At each site the geophysical logs were performed in the following order:

Temperature log
Caliper log
Gamma ray log
SP-resistance log
Density log

Copies of the graphical logs obtained from wells D-3, D-5, D-6, and D-7 are provided in Appendix B.

4.1.3.4.2 Monitoring Well D-3. The depth of well D-3 was measured as 188 ft from the top of casing (TOC) at the time of geophysical logging. The caliper log indicated that the casing was securely seated at 52 ft below TOC.

A weathered bedrock zone at depths between 54-57 ft was confirmed by the caliper log, which showed an increase in the boring diameter in that zone. A water bearing zone was also indicated on the geologist's log at a depth of 61 ft and confirmed by the caliper log. Used conjunctively all of the logs indicated that this water bearing zone exists: the caliper log shows an increase in well bore diameter; the gamma log shows an increase in weathered or clay minerals; the density log indicates a decrease in density; and the SP-resistance log shows a divergent deflection indicating an increase in porosity.

A second water bearing zone occurs at a depth of 80-81 ft in this well. The gamma log indicates that the zone contains a higher amount of clay material, and the caliper log shows an increase in well bore diameter at that depth. The SP-resistance log indicates an increase in porosity, while the density log indicates a small decrease in density in the borehole wall.

A third water bearing zone occurring between 99-101 ft is confirmed by the caliper and SP-resistance logs. The caliper log shows an increase in well diameter, and the SP-resistance log shows an increase in porosity at that depth.

Another weathered zone shown on the geologist's well construction log (see Appendix F) at a depth of 111.5-113.5 ft is confirmed by the gamma and density logs. The gamma log shows an increase in gamma radiation within that zone, indicating an increased amount of clay in this zone. The density log shows that the zone has a lower relative density than the materials above and below it.

A third weathered zone at 116-117 ft and a fourth water bearing zone from 117-118 ft are confirmed by the caliper, gamma, SP-resistance, and density logs. The caliper log indicates a slight increase in borehole diameter from 116-118 ft. The gamma log shows an increased amount of clay minerals occurring in the zone from 116-117 ft. Because the resistance and SP logs have diverging deflections in the interval from 117-118 ft, the increase in porosity shown by these logs would confirm the presence of a water bearing zone. Finally, the density log indicates a small decrease in density in these zones.

A fifth and final water bearing zone occurring between 172-180 ft was confirmed by the caliper, SP-resistance, and density

logs. The caliper log shows an increase in borehole diameter, the divergence of the SP-resistance logs indicates an increase in porosity between 177-178 ft, and the density log shows a decrease in density from 172-180 ft.

The gamma log for well D-3 shows unusually high gamma counts at 54-65, 74-82, 110-117, and 124-151 ft. These anomalies are discussed in greater detail in Chapter 7 regarding site radioactivity.

The temperature log of well D-3 indicated a temperature increase of 0.5°F per 100 ft of well depth. This thermal gradient suggests that groundwater flow within well D-3 is downward.

4.1.3.4.3 Monitoring Well D-5. The caliper log of well D-5 shows that the well casing is seated 91.5 ft below TOC. The well depth is 165.3 ft below TOC.

A weathered zone located at a depth of 93-96 ft is confirmed by the increase in gamma radiation measured by the gamma log. At the same depth, the caliper log indicates a slight increase in well diameter. The SP-resistance log shows a small increase in porosity, and the density log indicates a slight decrease in density in this zone.

At 101.5-103 ft, a water bearing zone is confirmed by low gamma counts that indicate that fewer clay minerals are present within this zone. At the same time, the caliper log indicates an increase in borehole diameter, while the density log shows a slight decrease in density.

A second weathered zone from 105.5-106 ft was confirmed by the caliper, SP-resistance, and density logs. The caliper log

shows an increase in well diameter, while the SP-resistance logs indicate an increase in porosity. The density log also shows a slight decrease in density that correlates with the irregularity of the caliper log from 101.5-106 ft. This weathered zone appears to be associated with the water bearing zone occurring between 101.5-103 ft.

A third weathered zone between 110-115 ft is characterized by a significant increase in the measured gamma counts, indicating the presence of clay minerals within the weathered zone. Also, a large divergence between the SP and resistance logs indicates an increase in porosity within this zone. At the same time the density log shows a slight decrease in density.

Another weathered zone occurs between 125-126.5 ft as indicated by increasing gamma counts on the gamma log. At the same time, the SP-resistance log shows an increase in porosity within this zone.

A fifth weathered zone between 131-134 ft and a second water bearing zone between 136-138 ft appear to be related. The gamma log shows a concentration of clay minerals at the beginning of the weathered zone that appears to decrease in the 136-138 ft water bearing zone, based on decreasing gamma counts. The SP and resistance logs show a divergence between their respective deflections, indicating an increase in porosity along the entire interval between 131-138 ft. The caliper log shows a slight increase in borehole diameter at 133.5 ft and a large fracture between 136-138 ft.

A third water bearing zone from 140-145 ft recorded on the geologist's log was confirmed by the gamma, caliper, and SP-resistance logs. The caliper shows that the borehole wall

within this interval is relatively jagged in nature. The SP-resistance log is divergent, indicating that there is an increase in porosity in that part of the well.

Below 93 ft the temperature in well D-5 decreases at a rate of approximately 1.1°F per 100 ft. This anomalous decrease in temperature with depth reflects changes that occur as the water temperature, raised by decomposing refuse, reaches equilibrium within the well water column. In other words, the deeper (>100 ft) earth temperatures are cooler than the shallow groundwater, and the temperature log has recorded the dissipation of heat from the refuse decomposition. Because of these anomalous temperature gradients no conclusion can be made with respect to vertical groundwater flow directions within the borehole.

4.1.3.4.4 Monitoring Well D-6. The caliper log of well D-6 indicates that the casing is firmly seated at 112.5 ft, measured from TOC. However, a deflection appears at 54 ft on the caliper log. The log was repeated three times to determine if there was a casing defect or if the deflection was caused by generator noise. All three repeated logs produced smooth straight lines, indicating that the deflection on the first log was caused by a power surge in the portable generator. Copies of the original and repeat caliper logs are included in Appendix B of this report.

The well has a total depth of 176.9 ft measured from TOC. A weathered zone from 97-100.5 ft is confirmed by a large increase in gamma radiation within that zone and a large decrease in density.

A second weathered zone also exists at 114 ft, as indicated by the caliper log that showed an increase in borehole diameter at

that depth. Also, there is a decrease in density and an increase in porosity, as shown by the SP-resistance log, at this depth.

The caliper log shows a jagged borehole wall accompanied by increases in borehole diameter at depths between 117-119 ft and 159-164 ft. The presence of water bearing zones at these depths is indicated by the SP-resistance logs, which show a divergence in their deflections, indicating an area of high porosity, and the density log that shows a slight decrease in borehole well density.

Starting at a depth of 176.9 ft and a temperature of 55°F and continuing upward to a depth of approximately 100 ft, water temperature increases in well D-6. Above 100 ft in depth, temperatures increase more rapidly (i.e., there is a steeper thermal gradient) until a temperature of 84°F is reached at a depth of 63 ft. A depth of 63 ft appears to correspond to the depth of the static water level as shown on the density log. Continuing upward, temperatures then decline to approximately 79.5°F at a depth of 57 ft. Above 57 ft temperatures again rise to about 81.5°F at a depth of 11 ft. Above 11 ft in depth temperatures decline again to 77°F at 3 ft where the probe was removed from the borehole; the probes were very warm to the touch when removed from the well. These high temperatures are caused by the decomposition of the refuse in the fill whose base, as described by the density and temperature logs, is estimated to be at 82 ft below TOC. Because of these diverse thermal gradients, no conclusion can be made as to the vertical direction of groundwater flow in well D-6.

Increased gamma radiation noted in the interval between 97-100 ft indicates a zone of lower density as compared to the rest of

the well. This is probably an area containing saprolite or clay minerals. Using the density log, the density of the refuse is estimated as 1.99 grams per cubic centimeter.

4.1.3.4.5 Monitoring Well D-7. Well D-7 has a total depth of 125.9 ft as measured from TOC. The caliper log shows that the well has secure casing seated at a depth of 45 ft below TOC.

At a depth of 48.5 ft a water bearing zone occurs that is confirmed by both the caliper and density logs. The caliper log shows a radical increase in borehole diameter, while the density log indicates a decrease in material density. A second water bearing zone is also indicated between depths of 53-56 ft by a decreased gamma count. At the same time, the divergent deflection in the SP-resistance log curves indicates an increase in porosity. A slight deflection in the caliper log also indicates an opening in the borehole wall.

A weathered zone of increased porosity is apparent at a depth of 60.5 ft below TOC and is confirmed by the divergent deflection of the SP-resistance logs. Another weathered zone is located between 65-67 ft, closely related to a water bearing zone reported on the geologist's log at 68.5 ft. The weathered zone is indicated by a slight increase in gamma radiation that may be caused by the congregation of clay minerals within the zone. Also, there is a slight decrease in density along this section of the borehole. The two zones (65-67 ft and 68.5 ft) are related in that both zones are depicted on the SP-resistance logs within the same divergent deflection.

A third weathered zone also occurs at 74 ft. This zone is indicated by a slight increase in gamma radiation and a small divergent deflection in the SP-resistance logs. This zone is

underlain by a water bearing zone at a depth of 77 ft. This water bearing zone is indicated by a slight decrease in gamma radiation and a small divergence of the traces for the SP-resistance logs.

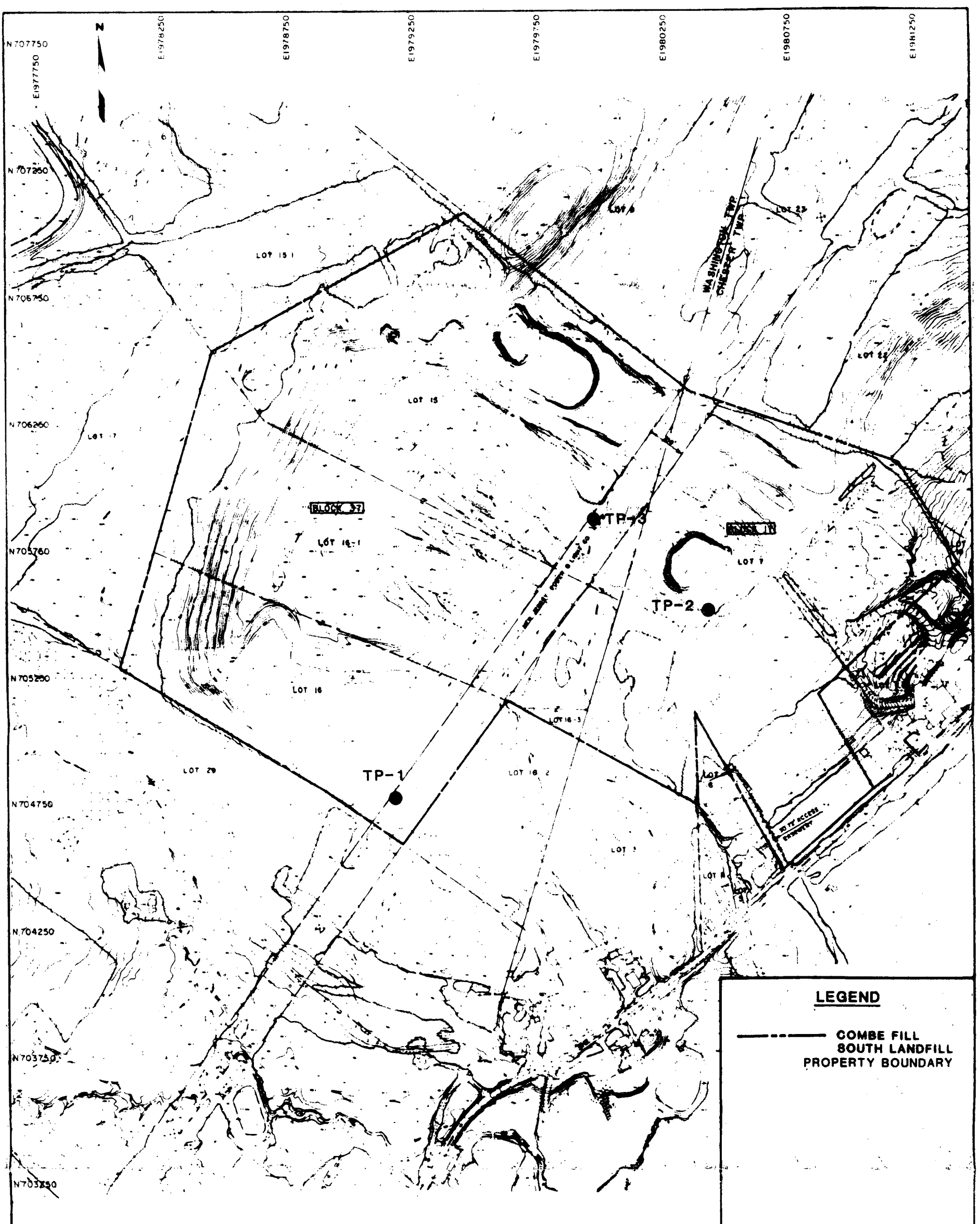
A fourth weathered zone occurs at 98 ft. This weathered zone is characterized by a slight increase in gamma radiation and a small divergence of the SP-resistance logs, indicating an increase in porosity in this zone.

The SP-resistance logs and gamma log confirm the existence of a fifth water bearing zone at 112.5 ft. The gamma log shows a small decrease in gamma radiation, and the divergence of the SP-resistance logs indicate a higher porosity at this depth.

The temperature log for well D-7 shows that the water within the well cools at a rate of 1.3°F per 100 ft of increased depth between 40-120 ft. Above a depth of 40 ft, the temperature is affected by the thermal conductivity of the well casing. Like well D-5, temperatures in this borehole are influenced by the heat of nearby refuse decomposition, and no conclusion can be offered concerning the vertical direction of groundwater flow within the borehole. At the very bottom of the well, between 124-127 ft, a rather large temperature anomaly occurs: the temperature within the well rises from 52-57°F with increased depth. The cause of this temperature rise is unknown.

4.1.4 Backhoe Test Pit Investigations

The following text summarizes the findings of the test pit excavations at Combe Fill South Landfill. Test pit locations are shown on Figure 4-7. Geologic logs of the three test pits are included



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earth resources consultants
harrisburg pennsylvania

TEST PIT SAMPLING STATIONS

FIGURE 4-7

in Appendix G. The purpose and procedures for completing these excavations are discussed in Chapter 1.

4.1.4.1 Materials Encountered

4.1.4.1.1 Test Pit No. 1 (TP-1). TP-1 was excavated on the southeastern corner of the landfill property near wells D-9 and S-3 to help define the source of this area that was characterized by high magnetometer readings (possibly indicating the presence of a buried metallic mass). In addition, the EM survey in this area showed very high soil conductivity values, which may be indicative of landfill leachate moving through the soil zone.

Material encountered in TP-1 consisted of medium to dark brown and red-brown, clayey silts and gravelly silty sands. Many granite cobbles and small boulders were present throughout the pit. The material appeared poorly sorted and was apparently all cover material used during landfill operation. No saturated soil was observed, but several locations in the test pit were moderately damp. There was no evidence of any type of refuse.

The source of the high magnetometer readings in this area was not resolved by the completion of TP-1. There was no evidence of foreign metal found in TP-1, but the possibility still exists that metallic mass is buried nearby, probably in the landfill proper, adjacent to this excavation. Excavation within the landfill was not attempted within this work scope.

Shortly after breaking the ground surface in TP-1, a slight odor was noticed. This odor increased greatly at depths of 9-11.3 ft. In this soils interval HNU readings were as high as 5

ppm above background levels (background levels in the TP-1 vicinity were 3-5 ppm). HNU readings were 1-2 ppm higher than background levels in damp areas of the pit.

In order to verify and further quantify these field observations, two soil samples were taken from TP-1. The first soil sample was a composite taken from the 0-9 ft depth interval where HNU readings were consistently low. The second sample was a composite collected between 9-11.3 ft where HNU readings were higher. The results of the priority pollutant analyses are summarized in Table 4-2 and are detailed in Table CC-3, Appendix CC. Results of related QA/QC samples are summarized in Table CC-25 in Appendix CC.

4.1.4.1.2 Test Pit No. 2 (TP-2). This excavation was made toward the eastern side of the landfill, as shown on Figure 4-7, in order to help define the source of the very high magnetometer readings encountered during the geophysical surveys here.

At TP-2, material from the surface to a depth of 2 ft consisted of medium brown, sandy to clayey silt, which was quite firm and tightly compacted. The remainder of the excavation, from depths of 2-12 ft, consisted of refuse and cover material. Most of the refuse appeared to be typical municipal-type garbage (e.g., glass, plastics, wood, paper, and garbage bags). There was, however, a significant amount of metallic refuse also present including metal pipes, car frames, wires, and springs. Cover material consisting of granite cobbles, sand, and silt occurred throughout the refuse. The material encountered between depths of 2-12 ft was highly permeable. A small quantity of water was observed entering the pit at a depth of 5 ft, flowing at a rate of about 0.25 gallons per minute (gpm).

TABLE 4-2

SUMMARY OF PRIORITY POLLUTANT CHEMICAL ANALYSES ON TEST PITS

Combe Fill South Landfill

PARAMETER	TP-1 COMPOSITE 0-9 ft	TP-1 DISCRETE 9-11 ft	TP-2 COMPOSITE 0-12 ft	TP-3 COMPOSITE 0-12 ft
DATE SAMPLED	8/27/85	8/27/85	8/27/85	8/27/85
VOLATILES, ppb				
Tetrachloroethylene	ND[a]	ND[a]	ND[a]	ND[a]
ACIDS/PHENOLICS, ppb	ND	ND	ND	ND
BASE/NEUTRALS, ppb				
Bis (2-ethylhexyl) phthalate	120[b]	370[b]	1300	ND
PESTICIDES/PCBs, ppb				
Aldrin	ND	ND	132	ND
Dieldrin	ND	ND	76	ND
METALS, ppm				
Arsenic	71	52	42	38
Beryllium	1.5	1.5	1.5	1.0
Cadmium	2.9	ND	13	1.3
Chromium	22	19	24	16
Copper	34	26	37	20
Lead	ND	ND	30	10
Nickel	7.7	7.2	12	7.5
Zinc	47[c]	38[c]	148[c]	50[c]
MISCELLANEOUS, ppb				
Cyanides	ND	ND	ND	ND
Phenols	ND	ND	ND	ND

[a]Data corrected based on QA/QC review.
[b]Estimated value; value is below method detection limit.
[c]Value is estimated because of interferences.
ND = Not detected.

The high magnetometer values observed in this area are readily explained by the large quantity of metallic refuse found to be buried at relatively shallow depths in TP-2. About 60% of the refuse volume uncovered in the pit was metallic in nature, based on visual estimates. However, no steel drums or materials of a suspicious nature were found in the excavation. A very strong odor and HNU readings at 4-5 ppm above background level were noted during the excavation.

A soil/refuse composite sample was taken from the depth interval of 0-12 ft. The results of the priority pollutant chemical analyses on this sample are summarized in Table 4-2. Additional chemical analyses are summarized in Table CC-3 of Appendix CC and the related QA/QC samples are summarized in Table CC-25 of Appendix CC.

4.1.4.1.3 Test Pit No. 3 (TP-3). This test pit is located along the dirt access road that borders the eastern side of the new fill area near the headwaters of the East Branch of Trout Brook (Figure 4-7). TP-3 was excavated in this location because of very high conductivity values measured in this area that could indicate the presence of contaminants moving through the soils.

Materials encountered in TP-3 consisted of medium brown to orange-brown, silty, gravelly sand, and sandy silt. Many granite cobbles were also present in the upper portion of the test pit. Refuse occurred in several spots between 3-8 ft in depth. All the material in the pit, to a depth of approximately 9 ft, was poorly sorted and considered to be cover material used in landfill operations. Water was also observed seeping into the test pit at an estimated rate of 0.5 gpm from the landfill (NW) side at a depth of 1.5 ft. Materials in this

area were sandy, highly saturated, and appeared quite permeable.

At a depth of 9 ft, the soils in the test pit became more natural in appearance and consisted primarily of gray-brown, silty, fine to medium grained sand, and sandy silt. Overall, this material is better sorted and more competent than the material encountered in the first 9 ft of the pit.

During the excavation of TP-3, HNU readings ranged from 0-2 ppm above background levels. Background HNU levels ranged from 4-5 ppm and were greatly influenced by the wind. A slight odor was noticed during most of the excavation. Water seeping into the pit exhibited HNU readings of 2-3 ppm above background levels. None of the refuse observed in TP-3 appeared to be suspicious or hazardous. To quantify and verify the presence of contaminants indicated by the HNU readings, a composite soil sample was collected from the entire excavated depth (0-12 ft). The results of the priority pollutant analyses of this sample are summarized in Table 4-2. Details of these analyses are presented in Table CC-3 of Appendix CC along with the results of the related QA/QC samples, Table CC-25 of Appendix CC.

4.1.4.2 Results of Chemical Analyses in Test Pits. The results of the priority pollutant chemical analyses of samples taken from the test pits are shown in Table 4-2. Although low concentrations of volatile organic priority pollutants were detected in the site samples, these same compounds (methylene chloride and tetrachloroethylene) were detected in field and trip blank QA/QC samples and therefore are not considered to be reflective of actual site conditions (see Tables CC-3 and CC-25 in Appendix CC). Adjustments to this analytical data from the test pits have been made in Table 4-2 to reflect this contamination of field and trip blanks.

Of the priority pollutant semi-volatiles analyzed, no acid/phenolics were detected and only one base/neutral organic, bis(2-ethylhexyl)phthalate, was identified. This base/neutral organic was found in each sample, except for the TP-3 composite sample. The highest concentration of bis(2-ethylhexyl)phthalate was found in the composite sample from TP-2 at 1300 ppb. In TP-1, 120 ppb of bis(2-ethylhexyl)phthalate were found in the upper 9 ft composite sample and an estimated 370 ppb were found in the 9-11 ft sample. At the 9-11 ft depth interval of TP-1 two additional non-priority volatile organics were also measured including 2-butanone (270 ppb) and 4-methyl-2-pentanone (28 ppb). This occurrence corresponds to the higher HNU meter readings for soils retrieved from this depth. These concentrations do not, however, suggest the nearby presence of highly concentrated source of volatile organics.

Relatively high concentrations of tentatively identified semi-volatile organics were found in each test pit (see Appendix CC). With the exception of bis(2-ethylhexyl)phthalate, this information suggests that non-priority acid and base/neutral organic contamination may be a problem, particularly in the vicinity of TP-2.

Most of the metals found in the test pits are common to the granitic parent material in bulk or trace amounts. At the same time however, some metals, particularly arsenic, cadmium, chromium, and lead, may be attributable to the landfill wastes.

Based upon the results of the test pit sample chemistry, it is apparent that concentrations of chemical wastes are present in the vicinity of these test pits and that the shallow soils have been affected by contaminated groundwater flow-through or surface water infiltration.

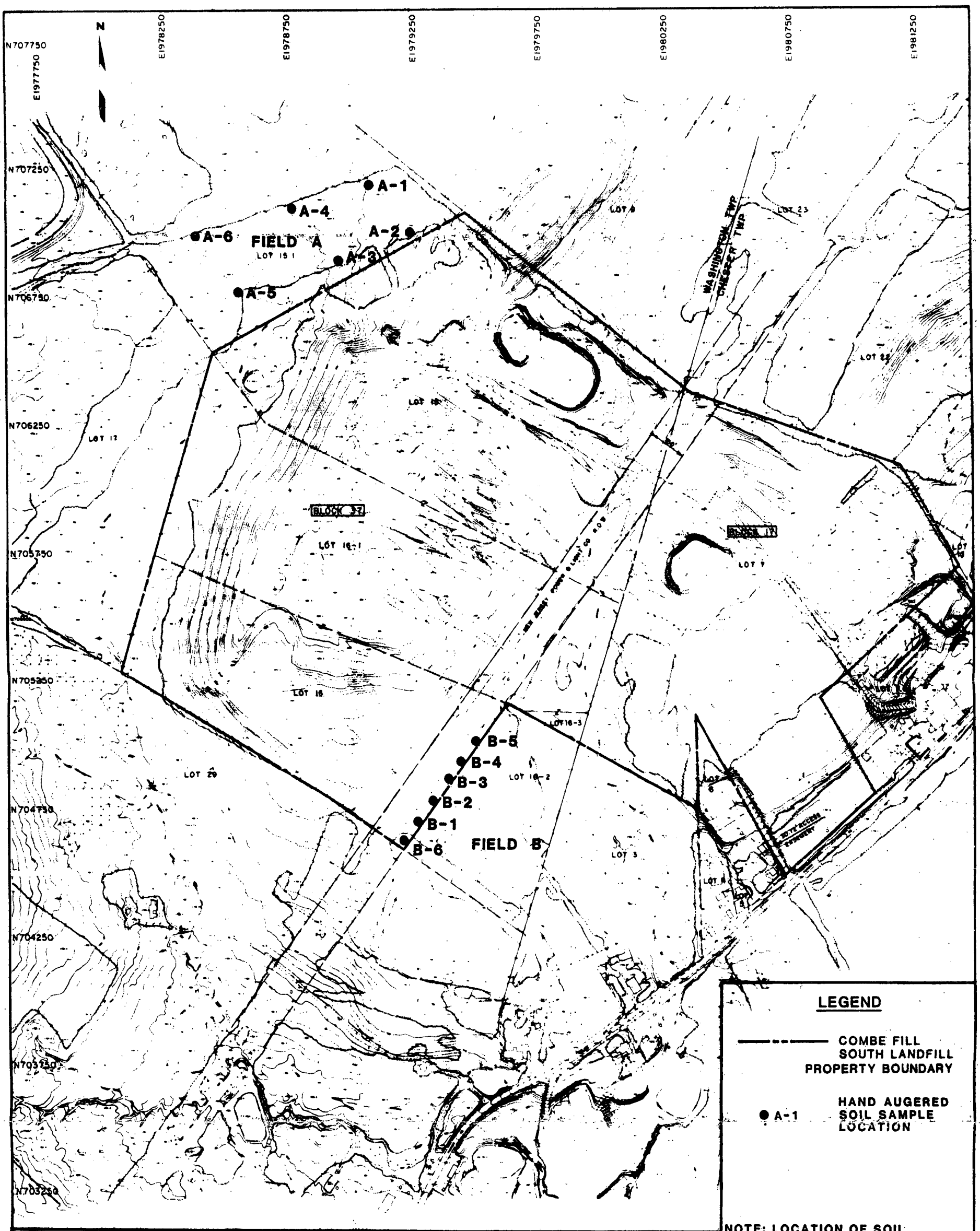
4.1.5 Field Soil Sampling (Hand Augering)

A shallow soil sampling program was conducted between 20 and 23 August 1985. The purpose of this sampling was to investigate alleged disposal of contaminants within the shallow soils in two field areas adjacent to the landfill shown as Fields A and B on Figure 4-8. According to representatives of URWA, bags of white powdery material were encountered near the northwest field (Field A), often referred to as the old soybean field, during the installation of a monitoring well near the landfill. Therefore, a shallow soils investigation was conducted in this area. Soil sampling in Field B was performed to determine if suspected surface disposal of contaminants and had been conducted in that area.

A third sampling field (Field C), located approximately one-half mile to the northwest of Field A, was also designated. This field does not appear on Figure 4-8 but is shown in Figure 1-7. Field C was established as a background field to provide a basis for comparing the chemistry results obtained from samples collected in Fields A and B.

4.1.5.1 Scope. The scope and procedures employed in this soil sampling investigation were modified following the completion of the FSP and after field investigations had begun. The sampling procedures presented below reflect the scope of sampling actually conducted at the site.

Field A, which was originally subdivided into Subfields A-1 and A-2 in the FSP, each consisting of five augering sites, was consolidated into one sampling Field A with six sampling points. Sampling Field B also had six sampling points. The number of sampling points is the same as that originally provided in the FSP; however, the FSP originally provided for six points scattered further to the



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LOCATION OF SOIL SAMPLING
FIELDS A AND B

FIGURE 4-8

east of the location shown on Figure 4-8. Because access to this field beyond the Combe Fill South property line was denied by the neighboring landowner, all six sampling points were confined to the Combe Fill South property.

4.1.5.2 Procedures. At each sampling site in Fields A, B, and C, soils were excavated using a 4-in. diameter bucket auger and various hand-digging implements, such as shovels and pry bars. Excavation at each site was performed to a depth of 3 ft or to refusal caused by coarse materials or other structures. Soils were removed in separate intervals of a few inches in thickness to allow for distinct interpretation of materials penetrated. Soils removed were piled on clean, new aluminum foil sheeting underlain by clean polyethylene sheeting.

Based on the geologic interpretation of materials removed, the depth intervals of the A and B soil horizons were determined. The main characteristics used to differentiate the A and B horizons were soil color and texture.

Organic vapor/flame ionization detectors (OVA/FID) or HNU/PID organic vapor analyzers were used to scan the material removed, as soon as reasonably possible. The air space at the surface of the excavated hole was also scanned periodically with the vapor analyzers. Results of these scans were included on the logs prepared for each excavation (see Appendix J). Segregated soils from distinct intervals of each excavation were placed in clean glass jars and stored on ice until all locations in the field area had been sampled. Stainless steel trowels were used to fill the jars with the soil samples. At the completion of each sampling excavation, all tools were decontaminated by steam cleaning with potable water. The chemical analysis of the potable water (see Table CC-24 in Appendix CC) used for this steam cleaning reveals low levels of

contamination by methylene chloride and diethyl phthalate. This contamination may be associated with the water supply (Washington Township public water), the potable water storage tank used on-site (polyethylene), or laboratory contamination. In any case, it does not appear that these contaminants are passed onto the other samples.

At the completion of all sampling in a given field, a composite sample of the A soil horizon of that field was made by combining the A soil horizon samples from each excavation in that field into a single composite sample using laboratory-cleaned sample jars. The same procedure was used in obtaining a representative B soil horizon composite for each field. In addition, six separate individual samples from Fields A and B were selected on the basis of the FID/PID readings or visual observations suggesting potential contamination. No individual samples were collected in Field C.

4.1.5.3 Results.

4.1.5.3.1. Field A. This field is outside of the current Combe Fill South property boundary and is being used as a horse pasture. The A soil horizon material here consisted primarily of yellowish-brown silty loam. Coarse fragments varied in content from 5-50%. Soils in the B horizon were darker in color, varying from dark yellow-brown to gray-brown. The material in the B horizon is primarily a silty loam; however, clay and coarse fragments are abundant.

Three individual samples were collected in Field A. Two of the samples were randomly selected because no HNU readings above background levels were observed throughout the excavations. At Location A-4, a white, moist, unrecognizable material was discovered at a depth of 2.5 ft, as shown on the log included in

Appendix J. Although HNU readings of this material were not above background levels, the reported occurrence of a possibly suspicious material, visually similar to this, warranted the discreet sampling and chemical analysis of this material.

The complete results of the chemical analyses conducted on soil samples obtained in this investigation are included as Table CC-2 of Appendix CC. The results of the related QA/QC samples are presented in Table CC-25, also in Appendix CC. Table 4-3 presents a summary of the priority pollutant chemical analyses of the field soil samples. Volatile organic data in Table 4-3 have been adjusted to reflect low-level contamination by methylene chloride (<17 ppb) and tetrachloroethylene (<4 ppb) detected in the field and trip blank QA/QC samples.

The results of the analysis of the white powdery material are shown under the heading "FIELD A, 4, WHITE." Only one priority pollutant volatile organic was identified in this sample, i.e., methylene chloride, at a concentration of 569 ppb. Although no acid/phenolic compounds were identified, three base/neutral compounds were identified in this sample including bis(2-ethylhexyl)phthalate at 1200 ppb, and benzo (a) pyrene at an estimated concentration of 310 ppb. Di-n-butyl phthalate, at an estimated concentration of 160 ppb, was also detected. Acetone, a non-priority volatile organic, was also found at a concentration of 50,000 ppb in this white sample, far exceeding all other organic compounds identified in this sample with the exception of the non-priority metals. In view of the failure of the HNU to detect volatile organic concentrations in this sample, the acetone measured in the chemical analysis is probably not related to the material sampled. A review of the quality control data indicates that acetone was detected in

TABLE 4-3

SUMMARY OF SOIL DATA ON HAND-AUGERED SOIL SAMPLES

Combe Fill South Landfill

PARAMETER	FIELD A 4 WHITE	FIELD A A HORIZON COMPOSITE	FIELD A B HORIZON COMPOSITE	FIELD A (LOC 5) B HORIZON	FIELD A (LOC 6) A HORIZON	FIELD B (LOC 5) B HORIZON	FIELD B (LOC 6) A HORIZON	FIELD B (LOC 3) A HORIZON	FIELD B A HORIZON COMPOSITE	FIELD B B HORIZON COMPOSITE	FIELD C A HORIZON COMPOSITE	FIELD C B HORIZON COMPOSITE
DATE SAMPLED	8/21/85	8/22/85	8/22/85	8/21/85	8/21/85	8/22/85	8/22/85	8/22/85	8/22/85	8/22/85	8/23/85	8/23/85
VOLATILES[a], ppb												
Methylene chloride	569	ND[b]	ND[b]	ND[b]	ND[b]	ND[b]	ND[b]	ND[b]	ND[b]	ND[b]	ND[b]	ND[b]
Tetrachloroethylene	ND	ND	ND	ND	5[b,c]	4[c]	3[b,c]	6[b]	3[b,c]	3[b,c]	2	1
ACID/PHENOLICS, ppb												
Pentachlorophenol	ND	150[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BASE/NEUTRALS, ppb												
Benzo (A) pyrene	310[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bis (2-ethylhexyl) phthalate	1200	2200	150[c]	960	770	110[c]	110[c]	150[c]	110[c]	150[c]	330[c]	240[c]
Di-n-butyl phthalate	160[b,c]	ND	ND	ND	ND	ND	ND	ND	110[c]	ND	ND	ND
Di-n-octyl phthalate	ND	150[c]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PESTICIDES/PCBs, ppb												
4,4'-DDE	ND	ND	ND	ND	11	ND	ND	ND	ND	ND	ND	ND
4,4'-DDT	ND	ND	ND	ND	17	ND	ND	ND	ND	ND	ND	ND
METALS, ppm												
Arsenic	12	18	26	29	20	26	18	18	21	23	12	9.7
Beryllium	ND	3.0	1.6	3.3	1.7	1.1	1.4	1.2	1.5	1.0	1.0	1.0
Cadmium	4.7	3.9	1.9	3.1	2.7	2.0	4.0	2.4	2.8	3.2	2.0	2.1
Chromium	33	57	50	46	25	22	22	21	21	27	12	9.1
Copper	33	57	35	74	20	40	22	26	24	22	15	7.0
Lead	37	27	14	17	2	14	25	26	29	11	16	9.7
Mercury	ND	ND	ND	ND	0.1	ND	0.1	0.1	0.1	0.1	0.2	0.1
Nickel	15	17	14	21	13	10	13	9.0	14	12	ND	ND
Silver	ND	ND	ND	ND	ND	41	ND	ND	ND	ND	ND	ND
Thallium	ND	3.6	5.1	4.5	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	48[c]	67	52	60	54	8310	62	60	62	44	46	33
MISCELLANEOUS, ppb												
Cyanides	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenols	ND	ND	ND	ND	ND	ND	1000	ND	ND	1200	ND	ND

[a]Data has been adjusted to reflect concentrations in QA/QC field and trip blank samples.
[b]Also Found in method blank.
[c]Estimated value. Value is below method detection limit.
ND = Not detected.

four of six trip and field blanks associated with this sampling. However, since it is improbable that such high levels of acetone contamination could be imparted to a solid material sample from a steam decontaminated sampling tool, particularly since no acetone was used in the decontamination process, the source of the acetone measured in sample 4 remains undefined.

Bis(2-ethylhexyl)phthalate was also found in the white material at Location A-4 in Field A. This compound, however, is also common to all other hand-augered samples submitted for analysis, including the background samples from Field C. The detection of benzo (a) pyrene in Location A-4 suggest potentially low levels of contamination of this substance. A wide variety of non-priority acid and base/neutral compounds, tentatively identified and unknown, were also detected in this sample (see Table CC-2 in Appendix CC).

Although the exact nature of this white powdery substance at Location A-4 in Field A has not been determined, it is possible, based on field observations of color and consistency, that it may be lime. This conclusion is supported by a review of the non-priority metal concentrations measured for this sample, indicating high concentrations of magnesium and potassium that are constitutents of lime; calcium was not measured. The material may also be related to a talc or a similar aluminum or magnesium silicate mineral. Resampling and reanalysis of this material would be necessary for further identification of the source material.

The chemistry in the remaining samples from Field A are generally comparable to the background Field C with the exception of the sample from Location 6. The significantly lower levels

of magnesium, potassium, and sodium in the remainder of the field soil samples as compared to the specific sample at Location 4 are notable. This decrease, coupled with an increase in both iron and aluminum, suggests a possible relationship to a micaceous silicate. At Location A-6 the pesticides 4,4'-DDE and 4,4'-DDT were detected within the A horizon sample at concentrations of 11 and 17 ppb, respectively. Their presence could be associated with past farming activities in this field.

Concentrations of priority pollutant metals, particularly arsenic, chromium, copper, lead, nickel, thallium, and zinc, are found in higher concentrations in Field A samples as compared to the background field. These concentrations are however not significantly higher and therefore may represent accumulations of solids from contaminant-laden runoff from the landfill rather than a discreet source of contamination in the field itself.

4.1.5.3.2. Field B. Six locations were sampled in Field B as shown on Figure 4-8, and as in Field A, composite A and B horizon samples were prepared. Three individual samples were also randomly selected for laboratory analysis; there was no specific indication of contamination at any of these locations. The individual sample sites include the A soil horizon at Location B-3, the B soil horizon at Location B-5, and the A horizon at Location B-6.

The material in the A horizon of Field B can generally be described as dry, brown silty loam with 5-10% coarse fragments. Soils in the B horizon consisted primarily of dark-brown, silty clay loam with 10-20% coarse fragments. At several sites in Field B, the soil became moist in the lowermost portion of the soil sample excavations. HNU observations conducted in Field B

were below background levels for both the A and B horizons and no unusual or suspicious materials were encountered.

A summary of the priority pollutant chemical analyses of soil samples taken from Field B are included on Table 4-3. The soils in Field B contain low concentrations of acetone, tetrachloroethylene, and bis(2-ethylhexyl)phthalate. However, all concentrations of these chemicals were similar to those found at the background Field C and are therefore either representative of the soils in the area, or more likely, are the result of indeterminant field or laboratory contamination.

The concentrations of priority pollutant metals in Field B are somewhat higher than those in the background field but generally lower than those in Field A. The highest concentration of any metal was 8310 ppm for zinc found in Location 5 in the B soil horizon of Field B. A number of tentatively identified, non-priority semi-volatile organic compounds were also detected in the soils of Field B, but their concentration and variety were similar to those found in the background field.

These soils have not been subjected to groundwater saturation and are therefore probably not influenced by direct landfill contamination via groundwater, but they may be influenced by surface water runoff from the landfill. Within the area of the soil samples, this field did not appear to be a source of any concentrated contamination. No conclusions can be reached as to the nature of any contaminant source in the unsampled eastern portion of this field.

4.1.5.3.3 Field C. Field C was sampled for use as a background field against which the results of the other soil samples could be compared. Although not shown on Figure 4-8 it is

shown in Figure 1-7 in an area adjacent to existing horse corrals, approximately one-half mile northwest of the landfill.

As in the other sample fields, composite A and B soil horizon samples were obtained for Field C. Soils in the A soil horizon in Field C were a brown loam or sandy loam with 5-20% coarse fragments. These materials were dry to moist and tightly compacted. Soils in the B soil horizon were a yellow-brown sandy loam with 10-40% coarse fragments.

HNU readings in field C were all at 0 ppm. No material of a supsicious nature was encountered. Results of the priority pollutant chemical analyses in Table 4-3 indicated the presence of low levels of tetrachloroethylene and bis(2-ethylhexyl) phthalate, which may be a laboratory contamination problem. In addition, a number of non-priority, tentatively identified semi-volatile organics were detected in the soils along with low concentrations of priority pollutant metals.

4.2 GROUNDWATER

4.2.1 Identification of Major Aquifers and Their Use

The granite bedrock is the major aquifer in the vicinity of the landfill. Numerous residential wells within one mile of the site draw water from this aquifer. NJDEP records indicate six public water supply wells within three miles of the landfill, which tap the bedrock aquifer. The nearest municipal water system is about one mile southwest of the site.

In localized areas, the soils and saprolite, which overlie the granitic rock, are of sufficient thickness to provide domestic water supplies. It is often the practice of well drillers to take

advantage of interface between the saprolite and the weathered, but competent, bedrock. This zone, where saturated, often produces suitable supplies for domestic use. No specific information was discovered during research or interviews concerning the use of the saprolite, which generally has a greater permeability than the rock, as a water supply.

4.2.2 Aquifer Characteristics

The aquifer system that underlies and surrounds Combe Fill South landfill consists of fractured granitic bedrock and an overlying layer of soil and saprolite. It is necessary to consider the aquifer as a two-layered system because the hydrologic properties of these two materials are very different.

4.2.2.1 Fractured Bedrock. In weathered and fractured bedrock aquifers, such as those that occur beneath Combe Fill South, groundwater is stored and transmitted along discontinuities within the rock mass of the aquifer. These discontinuities may include fractures, joints, cleavage planes, foliations, and schistosity partings, which form an interconnected network for groundwater flow. As described later in this chapter, the most prominent discontinuity features (openings), as determined from examination of outcrops of the bedrock on and near the landfill, are partings parallel to the foliation that is oriented N50°E and dipping 80°SE. In addition, joint sets present in the rock mass are oriented N35-43°E, with a vertical dip nearly parallel to the orientation of the foliation partings. Discontinuities with other orientations were observed, but the major planar features tend to be parallel and subparallel to the foliation. Under these conditions, groundwater migration is biased in the direction of the predominant discontinuities. Permeability and transmissivity (ability of the rock material and the aquifer to transmit water) is the greatest parallel to

these planes and lower perpendicular to the same planes. This directional permeability is referred to as anisotropy.

In order to measure aquifer transmissivity, short duration (4-hr) constant-rate pumping tests were conducted in the nine deep (D-series) wells that were completed in the bedrock. Numerous short duration tests were conducted rather than fewer, longer term tests because the transmissivity of the fractured aquifer was expected to be extremely variable over the site. The degree of this variability can be best measured by a relatively large number of short-term pumping tests that generally measure transmissivity in the vicinity of the well. Data from the pumping tests and the analysis and calculations associated with this data are shown in Appendix P. Table 4-4 summarizes the calculated transmissivity values for each pumping test, which range from 25 to 2640 gpd/ft.

The slopes of the pumping test time-drawdown curves for each well can be approximated with a straight line within the first 10-30 min of pumping. Shortly thereafter, the slopes of the time-drawdown curves flatten considerably, indicating the influence of recharge. Transmissivity values for each pumping well were calculated from a straight line fitted to the first 30 min of pumping as recorded on the time-drawdown curves in Appendix P.

After cessation of pumping, water level recovery was generally recorded over a 2-hr time period. Semilogarithmic plots of the residual drawdown (recovery time) vs the function t/t' were also used to calculate aquifer transmissivity. [The function t/t' is the ratio of time since pumping began (t) to time since pumping stopped (t').] Straight lines were fitted to the recovery curves where t' = 1-10 min and were used to calculate transmissivities. The transmissivities calculated from the recovery and pumping tests were then averaged to obtain a best approximation of overall aquifer

TABLE 4-4

SUMMARY OF VALUES CALCULATED FROM PUMPING TESTS

Combe Fill South Landfill

WELL	AQUIFER MATERIAL	AVERAGE TRANSMISSIVITY (T)	T VALUE FROM PUMPING TEST	T VALUE FROM RECOVERY TEST
D-1	Granite	25.2	28.2	22.2
D-2	Granite	254	309.5	199.5
D-3	Granite	70.8	81.2	60.3
D-4	Granite	40.9	46.5	35.2
D-5	Granite	54.7	59.7	49.7
D-6	Granite	66.0	70.8	61.1
D-7	Granite	204	211	198
D-8	Granite	2640	2640	-
D-9	Granite	154	166.1	142
Geometric average		121		

transmissivity as shown on Table 4-4. Although the range of the transmissivities is quite large, other characteristics of the pumping tests are quite similar:

- After a pumping period ranging from as few as 10 to as many as 100 min, the slope of the time-drawdown curves from the pumping wells in the bedrock aquifer decrease significantly. This reduction probably results from the influence of delayed gravity drainage (or vertical leakage) of water from the overlying saturated saprolite.

- In all cases, except at well D-1, the slope of the recovery curve was steeper than the slope of the drawdown (pumping curve). As a result, transmissivity values calculated from the recovery curves were lower than those calculated from the drawdown curves. This indicates that the aquifer has undergone a reduction in storage (storativity), probably due to consolidation of the saprolite aquifer or, more likely, entrapment of air within the dewatered portion of the aquifer.

- Six of the pumping wells (wells D-1, D-4, D-5, D-7, D-8, and D-9) were located in close proximity to shallow observation wells constructed in overlying saturated soil and saprolite. (Wells D-1, D-3, and D-6 had no accompanying observation wells; both drawdown and recovery were measured in the same well.) However, drawdown in the observation wells occurred only during four of the pumping well tests (D-1, D-4, D-7, and D-9). In all cases the slopes of the time-drawdown curves for the observation (recovery) wells were much lower than the slopes of the time-drawdown curves for the pumping wells because the observation wells were screened in the saprolite while the pumping wells were tapping the bedrock. Thus, the calculated higher transmissivities in the observation wells are reflecting the saprolite, not the bedrock. These lower transmissivities in the bedrock wells also may be related to the influence of frictional well losses on drawdown values in the pumping well, or to the effects of time lag between pumping in one well and drawdown response in an observation well.

Because no observation wells were available in the bedrock aquifer within the influence of the bedrock wells that were test pumped, no measure of directional transmissivities was made. Such measurements would have been useful in quantitatively characterizing the anisotropy of the bedrock aquifer. For the same reason, the storativity of the bedrock aquifer was not measured.

4.2.2.2 Saprolite Aquifer. The unconsolidated overburden, predominantly saprolitic in nature and including landfilled wastes in the filled areas, is generally saturated across the site. As such, this unit, termed the saprolite aquifer, constitutes a significant aquifer on the site. The saprolite aquifer has a saturated thickness ranging from 0-40 ft deep with an average thickness of 30 ft as shown on Plate 6 (in the back pocket of this report). The maximum saturated thickness occurs at well D-6, one of the highest elevations on the landfill, and consists almost entirely of saturated wastes. Generally, the saturated waste thicknesses are 30-35 ft as shown on Plate 6. Substantial thicknesses of saturated saprolite occur along the northern perimeter of the landfill between wells D-4 and D-1; along the northeast perimeter between wells D-5 and DW-4; along the entire southeast perimeter, parallel to the NJP&L power line; and along the southwest perimeter, from well D-7 to well D-9. As such, groundwater and leachate flows away from the landfill within the saprolite aquifer.

The saprolite consists of sandy silt to gravelly silt, and is substantially more porous than the bedrock aquifer because of its unconsolidated nature. For this reason, permeability measurements and transmissivity calculations for the saprolite aquifer were also made from data obtained in slug and pump tests of wells screened in the saprolite. On 17, 18, and 19 April 1985 slug tests were conducted on wells S-1, S-2, S-4, S-5, and S-6. These wells consist of 4-in. diameter stainless steel casings with a 10-ft section of

20-slot screen. The screens were placed in saprolite intervals. The slug tests used a 0.193-ft diameter by 6 ft solid stainless steel slug to alternately raise and lower the well's static water level. The change in water level over time was recorded in each well by use of a pressure transducer connected to a strip chart recorder.

To perform a slug test, a slug was lowered into the test well and then quickly and smoothly submersed below the original static water level, creating an instantaneous water level recovery. After the water level declined to the static condition, the slug was withdrawn and water in the well was allowed to recover to its original height. The rate at which the water level declines or recovers during these tests is a direct measure of the permeability or hydraulic conductivity of the saprolite aquifer. A cycle of one insertion and one withdrawal constitutes two permeability tests. At least four permeability tests were conducted on each well.

The slug test results were analyzed by use of the method developed by Bouwer and Rice (1976). Individual analyses for each well tested are presented in Appendix Q. The calculated permeabilities are shown on Table 4-5 and range from 10.48 to 373.8 gpd/ft^2, with a geometric average permeability of 47.6 gpd/ft^2.

Based upon the saturated thicknesses of the saprolite aquifer at each well (from Plate 6 in back pocket), transmissivities for wells S-1, S-2, S-4, S-5, and S-6 were calculated. These values are summarized in Table 4-5 and range from 314 to 7100 gpd/ft. The geometric average transmissivity for the saprolite aquifer, based upon the slug tests, is 1187 gpd/ft. Compared to the bedrock aquifer (see Table 4-4) the transmissivity of the saprolite aquifer is an order of magnitude higher (121 gpd/ft for the bedrock as compared to 1187 gpd/ft for the saprolite). Thus, the flow of groundwater

TABLE 4-5

SUMMARY OF PERMEABILITY AND TRANSMISSIVITY VALUES OF SAPROLITE DERIVED FROM SLUG TESTS AND PUMPING TESTS

Combe Fill South Landfill

WELL	PERMEABILITY (gpd/ft^2)	TRANSMISSIVITY (gpd/ft)
S-1	373.8	7100
S-2	14.97	494
S-3[a]	28.9	694
S-4	10.48	314
S-5	288	6050
S-6	14.4	605
Geometric average	43.8	1187

[a]Values for well S-3 derived from well S-3 pumping test. All other values derived from slug tests.

and leachate from the saprolite aquifer becomes an important consideration in the overall evaluation of groundwater flow.

A 4-hr constant-rate pumping test was conducted using monitoring well S-3, which is screened in the saprolite, to correlate slug test permeabilities. (The log of well S-3 appears in Appendix E.) A transmissivity of 694 gpd/ft calculated from the time-drawdown curve from the pump test of well S-3 is in good agreement with those for the other S-series wells.

Based on these test results and calculations, the following average transmissivity values are assumed to be representative of bedrock and saprolite aquifers.

AQUIFER	TRANSMISSIVITY
Bedrock	121 gpd/ft
Saprolite	1187 gpd/ft

The storativity of the saprolite was not measured in the field during the remedial investigation. To determine storativity requires monitoring of a well in the saprolite adjacent to a pumping well in the saprolite. No such monitoring well was available during the pumping of well S-3.

4.2.2.3 Water Table Configuration. Water levels were frequently measured in 22 monitoring wells from 29 November 1984 to 28 August 1985 at the Combe Fill South site. These water level measurements are summarized on Table 4-6. In addition, water level measurements were made in private wells during the sampling of the potable wells where accessible. These water level measurements, in conjunction with stream position, topography, and geology, were used

TABLE 4-6

COMBE FILL SOUTH
STATIC WATER LEVELS

Static Water Level Elevation (ft)

WELL NO.	TOC Elev. (ft.)	1984 11/29	12/6	12/13	12/19	12/27	1985 1/3	1/8	1/15	1/17	1/23	1/29	4/22	8/28
SB-1	850.35	--	814.30	814.08	813.85	814.20	815.91	816.30	816.05	815.75	--	815.89	815.00	813.52
SB-2	812.76	792.36	792.72	792.84	792.86	791.88	793.28	792.51	792.41	792.38	--	793.38	793.59	793.11
SB-3	815.01	793.01	793.54	794.66	793.49	793.97	794.43	794.56	794.25	794.19	--	793.59	792.43	792.68
SB-4	794.15	788.45	788.98	789.47	788.71	788.84	789.41	789.36	789.32	789.35	789.05	789.27	788.84	789.19
D-1	837.72*	812.87	812.82	815.62	812.84	813.32	812.72	812.77	812.62	812.56	812.67	812.49	812.85	810.59
D-2	794.47	--	--	--	--	--	--	--	--	--	--	--	787.97	--
D-3	826.09	--	--	--	--	--	--	--	778.59	778.46	--	779.13	779.78	778.07
D-4	803.69	--	--	--	--	--	--	--	--	--	795.29	795.69	796.03	794.67
D-5	843.50	808.50	808.40	807.50	807.81	807.87	807.48	807.55	807.50	807.38	--	807.42	807.42	806.27
D-6	872.32	--	--	--	--	--	--	--	--	--	--	809.74	808.81	808.26
D-7	792.65	--	--	--	787.44	787.73	787.94	787.80	787.65	787.33	787.31	786.88	787.24	787.15
D-8	810.16	797.41	798.96	798.70	798.62	798.74	799.15	799.03	798.97	798.96	798.76	798.47	798.10	797.03
D-9	809.24	--	--	--	--	782.97	783.50	783.68	783.42	783.31	--	783.03	781.95	781.59
S-1	793.67	--	--	--	788.75	788.96	789.12	789.09	788.97	788.92	788.60	787.96	787.59	788.25
S-2	817.92	--	--	--	--	--	--	799.32	799.05	799.00	--	19.13	19.76	21.42
S-3	809.93	--	--	--	--	--	786.26	786.14	786.01	786.01	--	785.35	784.45	784.26
S-4	810.33	--	799.08	798.83	798.75	798.89	799.31	799.15	799.08	799.06	798.33	798.00	797.66	796.58
S-5	804.77	--	--	--	--	--	--	--	--	--	795.07	796.50	796.84	795.33
S-6	840.09	--	--	--	--	--	--	813.34	813.19	813.11	813.44	813.19	813.38	811.49
SW-2	799.08	795.58	796.00	795.33	795.41	795.48	795.57	795.20	795.33	795.46	--	793.91	--	792.20
SW-4	785.31	783.31	783.31	783.31	783.31	783.31	783.31	783.31	783.31	783.31	--	--	--	783.39
DW-4	820.87	--	--	--	--	--	--	--	--	--	--	--	--	797.60

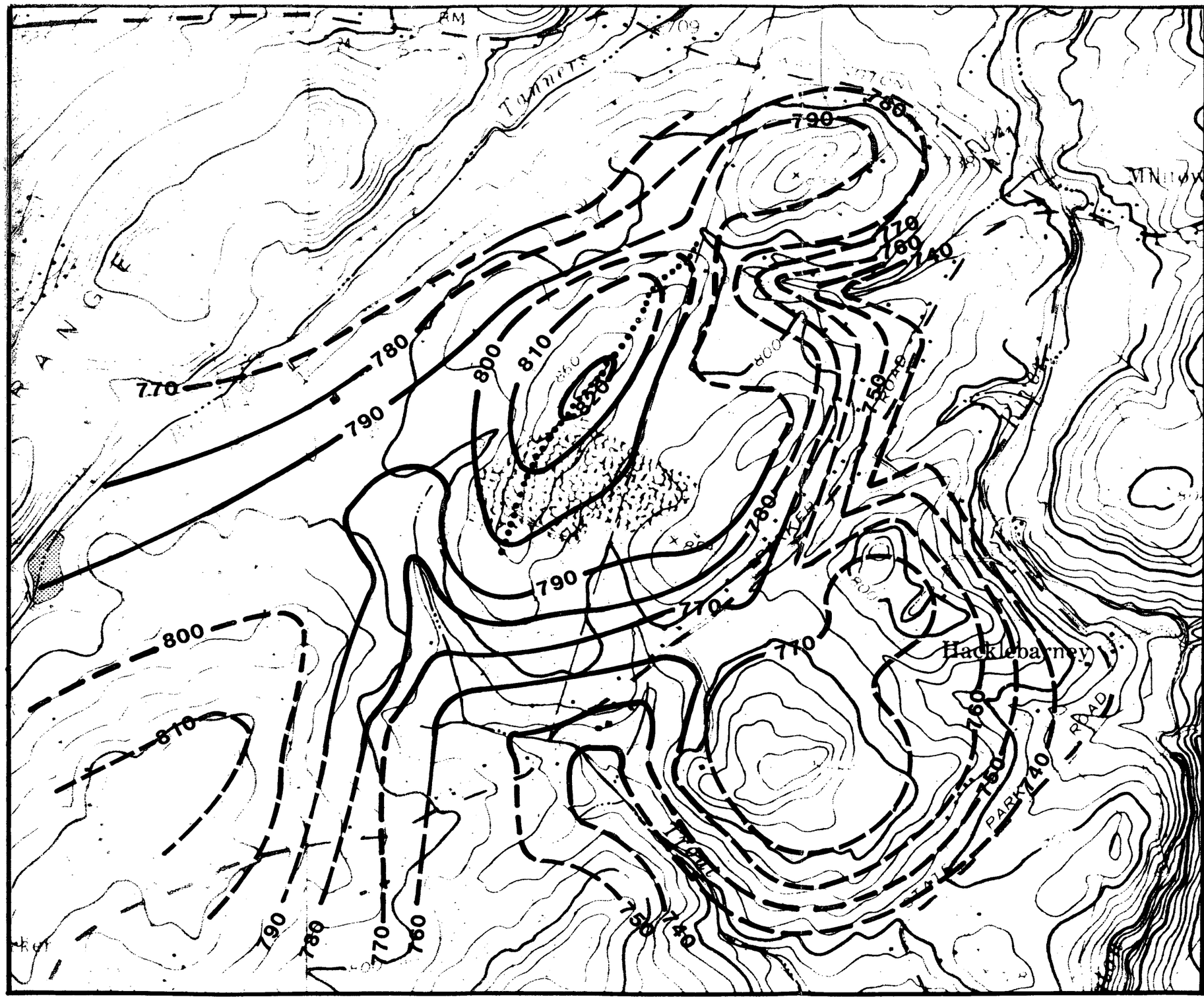
* Bottom of box

to develop the regional and local (on-site) water table contour maps included in Figure 4-9 and Plate 7 (in back pocket of report), respectively.

These illustrations indicate that the water table configuration is a subdued version of surface topography. A major groundwater divide runs through the landfill in a northeasterly direction (see Figure 4-9) and directs flow northwest to Tanners Brook, southwest to the West Branch of Trout Brook, northeast to the unnamed tributary of the Black River, and southeast to the East Branch of Trout Brook. As shown on Plate 7, the horizontal hydraulic gradient of the water table is generally 0.01-0.03 ft/ft.

The water table contour map (Plate 7) is a best-fit of the water level measurements taken from all wells on 28 August 1985 that are also shown on Plate 7. Differences in water levels between the saprolite and bedrock aquifers are described in the following section.

On the landfill, the depth to the water table ranges from 5 ft near wells S-1 and D-7 at the southeast corner of the fill to 65 ft under the northernmost portion of the site between wells D-5 and D-1. Seasonal fluctuations in water levels over the nine-month period of water table measurements were no greater than 3-5 ft. However, because the monitoring of water levels was not continuous and some of the wells (wells D-2, D-3, D-4, and D-6) were not monitored through the entire period, it is possible that water level fluctuations may occur over a greater range. Water levels in wells such as D-6 located in the higher portions of the groundwater flow system may experience water level fluctuations of 15 ft or more.



N

LEGEND

780 — ELEVATION OF THE WATER TABLE IN FEET ON 8/28/85, DASHED WHERE APROXIMATE

PERENNIAL STREAM

GROUNDWATER DIVIDE

1000′ 0 1000′

SCALE IN FEET

FIGURE 4-9

COMBE FILL SOUTH LANDFILL

REGIONAL GROUNDWATER TABLE IN FEET ON 8/28/85

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drawn DLB	approved	drawing no.
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4.2.2.4 Vertical Piezometric Head Distribution. Between 18 and 26 April 1985, packer tests were conducted on five selected wells (D-1, D-6, D-7, D-8, and D-9) to acquire a representative sampling of piezometric head with depth at various positions within the groundwater flow system on the site. With this data, a three-dimensional characterization of groundwater flow direction and magnitude was made.

The results of the packer tests are shown on Table 4-7. Wells D-1, D-6, D-8, and D-9 showed minor changes in vertical head (0.00 to 0.003 ft/ft), as measured by changes in static water levels. Measurements in well D-7 demonstrated a downward gradient in the upper portion of the well, no vertical gradient in the central portion of the well, and an upward gradient in the bottom of the well. Therefore, there is virtually no head potential to cause vertical groundwater flow within the bedrock aquifer at this well.

Over the majority of the site the vertical head gradients (0 to 0.003 ft/ft) within the bedrock aquifer (as measured by the packer tests) are an order of magnitude (10x) smaller than horizontal gradients (0.01 to 0.03 ft/ft). Therefore, with respect to groundwater movement and chemical transport, lateral flow is predominant in the bedrock.

Water levels in the saprolite aquifer are consistently higher than the bedrock aquifer (see Table 4-6) at the same relative position (i.e., monitoring well location), indicating a downward vertical groundwater gradient between saprolite and bedrock. These water level differences can be summarized as follows:

TABLE 4-7

PACKER TEST RESULTS

Combe Fill South Landfill

WELL	DEPTH INTERVAL TESTED FROM TOC (ft)	STATIC WATER LEVEL ELEVATION FROM TOC (ft)	VERTICAL HEAD GRADIENT (ft/ft) AND DIRECTION
D-1	91.0 - 99.81	812.81	0.002, downward
	99.81 - 109.81	812.75	
	109.81 - 120.81	812.70	
	120.81 - 130.81	812.70	
	130.81 - 138.81	812.70	
	138.81 - 148.81	812.68	
D-6	112.33 - 114.37	808.90	0.001, downward
	114.37 - 124.37	808.99	
	157.37 - 167.37	808.94	
D-7	47.3 - 57	786.76	0.05, downward
	57 - 67	787.27	
	62 - 72	787.18	0.01, upward
	72 - 82	787.17	
	86.67 - 96.67	787.18	
	96.67 - 106.67	786.99	0.01, upward
	106.67 - 116.67	787.02	
	115 - 125	787.18	
D-8	50.7 - 58	798.04	0.001, upward
	58 - 68	798.06	
	68 - 78	798.06	
	78 - 88	798.02	0.001, downward
	88 - 98	798.01	
D-9	83.5 - 94.88	776.91	0.003, upward
	94.88 - 104.88	776.89	
	104.88 - 114.88	776.94	
	112.88 - 122.88	777.00	

BEDROCK WELL	SAPROLITE WELL	SAPROLITE HEAD DIFFERENTIAL (ft)
D-7	S-1	+1 (higher)
D-9	S-3	+2.5 (higher)
D-8	S-4	+0.25 (higher)
D-5	SB-1	+8.0 (higher)
D-1	S-6	+0.5 (higher)
D-4	S-5	+0.75 (higher)

On the other hand, the existence of consistently higher water levels in the saprolite clearly suggests that the saprolite aquifer is underlain by an aquifer unit that has lower permeability. As a result, overall vertical drainage from the saprolite to the bedrock aquifer is less than would be expected by the head differences. This contributes to a mounding of water levels in the saprolite (and waste) aquifer. The pumping test and slug test analyses confirm these differences in permeabilities between the saprolite and bedrock aquifers.

In conclusion, although there is a downward vertical gradient and movement of groundwater between the saprolite (and waste) and the underlying bedrock, lower permeabilities in the bedrock counteract much of this potential downward movement, resulting in a mounded groundwater table in the waste and a horizontal movement of groundwater in the saprolite.

4.2.3 Landfill Characteristics

The approximate locations of the landfilled areas are shown as shaded areas on Figure 4-4. Fill thicknesses are greatest in the western section, which is the newest area of the landfill. In this vicinity, the fill ranges in depth from 10 to 80 ft. The water table is in contact with the fill throughout this new fill section, resulting in 5 to 20 ft of saturated fill. The easternmost portion

of the landfill, which is the oldest section, is considered to be no greater than 50 ft deep, based on the landfill design documents and original topography. However, no wells of record have been completed to confirm this.

The landfill cover is coarse textured with much gravel and larger materials. Based on the textures, types of material, and landfilling plans, the cover soils were probably excavated from the saprolite zones prior to filling. The permeability of this soil cover is very high, greater than the permeability of the preexisting natural soils, which were finer in texture. In addition, the fill itself has greater permeability and storativity than the underlying saprolite and granitic bedrock. These higher permeabilities of the fill and waste materials, coupled with reduced permeabilities of compacted soils beneath the fill and low permeability of the bedrock, contribute to mounding of groundwater within the landfill.

The landfill surface, although similar to the preexisting topography, has much steeper slopes that promote greater rates of surface runoff than those produced during prelandfill conditions. However, the increased permeability of the cover soils appears to offset this effect. Although measurements of the rate of infiltration through the existing cover were not within the scope of the remedial investigation, estimates are made in the following paragraphs.

4.2.4 Direction and Magnitude of Groundwater Flow

4.2.4.1 Direction of Groundwater Flow. If the bedrock and saprolite aquifers underlying the site had isotropic permeabilities, flow of groundwater would be perpendicular to the water table contours shown on Plate 7. However, the near vertical foliations and joints, which strike N50°E, cause a higher permeability in this

direction. This preferential orientation causes groundwater flow to be biased toward the strike direction (N50°E), which is the direction of maximum permeability. This condition describes the anisotropy of the bedrock aquifer.

Measurement of the maximum permeability in the direction of the foliation and jointing can be made by conducting a pumping test at a well that is surrounded by two or more observation wells located parallel and perpendicular to the direction of maximum permeability. These conditions were not met during the field investigation, and no quantitative differences in directional permeabilities were determined. However, aquifers with structural features similar to the granitic bedrock at the Combe Fill South site often have permeability values in the direction along the foliation planes that are two to five times greater than across or perpendicular to the planes.

A graphical technique was developed by Liakopoulous (1965) to determine the actual direction of groundwater, under these anisotrophic conditions, given the ratio of maximum to minimum permeability. Using this technique reveals that although there is little additional change in flow direction after the ratio exceeds 5:1, there is a marked change in flow direction between ratios of 1:1 and 3:1. Therefore, a ratio of 2.5:1 has been selected to estimate the direction of groundwater flow at the Combe Fill South site. This ratio is based on permeabilities measured at other locations similar to the Combe Fill South site, i.e., where the bedrock aquifer is dominated by structural discontinuities that are aligned along a single predominant direction. Also, this ratio was selected because it is between the range of ratios (1:1 to 5:1) wherein the most significant alteration in groundwater flow direction results. While this ratio may be inexact, the use of a 1:1

ratio, connoting an isotropic condition, is inappropriate, given the dominance of the N50°E vertical to subvertical foliation and jointing that is present in the granitic bedrock at the Combe Fill South site. The methodologies and references used in approximating this anistropic condition at the Combe Fill South landfill is provided in Appendix FF. Field testing should be conducted if better estimates of the groundwater flow direction are necessary.

A groundwater flow direction analysis using this 2.5:1 anisotropic condition produces the directions of groundwater flow that are shown on Plate 7. Under these conditions more flow from the landfill is directed to the northeast and southwest than under isotropic conditions where a much larger volume of flow would be directed due south and southeast. These general groundwater flow directions shown in Plate 7 are applicable to both the saprolite and bedrock aquifers.

4.2.4.2 Magnitude of Groundwater Flow. One of the major goals of this remedial investigation has been to determine the direction and quantity of groundwater flow from the landfill. Three methods were used to calculate the quantity of groundwater flow from the landfill:

- Area-wide groundwater recharge estimates based on USGS streamflow records
- Localized groundwater recharge estimates based on measured streamflows on-site and on immediately adjacent areas
- Darcy's Law calculations based on aquifer hydrology (transmissivity) and measured hydraulic gradients on-site

The following sections discuss each of these approaches and the results obtained.

4.2.4.3 USGS Streamflow Record Method. The ultimate source of all groundwater is precipitation, which, after infiltrating the ground surface, drains to the groundwater flow system. Except where groundwater is directly removed from the subsurface by well production and used in a consumptive manner or otherwise expelled from the basin, groundwater ultimately is discharged to the surface in springs and as streamflow. By examining long-term stream gaging records, the groundwater discharge component (baseflow) of streamflow can be determined and used to estimate the rate of groundwater recharge within a basin. Streamflow hydrographs and calculated groundwater baseflow in nearby basins can be used to estimate the groundwater recharge in other basins with similar geology.

A groundwater baseflow separation was performed using an average streamflow and precipitation year selected from the 60 years of existing USGS records for the stream gage on the Lamington (Black) River near Pottersville, NJ. This stream basin (shown on Plate 8 in the back pocket), in which the Combe Fill South landfill is located, is underlain almost completely by the granitic bedrock typically found beneath the landfill. The baseflow separation procedure indicated that the normal (long-term average) annualized rate of groundwater recharge of streamflow in the basin is 800,000 gpd/mi^2.

Similar baseflow separations of USGS streamflow hydrographs from igneous and metamorphic bedrock areas in the Delaware River Basin (Source: "Special Groundwater Study of the Middle Delaware River Basin - Study Area II," R.E. Wright Associates, Inc., August 1982) indicate a normal annualized groundwater recharge rate of 615,000 gpd/mi^2. However, precipitation in these areas of the Delaware River Basin averages only 39 in. per year, as compared to the 50.58 in. per year in the Black River Basin. Proportionately adjusting the recharge rate in the Delaware River Basin for this precipitation difference results in an estimated 800,000 gpd/mi^2 of ground-

water recharge to streams, which is the same as the recharge value that was determined from the Black River hydrographs.

Assuming that overall infiltration at the Combe Fill South site occurs at this same rate per unit surface area estimates of total groundwater (in both saprolite and bedrock) flow for the landfill can be developed based strictly on surface area. This approach assumes that there is no upgradient groundwater source that contributes substantial flow to the site. Such an assumption is appropriate for the Combe Fill South site (see Plate 7).

As shown in Plate 7, discharge from the landfill has been divided into six separate flow channels or paths. These flow channels are assumed to have consistent hydrogeologic properties along the entire cross-sectional area at the downgradient end of each flow channel. These groundwater flow channels are not meant to represent physical groundwater paths, such as cracks or fractures; they are merely representative of general groundwater flow directions. The areas of each flow channel above the downgradient cross-section line were measured and multiplied by the baseflow-derived groundwater recharge value calculated above to determine the approximate quantity of groundwater flow. Table 4-8 summarizes the estimated groundwater flow within each of the six flow paths. Based on these calculations, 110,880 gpd of groundwater would discharge from the landfill through all the hypothetical flow pathways on an average annualized basis.

4.2.4.4 Local Streamflow Measurement Method. An attempt was made to refine the previously described USGS groundwater baseflow approximation of groundwater flow by using streamflow measurements taken in the area surrounding the landfill during this investigation. These near-site measured streamflows are listed in Table 4-9, and the location of the flow gaging stations and drainage

TABLE 4-8

GROUNDWATER FLOW CALCULATIONS FROM USGS STREAMFLOW RECORDS AND BASEFLOW SEPARATION

Combe Fill South Landfill

GROUNDWATER FLOW CHANNEL	RECHARGE AREA (mi^2)	NORMAL ANNUALIZED[a] GROUNDWATER FLOW (gpd)
1	0.049	39,200
2	0.040	32,000
3	0.013	10,400
4	0.016	12,800
5	0.0016	1,280
6	0.019	15,200
Total	0.1386	110,880

Notes: 1. A groundwater recharge rate of 800,000 gpd/mi^2 was used in this calculation.

2. Reference Plate 7 for flow channel locations.

TABLE 4-9

LOCAL STREAMFLOW MEASUREMENTS AND CALCULATED GROUNDWATER BASEFLOW

Combe Fill South Landfill

STREAMFLOW MEASUREMENT POINT[a]	DATE OF MEASUREMENT	STREAMFLOW (gpd)	DRAINAGE BASIN AREA (mi^2)	MULTIPLICATION FACTOR BASED ON BLACK RIVER FLOW ON THIS DATE VS ITS NORMAL BASEFLOW	CALCULATED NORMAL ANNUALIZED GROUNDWATER BASEFLOW (gpd/mi^2)
W-2	12/07/84	885,400	0.39	0.924	2,097,000
	12/14/84	297,300	0.39	1.308	996,900
	12/19/84	355,400	0.39	1.195	1,089,000
	12/26/84	569,400	0.39	1.230	1,794,000
	1/10/85	386,600	0.39	1.562	1,547,000
	1/15/85	196,300	0.39	1.450	731,000
	1/31/85	182,800	0.39	1.015	476,000
	8/13/85	161,600	0.39	3.123	1,290,000
W-2 (Avg.)	-	-	-	-	1,240,000
W-4	8/13/85	200,300	1.35	3.123	464,000
W-5	8/13/85	588,100	2.28	3.123	805,000
W-6	8/13/85	1,357,000	1.34	3.123	3,164,000
W-7	8/13/85	4,989,000	19.29	3.123	808,000
W-8	8/13/85	7,736,000	30.39	3.123	795,000

[a]Locations correspond to those in Plate 8.

basins are shown on Plate 8. The normal annualized groundwater baseflow at each of the study stream gaging stations was calculated based on the ratio of actual:normal surface water flows at the Pottersville gaging station (on the Black River), which were measured on the same days as the site streamflows. The resultant annualized groundwater baseflow rates for the streams are listed on Table 4-9.

As shown on Table 4-9 under the column "Calculated Normal Annualized Groundwater Baseflow," these calculated baseflows range from 464,000 to 3,164,000 gpd/mi^2. This range is very extreme, indicating that either the streamflow measurements are inaccurate or, more likely, that differences in the hydrology between the stream gaging stations are so great as to yield spurious results. Therefore, the streamflow measurements made during this investigation are inappropriate for approximating the on-site rate of groundwater discharge.

4.2.4.5 Groundwater Discharge as Calculated by Darcy's Law. The groundwater discharge from the landfill was also computed using a form of Darcy's Law. The same flow paths, shown on Plate 7 and used in the previous USGS baseflow method, were used for this calculation; however, here they can be separated into saprolite and bedrock components within each flow path. Using the transmissivities measured during the pumping and slug tests, and applying the assumed 2.5:1 anisotrophic permeability ratio discussed previously, a set of aquifer parameters specific to saprolite and bedrock were selected for each flow path. The quantity of groundwater flow in each path was estimated by use of the following equation, a modified version of Darcy's Law:

$$Q = TiW$$

where

Q = Quantity of groundwater flow in gallons per day (gpd)
T = Transmissivity of aquifer in gpd/ft
i = Hydraulic gradient of water table
W = Width of flow path in ft

This equation can also be used by replacing the transmissivity (T) with the hydraulic conductivity or permeability (k) such that:

$$T = kd$$

where

k = Hydraulic conductivity in gpd/ft^2
d = Thickness of the aquifer in ft

The average transmissivities (T) and hydraulic conductivities (k) calculated from the pumping tests and slug tests (121 and 43.8 gpd/ft^2, respectively) were used to calculate the average T_{max} and K_{max} (191.3 and 69.3 gpd/ft^2, respectively) along the preferential direction of permeability (N50°E). From this, the angle between the projected flow direction and the direction of T_{max} or K_{max} was measured so that the actual T and k values in the flow directions could be used for the flow calculations. The calculated T and k values for each flow channel and resultant flow calculations are shown on Table 4-10. The total groundwater flow in both aquifer layers, in each of the six flow channels is also shown on Plate 7.

In flow path 1, for example, the directional hydraulic conductivity (permeability) of the saprolite was calculated as 68 gpd/ft^2. The average saturated thickness along the scaled width (W) of this flow channel (1275 ft) is 26 ft. The flow channel has a hydraulic gradient of 0.021 (i). Substituting these statistics into the above

TABLE 4-10

GROUNDWATER FLOW CALCULATIONS
COMBE FILL SOUTH LANDFILL

Groundwater Flow Channel	Geologic Material	Transmissivity(T) Along Flow Path (gpd/ft)	Hydraulic Conductivity(k) Along Flow Path (gpd/ft^2)	Aquifer Thickness (d) (ft)	Gradient (i)	Width of (W) Channel (ft)	Groundwater Flow (Q) (gpd)	Net Flow Channel Groundwater Flow (Q) (gpd)
1	Saprolite	----	68	26	0.021	1275	47,338	52,372
	Granite	188	----	---	0.021	1275	5,034	
2	Saprolite	----	65	25	0.025	1120	45,500	50,540
	Granite	180	----	---	0.025	1120	5,040	
3	Saprolite	----	34	29	0.014	490	6,764	7,409
	Granite	94	----	---	0.014	490	645	
4	Saprolite	----	38	14	0.017	850	7,687	9,204
	Granite	105	----	---	0.017	850	1,517	
5	Saprolite	----	43	27	0.005	390	2,264	2,498
	Granite	120	----	---	0.005	390	234	
6	Saprolite	----	68	38	0.006	820	12,713	13,633
	Granite	187	----	---	0.006	820	920	
						Totals: Saprolite	122,266	Total: 135,656
						Granite	13,390	

Notes: $Q = TiW$
$Q = kdiW$

equation yields a flow rate (Q) in the saprolite/unconsolidated aquifer of approximately 47,338 gpd as follows:

$$Q = KdiW$$
$$Q = (68\ gpd/ft^2)\ (26\ ft)\ (0.021)\ (1275\ ft)$$
$$Q = 47{,}338\ gpd$$

For the same flow pathway, the directional transmissivity for the bedrock aquifer was 188 gpd/ft and the groundwater discharge calculated for the bedrock aquifer through flow channel was 5034 gpd, calculated as follows:

$$Q = Tiw$$
$$Q = (188\ gpd/ft)\ (0.021)\ (1275\ ft)$$
$$Q = 5034\ gpd$$

The total groundwater flow through this flow path is the combined flow through the saprolite and bedrock portions of the aquifer, i.e., 52,372 gpd. The results of similar calculations for the other flow channels are shown on Table 4-10 and indicate a combined groundwater flow of approximately 135,656 gpd. On average, the saprolite aquifer layer conducts nearly nine times the flow of the granite bedrock.

4.2.4.6 Groundwater Flow Conclusions. The two values calculated for the total quantity of groundwater flow from the landfill area as follows:

METHOD	GROUNDWATER FLOW RATE (gpd)
USGS streamflow records	110,880
Darcy's Law calculation	135,656

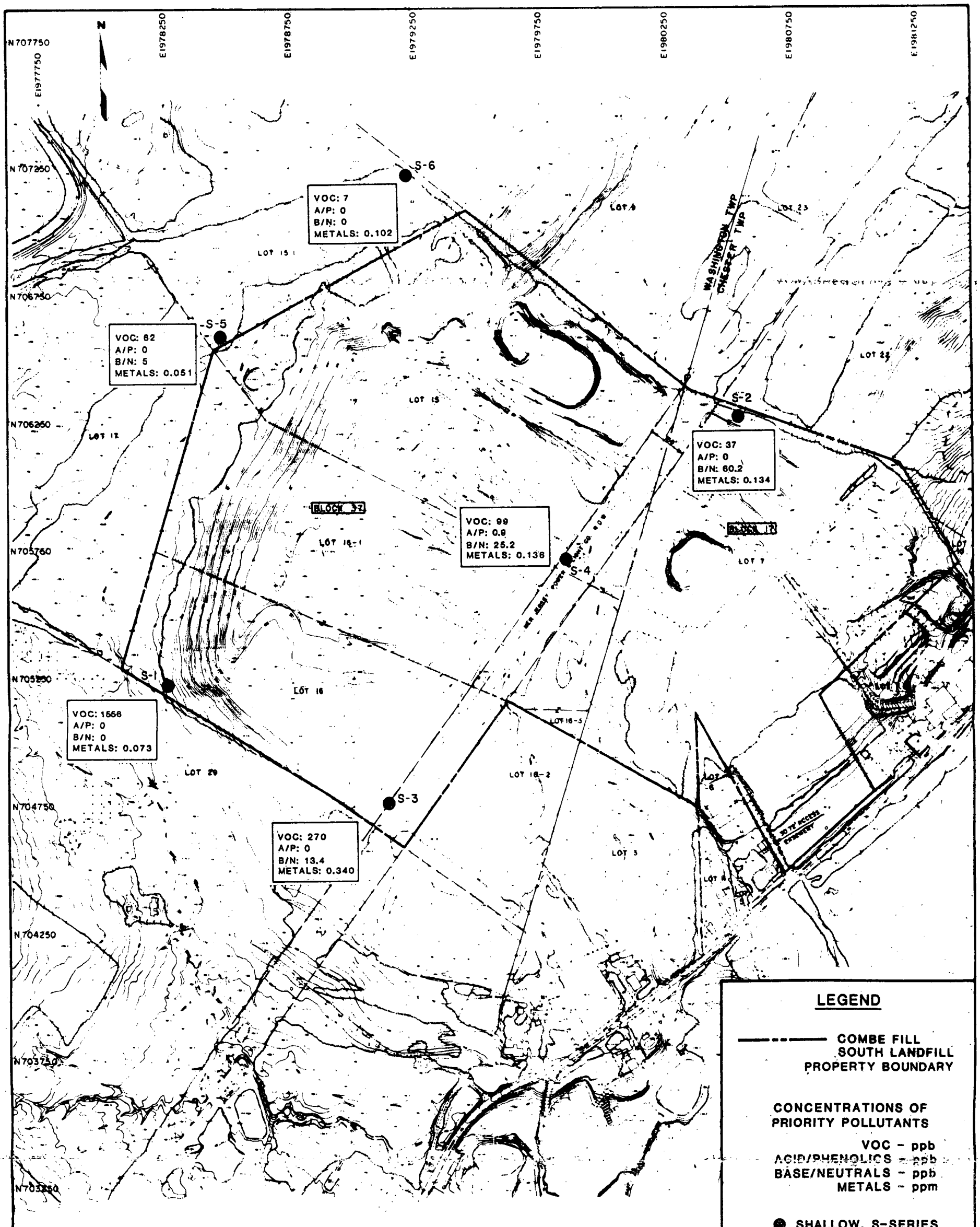
4.2.5 Groundwater Quality

Based on the above description of the hydrogeologic regimes in and around the Combe Fill South Landfill, the following discussion of groundwater quality is divided into the shallow water table aquifer and the deep bedrock aquifer.

4.2.5.1 Shallow Aquifer. Six of the monitoring wells (S-1 through S-6) constructed on and near the landfill for this RI are screened in the shallow aquifer. Figure 4-10 summarizes the concentrations of the priority pollutant fractions measured at each shallow well. Individual priority pollutants are presented for each well in Table 4-11. The chemistry data presented in Figure 4-10 and Table 4-11 have been adjusted based on the chemical analysis of the field and trip blank samples that accompanied the shallow well samples. These QA/QC samples consistently showed low levels of contamination by methylene chloride (<11.4 ppb), which may have been introduced as a laboratory contaminant. In addition, on two days of sampling, the field blanks contained two priority pollutant acid/phenolics; however, these were not detected in site samples on the same days and the source of this field contamination is unknown. Unadjusted data for these wells is presented in Table CC-4 of Appendix CC; the results of the related field and trip blanks are presented in Table CC-24 of the same Appendix.

The pattern of contamination found in these shallow wells shown in Figure 4-10 confirms that the groundwater flow in the saprolite generally mirrors surface topograhy and surface water flows (see Chapter 4 for discussion of groundwater flow in saprolite and Chapter 5 for surface drainage areas).

Well S-1, located in the southwest corner of the landfill near several major seeps and the West Branch of Trout Brook, had the



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COMBE FILL SOUTH LANDFILL
REMEDIAL INVESTIGATION/
FEASIBILITY STUDY

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CONCENTRATION OF
PRIORITY POLLUTANT ORGANICS AND
METALS IN SHALLOW MONITORING WELLS

FIGURE 4-10

TABLE 4-11 (Page 1 of 3)

SUMMARY OF SHALLOW MONITORING WELLS PRIORITY POLLUTANTS

Combe Fill South Landfill

PARAMETER	S-1	S-2	S-3	S-4	S-5	S-6
DATE SAMPLED	9/4/85	9/5/85	8/29/85	9/4/85	8/28/85	8/28/85
VOLATILES, ppb						
Benzene	64.7	BM @ 4.4	80.2	BM @ 4.4	ND	BM @ 4.4
Chlorobenzene	ND	30.3	21.1	18.2	ND	ND
Chloroethane	ND	ND	BM @ 10	62.0	ND	ND
Chloroform	ND	ND	ND	ND	57.5	ND
1,1-Dichloroethane	65.2	ND	51.4	BM @ 4.7	ND	ND
1,2-Dichloroethane	ND	ND	ND	6.10	ND	ND
1,1-Dichloroethylene	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	BM @ 6	ND	ND	ND
Ethylbenzene	ND	ND	BM @ 7.2	ND	ND	ND
Methylene chloride[a]	56.0	4.44	18.4	8.2	4.67	4.67
Tetrachloroethylene	ND	ND	BM @ 4.1	ND	ND	ND
Toluene	1370	ND	68.2	ND	ND	ND
Trans-1,2-dichloroethylene	ND	ND	8.02	ND	ND	ND
Trichloroethylene	ND	ND	4.04	ND	ND	ND
Vinyl chloride	ND	ND	BM @ 10	ND	ND	ND
ACID/PHENOLICS, ppb						
2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND
2-Nitrophenol	ND	ND	ND	ND	ND	ND
Phenol	ND	ND	ND	BM @ 1.5	ND	ND

ND = Not detected.
BM = Below method detection limit.
[a]Corrected based on analysis of QA/QC samples.

TABLE 4-11 (Page 2 of 3)

SUMMARY OF SHALLOW MONITORING WELLS PRIORITY POLLUTANTS

Combe Fill South Landfill

PARAMETER	S-1	S-2	S-3	S-4	S-5	S-6
DATE SAMPLED	9/4/85	9/5/85	8/29/85	9/4/85	8/28/85	8/28/85
BASE/NEUTRALS, ppb						
Bis (2-chloroethyl) ether	ND	ND	ND	BM @ 5.8	ND	ND
Bis (2-ethylhexyl) phthalate	ND	BM @ 11	ND	ND	BM @ 10	ND
1,2-Dichlorobenzene	ND	9.77	ND	7.25	ND	ND
1,4-Dichlorobenzene	ND	39.4	ND	10.1	ND	ND
Di-ethyl phthalate	ND	ND	10.2	ND	ND	ND
Di-n-butyl phthalate	ND	BM @ 11	ND	BM @ 10	ND	ND
Di-n-octyl phthalate	ND	ND	ND	ND	ND	ND
Isophorone	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	3.16	ND	ND	ND
N-nitrosodiphenyl amine	ND	ND	ND	ND	ND	ND
PESTICIDES/PCBs, ppb	ND	ND	ND	ND	ND	ND
METALS, ppm						
Beryllium	ND	ND	BM @ 0.002	ND	ND	ND
Cadmium	ND	ND	ND	BM @ 0.003	ND	ND
Chromium	ND	BM @ 0.01	0.02	0.03	BM @ 0.02	ND
Copper	0.01	0.01	0.03	0.02	0.01	0.04
Lead	BM @ 0.01	0.014	0.022	0.009	0.028	0.017

ND = Not detected.
BM = Below method detection limit.

TABLE 4-11 (Page 3 of 3)

SUMMARY OF MONITORING WELL SAMPLES

Combe Fill South Landfill

PARAMETER	S-1	S-2	S-3	S-4	S-5	S-6
DATE SAMPLED	9/4/85	9/5/85	8/29/85	9/4/85	8/28/85	8/28/85
METALS, ppm						
Mercury	ND	ND	BM @ 0.0002	ND	BM @ 0.0002	BM @ 0.0002
Nickel	ND	BM @ 0.01	0.02	0.03	ND	BM @ 0.009
Selenium	ND	ND	ND	ND	BM @ 0.005	ND
Silver	BM @ 0.01	ND	BM @ 0.009	BM @ 0.01	ND	ND
Thallium	BM @ 0.005	ND	BM @ 0.005	ND	ND	ND
Zinc	0.05	0.10	0.24	0.04	ND	0.04
MISCELLANEOUS, ppb						
Cyanides	ND	ND	ND	ND	ND	ND
Phenols	270	ND	ND	ND	ND	ND

ND = Not detected.
BM = Below method detection limit.

highest concentration of priority pollutants consisting primarily of volatile organics (1556 ppb). Shallow well S-1 is located downgradient of the fill area in the major groundwater flow path through the landfill (see Plate 7). As shown in Table 4-11, toluene accounts for almost 90% of this volatile organic concentration. Other volatile organics found in elevated concentrations in this well include benzene, 1,1-dichloroethane, and methylene chloride. No priority pollutant base/neutrals, pesticides/PCBs, or cyanides were detected in well S-1. Metals were measured in low concentrations with only copper and zinc being measured in concentrations above the method detection limit. Although no priority pollutant acid/phenolics were detected, total phenols in well S-1 were measured at 270 ppb. A variety of tentatively identified organics, particularly base/neutrals, were also detected in well S-1.

Well S-5, located at the headwaters of the West Branch of Trout Brook, is near the limit of the flow path of groundwater downgradient of the landfill (see Plate 7) and therefore has significantly lower concentrations of priority pollutants than well S-1. Concentrations of priority pollutant volatile and semi-volatile organics totaled 67 ppb, of which chloroform accounted for 85%. No priority pollutant acid/phenolics, pesticides/PCBs, cyanides, or phenols were measured in well S-5. Priority pollutant metals were also measured in well S-5 at lower concentrations than well S-1. Two former priority pollutant volatile organics (both freon compounds) were detected at a total concentration of 31 ppb, but the tentatively identified organic compounds noted in well S-1 were absent from well S-5. Overall, well S-5 had the second lowest concentration of priority pollutants of the six shallow monitoring wells sampled.

The second highest concentration of priority pollutants was measured in well S-3, located in the southeast corner of the fill near several leachate seeps. Groundwater in this area contributes flow to the West Branch of Trout Brook and is affected by the landfill. As compared to well S-1, which is also affected by the landfill, well S-3 had lower total concentrations, but a wider variety of priority pollutant volatile organics, and higher concentrations of metals. Concentrations of priority pollutant volatile organics in well S-3 totaled 270 ppb and consisted primarily of benzene (80.2 ppb), toluene (68.2 ppb) and 1,1-dichloroethane (51.4 ppb). Other priority pollutant volatile organics measured above the method detection limits included methylene chloride, chlorobenzene, trans-1-2-dichloroethylene, and trichloroethylene. Elevated concentrations (89.7 ppb) of the freon dichlorodifluoromethane (a non-priority pollutant) were also measured in well S-3. Two priority pollutant base/neutral extractable organics were also detected in low concentrations in well S-3: di-ethyl phthalate and naphthalene. Priority pollutant metals were generally measured at low concentrations with only zinc (at 0.24 ppm) showing any significant concentration. No priority pollutant acid/phenolic extractable organics, pesticides/PCBs, cyanides, or phenols were measured in well S-3. A variety of tentatively identified volatile and semi-volatile organic compounds further attest to the contamination of well S-3. The concentrations of sanitary constituents measured in well S-3 (see Table CC-4 in Appendix CC) are similar to those in the sampled leachate and further confirm the effect of the landfill on the upper aquifer in the vicinity of well S-3.

The third highest concentration of priority pollutants in the shallow aquifer was measured in well S-4 along the northeastern edge of the new fill, within the headwaters drainage area of the East Branch of Trout Brook. This well lies within a groundwater flow path impacted by the landfill (see Plate 7). Total priority pol-

lutant volatile organics in well S-4 were measured at a concentration of approximately 99 ppb. Of this total, chloroethane (62 ppb) and chlorobenzene (18.2 ppb) are of significance. Well S-4 contains low concentrations of priority pollutant base/neutral organics, with only 1-4-dichlorobenzene (10.1 ppb) and 1-2-dichlorobenzene (7.25 ppb) being measured above method detection limits. No priority pollutant pesticides/PCBs, cyanides, or phenols were detected in well S-4 and only one acid/phenolic organic was detected (below its method detection limit). Some tentatively identified volatile and semi-volatile organics were detected in well S-4 but in less variety and in lower concentrations than in either well S-1 or S-3. Similarly, concentrations of sanitary constituents measured in well S-4 were lower than in well S-3, although they were still indicative of landfill contamination.

Shallow well S-2 located along the northern edge of the property line near the old fill area and power line right-of-way had the fourth highest concentration of priority pollutants. The shallow groundwater in this area, along with surface water runoff, flows northeast away from the site toward the unnamed tributary near Schoolhouse Lane and is affected by the landfill (see Plate 7) Total priority pollutant volatiles in well S-2 were measured at approximately 37 ppb, of which chlorobenzene contributed 30.3 ppb. Well S-2 had the highest concentration of priority pollutant base/neutral organics at 60.2 ppb; of this base/neutral concentration, 1,4-dichlorobenzene and 1,2-dichlorobenzene accounted for 82%. Priority pollutant metals were detected in only low concentrations in well S-2, and no priority pollutant acid/phenolics, pesticides/PCBs, cyanides, or phenols were detected. Well S-2 also contained a number of tentatively identified volatile and semi-volatile organics.

The lowest concentrations of priority pollutants in the shallow groundwater aquifer were measured in well S-6. This well is located in a field 300 ft north of the landfill and is within the surface and groundwater drainage areas of Tanners Brook and is not affected by the landfill. Only priority pollutant volatiles (primarily methylene chloride) and metals were detected at low levels in well S-6, 6.9 ppb and 0.102 ppm, respectively. Well S-6 also showed a few tentatively identified organics.

One of the residential wells sampled as part of the potable well program is actually a spring tapping the shallow aquifer. The residents (No. 25) served by this well currently use bottled water for drinking. The chemical analysis of this well water (see Table CC-8 in Appendix CC) shows somewhat elevated concentrations of priority pollutants, particularly volatile organics. Chloroform (at 59 ppb) accounts for 97% of this organic contamination in this well. Chloroform at higher concentrations is also found in the landfill in well DW-4, which is upgradient of this residential well, and suggests the lateral movement of the contaminant from the landfill as shown in Plate 7.

4.2.5.2 Bedrock Aquifer. The deep monitoring wells and residential potable wells sampled during this study both tap the bedrock aquifer. The results of the chemical analyses of these samples and their implications regarding contaminant migration from the landfill are discussed in the following paragraphs.

4.2.5.2.1 Deep monitoring wells.

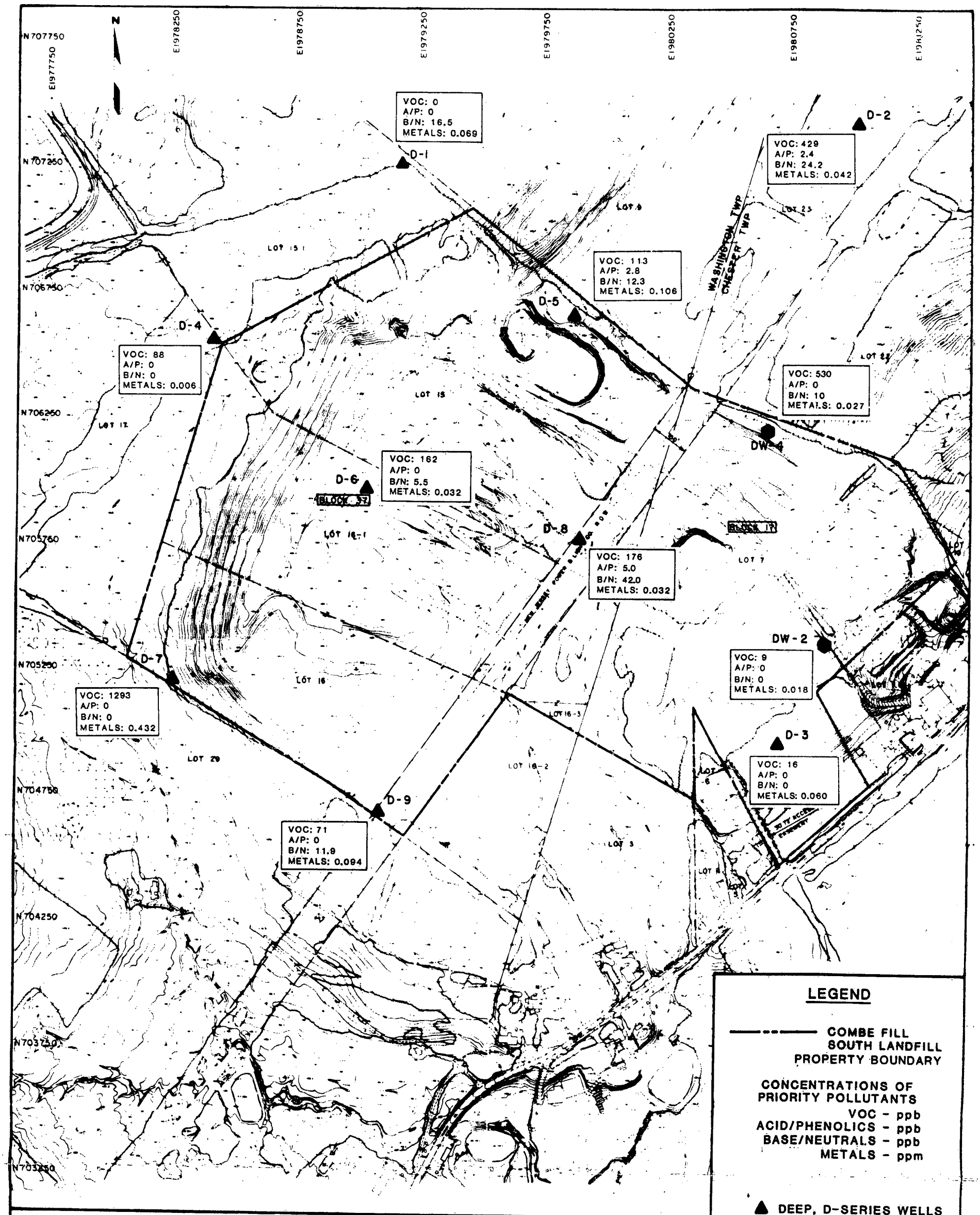
Remedial Investigation: Groundwater from each of the nine new deep monitoring wells and two previously installed deep wells was sampled once in late August/early September 1985. With the exception of well D-2, all these wells are located within 300

ft of the Combe Fill South property; well D-2 is located 1200 ft to the north and east of the landfill.

The priority pollutants measured in these deep monitoring wells during the RI study are summarized in Figure 4-11; Table 4-12 identifies the individual priority pollutant chemicals. These data have been adjusted on the basis of the chemical analyses of the field and trip blank samples that accompanied these deep well samples. (Since these QA/QC samples for the deep wells are the same as those described for the shallow wells, the data adjustments previously described for the shallow wells also apply to the deep wells.) Unadjusted chemistry data for these deep monitoring wells can be found in Table CC-4 of Appendix CC.

As shown in Figure 4-11, the greatest concentrations of priority pollutants appear to be clustered in a southwest/northeast corridor encompassing wells D-7, D-9, D-8, D-6, D-5, DW-4, and D-2. Significantly lower concentrations of contaminants are found in the other four monitoring wells. These findings are consistent with the groundwater flow pathways defined previously (see Plate 7).

Well D-7 had the highest concentration of priority pollutants, most of which were volatile organics. This well, located in the southwest corner of the landfill, is near the most contaminated shallow well (S-1) and lies in the downgradient direction of the groundwater flow pathway most affected by the landfill (see Plate 7). Toluene at a concentration of 1140 ppb accounted for 88% of the priority pollutant volatile organics measured in this well; benzene at a concentration of 66.4 ppb was the second most significant organic contaminant. Toluene and benzene occur in almost precisely the same concentrations



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CONCENTRATION OF
PRIORITY POLLUTANT ORGANICS AND
METALS IN DEEP
MONITORING WELLS

FIGURE 4-11

TABLE 4-12 (Page 1 of 2)

SUMMARY OF PRIORITY POLLUTANTS
DEEP MONITORING WELLS

Combe Fill South Landfill

PARAMETER	D-1	D-2	D-3	D-4	D-5	D-6	D-7	D-8	D-9	DW-2	DW-4
DATE SAMPLED	8/28/85	8/28/85	9/4/85	8/28/85	8/28/85	8/29/85	9/4/85	9/4/85	9/4/85	9/5/85	9/5/85
VOLATILES, ppb											
Benzene	ND	ND	ND	ND	16.9	39.1	66.4	31.5	18.6	ND	252
Chlorobenzene	ND	ND	ND	ND	ND	BM @ 6	9.88	10.8	ND	ND	BM @ 6
Chloroethane	ND	ND	ND	ND	ND	ND	22.5	74.3	BM @ 10	ND	ND
Chloroform	ND	209	ND	82.6	ND	ND	ND	ND	ND	ND	155
1,1-Dichloroethane	ND	6.41	ND	ND	10.6	BM @ 4.7	ND	14.8	30.2	ND	ND
1,2-Dichloroethane	ND	7.98	ND	ND	40.5	37.2	ND	11.2	4.54	ND	14.2
1,1-Dichloroethylene	ND	6.41	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	BM @ 6	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	34.2	11.7	ND	ND	ND
Methylene chloride[a]	5.92	176.07	16.0	ND	9.77	ND	20.0	18.8	12.6	9.3	20.6
Tetrachloroethylene	ND	14.3	ND	ND	6.89	BM @ 4.1	ND	ND	ND	ND	5.58
Toluene	ND	ND	ND	ND	ND	ND	1140	ND	ND	ND	ND
Trans-1,2-dichloroethylene	ND	ND	ND	5.40	25.8	47.5	ND	ND	ND	ND	17.5
Trichloroethylene	ND	8.34	ND	ND	2.72	26.0	ND	ND	ND	ND	56.8
Vinyl chloride	ND	ND	ND	ND	ND	BM @ 10	ND	ND	ND	ND	BM @ 10
ACID/PHENOLICS, ppb											
2,4-Dimethylphenol	ND	ND	ND	ND	ND	ND	ND	3.12	ND	ND	ND
2-Nitrophenol	ND	ND	ND	ND	ND	ND	ND	BM @ 3.7	ND	ND	ND
Phenol	ND	2.35	ND	ND	2.75	ND	ND	ND	ND	ND	ND
BASE/NEUTRALS, ppb											
Bis (2-chloroethyl) ether	ND	ND	ND	ND	ND	ND	ND	BM @ 5.9	ND	ND	ND
Bis (2-ethylhexyl) phthalate	BM @ 11	ND	ND	BM @ 10	ND	BM @ 11	ND	BM @ 10	BM @ 10	ND	ND
1,2-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	5.58	1.92	ND	ND
1,4-Dichlorobenzene	ND	BM @ 4.6	ND	ND	BM @ 4.5	ND	ND	14.2	ND	ND	ND
Di-ethyl phthalate	ND	ND	ND	ND	BM @ 10	ND	ND	BM @ 10	ND	ND	ND
Di-n-butyl phthalate	BM @ 11	ND	ND	BM @ 10	BM @ 10	ND	ND	BM @ 10	BM @ 10	ND	BM @ 10
Di-n-octyl phthalate	BM @ 11	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Isophorone	ND	21.9	ND	ND	ND	ND	ND	ND	ND	ND	ND
Naphthalene	ND	ND	ND	ND	ND	ND	ND	3.24	ND	ND	ND
N-nitrosodiphenylamine	ND	ND	ND	ND	ND	ND	ND	BM @ 2	ND	ND	ND

[a]Corrected based on analysis of QA/QC samples.
ND = Not detected.
BM = Below method detection limit.

TABLE 4-12 (Page 2 of 2)

SUMMARY OF PRIORITY POLLUTANTS
DEEP MONITORING WELLS

Combe Fill South Landfill

PARAMETER	D-1	D-2	D-3	D-4	D-5	D-6	D-7	D-8	D-9	DW-2	DW-4
DATE SAMPLED	8/28/85	8/28/85	9/4/85	8/28/85	8/28/85	8/29/85	9/4/85	9/4/85	9/4/85	9/5/85	9/5/85
PESTICIDES/PCBs, ppb	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
METALS, ppm											
Arsenic	ND	ND	ND	ND	BM @ 0.01	ND	ND	ND	ND	ND	ND
Beryllium	ND	ND	ND	ND	ND	BM @ 0.002	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	ND	ND	ND	ND	ND	ND	ND	ND	BM @ 0.01	BM @ 0.009	BM @ 0.009
Copper	0.04	0.007	0.03	BM @ 0.006	BM @ 0.006	BM @ 0.006	0.02	BM @ 0.009	BM @ 0.009	0.011	ND
Lead	0.009	BM @ 0.005	0.01	BM @ 0.005	0.008	0.008	0.007	BM @ 0.005	0.014	ND	ND
Mercury	BM @ 0.0002	0.0002	ND	BM @ 0.0002	BM @ 0.0002	BM @ 0.0002	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND	ND	0.02	ND	ND	ND	ND
Selenium	ND	BM @ 0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	BM @ 0.01	BM @ 0.01	ND	BM @ 0.005	BM @ 0.005
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	0.02	0.03	BM @ 0.04	ND	0.09	0.02	0.38	BM @ 0.04	0.07		
MISCELLANEOUS, ppb											
Cyanides	ND	29.5	ND	ND	ND	ND	ND	ND	ND	ND	ND
Phenols	ND	ND	ND	ND	ND	ND	428	ND	ND	ND	ND

ND = Not detected.
BM = Below method detection limit.

and proportions in well D-7 as they do in well S-1. Well D-7, like well S-1, also contained a number of tentatively identified organic compounds and had a high concentration of total phenols (428 ppb). Concentrations of sanitary constituents measured in well D-7 were the highest of any deep well analyzed and were similar to those in the leachate samples. These findings suggest downward movement of contaminants between the unconsolidated and bedrock water bearing zones in this portion of the landfill.

Well DW-4, located along the northern border of the Combe Fill South property near the old fill areas, had the second highest concentration of priority pollutants in deep monitoring wells and lies within a groundwater flow path downgradient of the landfill. Well DW-4 had concentrations of priority pollutants that were an order of magnitude higher than the nearby shallow well S-2, suggesting more vertical and less lateral movement of contaminated groundwater in this area of the landfill as compared to the southeast corner of the landfill. This may also suggest that contaminants from fill/waste may have been introduced directly into the bedrock; such would be the case if fill/waste had been placed directly on the bedrock. As previously described in Chapter 1, such practices apparently took place at Combe Fill South. The predominant priority pollutants in well DW-4 were benzene (252 ppb), chloroform (155 ppb), and trichloroethylene (56.8 ppb). No priority pollutant acid/phenolics, pesticides/PCBs, cyanides, or phenols were detected in well DW-4; only one base/neutral was detected, at its detection limit.

Groundwater in well D-2, 1200 ft to the north and east of the site, had the third highest concentration of priority pollutants in the deep monitoring wells and is located on the same

groundwater flow path as well DW-4. Chloroform (209 ppb), methylene chloride (176 ppb), and isophorone (21.9 ppb) accounted for most of the priority pollutant organic contamination in this well. Dichlorodifluoromethane (freon), a non-priority volatile organic, was also measured in this well at a concentration of 23.7 ppb. Cyanides and metals were measured in low concentrations but only a few tentatively identified semi-volatile organics were detected. Concentrations of sanitary constituents were low but elevated in comparison to concentrations measured in potable wells tapping this aquifer (see Section 4.2.6.2.2). The fact that well D-2 is the farthest monitoring well from the landfill (0.25 miles), yet is high in concentration of priority pollutants, suggests that there may be high directional permeability (such as along a fracture or set of fractures) between the landfill and this well. The fact that the constituents of concern in well D-2 are entirely different from those in D-7 at the other end of the "contamination corridor" supports the location and direction of the groundwater flow pathways shown in Plate 7.

The fourth and fifth highest concentrations of priority pollutants in deep monitoring wells were measured in wells D-8 and D-6, respectively. As seen in Figure 4-11, well D-6 is located in the approximate center of the new fill area and well D-8 is located along the eastern edge of the new fill area near the power line right-of-way. Well D-6 is located upgradient of wells D-7 and S-1, in the same groundwater flow path. Well D-8 is located next to shallow well S-4; both D-8 and S-4 lie in the same groundwater flow path. In both wells, priority pollutant volatile organics were the primary contaminants of concern: 176 ppb in well D-8 and 162 ppb in well D-6. Both wells contained a variety of priority pollutant organics with chloroethane (74 ppb) and trans-1,2-dichloroethylene (47.5 ppb)

having the highest concentrations in wells D-8 and D-6, respectively. Unlike well D-6, however, well D-8 also contained a variety of priority pollutant semi-volatile organic compounds, particularly 1,4-dichlorobenzene at 14.2 ppb. No pesticides/PCBs, cyanides, or phenols were detected in either well D-6 or well D-8. Priority pollutant metals were detected in both wells at low concentrations. Sanitary analyses of the groundwater showed more contamination in well D-8 than in well D-6, suggesting more vertical movement of contaminants in well D-8 than in well D-6. This conclusion is supported by the fact that in well D-6 a 10-ft silt/clay layer of very low permeability separates the fill/wash and the underlying bedrock, while in well D-8 a higher permeable saprolite lies above the bedrock. In addition, the concentration of benzene in well S-4 (the shallow well near well D-8) is almost the same as the concentration in the deeper aquifer tapped by well D-8, but the concentration of priority pollutant metals is higher in the shallow aquifer. These concentrations suggest a downward movement of the groundwater through the soil/saprolite into the bedrock aquifer accompanied by filtration or sorption of some contaminants (such as metals) but little retention of more soluble contaminants. At the same time, the higher total concentration of priority pollutant organics in the bedrock aquifer of well D-8, as compared to the shallow aquifer of well S-4, suggest a strong lateral movement of contamination in the bedrock aquifer from some more contaminated upgradient area.

Deep wells D-5 and D-9 appear to straddle the edges of the bedrock contamination corridor and are next in terms of overall priority pollutant contamination. Well D-5, although located on the landfill, is at the very edge (upgradient) of one of the groundwater flow channels and is not significantly affected by

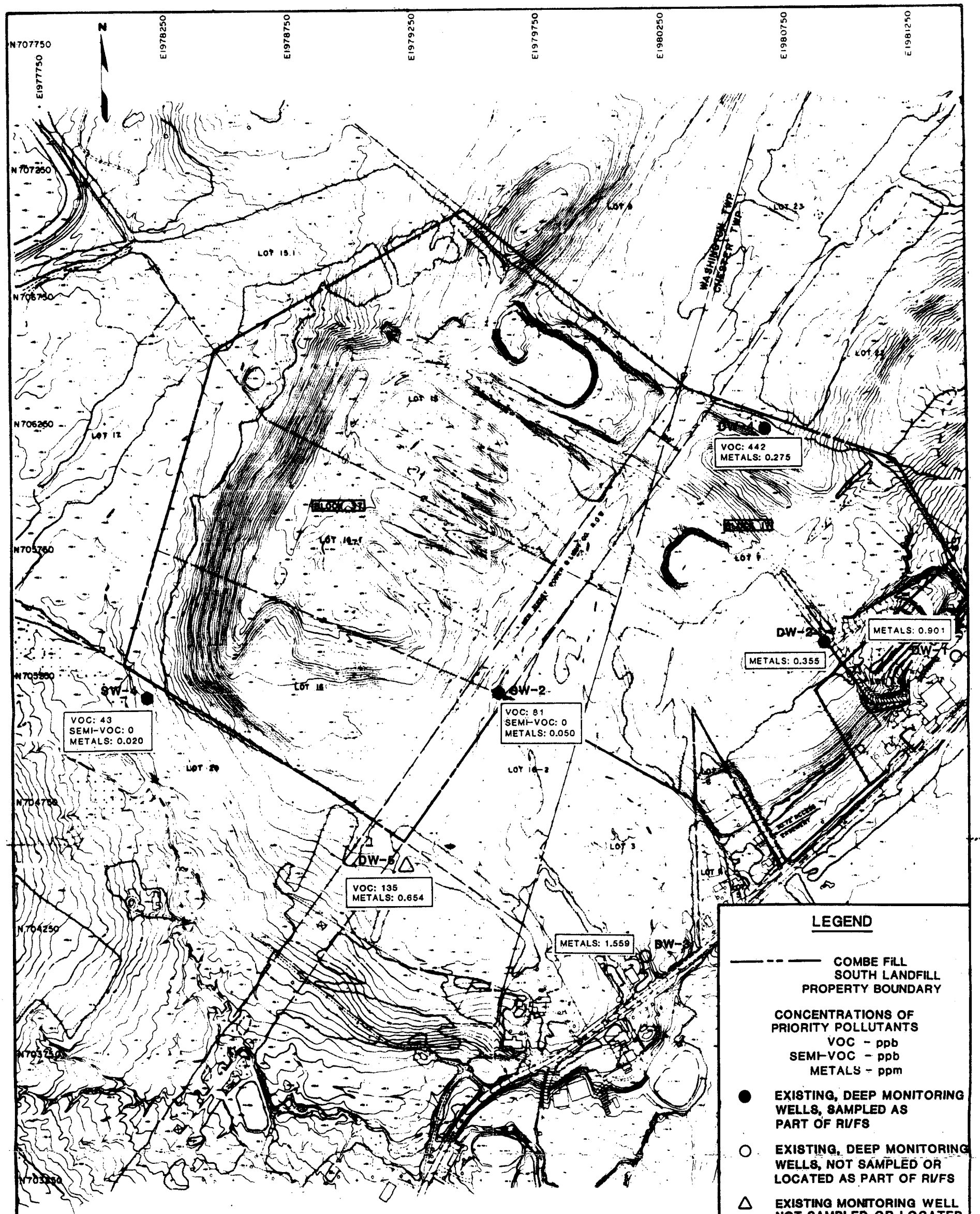
groundwater flows through the fill. On the other hand, well D-9 is located relatively far downgradient along another groundwater channel and may not yet be experiencing its full potential impact from movement of contaminants within the groundwater. Also, the body of sampling results shows that the chemicals are not uniformly distributed in the fill, either by species or concentrations. In both well D-5 and D-9 the contaminants of greatest concentration are volatile organics and the variety and type of organic compounds is similar in both wells. However, well D-9 also contains an elevated concentration (85 ppb) of the freon, dichlorodifluoromethane, a non-priority volatile organic. Similarly, high concentrations of this volatile organic are found in well S-3, the companion shallow well near well D-9. Concentrations of sanitary constituents in well D-9 are somewhat higher than those measured in well D-6 (in the fill itself). Since the shallow well S-3 has higher concentrations of all contaminants, including conventional sanitary constituents, than well D-9, vertical movement of groundwater appears to be of greater significance in this area of the landfill than lateral movement. Also, chemicals in this area may have been placed in soil/saprolite rather than on bedrock as occurs near well D-6.

Deep well D-4, to the north and west of the new fill near shallow well S-5, also borders the contamination corridor and is not significantly influenced by groundwaters from the landfill. It has somewhat elevated concentrations of chloroform (83 ppb) and low concentrations of trans-1,2-dichloroethylene (5.4 ppb). This and the other chemical constituents (both priority and non-priority) measured for well D-4 are similar to those measured for the nearby shallow well S-5 and suggest some contaminant movement from the shallow aquifer into the deep bedrock aquifer in this area of the landfill.

The three remaining deep monitoring wells, (D-1, D-3, and DW-2) had very low levels of priority pollutant organics (primarily methylene chloride, which may represent unidentified additional laboratory contaminant) and priority pollutant metals. They also had a few tentatively identified organics. Sanitary analyses of well D-3 show only minor amounts of conventional pollutants. Wells D-3 and DW-2 are in a groundwater pathway that encompasses only a small portion of the main fill where chemicals may not have been placed. Clearly, these three deep wells show little effect from any activities on the landfill. However, since both well DW-2 and well D-3 are located within one of the defined groundwater pathways from the landfill, they may experience some additional effects as contaminants move downgradient with the groundwater.

Previous Sampling: On-site sampling in the landfill was primarily conducted by the operators of the landfill from 1977 to the close of the landfill. During this time, from two to five wells were sampled for conventional sanitary landfill constituents, particularly metals. Often the well designations were changed without any explanatory maps or drawings, making interpretation of the data difficult. Table CC-5 in Appendix CC summarizes this well data based on certain assumptions regarding well sample locations as discussed in Appendix C.

In 1981 URWA and NJDEP resampled two of the wells (DW-4, a deep well and DW-5, actually a shallow well that was not relocated during this RI) and installed and sampled two new shallow wells (SW-1 and SW-2 consisting of a pit fitted with PVC piping). Groundwater samples from these wells were analyzed at that time for priority pollutants, metals, and conventional sanitary constituents. This data is also summarized in Table CC-5. Figure 4-12 shows the approximate location of the previous monitoring



LEGEND

COMBE FILL SOUTH LANDFILL PROPERTY BOUNDARY

CONCENTRATIONS OF PRIORITY POLLUTANTS
VOC - ppb
SEMI-VOC - ppb
METALS - ppm

● EXISTING, DEEP MONITORING WELLS, SAMPLED AS PART OF RI/FS

○ EXISTING, DEEP MONITORING WELLS, NOT SAMPLED OR LOCATED AS PART OF RI/FS

△ EXISTING MONITORING WELL NOT SAMPLED OR LOCATED AS PART OF RI/FS PROBABLY SCREENED IN SHALLOW AQUIFER

⬢ EXISTING SHALLOW MONITORING WELLS NOT SAMPLED AS PART OF RI/FS

400 0 400
Scale in feet

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CONCENTRATION OF
PRIORITY POLLUTANT ORGANICS AND
METALS IN PREVIOUSLY SAMPLED
MONITORING WELLS

FIGURE 4-12

well sites and summarizes the chemistry for each well. As explained in Chapter 1, only two of the previously established monitoring wells (DW-2 and DW-4) were sampled during this investigation.

Comparison of the recent RI data to these previous sampling data shows comparable concentrations of volatile organics in 1981 and 1985 for well DW-4 but generally lower concentrations of metals in groundwater samples taken in 1985 than in previous samplings. However, elevated concentrations of metals appear to be a characteristic of all samples taken by the landfill operators and may reflect some analytical or sampling interferences.

The old shallow well SW-2 had concentrations of priority pollutants similar to those measured at nearby well S-4 during this RI. Old well DW-5 had higher concentrations of all priority pollutants in the 1981 survey than during the RI sampling of new shallow well S-3 located nearby. Finally, well SW-4, located near the new shallow well S-1, had significantly lower concentrations of all priority pollutants in 1981 as compared to well S-1 in 1985. These differences in chemical concentrations may reflect actual changes in landfill reactions from 1981 to 1985, such as a shift in the location or amount of physical/chemical/biological activity. These differences in a chemical concentration may reflect differences in well construction, or field sampling and laboratory error.

4.2.5.2.2 Potable wells.

Remedial Investigation. Twenty-five private potable wells within approximately 0.5 miles of the landfill were sampled in August and September 1985. Twenty-four of these wells tap the

bedrock aquifer and one (resident No.25) is a spring tapping the upper saprolite aquifer. Appendix EE presents pertinent data, i.e., drillers name, depth, SWL, etc on each of these potable wells. The results of the chemical analyses of these samples are summarized in Figure 4-13. The data summarized in this figure have been adjusted to reflect the analysis of field and trip blank samples taken during these surveys, which revealed low levels of contamination by methylene chloride (<21 ppb), 1,1,1-trichloroethane (BM @ 3.8 ppb), and bis(2-ethylhexyl)phthalate (BM @ 10 ppb). Unadjusted data are presented in Tables CC-6 through CC-9 in Appendix CC. These appendix tables of potable well data are grouped into four categories on the basis of their location from the landfill:

- Schoolhouse Lane and northeast of Schoolhouse Lane on Parker Road (northeast of the landfill)
- Parker Road between Trout Brook and Schoolhouse Lane (east and south of landfill)
- South of Tanners Brook (north and west of landfill)
- North of Tanners Brook and West of Trout Brook (farther north and west of landfill)

Potable wells to the northwest of the landfill along East Valley Brook Road near Tanners Brook had no detectable concentrations of the volatile organics typically found in the deep and shallow groundwater monitoring wells on and near the landfill. Concentrations of the one base/neutral (di-n-butyl phthalate) found in two of these potable wells were only at the method detection limit of the compound and may represent undetermined field or laboratory contamination. No acid/phenolics, pesticides/PCBs, cyanides, or phenols were detected in any of these samples. Concentrations of metals were generally low, with copper having the highest overall concentration (up

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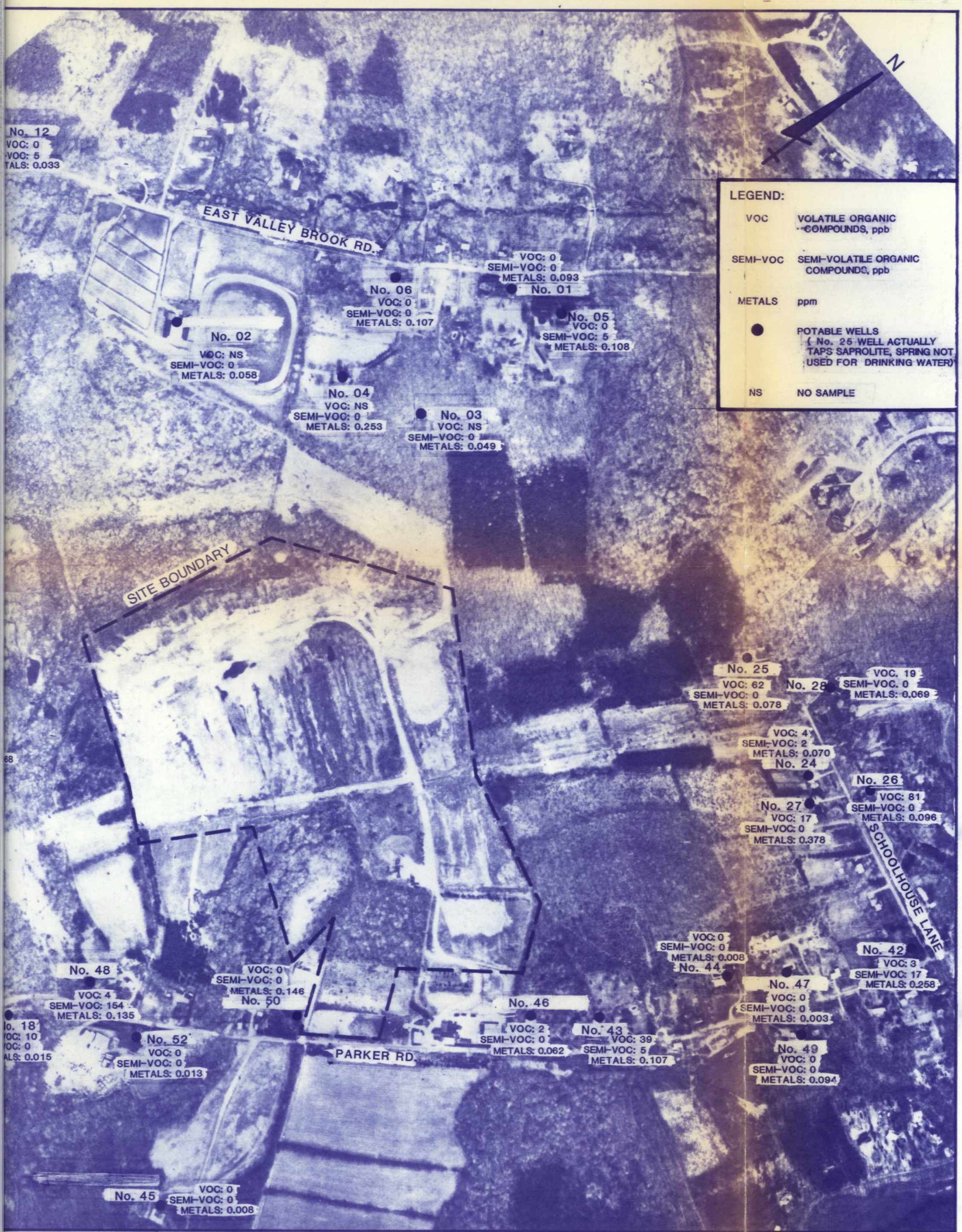
500 0

CONCENTRATION OF PRIORITY POLLUTANT ORGANICS AND METALS IN POTABLE WELL SAMPLES

FIGURE 4-13



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500 0 500 1000 FEET
SCALE APPROX.

CONCENTRATION OF PRIORITY POLLUTANT ORGANICS AND METALS IN POTABLE WELL SAMPLES

FIGURE 4-13

to 0.23 ppm), probably reflective of copper piping in the household plumbing system. Sanitary analyses performed on three of these samples met all NJ criteria for class GW-2 (see Chapter 8) public groundwater drinking water supplies and show no apparent influence from the landfill. The overall results of these chemical analyses support the hydrogeologic conclusion that groundwater from the landfill does not recharge this area near Tanners Brook.

As seen in Figure 4-13, of the seven wells (resident numbers 17, 18, 45, 48, 50, 51 and 52) located to the south of the landfill near Trout Brook along Parker Road, only one (resident No. 48) shows elevated concentrations of priority pollutant organics. This potable well had a total priority pollutant volatile concentration of 4 ppb and a concentration of 154 ppb of pentachlorophenol. Other chemicals, including metals and sanitary constituents, measured in the resident No. 48 well were low and meet GW-2 drinking water criteria. Because the expected landfill contaminants, i.e., priority pollutant volatiles, were barely above detectable limits in this well and because no other nearby residential well or RI monitoring well showed any similar concentration of pentachlorophenol, it is unlikely that landfill-contaminated groundwater is the source of this priority pollutant. Pentachlorophenol was only found on the landfill in soil samples, at concentrations below its method detection limit, and as a contaminant in field blanks. Commonly used as a wood preservative, the source of the pentachlorophenol may therefore be on the resident No. 48 property itself.

The remaining six private wells in the vicinity of the resident No. 48 well show no apparent contamination from the landfill as determined by the analysis of the priority pollutants.

Another six potable wells were sampled along Parker Road and the intersection of Parker Road and Schoolhouse Lane to the north and east of the landfill. Three of these wells (resident numbers 44, 47 and 49) showed no concentration of priority pollutant organics and only low concentrations of metals, primarily copper and lead that may be attributed to well construction and plumbing materials. Two residential wells, No. 42 and 46, have low concentrations of priority pollutant volatiles (2 ppb of chloroform and 3 ppb of methylene chloride, respectively) in addition to low concentration of copper and lead. These findings are in agreement with the groundwater flow paths shown on Plate 7, which show that a relatively small area of the landfill contributes groundwater flow to these wells.

The resident No. 43 well, located 500 ft north of the resident No. 46 well on Parker Road, had elevated concentrations of trichloroethylene (TCE) at 37 ppb and di-n-butyl phthalate at its detection limit, but no other elevated concentrations of priority pollutants; the low levels of copper and lead found in this well are again probably associated with the household plumbing. Although TCE is a contaminant associated with the landfill and is found at low, but elevated concentrations (57 ppb) in well DW-4, 1300 ft west of the resident No. 43 well, the groundwater flow pathways (Plate 7) from the landfill suggest that the landfill may not be the source of this contamination because the slightly upgradient resident No. 46 well revealed no TCE. Nevertheless, without further evidence, it is prudent to assume at this time that the landfill is the source for this contamination.

The remaining five potable wells sampled during this RI are located along the western half of Schoolhouse Lane and are about

2200 ft north of the landfill. One well (resident No. 25) is actually a spring tapping the saprolite aquifer and has been discussed previously. The four remaining wells (resident numbers 24, 26, 27 and 28) all tap the bedrock aquifer. Three of these wells show low (4 to 19 ppb) concentrations of priority pollutant volatile organics with chloroform (up to 12 ppb) and 1,2-dichloroethane (up to 19 ppb) as the main individual pollutants. The resident No. 26 well had elevated concentrations of priority pollutant volatile organics (81 ppb) consisting primarily of chloroform (70 ppb) and tetrachloroethylene (6 ppb). All three of these individual priority pollutant volatiles were also found in monitoring well DW-4 located upgradient in the groundwater flow path from the landfill leading to these domestic wells. Therefore, it is likely that the contamination in these wells emanates from the landfill.

Several pieces of information, however, also suggest that there may be another source or sources of contamination for the wells at the end of Schoolhouse Lane including:

- The resident No. 26 well, having the highest concentrations of priority pollutants, is located to the north (downgradient) of both resident numbers 24 and 27 wells, which both have much lower concentrations of priority pollutants.
- Although within one of the groundwater flow pathways from the landfill described in Plate 7, these wells also receive groundwater flow from the wooded area north of the landfill and from the NJP&L right-of-way located northwest of the private wells.
- Finally, the shallow residential well No. 25 is also contaminated with chloroform but neither the shallow well S-2 nor the leachate seep L-1 located upgradient of the resident No. 25 well contain chloroform. This suggests the possibility of another source of chloroform contamination in the resident No. 25 well that may also be impacting the resident No. 26 well.

Without additional evidence, however, it is prudent to assume that the landfill contributes to the pollution in the wells at the end of Schoolhouse Lane.

Previous Investigations. The results of previous samplings of residentials wells in the Combe Fill South landfill area are summarized in Tables CC-10 through CC-15 in Appendix CC. These data have not been adjusted to reflect any field or laboratory contamination.

Previous samplings of residentials wells along Tanners Brook to the northwest of the landfill showed low concentrations of priority pollutant organics, unlike the "not detected" results obtained during the RI. These low concentrations (<23 ppb) of total volatiles may reflect uncorrected field and laboratory contamination because several samples contained measurable quantities of methylene chloride and 1,1,1-trichloroethane, two possible laboratory contaminants. Since groundwater from the landfill apparently does not flow toward Tanners Brook (see Plate 7), it is likely that residential well contaminants measured by previous samplings are reflective of other sources of contamination in the vicinity of East Valley Brook Road and Tanners Brook.

Except for one previous sample, at location No. 45, all previous analyses of residential wells located to the southeast of the landfill on Parker Road compare well with the findings of the RI, i.e., there is no apparent impact on these wells from landfill-contaminated groundwater. The only previous sample of the well at location No. 45 had elevated chloroform concentrations (40 ppb) that were not confirmed by the sampling done during the RI. On the other hand, previous samplings of

resident No. 48 well do not show any elevated concentrations of the pentachlorophenol measured during the RI, but do confirm low levels of other priority pollutant organics.

Previous samplings of other residential wells on Parker Road and the eastern end of Schoolhouse Lane to the northeast of the landfill are in general agreement with the findings of the RI; i.e., little if any contamination by the landfill. The No. 43 residence had not been sampled previously so no comparison was available for the elevated trichloroethylene concentrations found during the RI.

Previous residential well samples along the western end of Schoolhouse Lane generally show somewhat higher concentrations of priority pollutants than those taken during the RI, but they do show similar constituents of concern, primarily chloroform. The higher concentrations of contaminants measured previously may reflect uncorrected field and laboratory contamination (methylene chloride was often found in elevated concentrations) or they may reflect more active or concentrated leachate production and more groundwater flow in previous years that had more normal rainfall conditions.

4.2.6 Contaminant Migration in Groundwaters from the Landfill

Of the priority pollutant contaminants in groundwater, volatile organics are the most mobile and therefore the most useful and sensitive gauges of landfill-oriented contamination. Based on the groundwater flow paths shown in Plate 7 and the concentrations of priority pollutant volatiles measured in groundwater on and near the landfill during this RI, contaminant concentration contours of 100 ppb and 1000 ppb of total volatiles have been developed for the upper saprolite and lower bedrock aquifers. These concentration

△ from "plumes"

plumes are shown in Figures 4-14 and 4-15, respectively. Priority pollutant volatiles measured in leachate during the RI were considered to be reflective of the upper aquifer and were included as part of the data base for delineating the concentration plumes in the upper aquifer. The concentration contours are best-estimates only and are intended to show only overall chemical contamination on-site and the trends of chemical migration from the site, not individual concentrations or locations.

As seen in Figure 4-14, a small plume of volatile organic chemicals at a concentration of 1000 ppb or more currently occurs in the southwestern portion of the landfill around monitoring well S-1 and leachate seeps L-8 and L-7. This area of contamination has the NE/SW orientation previously described as being the directions of greatest groundwater flow. A similar orientation is apparent for the 100-ppb concentration contour except that the 100-ppb contour encompasses almost the entire width and length of the site. In addition, a smaller width tongue of this 100-ppb concentration contour extends about 1000 ft beyond the site boundary northeast towards Schoolhouse Lane. This tongue is located in the approximate area of the number 6 groundwater flow path shown in Plate 7.

Contaminant concentration contours of priority pollutant volatile organics in the bedrock aquifer are shown in Figure 4-15. Although the general shapes of the concentration plumes in the bedrock aquifer are similar to those in the saprolite aquifer, the bedrock aquifer is shown as having a broader and longer tongue of the 100 ppb contamination contour moving northeast towards Schoolhouse Lane, and a slightly less advanced edge of the 100-ppb contour near Trout Brook and Parker Road. This longer tongue of contamination may be due to faster movement of contaminants in bedrock fractures than in the saprolite in this area.

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500

CONCENTRATION OF TOTAL PRIORITY POLLUTANT VOLATILE ORGANICS WITHIN THE SAPROLITE AND UNCONSOLIDATED MATERIAL AQUIFER -- FALL 1985

FIGURE 4

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500 0 500 1000 FEET
SCALE APPROX.

CONCENTRATION OF TOTAL PRIORITY POLLUTANT VOLATILE ORGANICS WITHIN THE SAPROLITE AND UNCONSOLIDATED MATERIAL AQUIFER -- FALL 1985

FIGURE **4-14**

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The contaminant concentration contours in both the saprolite and bedrock aquifers are shown in Figures 4-14 and 4-15 and extend to, but not beyond (i.e. south and west) of the West Branch of Trout Brook. Hydrogeological testing and groundwater table measurements suggest that the West Branch of Trout Brook acts as a hydrological barrier to further groundwater flow (and associated contamination) toward the southwest in the saprolite (upper) aquifer. Therefore, further movement of contaminants in the upper aquifer directly southwest across the West Branch of Trout Brook is not expected ~~in the future.~~ Chemical analyses, made during this investigation of residential well No. 51, located in the deeper bedrock aquifer to the south of the West Branch of Trout Brook, suggest that contamination in the bedrock aquifer has not moved past (south and west) of the brook. However, the possibility exists that contaminants may move in fractures in the bedrock in the southwest direction beyond the brook in the future.

The tongue of contamination in the northeast is expected to continue to migrate in the direction of the major groundwater flow path (No. 6) to the northeast across Schoolhouse Lane and to the unnamed tributary to the north of the site. At that point, the unnamed tributary may function as a barrier to further migration in the saprolite in a manner similar to that of the West Branch of Trout Brook; however no data is available to further substantiate this hypothesis.

Finally, the contamination may spread generally eastward along the other groundwater flow paths leaving the site as shown in Plate 7. Although these groundwater flow paths carry less groundwater flow than the two paths to the northeast (No. 6) and southwest (No. 1), they do intercept the waste area and are capable of moving contaminants off-site.

CHAPTER 5

SURFACE WATER AND SEDIMENTS INVESTIGATION

5.1 INTRODUCTION

The potential surface water pathways of contamination from the landfill include leachate seeps and direct surface runoff. Leachate seeps are formed when rainfall that has infiltrated and percolated through the fill re-emerges at the land surface, generally at the toe or base of the fill. Leachate may also move down the soil column into underlying soils and into bedrock. Leachate flow and location will depend on such factors as the permeability of the soils, height of the groundwater table, extent of saturation in the unsaturated zone, etc. Leachate may reinfiltrate the soil as the flow moves downslope or may enter nearby surface waters such as streams, wetlands, or other standing water bodies. Leachate and its relationship with groundwater are discussed in detail in Chapter 4 as is the quantity of groundwater discharge to surface waters.

The amount and direction of flow from direct surface runoff is dependent on such factors as topography, the amount of rainfall at the site, the permeability of the surface materials, and the nature of the vegetative cover. Some runoff may infiltrate the soil as it moves downgradient but most will enter surface waters such as streams, wetlands, or standing water bodies. These surface waters therefore become secondary pathways for the spread of contaminants from the landfill.

Field investigations at and near the Combe Fill South landfill were conducted to determine the magnitude and extent of direct contaminant migration via leachate and indirect contaminant migration via

surface runoff and streams. Sample sites and methodologies are discussed in Section 1.3 of this report and in the FSP.

5.2 LEACHATE SEEPS AND SEDIMENT

Below normal rainfall from 1984 into 1985 resulted in substantially reduced leachate seep flow. As a result, despite two sampling attempts to obtain water samples from the leachate seep sites, only six of the originally planned eight sampling sites (L-1, L-2, L-3, L-6, L-7, and L-8) had sufficient flow by early October 1985 to permit leachate seep sampling. Sediment (i.e., soil) samples at the point of emergence of all eight seeps were obtained.

5.2.1 Leachate Quantity

The total volume of leachate at the landfill, although somewhat dependent on the moisture content of the garbage itself, varies primarily as a function of rainfall and is equivalent to the volume of groundwater created by rainfall infiltration. Under average rainfall conditions, the total volume of leachate/groundwater would therefore be about 135,000 gpd (see Chapter 4). Depending on the degree of saturation of the soils (or degree of mounding of groundwater within the fill), which in turn is dependent on antecedent rainfall conditions, some of the leachate reemerges as leachate seeps. As described in Chapter 4, leachate seeps occur at a landfill because compaction of the garbage and soil lifts results in lower permeabilities than the original soil/saprolite, creating a mounding of the groundwater above the bedrock and breakout of leachate seeps at the intersection of the groundwater mound and the landfill surface. During 1984, for example, when the landfill was originally evaluated for the location of leachate sampling sites, numerous seeps occurred along the fill borders. By mid-1985 after

several months of below-average rainfall, most of these seeps were no longer flowing.

5.2.2 Leachate Quality

5.2.2.1 Field Investigation Results. Sampling and analysis of leachate seeps at their point of emergence provides not only an estimate of the quality of leachate entering surface waters but also an estimate of the quality of leachate entering the shallow and deeper groundwater aquifers. Analysis of soil samples gives a historical or composite view of leachate quality, rather than the instantaneous view given by the water sample. However, this view emphasizes adsorptive rather than soluble chemicals. Sampling and analysis of soils/sediments at leachate seep sites also provides additional information on the nature, level, and extent of surface soil contamination, and an indication of the nature and extent of contaminants released into the air during evaporation as the leachate emerges from the ground.

The results of the chemical analysis of the leachate seep and soil/sediment samples taken for this RI/FS are summarized in Appendix CC, Tables CC-16 and CC-17, respectively. The daily QA/QC analytical sample data associated with these leachate samples are summarized in Appendix CC, Tables CC-24 and CC-25 for water and soil matrices, respectively.

Table 5-1 summarizes the total concentration of priority pollutants within seven priority pollutant categories including volatile organics, acid/phenolic extractable organics, base/neutral extractable organics, pesticides/PCBs, metals, total cyanides, and total phenols for each leachate seep. Figure 5-1 shows the total priority pollutant volatiles, semi-volatiles (acid/phenolics, base/neutrals, and pesticides/PCBs), metals, cyanides, and phenols at each

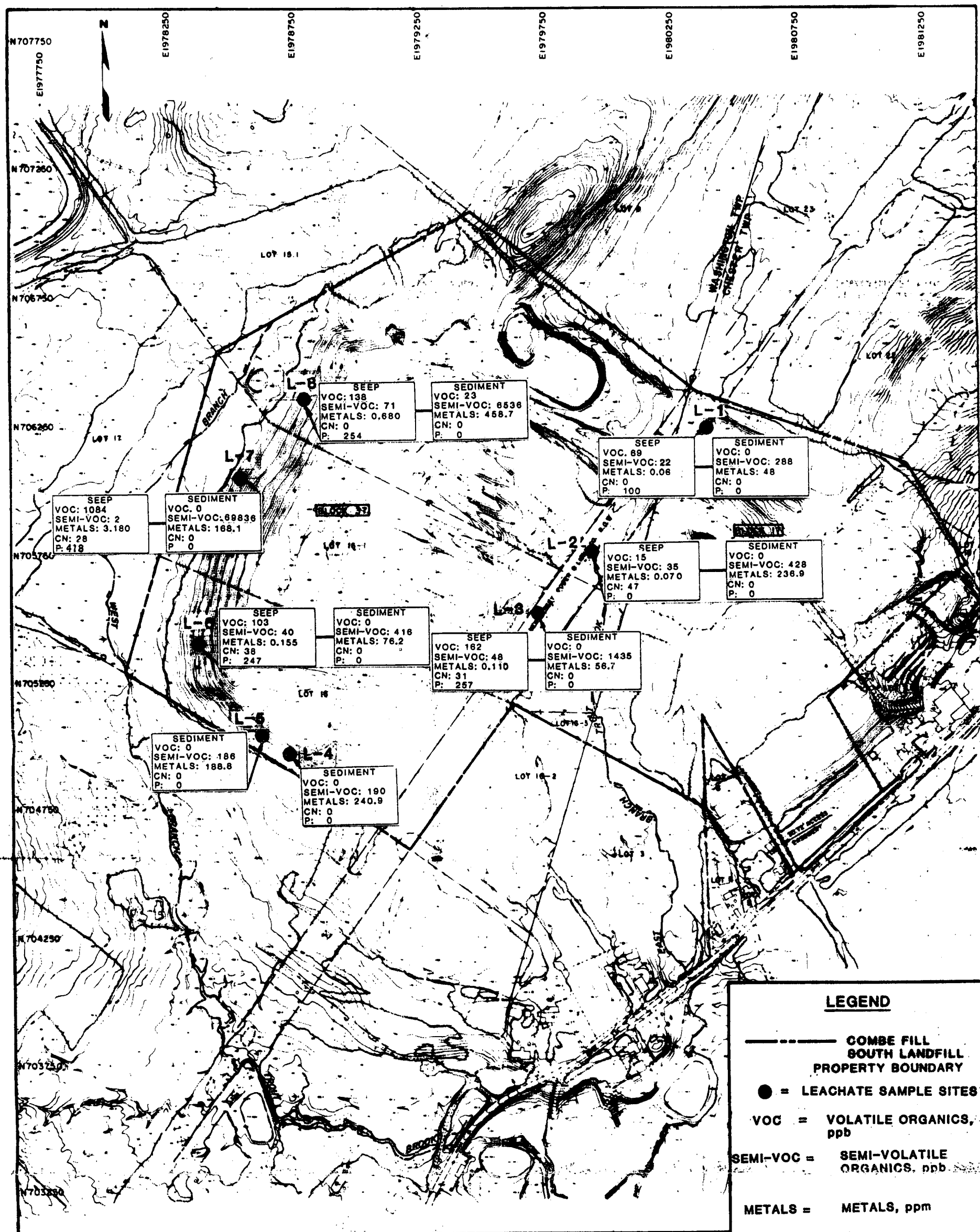
TABLE 5-1

LEACHATE SEEP QUALITY SUMMARY[a,b]

Combe Fill South Landfill

PRIORITY POLLUTANT CONTAMINANTS	LEACHATE SEEP					
	L-1	L-2	L-3	L-6	L-7	L-8
Volatiles, ppb	69	15	162[c]	103[c]	1084[c]	137[c]
Acid/Phenolics, ppb	3	1	0	7	0	0
Base/Neutrals, ppb	19	34	48	33	2	71
Pesticides/PCBs, ppb	0	0	0	0	0	0
Metals, ppm	0.064	0.070	0.110	0.155	3.180	0.680
Cyanides, ppb	0	47	31	38	28	0
Phenols, ppb	100	0	257	247	418	254

[a]Statistical calculations assume BM = 1/2 detection limit and ND = 0.
[b]Concentrations adjusted in accordance with QA/QC review.
[c]Average of data from 13 August 1985 and 17 October 1985.



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SUMMARY OF PRIORITY POLLUTANTS
AT LEACHATE SAMPLING LOCATIONS

FIGURE 5-1

sampled seep site. (Figure 5-1 also summarizes the soil/sediment quality data, discussed below after the seep quality.)

Seep L-7, located on the steep western edge of the new fill area, had the highest total concentration of volatiles (1084 ppb), metals (3.18 ppm), and phenols (418 ppb), and visually appeared to be the most contaminated. Seeps L-8 and L-3 were the next most highly contaminated, with L-8 having the highest concentration of base/neutral organics (71 ppb) of any sample. Seep L-8 is located just to the northeast of L-7 along the same western edge of the new fill. Seep L-3 is located near the power line right-of-way to the east of the new fill.

Seep L-6, just to the south of L-7, was fourth highest in total chemical concentration and had the highest concentration of acid/phenolics. Seep L-1, located on the northern edge of the property near the old fill area, had the largest flow rate and was flowing during the generally dry period in August 1985, but only ranked fifth in total concentrations of contaminants. Seep L-2, just to the northeast of L-3 along the right-of-way at the eastern edge of the new fill, had the lowest concentration of contaminants in general but had the highest concentration of total cyanides (47 ppb). Seeps L-4 and L-5 were not sampled due to insufficient flow in 1985.

The data summarized in Table 5-1 and Figure 5-1 have been adjusted to reflect the results of the field and trip blank quality control samples taken on the two leachate sample days. On 13 August 1985 no measurable quantities (i.e., >BM) were found in either the field or trip blank samples. However on 17 October 1985, methylene chloride was detected at concentrations of 3.5 and 3.82 ppb in the trip and field blanks, respectively; phenol was detected at a concentration of 7.49 ppb in the field blank, and butyl benzyl phthalate was

detected at a concentration of 17.2 ppb in the field blank. The methylene chloride is probably a laboratory contaminant (based on past LMS experience), while the phenol and butyl benzyl phthalate may be contaminants associated with field sampling, preparation, or cleaning procedures. In all cases, concentrations of contaminants in the QA/QC samples have been subtracted from the data presented in Appendix CC prior to summation in Figure 5-1 and Table 5-1. In these as well as all statistical presentations of data, a value of one-half the detection level is used where concentrations are measured as BM (below method detection limit) and a value of zero is used for ND (not detected). These assumptions may overemphasize the magnitude of the concentration of contaminants if the actual BM value is closer to zero.

The results of the chemical analyses of priority pollutants for the soil/sediment samples taken at these same leachate seep locations are summarized in Table 5-2. Data in this table have also been adjusted to reflect the QA/QC review of the associated field and trip blanks that showed some contamination by methylene chloride, bis(2-ethylhexyl)phthalate, and several metals, particularly cadmium, chromium, and zinc. Unadjusted data are presented in Appendix CC for these leachate soil/sediment samples. Figure 5-1 summarizes these data on the site map.

As expected, the results of these analyses indicate that the less volatile, less soluble contaminants, and those that are adsorbed onto soil particles or form insoluble complexes are found in the greatest concentrations in these soils/sediments. No acid/phenolics, pesticides, PCBs, cyanides, or phenols were measured in any sample, and volatiles were found at only one site (L-8) at relatively low concentrations. Base/neutral extractable organics and metals were, however, found at each sample site. Bis(2-ethylhexyl)phthalate occurred at each sample site, with L-8 having the

TABLE 5-2

LEACHATE SOIL/SEDIMENT QUALITY SUMMARY[a,b]

Combe Fill South Landfill

PRIORITY POLLUTANT CONTAMINANTS	LEACHATE SEEP							
	L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8
Volatiles, ppb	0	0	0	0	0	0	0	23
Acid/Phenolics, ppb	0	0	0	0	0	0	0	0
Base/Neutrals, ppb	288	428	1435	190	186	416	69,836	6536
Pesticides/PCBs, ppb	0	0	0	0	0	0	0	0
Metals, ppm	48.0	236.9	56.7	240.9	188.8	76.2	168.1	458.7
Cyanides, ppb	0	0	0	0	0	0	0	0
Phenols, ppb	0	0	0	0	0	0	0	0

[a]Statistical calculations assume BM = 1/2 detection limit and ND = 0.
[b]Concentrations adjusted in accordance with QA/QC review.

highest concentration, 6536 ppb. Site L-8 also had the highest concentration of metals (458.7 ppm), with zinc, arsenic, and copper occurring in the highest concentrations at each site. The soil/sediments of L-7 had the highest total base/neutral concentration of chemicals because of the high concentration of butyl benzene phthalate (68,000 ppb); this compound was, however, not detected at any other leachate soil/sediment site.

Chemistry analyses of soils in the background field (Table 4-3, Chapter 4) suggest that concentrations of priority pollutant base/neutrals up to 350 ppb and concentrations of priority pollutant metals up to 100 ppm are normal for the soils in the vicinity and are not reflective of landfill contamination. Based on these background concentrations, the most contaminated leachate soils are associated with seeps L-7 and L-8, followed by soils associated with seep L-3. Soils associated with seeps L-2, L-4, L-5, and L-6 have minor, but elevated concentration of either or both the base/neutrals and metals as compared to background soils. The soils of leachate seep L-1 show no elevated concentrations of priority pollutant as compared to the background soils.

In addition to the priority pollutants discussed above, a number of other organic compounds were quantified or tentatively identified during sample analysis; they are summarized in Appendix CC, Tables CC-16 and CC-17 for leachate seeps and their associated soils/sediments, respectively. In the leachate seep samples 10 volatile compounds, 15 acid/phenolic compounds, and 27 base/neutral compounds were tentatively identified along with numerous other unidentified constituents. The number and variety of the chemicals found in these seep samples affirm the contamination of the landfill leachate. In the leachate soil/sediment samples two volatile organic compounds and six semi-volatile organic compounds were tentatively identified, in addition to numerous other unidentified compounds.

Four of the 1985 leachate seep samples were also analyzed for conventional sanitary constituents. A summary of the average and range of these sanitary constituents at Combe Fill South is presented in Table 5-3 along with the median and range of the concentrations of these constituents in typical municipal solid waste leachate. The leachate from Combe Fill South landfill is generally comparable to the leachate from a typical municipal landfill.

5.2.2.2. Previous Sampling Results. Sampling of leachate seeps had been previously conducted once in March 1981 on one area of the landfill and once in February 1984 on two sites at the landfill. The results of the chemical analysis of these seep samples are presented in Appendix CC, Table CC-18, and the priority pollutant concentrations are summarized in Figure 5-2. The locations of these previously sampled locations were based on notes and sketches available with the data and are approximations only. Previously sampled stations I and Y are located in the vicinity of RI stations L-6 and L-7, and the 1984 sampling station X is in the vicinity of the RI station L-2.

The range of concentrations of priority pollutants analyzed in the 1981 and 1984 seep sampling is within the range of concentrations found on-site during the 1985 field investigations for this RI. The average concentration of volatile organics and metals is however higher in 1981 and 1984 than in 1985 due primarily to differences in the concentrations of contaminants in the vicinity of L-2 (X in the 1984 sampling) and L-3. This area had greater diversity and higher concentrations of volatile organics and metals in 1984 than in 1985. In 1981, 1984, and 1985 the most active and generally most contaminated leachate seep area was at the western edge of the new landfill area (near L-7 and L-6).

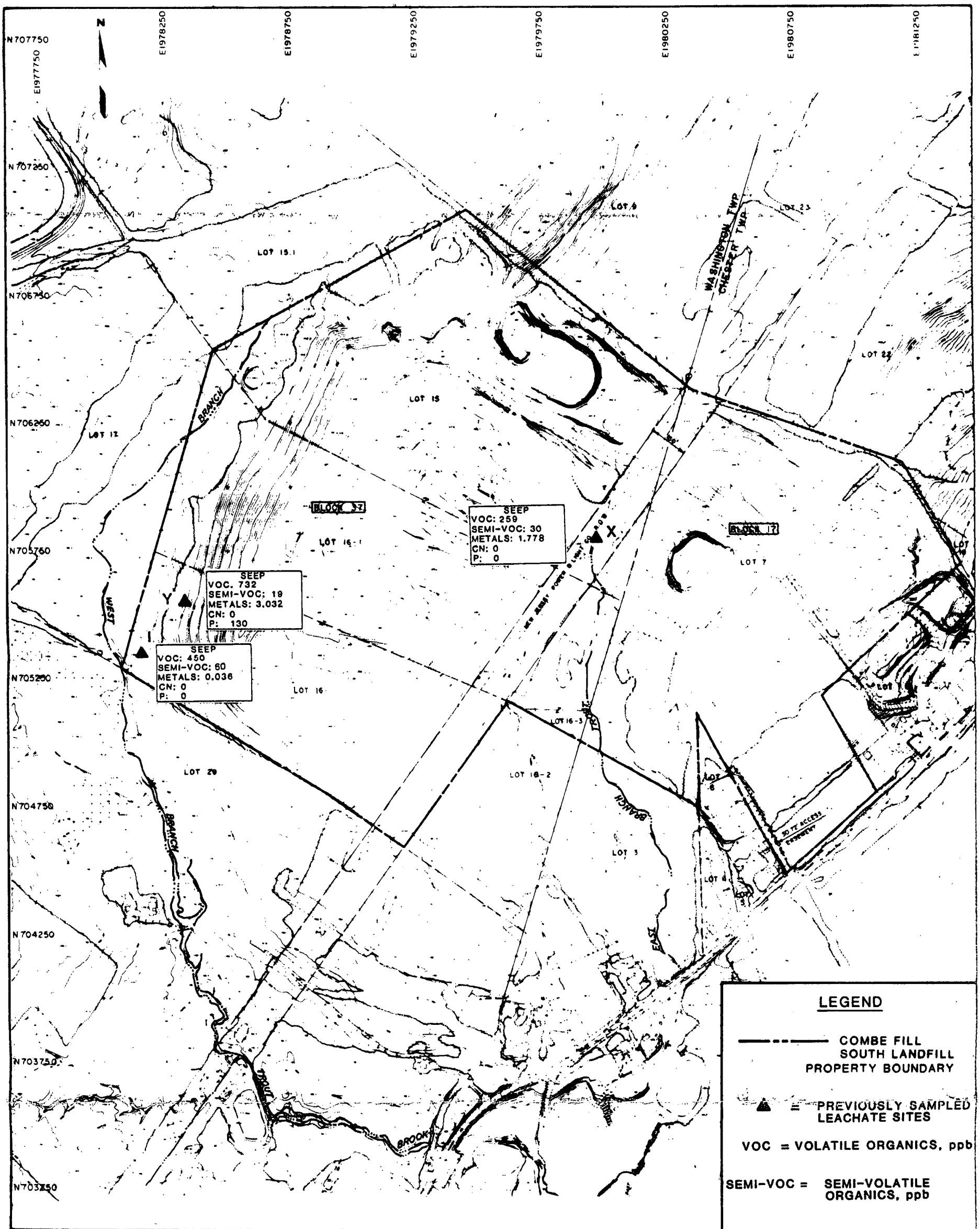
TABLE 5-3

LEACHATE SEEPS
CONVENTIONAL SANITARY CHARACTERISTICS

Combe Fill South Landfill

COMPONENT	COMBE FILL SOUTH LEACHATE SEEPS AVERAGE (ppm)[a]	COMBE FILL SOUTH LEACHATE SEEPS RANGE (ppm)[a]	TYPICAL MUNICIPAL SOLID WASTE LEACHATE[d,e] MEDIAN (ppm)[a]	TYPICAL MUNICIPAL SOLID WASTE LEACHATE[d,e] RANGE (ppm)[a]
pH (pH units)	6.8	6.3 - 7.1	-	3.7 - 8.5
Alkalinity	2550	300 - 4700	3050	0 - 20,850
Hardness	725	180 - 1020	2750	0 - 22,800
BOD	129	9 - 360	5700	81 - 33,360
COD	877	48 - 2300	8100	40 - 89,520
TOC	612	87 - 1600	-	-
Nitrate (as N)	0.3	<0.1 - 1.3	-	-
Ammonia (as N)	299	25 - 670	218	0 - 1106
TKN	369	25 - 880	-	2.6 - 1395
TDS	3662	498 - 7640	8955	584 - 44,900
TSS	576	14 - 1700	220	10 - 26,500
Total Coliform (c/100 ml)	7100(4583)[b]	900 - 14,000	-	-
Fecal Coliform (c/100 ml)	0	0	-	-
Specific conductance (μmhos/cm)	4437[c]	800 - 9000[c]	-	6000 - 9000

[a]ppm except where noted.
[b]Geometric mean.
[c]Field measurements.
[d]Active and inactive landfills.
[e]From Cheremisinoff, P.N., and K.A. Gigliello, 1983.



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PRIORITY POLLUTANT
LEACHATE SEEP QUALITY
PREVIOUS LEACHATE SAMPLING

FIGURE 5-2

The predominant leachate seep contaminants measured in 1985 were generally the same as those measured previously with a few exceptions. Methylene chloride and trichlorofluoromethane (a freon that is no longer listed as a priority pollutant) were found in significantly higher concentrations in 1981 and 1984 than in 1985. Dichlorofluoromethane (another non-priority pollutant freon) and 1,1-dichloroethane were found at high concentrations in 1981 and 1984 but were not detected in 1985. On the other hand, toluene, total cyanides, and phenols were found in significantly higher concentrations in 1985 than in 1981 and 1984.

These differences in leachate seep quality from 1981 to 1985 may be attributed to a number of factors including:

- Dynamic changes (i.e., reductions) in release of contaminants from the site resulting from physical, biological, and chemical interactions in the landfill
- Higher leachate seep flows in 1981 and 1984 as compared to 1985 due to higher rainfall
- Field (i.e., inadequate or inappropriate equipment decontamination) or undefined laboratory contamination because QA/QC samples were often not taken during previous samplings

5.3 SURFACE WATER AND SEDIMENTS

The Combe Fill South landfill lies essentially within the drainage basin of Trout Brook at the headwaters of the West and East Branches. Therefore, most surface water runoff and emergent leachate from the site enters either the West or East Branch of Trout Brook. In a small portion of the northeast corner of the landfill, near the power line right-of-way, surface drainage is to the north and east toward a small unnamed tributary of the Lamington (Black)

River. Figure 5-3 shows the approximate surface water drainage divides in the study area.

As discussed in Chapter 1, eight surface water sites were sampled in order to measure the nature and extent of contamination attributable to the landfill. Because of below normal precipitation during 1985, site W-2 (East Branch of Trout Brook) had to be sampled in October 1985 because there was no flow in August 1985 when the other surface water sites were sampled.

5.3.1 Surface Water Flow

Assuming that the average annual surface water discharge recorded on the Black River at the Pottersville gaging station (1.6 miles downstream of the Trout Brook confluence) is representative of the landfill area, which is located within the drainage area of the gaging station, an approximation of the annual surface water discharge generated at the landfill site can be calculated. At the Pottersville station, the average annual discharge of surface water is 55.9 cfs or 23.14 in./yr. This represents 46% of the annual average rainfall of 50 in./yr. For the 115-acre Combe Fill South site this would translate into an annual average total surface water discharge of 72.3 x 10^6 gal/yr (198,000 gal/day). This discharge would consist of direct surface runoff plus groundwater (discussed in Chapter 4) and leachate seeps. On the basis of soil type, vegetative cover, and slopes at the site, a direct runoff coefficient of 25% would be reasonable. This runoff coefficient translates into 39 x 10^6 gal/yr (150,000 gpd) of direct runoff from the 115-acre Combe Fill South property under normal rainfall conditions.

Rainfall and, consequently, surface water flows were below normal during most of 1985 when the field investigations for this study

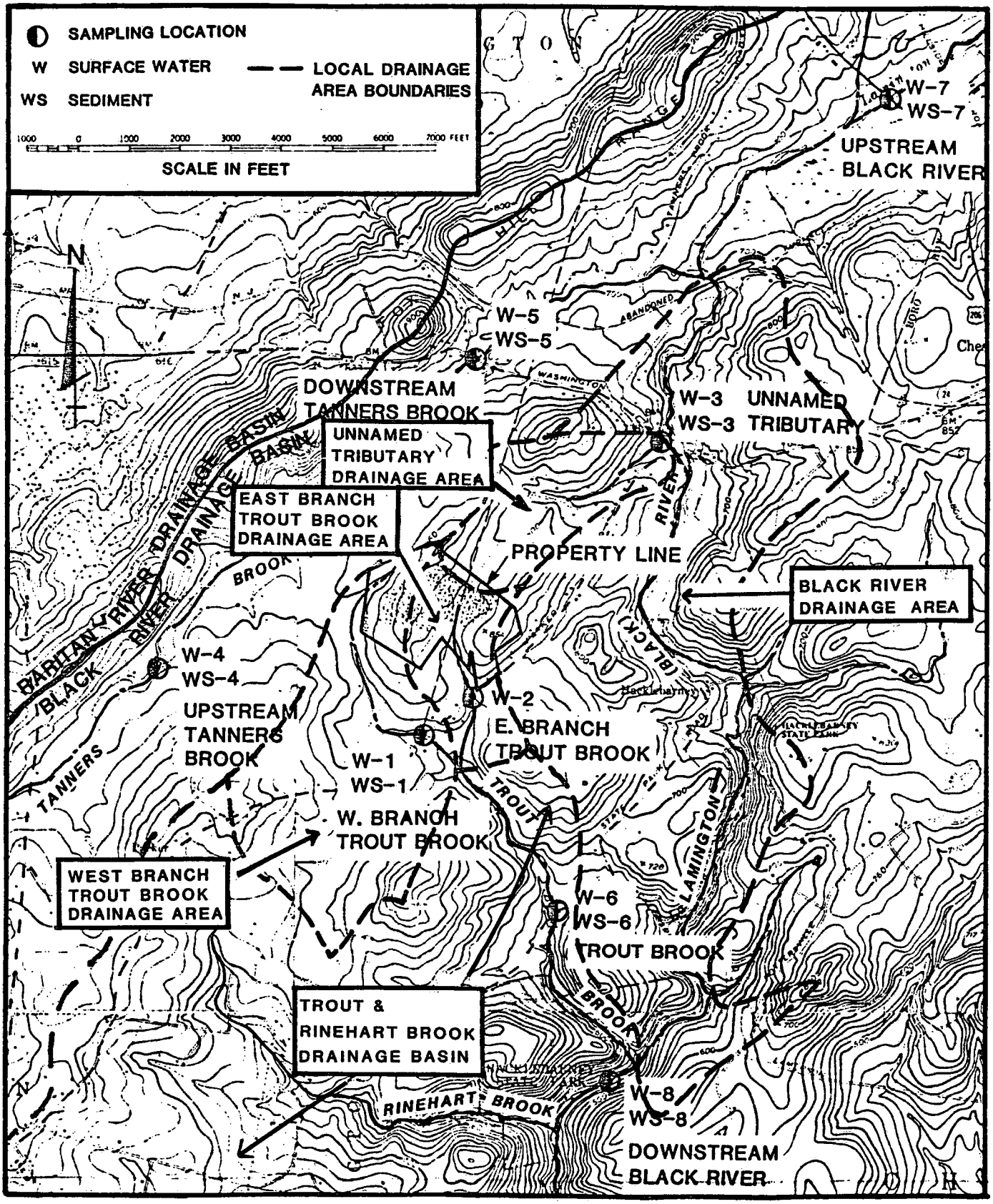


FIGURE 5-3

COMBE FILL SOUTH LANDFILL RI/FS

SURFACE WATER DRAINAGE

were conducted. Table 5-4 compares long-term (1922-1967) average surface water discharge at the Pottersville gaging station to flows recorded during this study. During August 1985, when most of the surface water sites were sampled, the flow measured at the gaging station was less than 40% of the average daily August flow. In October 1985, flow in the Black River had increased by 50% from its August flow but was still only at 60% of the average daily flow for that time of year. Flow measurements made on the West and East Branches of Trout Brook at stations W-1 and W-2 during the field investigations for this study and used in the hydrogeological analysis of the landfill are discussed in Chapter 4 of this report.

5.3.2 Surface Water Quality

5.3.2.1 NJDEP Classifications. Trout Brook, Tanners Brook, and the Black (Lamington) River in the vicinity of the Combe Fill South landfill are classified as FW-2 waters by NJDEP. The water quality criteria for FW-2 waters are discussed in Chapter 8 and summarized in Appendix Y. FW-2 waters are designated for:

- Maintenance, migration, and propagation of the natural and established biota
- Primary and secondary contact recreation
- Industrial and agricultural water supply
- Public potable water supply after such treatment as required by law or regulation
- Any other reasonable use

Trout Brook and the Black (Lamington) River, below its confluence with Trout Brook to Bedminster, is classified as a trout production water. Each spring, Trout Brook is stocked just upstream of its entrance into Hacklebarney State Park, about 1.5 miles downstream of the Combe Fill South landfill. In 1983, 350 rainbow trout were

TABLE 5-4

FLOWS MEASURED AT POTTERSVILLE GAGING STATION[a]

Lamington (Black) River

	FLOWS (cfs)
Average Daily for Period of Record	55.9
13 August 1985	13
Average Daily August Flow	33.54
17 October 1985	19
Average Daily October Flow	32.62

[a]USGS surface water flow records.
[b]Long-term average 1922-1967.

stocked and in 1984, 300 brook and 50 rainbow trout were stocked. The NJDEP Division of Fish and Game is aware of the location and present status of the Combe Fill South landfill; however, based on their measurements and surveys of Trout Brook, they continue to stock its lower reaches above the state park.

The Black River upstream of its confluence with Trout Brook to its crossing by Rt. 206 is designated as a trout maintenance water. Upstream of the Rt. 206 crossing, the Black River is designated a nontrout water. Tanners Brook, to the north and west of the landfill, is also designated as a nontrout water.

Trout Brook and its branches are furthermore designated as Category One: Nondegradation Water. NJDEP requires that nondegradation waters be maintained in their natural state and not be subject to any further man-made wastewater discharges. In a Category One: Nondegradation Water, NJDEP requires that water quality characteristics that are generally worse than the state water quality criteria, except due to natural conditions, be improved to maintain or provide for the designated uses.

5.3.2.2 RI Field Investigation Results. The four surface waters shown in Figure 5-3, which were investigated, included:

- Trout Brook and its east and west branches. These waters receive not only direct runoff from the landfill but also receive contaminants via leachate seeps and leachate-contaminated groundwater, which provides baseflow for the stream. Chapter 4 provides additional information on the groundwater recharge of Trout Brook.

- Tanners Brook, to the north and west of the site, does not receive any direct runoff or direct leachate from the site because of topography, but because uncertainties existed as to the influence of groundwater from the landfill on the Brook it

was included in the RI study. As shown in Chapter 4, however, it was determined that groundwater from the landfill does not recharge Tanners Brook.

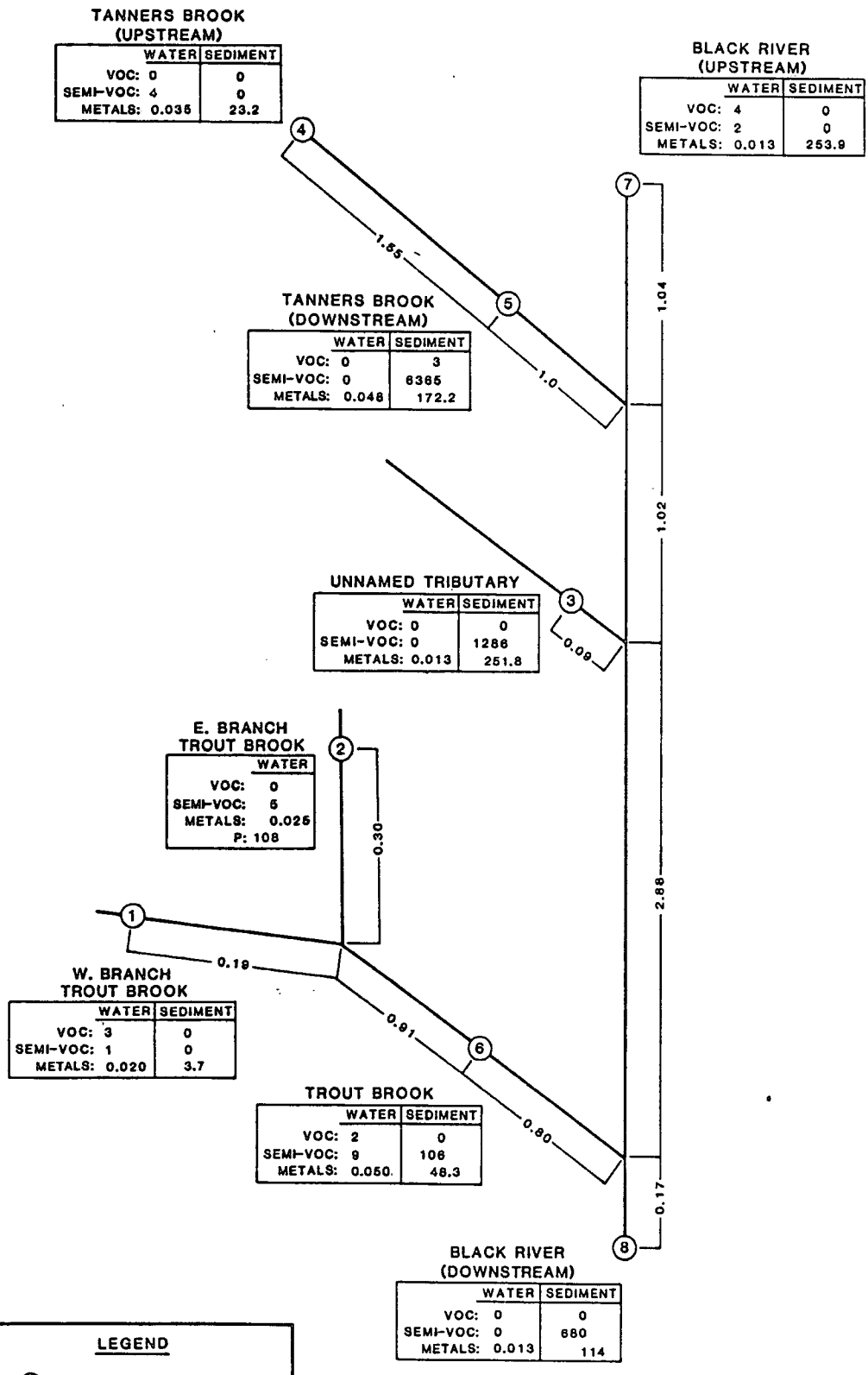
- The unnamed tributary to the north and east of the site also receives some surface runoff containing diluted leachate and leachate-contaminated groundwater from the landfill (see Chapter 4).

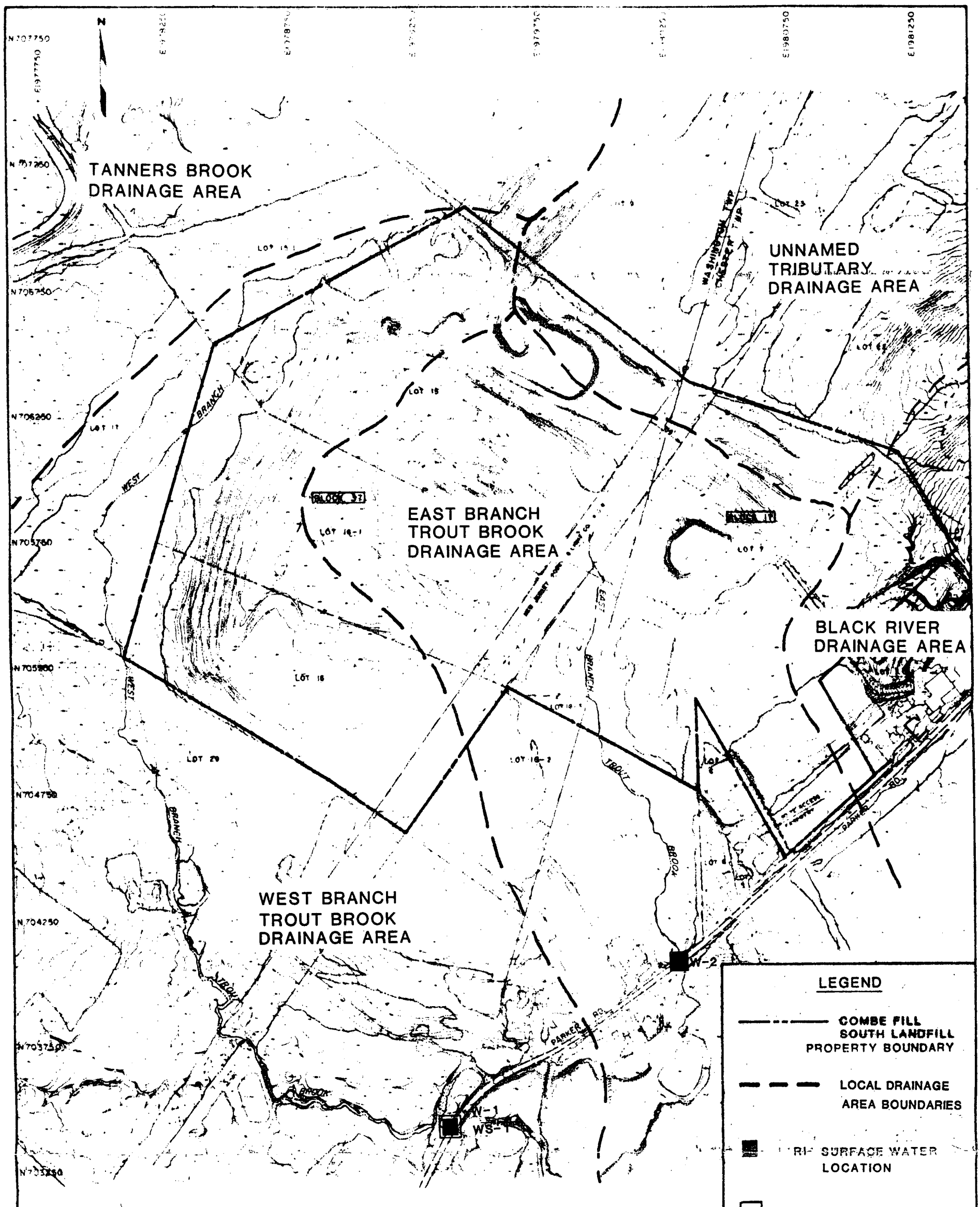
- The Black River, downstream of the landfill, although not directly impacted by surface runoff or leachate seeps from the site, is affected by contaminants carried to it by Trout Brook, Tanners Brook, and the unnamed tributary. Groundwater recharging the Black River is only marginally, if at all, affected by contaminants leaching from the landfill (see Chapter 4 discussion on groundwater flows). The upstream station of the Black River (W-7) was selected to be representative of background surface water quality unaffected by the Combe Fill South landfill.

The surface water and sediment sampling sites shown in Figure 5-3 are presented schematically in Figure 5-4, along with total concentrations of priority pollutants by fractions as measured at each location. Figure 5-5 shows the approximate surface water drainage boundaries at the site as modified by the landfill. Appendix Tables CC-19 and CC-20 present individual priority pollutant concentrations at each station for water and sediments, respectively. The data presented in Figure 5-4 has been adjusted to reflect the occurrence of contaminants that were detected in the field and/or laboratory QA/QC samples taken on the same day. Low levels (<BM) of methylene chloride and di-n-butyl phthalate were found as contaminants in the QA/QC water samples. Bis(2-ethylhexyl)phthalate (64 ppb) and several metals including arsenic, cadmium, chromium, copper, nickel, and zinc were found as contaminants in the QA/QC samples associated with the sediment samples. Because these contaminants were all found in the trip blanks they are suspected of being laboratory contaminants of an unknown origin.

FIGURE 5-4

COMBE FILL SOUTH LANDFILL SURFACE WATER PRIORITY POLLUTANTS





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LANDFILL MODIFIED
SURFACE WATER DRAINAGE

FIGURE 5-5

In comparison to the background water station (W-7) on the upstream on the Black River, the surface water samples in the vicinity of the Combe Fill South landfill show only slightly elevated concentrations of priority pollutant chemicals above background. With few exceptions, the chemicals found in the surface water samples were detected at concentrations below their quantifiable method detection limits. The highest concentrations of priority pollutant chemicals in surface water samples were measured on Trout Brook (including 108 ppb of total phenols at W-2 and 9.05 ppb of phenol at W-6). The highest concentration of soluble metals (0.05 ppm of zinc) was also found in Trout Brook, but this concentration was not significantly higher than that measured at the background site (0.013 ppm). Examination of the individual metals concentrations at the Black River background station (W-7) reveals concentrations of chromium and zinc higher than would be expected of such a river sediment, suggesting an upstream point source discharge of these metals such as a plating industry (Fitchko and Hutchison 1975). No pesticides, PCBs, or cyanides were found in any surface water sample.

The water samples taken from the West and East Branches of Trout Brook had numerous tentatively identified organic compounds not found in the downstream station of Trout Brook. Both of the Tanners Brook stations also had a number of tentatively identified compounds. Likewise, the Black River also had some tentatively identified organic compounds in its water samples, even at the background station, but not at the concentrations or with the variety found at the upstream West Branch Trout Brook station (W-1).

Examination of the chemical analyses of the sediments taken at the same locations as the surface water sites reveals a large concentration of base/neutral extractable organics (6345 ppb) at the

downstream station on Tanners Brook as compared to the background station on the Black River. Since the upstream station on Tanners Brook does not contain any of the base/neutral compounds measured downstream, a source of these chemicals would appear to exist between stations WS-4 and WS-5. However, because no other samples have been taken at this site no confirmation of these chemical concentrations or their source is possible. Based on the findings concerning groundwater movement from the landfill (Chapter 4), it is unlikely that the source of the contamination is the Combe Fill South landfill. As described in Chapter 4, the contribution of groundwater from the landfill to Tanners Brook is not significant and therefore it is likely that some other source of contamination is contributing to these high concentrations of base/neutrals at the downstream sediment site. Although the literature reviewed to date does not specifically describe the importance of base/neutral organics in highway runoff, contaminated road runoff from Rt. 24 (Washington Avenue), which is located just upstream of the sample site, may be a source of additional contamination in Tanners Brook.

Sediments in the unnamed tributary to the north and east of the site also show elevated concentrations of base/neutral organics (1286 ppb). Although this tributary appears to receive contaminated groundwater from the landfill, it is possible that other sources of contamination contribute to these high concentrations of base/neutrals (as suggested in Chapter 4). Additionally, the sample site is slightly downstream of the crossing of Rt. 24 and may be impacted by storm runoff from the highway. Also, because this is the only sample from this site, no conclusions can be reached as to the accuracy with which this sample represents the actual sediment over the length of the unnamed tributary.

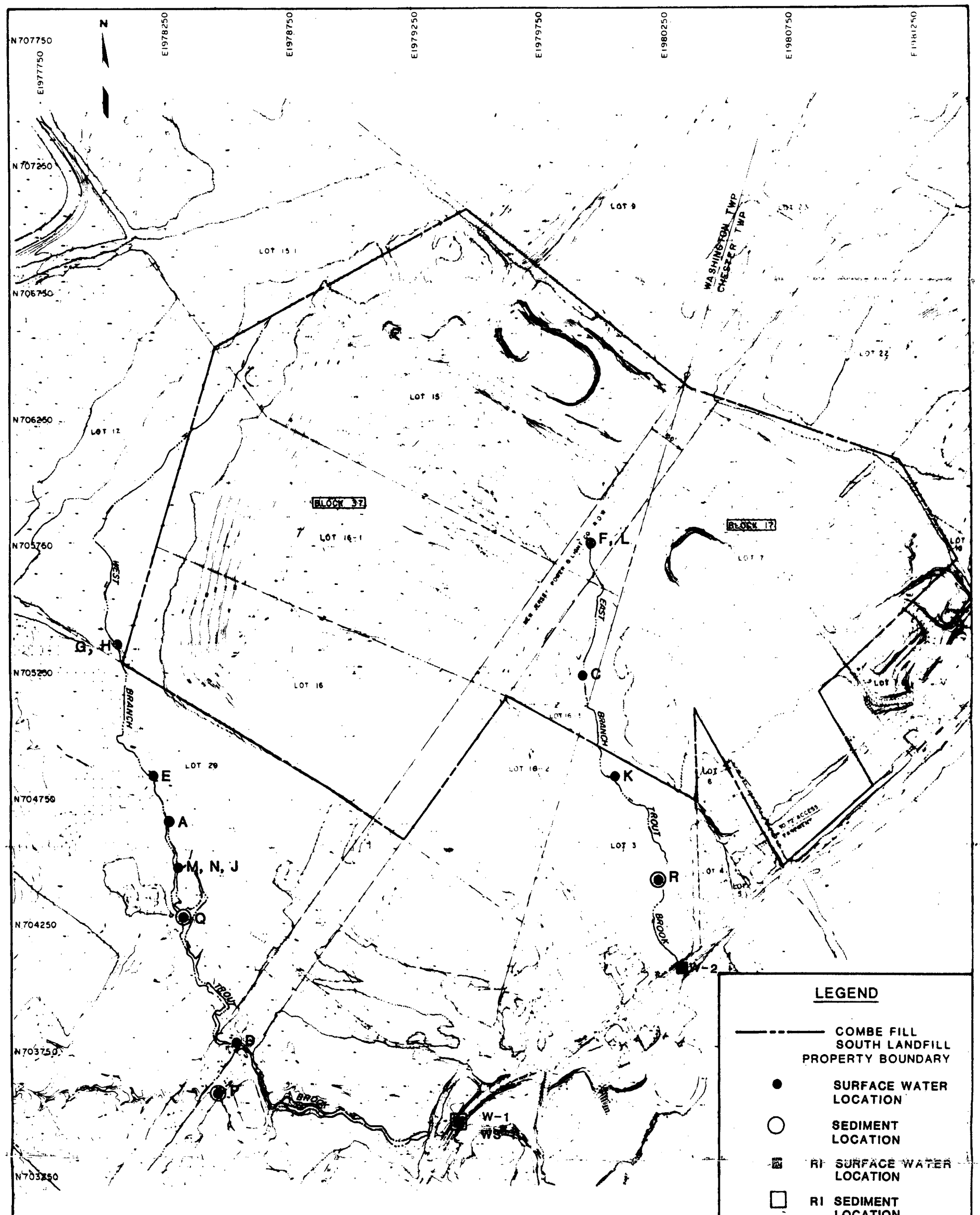
The downstream station on the Black River had the third highest concentration of base/neutral organics at 680 ppb, followed by the

downstream station on Trout Brook, which had concentrations of base/neutral organics at 106 ppb. The West Branch of Trout Brook showed no such contamination. No sediment samples were obtained in the East Branch of Trout Brook because this station was located in a culverted portion of the stream. It is likely that runoff carries the contaminated sediments downstream during heavy rainfall. This would be consistent with the field observations that the stream channels of the West and East Branches of Trout Brook cut into granite bedrock. The Trout Brook station below the confluence of the East and West Branches showed only minor amounts of contamination and it was not until further downstream, at the Black River station, that elevated chemical concentrations were observed in the stream sediments.

5.3.2.3 Previous Sampling Events. Previous sampling and analyses of surface water and related sediment samples have been conducted from 1973 to 1985 principally by NJDEP and URWA (see Appendix BB, Chronology of Sampling Events). Previous sampling was limited to Trout Brook and its branches and the Black River; no sampling of Tanners Brook or the unnamed tributary of the Black River to the northeast of the landfill was done.

Figures 5-6 and 5-7 show the locations of these sample sites. Table 5-5 summarizes the average concentration of priority pollutants measured at each of these locations in water and sediment samples. These data are further synthesized into the schematic shown in Figure 5-8. In Table 5-5 the sampling stations are presented in an upstream to downstream sequence for the surface water system as a whole, and within major stream segments.

As with all other data summaries, a concentration measured at BM was assumed to equal one-half the detection limit for the chemical in that matrix. This assumption may tend to overestimate the total



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LOCATION OF SAMPLING STATIONS
FOR PREVIOUS
SURFACE WATER AND SEDIMENT SAMPLES

FIGURE 5-6

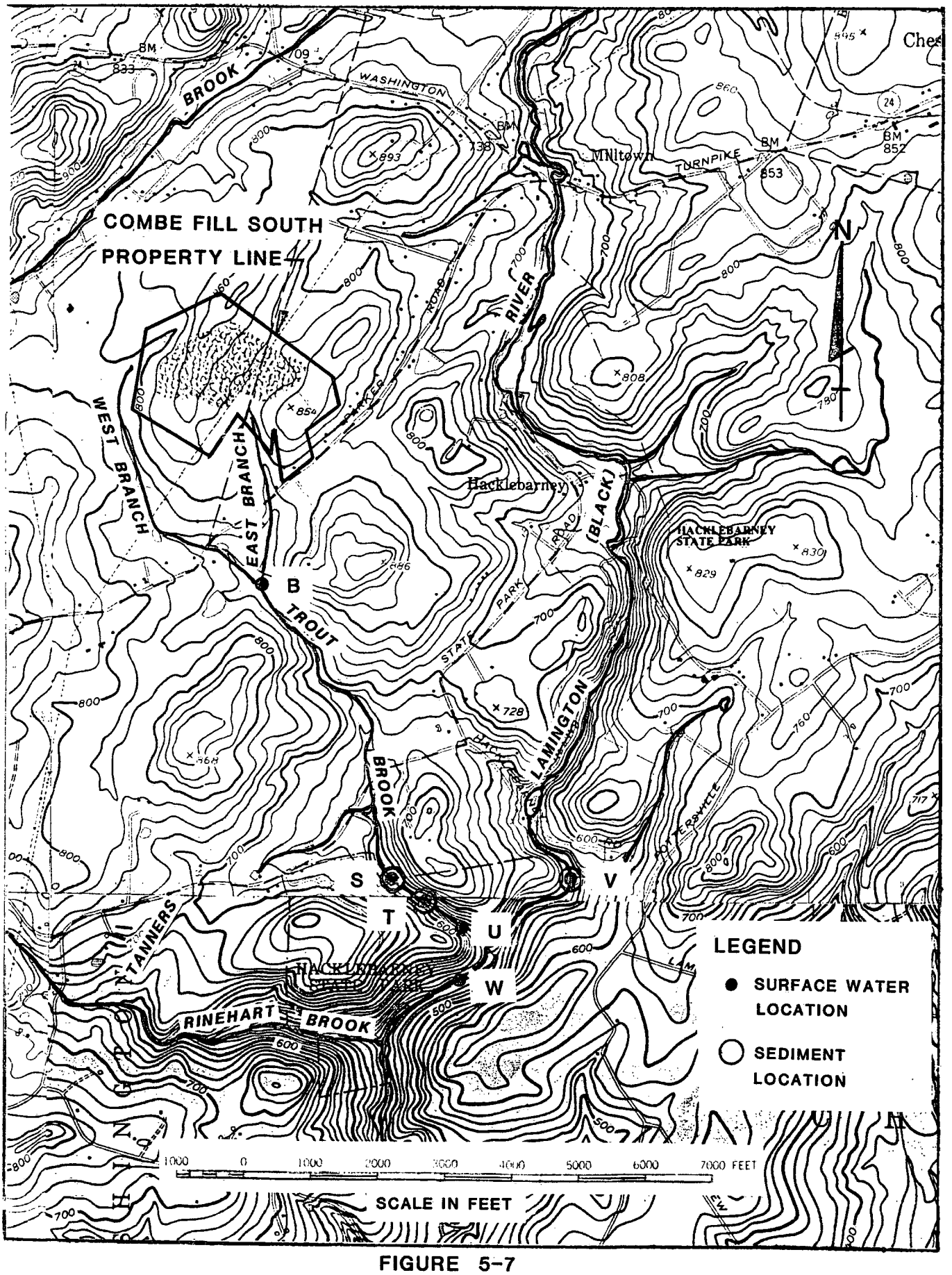


FIGURE 5-7

COMBE FILL SOUTH LANDFILL RI/FS

LOCATION OF SAMPLING STATIONS

FOR PREVIOUS SURFACE WATER / SEDIMENT DATA

TABLE 5-5 (Page 1 of 3)

SUMMARY OF PREVIOUS SURFACE WATER AND SEDIMENT PRIORITY POLLUTANT CHEMICAL DATA

Combe Fill South Landfill

STATION LOCATION	STATION NUMBER(S)	SAMPLE TYPE	AVERAGE TOTAL VOLATILES (ppb)	AVERAGE TOTAL ACID/PHENOLS (ppb)	AVERAGE TOTAL BASE/NEUTRALS (ppb)	AVERAGE TOTAL PESTICIDES/PCBs (ppb)	AVERAGE TOTAL METALS (ppm)
WEST BRANCH TROUT BROOK							
SE Corner of Landfill	G, H	Water	64	0	5	1	0.1025
Above Bridge	E	Water	NR	NR	NR	NR	0.0685
N of Tingue	A	Water	NR	NR	NR	NR	0.057
Upstream of Tingue	J, M, N	Water	15	0	0	0	0.0910
Tingue Driveway	Q	Water	1717	0	106	0	0.1185
		Sediment	457	0	0	0	61.050
Inflow to Pond	D	Water	NR	NR	NR	NR	0.0415
Trib. to W. Br, Upstream of Pond	P	Water	5	0	0	0	0.5779
		Sediment	75	0	15,000	5,000	171.400
EAST BRANCH TROUT BROOK							
Headwaters	F, L	Water	152	0	90	0	0.1723

NR = Not run.

TABLE 5-5 (Page 2 of 3)

SUMMARY OF PREVIOUS SURFACE WATER AND SEDIMENT PRIORITY POLLUTANT CHEMICAL DATA

Combe Fill South Landfill

STATION LOCATION	STATION NUMBER(S)	SAMPLE TYPE	AVERAGE TOTAL VOLATILES (ppb)	AVERAGE TOTAL ACID/PHENOLS (ppb)	AVERAGE TOTAL BASE/NEUTRALS (ppb)	AVERAGE TOTAL PESTICIDES/PCBs (ppb)	AVERAGE TOTAL METALS (ppm)
EAST BRANCH (Cont.)							
NE of Township Line	C	Water	NR	NR	NR	NR	0.054
Below Property Boundary	K	Water	131	0	0	0	0.0610
Trib. to E. Br, Above Parker Rd.	R	Water	10	0	0	0	1.1392
		Sediment	76	0	24,800	0	339.950
TROUT BROOK (MAIN SEGMENT)							
30-yd below Confluence of Branches	B	Water	NR	NR	NR	NR	0.0300
100-yd upstream of Long Hill Rd.	S	Water	0	0	0	0	0
		Sediment	23	0	41	0	157.250
50-yd upstream of Bridge at Ranger Station	T	Water	1	0	0	0	0.0040
		Sediment	8	0	19	0	111.450
100-yd upstream of Black River	U	Water	1	0	0	0	0.0025

NR = Not run.

TABLE 5-5 (Page 3 of 3)

SUMMARY OF PREVIOUS SURFACE WATER AND SEDIMENT PRIORITY POLLUTANT CHEMICAL DATA

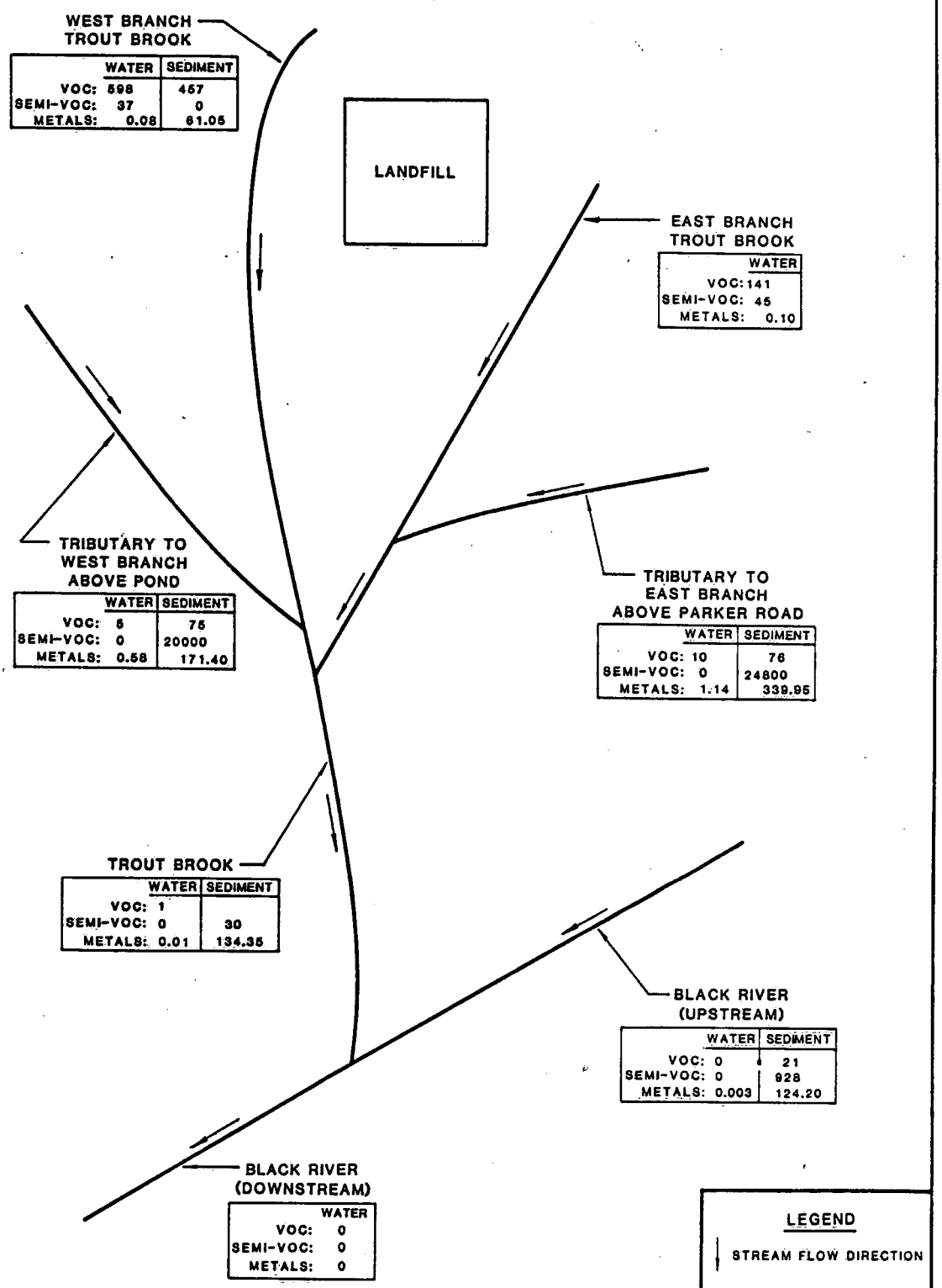
Combe Fill South Landfill

STATION LOCATION	STATION NUMBER(S)	SAMPLE TYPE	AVERAGE TOTAL VOLATILES (ppb)	AVERAGE TOTAL ACID/PHENOLS (ppb)	AVERAGE TOTAL BASE/NEUTRALS (ppb)	AVERAGE TOTAL PESTICIDES/PCBs (ppb)	AVERAGE TOTAL METALS (ppm)
BLACK RIVER							
300-yd Upstream of Trout Brook	V	Water	0	0	0	0	0.0025
		Sediment	21	0	928	0	124.200
100-yd Downstream of Trout Brook	W	Water	1	0	0	0	0.0002

NR = Not run.

FIGURE 5-8

CHEMICAL CONCENTRATIONS IN TROUT BROOK AND ITS BRANCHES, AND BLACK RIVER IN PREVIOUS SAMPLINGS



concentration of a chemical. Such an overestimation may be true for station P on the West Branch of Trout Brook (Table 5-5), which is shown to have a total concentration of priority pollutant base/neutral extractable organics of 15,000 ppb, and 5000 ppb for pesticides, when actually all the contaminant concentrations were below their respective method detection limits (i.e., 10,000 ppb at the time of these sediment analyses).

In comparison to the data obtained during the R1 field work, the previous sampling data show:

- Higher concentrations of contaminants, particularly volatile organics at the surface water sites in Trout Brook, especially at its upstream reaches
- Higher concentrations of contaminants in the sediments of the two branches of Trout Brook
- Somewhat less contamination of surface waters in Black River
- The 1984 NJDEP sample sites in the West and East Branches of Trout Brook show significantly higher concentrations of chemicals in both water and sediment samples than the RI samples taken in approximately the same locations.
- The most recent, previous sampling (spring 1985) at the downstream reaches of Trout Brook and in the Black River near its confluence with Trout Brook shows chemical concentrations similar to those measured during the RI for these areas. However, the RI showed more chemical contamination in the Black River below its confluence with Trout Brook. This information correlates with the continued trout stocking of the downstream reach of Trout Brook.

The reasons for the differences in previous (except for the 1985 NJDEP samplings) and present surface water quality as measured during the RI may include:

- Dynamic changes, i.e., reductions, in the release of contaminants from the site resulting from physical, biological, and chemical interactions in the landfill as it ages. Several samples were taken from 1973 through 1981 when the landfill was in operation and may therefore reflect greater environmental impacts occurring at that time.

- Greater discharge of contaminated leachate directly into surface waters because of higher groundwater levels in previous years.

- Greater field and/or laboratory contamination in previous sampling efforts

5.4 CONCLUSIONS

Based on the discussion of the leachate and surface water samplings conducted in the vicinity of the Combe Fill South landfill, the following conclusions can be made:

- Leachate generated by the landfill moves contaminants to surface and groundwaters.

- Generally, surface waters do not show the long-term impacts of any leachate discharge because pollutants are either volatilized, diluted, chemically transformed, or settle out into stream sediments.

- Where stream sediments have accumulated and not been washed away by heavy rains or streamflows, they show elevated concentrations of priority pollutant chemicals, particularly those with lower solubilities, less chemical reactivity, and greater adsorptive potential, i.e., generally base/neutral extractable organics and metals. One of the sources of these elevated concentrations of chemicals is the Combe Fill South landfill.

- Contamination of Tanners Brook sediment samples are probably not associated with the landfill.

CHAPTER 6

AIR QUALITY INVESTIGATION

6.1 INTRODUCTION

Chester and Washington townships are located in the Suburban Pollutant Standard Index (PSI) Reporting Region along with such other Morris, Somerset, and Middlesex county communities as Dover, Morristown, New Brunswick, and Plainfield. An air monitoring station in Chester samples the air for sulfur dioxide, ozone, and nitrogen oxide analysis as part of this state monitoring program. No violations of the national or state air standards for these constituents were measured at the Chester station in 1984.

From 1983 to 1984 the New Jersey Project on Airborne Toxic Elements and Organic Substances (ATEOS) was conducted by the NJDEP Office of Science and Research. Concentrations of several metals and polycyclic aromatic hydrocarbons in the ambient air were measured at five stations in New Jersey. The results of the analyses for the Ringwood, NJ, station (Table 6-1) show very low levels of polycyclic aromatic hydrocarbons but more elevated concentrations of metals. Ringwood is the closest geographic station to the study area and is probably also most like the study area in terms of land use and population of the five sites.

6.2 SAMPLING AND ANALYSIS

Air sampling and analysis, conducted as part of the air quality investigation for the Combe Fill South landfill, was undertaken to evaluate the extent and nature of non-methane contamination attributable to the landfill, and the movement of any such contamination off-site. Fifteen gas and particulate air fractions were sampled at 11 on-site locations and five upwind/downwind locations (upwind or downwind was determined by the site's predominant wind direction

TABLE 6-1

SUMMARY OF AIR QUALITY ANALYSES
AT RINGWOOD, NJ

New Jersey Project on Airborne
Toxic Elements and Organic Substances

CHEMICAL	CONCENTRATION ($\mu g/m^3$)
Metals	
Arsenic	0.002
Barium	0.019
Cadmium	0.005
Copper	0.024
Iron	0.103
Potassium	0.063
Manganese	0.006
Nickel	0.014
Lead	0.069
Vanadium	0.034
Zinc	0.029
Total	0.368
Polycyclic Aromatic Hydrocarbons	
Benz(a)anthracene	0.00014
Benzo (a) pyrene	0.00016
Fluoranthene	0.00022
Benzo (e) pyrene	0.00055
Benzo (ghi) perylene	0.00025
Benzo (j) fluoranthene	0.00014
Chrysene	0.00056
DiBenz (ah) anthracene	0.00005
Indeno (1,2,3-c,d) pyrene	0.00014
Benzo (b) floranthene	0.00022
Benzo (ghi) floranthene	0.00071
Benzo (k) floranthene	0.00012
Coronene	0.00014
Perylene	0.00009
Pyrene	0.00048
Total	0.00397

on the day of sampling). Section 1.3 of this report and the FSP for this study provide more detailed descriptions of the air sampling locations and methodologies. Tables summarizing the analytical results of the field samples and quality assurance/quality control (QA/QC) samples are provided in Tables CC-23 and CC-26 of Appendix CC, respectively.

Methane, a common landfill gas formed during bacterial decomposition of organic wastes, was not quantitatively evaluated. However, qualitative instrument measurements of methane were made with an explosimeter as part of the health and safety monitoring program. A rough estimate of the volume of methane produced by the landfill can be made by using literature values for landfill methane gas production in conjunction with the approximate size of the landfill. In the following calculation 65 acres is used because that is the presumed actual landfill acreage as opposed to the 115 acres of the Combe Fill property under investigation.

- Literature methane production value

  55-113 l methane/m^2 landfill/day (Handbook - Remedial Action at Waste Disposal Sites, 1982)

- Landfill size

  Approximately 65 acres or 263,055 m^2

- Estimated methane production for Combe Fill South

  $(55\text{-}113\ l/m^2)(2.6 \times 10^5\ m^2) =$
  14.3×10^6 to 29.4×10^6 l/day of methane
  or
  0.5×10^6 to 1.0×10^6 ft^3/day of methane

6.3 RESULTS

Table 6-2 summarizes the total average and range of concentrations of priority pollutant volatile organic compounds (VOC), semi-volatile organic compounds (semi-VOC), and metals for the upwind, down-

TABLE 6-2

AIR QUALITY SAMPLING PRIORITY POLLUTANT ANALYTICAL RESULTS[a]

LOCATION	TOTAL ($\mu g/m^3$) ORGANIC VOLATILES		TOTAL ($\mu g/m^3$) SEMI-VOLATILES		TOTAL ($\mu g/m^3$) METALS	
	AVE.[b]	RANGE	AVE.	RANGE	AVE.	RANGE
Upwind	48	38- 60	0.005	0.003-0.008	9.723	8.8556-10.5928
On-site	134	28-756	0.005	0-0.021	1.532	0.2007- 5.0733
Downwind	49	30- 78	0.006	0-0.011	3.768	0.5724- 8.2958

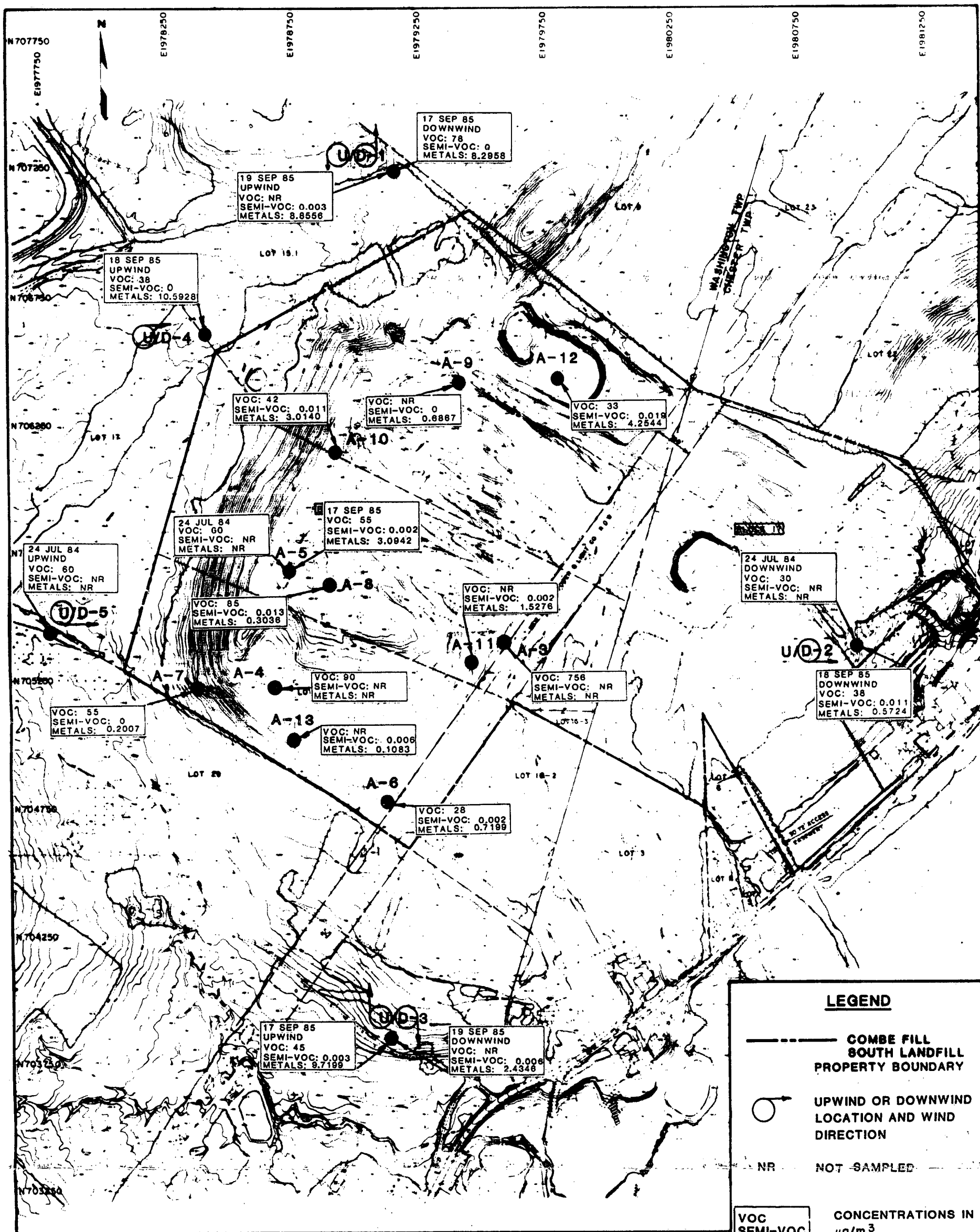
[a]Data have been corrected to reflect quality control findings that the air filter itself contained quantities of certain semi-volatiles and metals that were not reflective of any site contamination.
[b]Rounded to nearest $\mu g/m^3$.

wind, and on-site air quality stations. The semi-VOC category consists only of base/neutral extractable organics because no acid extractables, pesticides, or PCBs were detected in any of the samples. Likewise, no cyanides were detected in any sample. Figure 6-1 shows the total VOC, semi-VOC, and metals concentrations for each sample site. The concentrations of individual contaminants can be found in Table CC-23 of Appendix CC.

As explained previously, all statistical summaries and interpretations of the data assume that the analytical value of BM is equal to one-half of the detection limit of the chemical in the specific media being examined. ND is assumed to equal zero (0). This interpretation of BM and ND may overemphasize the magnitude of a chemical's concentrations and resulting impacts.

If the air is a major pathway for contaminant migration from the landfill, one would expect the lowest concentrations of chemicals at upwind stations, highest concentrations at on-site stations, and concentrations somewhat less than on-site (but above upwind concentrations) at downwind sites. Downwind sites, as seen in Figure 6-1, are generally located within 800 ft of the landfill property, precluding substantial diffusion and dispersion of contaminants, and would therefore be expected to show somewhat elevated concentrations of contaminants if the landfill was discharging quantities of contaminants above the normal background concentrations.

Examination of the data in Table 6-2 shows elevated concentrations of priority pollutant contaminants at on-site air stations but no significant difference in the concentrations of chemicals at upwind or downwind stations. Therefore, either the quantity of contaminants discharged to the atmosphere by the landfill is within the range of other atmospheric discharges in the area or various atmospheric dispersion and diffusion reactions act rapidly to reduce the chemical concentrations off-site. As described in Appendix A,



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WIND DIRECTIONS AND CONTAMINANT CONCENTRATIONS AT AIR MONITORING STATIONS

FIGURE 6-1

application of the Industrial Source Complex Long-Team (ISCLT) model showed little diffusion and dispersion of contaminants off-site.

The data discussed in this chapter have been adjusted according to the study's data QA/QC program. As seen in Table CC-26 of Appendix CC, the analysis of the laboratory (i.e., unexposed) particulate filter blanks revealed the contamination of the filter by semi-volatile organics (particularly ethylbenzene and toluene) and metals (e.g., cadmium, chromium, lead, beryllium, and zinc). This contamination is inherent in the filter and is not a result of site exposure. Therefore, data from all field samples presented in this chapter have been adjusted to reflect this inherent contamination. Table CC-1 in Appendix CC summarizes unadjusted sample data. QA/QC data adjustments were not made for trip blank data because these samples for the air program merely reflect differences in sample collection; for site samples air was pulled through the sample media, but for trip blanks the filter is merely exposed to the atmosphere. Because the trip blanks are exposed in this way to the matrix (air) being sampled, it is inappropriate to adjust the site data on the basis of trip blank results because the blanks themselves may reflect contamination from the air being sampled.

Contam of blanks

Individual priority pollutants, detected in measurable quantities (i.e., >BM) in the atmosphere at one or more stations, are summarized in Table 6-3 for upwind, downwind, and on-site locations. The average and range of concentrations of each chemical is presented. Of the six priority pollutant volatile organics listed in Table 6-3, five (benzene, ethylbenzene, toluene, tetrachloroethylene, and trichloroethylene) are found in higher concentrations on-site than up- or downwind. Three of these volatile organics - ethylbenzene (276 $\mu g/m^3$), toluene (216 $\mu g/m^3$), and benzene (144 $\mu g/m^3$) - had the highest on-site concentrations. The two priority pollutant base/neutral organics (diethyl phthalate and di-n-butyl phthalate)

TABLE 6-3

PRIORITY POLLUTANT CHEMICALS MEASURED IN AIR SAMPLES AT COMBE FILL SOUTH LANDFILL[a,b]

PRIORITY POLLUTANT CHEMICAL	UPWIND ($\mu g/m^3$)		ON-SITE ($\mu g/m^3$)		DOWNWIND ($\mu g/m^3$)	
	AVE.	RANGE	AVE.	RANGE	AVE.	RANGE
Volatiles						
Benzene	0	0	16	0-144	0	0
Ethylbenzene	6	0-10	39	0-276	8	0-13
Methylene chloride	11	0-30	9	0- 30	10	0-30
Tetrachloroethylene	4	0- 6	8	0- 30	8	0-18
Toluene	26	20-30	48	0-216	33	22-47
Trichloroethylene	<1	0- 1	5	0- 30	0	0
Base/Neutrals						
Diethyl phthalate	0.004	0.003-0.005	0.005	0-0.014	0.005	0-0.011
Di-n-butyl phthalate	0.001	0-0.003	0.0015	0-0.007	0.001	0-0.002
Metals						
Antimony	0	0	0.004	0-0.069	0.034	0-0.061
Beryllium	0.004	0.0034-0.0051	0.001	0-0.0024	0.002	0.0015-0.0029
Cadmium	0.005	0-0.0139	0.002	0-0.0089	0.002	0-0.039
Chromium	0	0	0.014	0-0.2563	0	0
Copper	0.147	0.057-0.223	0.126	0.036-0.406	0.117	0.047-0.164
Lead	0.279	0.081-0.611	0.158	0-0.438	0.293	0.181-0.448
Nickel	0.012	0-0.025	0.009	0-0.029	0.036	0.015-0.066
Zinc	9.3	8.6-9.9	1.2	0-4.5	3.3	0-7.8

[a]Contaminants found at greater than BM (i.e., greater than the detection level) at one or more stations based on QA/QC corrections. QA/QC corrections include subtracting filter blank data given on Table CC-26.

[b]Statistical averages assume BM = 1/2 the detection limit and ND = 0.

generally had comparable concentrations upwind, downwind, and off-site. Of the eight priority pollutant metals having measurable concentrations, four (including antimony, chromium, lead, and nickel) had greater on-site or downwind concentrations than upwind concentrations. The maximum on-site or downwind concentrations measured for these four priority metals were 0.0690 $\mu g/m^3$ for antimony, 0.2563 $\mu g/m^3$ for chromium, 0.4480 $\mu g/m^3$ for lead (however, a concentration of 0.6100 $\mu g/m^3$ was measured once upwind), and 0.0660 $\mu g/m^3$ for nickel. The concentrations of these metals were corrected by subtracting the quantity found in the filter blank (see Table CC-26).

Total xylenes, a quantified non-priority volatile organic, were measured at concentrations up to 360 $\mu g/m^3$ on-site and had higher average concentrations on-site than off-site. Tentatively identified volatile organics were generally found at higher average concentrations on-site than off-site (Table CC-23 in Appendix CC). High concentrations of these tentatively identified compounds and the xylenes mentioned above were recorded near the southern edge of the landfill. On-site odor observations and the need to use full-face masks in this area confirm the presence of generally higher total volatile organics at the southeastern edge of the new fill area. There was no difference in the average quantity of upwind, downwind, or on-site tentatively identified semi-volatile organics.

Comparison of the RI air quality investigation data with that of the New Jersey Project on Airborne Toxic Elements and Organic Substances data reveals greater similarities between the RI on-site/downward sites and upwind RI sites than between the upwind RI sites and the Ringwood station. For example, all RI study stations had greater concentrations of copper, lead, zinc, potassium, barium, and iron than did the Ringwood station. At the same time, all the RI study stations had lower vanadium concentrations than

the Ringwood station and had no arsenic or any of the polycyclic hydrocarbons found at Ringwood. Concentrations of cadmium, nickel, and manganese were approximately the same between the study site and Ringwood.

6.4 CONCLUSIONS

Based on the results of the analyses summarized in the preceding paragraphs, the following conclusions can be reached:

1. The landfill is a source of methane gas that is released into the air above the landfill.

2. The landfill is a source of volatile organic compounds that are discharged into the air above the landfill. The landfill also discharges some semi-volatile base/neutral organic compounds but to a much lesser extent than the volatile organics.

3. Particulates emitted by the landfill to the air do not appear to be a significant pathway for the transport of metals from the landfill.

4. Because the concentrations of volatile and semi-volatile organics in the air measured on-site or downwind were often within the range of concentrations of these same chemicals upwind of the site, it is possible that the landfill does not have a significant impact on overall air quality in the area. At the same time, since two-thirds of the air sampling was conducted during and after a period of below average rainfall conditions, and therefore subsequently below average leachate flows, it is also possible that under normal rainfall conditions and greater volumes of leachate flow additional volatilization of contaminants at leachate seeps would occur. Additional air sampling would be necessary to confirm this possibility.

CHAPTER 7

RADIOLOGICAL INVESTIGATION

7.1 INTRODUCTION

The total radiation levels measured during the drilling and borehole geophysical logging of the monitoring wells on the landfill fall within the range of 0.01-0.05 milliroentgens per hour (mr/hr). Measurements of 0.01-0.02 mr/hr total radiation are common and are considered to be normal background radiation levels in most areas. Measurements in excess of 0.02 mr/hr are generally investigated further to define the source, type, and magnitude of radioactivity. However, in areas underlain by granitic bedrock such as found at Combe Fill South, 0.02-0.04 mr/hr is considered normal and indigenous to the environment.

7.2 POSSIBLE SOURCES OF RADIOACTIVITY

Three forms of radioactivity were measured during this investigation: alpha, beta, and gamma radiation. During the decay of a radioactive particle, these three forms of radiation are produced. Two of these rays (alpha and beta) are actually high-energy particles, while the third (gamma) is high-frequency electromagnetic energy. Alpha particles consist of two protons and two neutrons, while beta particles are high-speed electrons.

The radioactivity that was detected at the Combe Fill South site during this investigation has two potential sources:

- Naturally occurring radioactive minerals
- Radioactive waste that may be buried at the landfill

The following paragraphs discuss these two possibilities.

7.2.1 Monitoring with Radiation Detector

The radiation detector used for this investigation (Solar Electronics Model 4) functions like a geiger counter, measuring the total amount of energy in all three forms of radioactivity (alpha, beta, and gamma) in mr/hr. Background total radiation levels were recorded at the land surface, and well cuttings from selected drilling depths were monitored. The radiation readings made during drilling operations are compiled in Table 7-1. Except for one reading of 0.05 mr/hr, none of the total radiation readings exceeded 0.04 mr/hr, which is consistent with the expected values for a granitic environment.

7.2.2 Borehole Logging

A gamma radiation probe was used to measure radioactivity of the subsurface during geophysical well logging. In contrast to the radiation detector, which measures the amount of energy being emitted by all three forms of radioactivity (in mr/hr), the gamma probe measures only the energy level of emitted gamma rays in gamma counts per second (cps).

Abnormally high (i.e., >100 cps) gamma counts were encountered at various depths during logging of well D-3. Figure 7-1, a reproduction of the gamma log of well D-3, illustrates the four depth zones that were characterized by gamma radiation exceeding 150 cps including: 54 to 65 ft, 74 to 82 ft, 110 to 117 ft, and 124 to 151 ft. The highest gamma reading was at a depth of 148 ft where the detector measured 570 cps. (Confirmation of the gamma radiation anomalies was made on 19 November 1985 by Mr. Daniel Toder, geologist with NJDEP.) This gamma count is approximately equal to 0.95 mr/hr, a value far above the site's background level of 0.02-0.04 mr/hr. However, the gross alpha and beta radioactivity measured in the water sample from well D-3 was not high in comparison to water

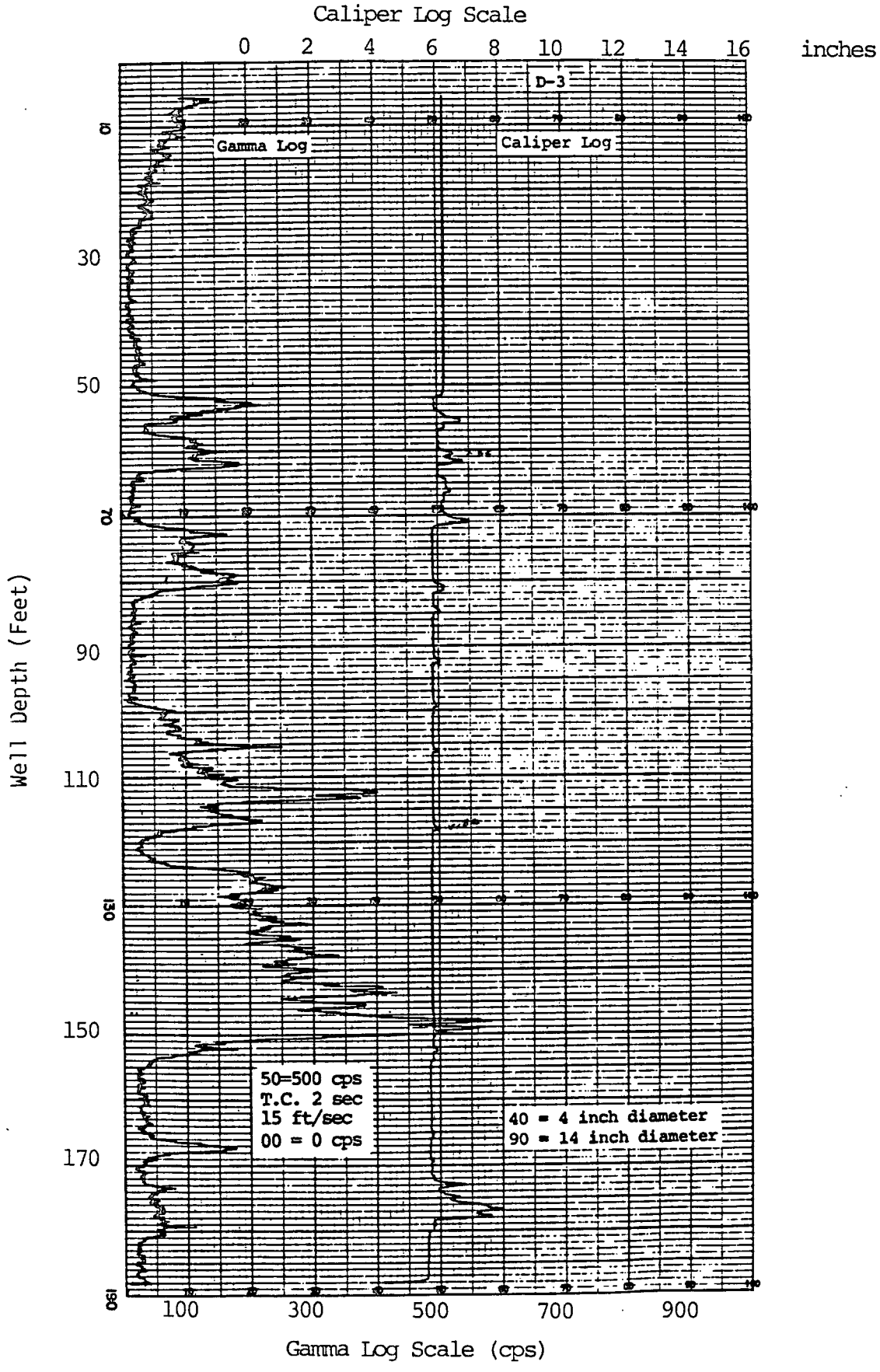
Table 7-1

COMBE FILL SOUTH LANDFILL
RADIATION MONITORING DATA DURING DRILLING
AND GEOPHYSICAL WELL LOGGING OPERATIONS

WELL #	S-1	S-2	S-3	S-4	S-5	S-6	D-1	D-2	D-3	D-4	D-5	D-6	D-7	D-8	D-9
DEPTH															
0	NT	0.02	NT	0.03	0.03	NT	0.03	0.02	0.03	NT	0.02	0.02	0.03	0.04	0.02
5	NT			N	N										
10	NT	N	NT	0.01	N	0.02	N	0.03	N	NT	N	NT	N	N	0.02
15	NT			0.01	N										
20	NT	N	NT	N	N	N	N	N	N	NT	0.04	NT	N	N	0.03
25	NT			N	N										
30		N	NT	N	N	N	0.03	N	N	NT	N	NT	N	N	NT
35				N											
40		N	NT	N		N	NT	N	N	NT	N	N	NT	N	0.02
45				NT											
50		N	NT			N	NT	N	NT	0.02	N	NT	NT	NT	0.02
55															
60		NR				N	0.03	NT	NT	N	N	NT	NT	NT	NT
65							N								
70						N	N	N	N	N	N	NT	0.02	NT	NT
75															
80							NT	NT	NT	N	0.03	NT	N	NT	0.02
85											N				
90							NT	NT	NT	N	N	NT	NT	NT	NT
95															
100							NT	NT	NT	N	N	NT	NT	NT	NT
105															
110							N	NT	NT	N	N	NT	NT		NT
115															
120							0.03	N	NT	NT	N	NT	NT		NT
125								N		NT			0.03		NT
130							NT		0.04		N	NT			
135															
140							NT		NT		N	NT			
145															
150							0.03		NT		N	NT			
155															
160									NT		N	NT			
165											N				
170									NT			NT			
175															
180									NT						
185									0.03						
BG									0.02		0.04	0.02	0.03		
WELL HEAD 1									0.02		0.03	0.05	0.03		
WELL HEAD 2									0.02		0.04	0.04	0.04		

COMMENTS: All readings are in milliroentgen per hour.
All measurements are to the nearest five feet in depth.
NT indicates that a reading was Not Taken.
N indicates that the reading was less than or equal to background.
BG indicates a background reading prior to geophysical well logging operations.
WELL HEAD 1 and 2 are radiation readings taken prior and after gamma-gamma or density well logging.

FIGURE 7-1
GAMMA LOG - WELL D-3



samples taken at other on-site monitoring wells and off-site potable wells.

Because well D-3 is not located in or near the old or new fill areas and because (as discussed in Chapter 4) the groundwater flows from the landfill probably do not significantly influence this well, it is likely that the higher gamma counts in well D-3 are from a natural source. Although the surface total radiation detector readings at D-3 were at normal background levels, the air rotary drilling could have easily dispersed a discrete mineral source of gamma radiation such as the suspected thorium in monazite. This conclusion is supported by the fact that the highest gamma counts were measured at almost 150 ft in well D-3, a depth significantly below the suspected fill depths.

None of the other wells (wells D-5, D-6, and D-7) showed any significant gamma anomalies, i.e., measurements of 100 cps or more (equivalent to 0.1-0.2 mr/hr). These gamma logs are included in Appendix B.

Because of the large anomalies present in well D-3, additional investigations in this area may be warranted in order to better characterize the source, extent, and magnitude of the measured radiation.

7.2.3 Naturally Occurring Radioactivity

Available historical records document locations where uranium, thorium, and rare earth minerals have been found within the Highland Region (Bell 1983) near Combe Fill South. However, no historical data exists that precisely documents the levels of natural background radiation at or near the site.

At German Valley, approximately two miles north of the landfill the mineral monazite occurs as an accessory mineral of both granite and gneiss. Monazite is a phosphate mineral containing either a rare earth metal or thorium. Thorium is a radioactive element with various isotopes occupying positions both in the thorium and actinium decay series. Thorium decay to lead isotopes is accompanied by the emission of alpha, beta, and gamma radiation. Since background radiation levels are typically higher in areas where deposits of radioactive elements are present (Sax 1979), the presence of thorium nearby may be causing the elevated background radiation levels at Combe Fill South. Thorium may also be responsible for the high gamma radiation measured by the gamma logging in well D-3.

7.2.3.1 Potential Occurrence of Radon. Recently, widespread concern has been raised about the public health significance of the natural occurrence of radon gas in residential dwellings throughout northern New Jersey and eastern Pennsylvania. Radon, the heaviest known gas (density 9.73 g/l), is colorless and radioactive. The geologic setting in which the gas has been found is the granites and granitoid gneisses of the Reading Prong. Geologically, the Reading Prong and the New Jersey Highlands Region are lithologically similar and structurally continuous; therefore, radon gas may be present on or near the Combe Fill South Landfill site. Radon is one of several decay (daughter) isotopes produced when isotopes of uranium and thorium decay by alpha or beta particle emission to new isotopes of the same or different elements. The daughter isotopes subsequently decay themselves, forming new isotopes. Eventually, stable isotopes of lead are produced and the decay process ends. All naturally occurring radioactive elements with atomic numbers greater than 83 belong to one of three decay series: uranium series, thorium series, or actinium series.

Much of the concern about radon is that as a mobile gas it may migrate through soil and subsurface materials to enter basements

and cellars through cracks in the floors and walls. Subsequently, its high density would prohibit movement away from these collection points. As the radon isotope decays, it forms a solid daughter isotope. Particles of the solid daughter isotope combine with dust that may be inhaled or injested. Because alpha and beta eliminations produce particles that are easily stopped by human skin, radon and its daughter isotopes do not present a dermal hazard. However, if radon or its particulate-borne daughter isotopes are injested or inhaled, internal tissue damage may occur. Radon has been linked with the occurrence of bone and lung cancer and leukemia. A good ventilation system can be used to keep large quantities of radon gas from accumulating in basements, and sealing of basement walls and floor will also keep radon gas from seeping in.

Because the proposed maximum contaminant level (MCL) for radon in drinking water is 0 pCi/l and because the regional geologic setting indicates that radon may be present, follow-up water sampling and testing for radon may be appropriate at any location where alpha counts are 5 pCi/l or greater; EPA primary drinking water regulations require that radium-226 must be analyzed if gross alpha activity exceeds 5 pCi/l in community water systems.

7.3 GROSS ALPHA AND BETA ANALYSES OF GROUNDWATER, SURFACE WATER, LEACHATE SEEPS, AND POTABLE WELLS

7.3.1 Previous Radioactivity Analyses

In May 1981 gross alpha and beta analyses were completed on eight water samples taken from groundwater and surface water sources at the Combe Fill South landfill. The analyses were performed by Radiation Management, Inc. of Philadelphia for URWA. The results were included as a supplement to their report entitled "Report to Chester and Washington Townships on the Results of the Water Quali-

ty Testing Program at the Combe-Fill Landfill" (see Appendix N). All results in this document were reported in terms of pCi/l.

This URWA report lacked a map showing the radioactivity sample locations. Of the locations sampled, three have been inferred on the basis of the report text as follows:

- Sample point G-2 is a shallow well located behind the Filiberto residence.
- Sample point S-3 appears to be a surface water source located along the West Branch of Trout Brook on the Tingue property.
- Sample point S-5 is also a surface water source located near or on the landfill on the East Branch of Trout Brook.

Sampling point G-5 is a control groundwater sample of unidentified location. Three other surface water and one groundwater sampling locations are referenced but their location could not be identified.

Of the URWA sample sites, S-3 on the West Branch of Trout Brook had the highest concentration of gross alpha (40.9 ± 11 pCi/l) and the second highest concentrations of gross beta (33.4 ± 3.7 pCi/l). Sample point S-5, located near or on the landfill on the East Branch of Trout Brook, had the highest gross beta concentration (34.9 ± 3.7 pCi/l). The shallow well G-2 on the Filiberto property had the highest gross beta reading (5.10 ± 2.0 pCi/l) of the wells tested.

The URWA report concluded that the West Branch of Trout Brook contained levels of radioactivity that exceeded the MCL for drinking water, i.e., 15 pCi/l for gross alpha and 50 pCi/l for gross beta (as a monitoring guide). While EPA's technical standard for beta

radiation in drinking water is a total dose of 4 mr/yr, the drinking water regulations for community water supplies require that when the beta counts exceed 50 pCi/l, analyses must be performed to identify the concentrations of beta-emitting radionuclides. These analyses are performed in order to determine whether isotopes are present, causing annual beta radiation doses in excess of the millirems standard. Tritium and strontium-80 are usually the first parameters for which testing is performed, followed by analysis for cesium-134, barium-131, and iodine-131.

The URWA report also stated that, because of the elevated levels of gross beta in the East Branch of Trout Brook at station S-5, there may be a man-made source of radioactive material in the older (north and east) sections of the landfill.

7.3.2 Results of RI Sampling

Selected potable wells, monitoring wells, surface waters, and leachate seeps were sampled for gross alpha and beta parameters during this RI/FS. Figure 7-2 shows the locations of monitoring wells, leachate seeps, and potable wells sampled for gross alpha and beta activity. Figure 7-3 shows the locations of surface water sites sampled for gross alpha and beta activity. Table 7-2 presents a summary of the gross alpha and beta assays.

Monitoring wells S-3 and S-4, both screened in the saprolite aquifer, had the highest groundwater gross alpha concentrations of 13 ± 12 pCi/l and 13 ± 7.8 pCi/l, repectively, which are close but below the MCL. These concentrations do, however, exceed the public water supply screening concentration of 5 pCi/l for gross alpha radioactivity, which would require testing for radium-226. None of the monitoring wells had elevated gross beta readings.

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Harrisburg pennsylvania

COMBE FILL SOUTH LANDFILL
REMEDIAL INVESTIGATION / FEASIBILITY STUDY

500 0 500
SCALE APPROX.

LEACHATE SEEPS, POTABLE WELLS AND MONITORING WELLS SAMPLED FOR GROSS ALPHA AND BETA

FIGURE 7-2

7-7A

ky & Skelly Engineers
& Engineering Consultants
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New York 10965

associates, inc.
ources consultants
pennsylvania

COMBE FILL SOUTH LANDFILL
REMEDIAL INVESTIGATION / FEASIBILITY STUDY

500 0 500 1000 FEET
SCALE APPROX.

LEACHATE SEEPS, POTABLE WELLS AND MONITORING WELLS SAMPLED FOR GROSS ALPHA AND BETA

FIGURE 7-2

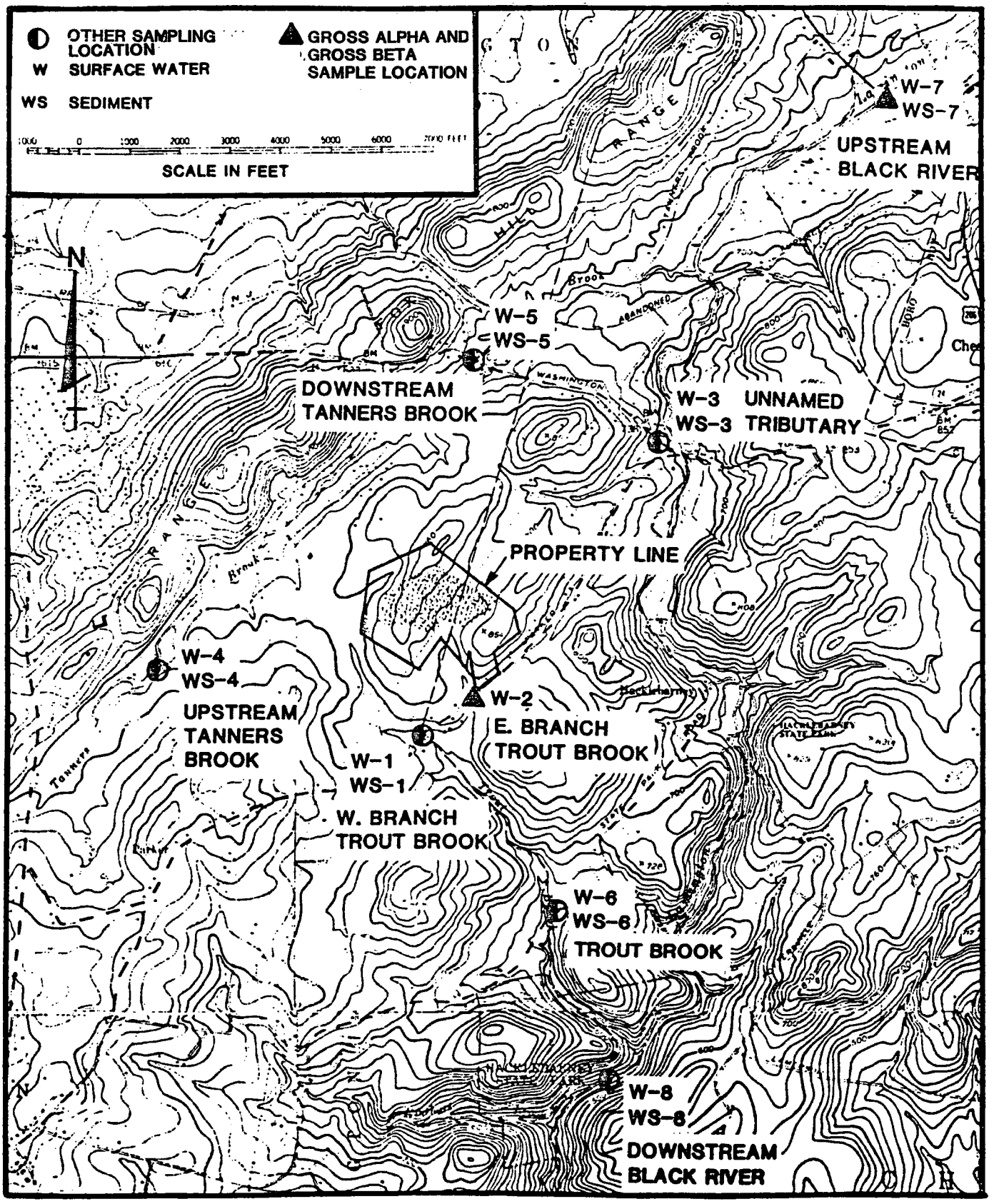


FIGURE 7-3

COMBE FILL SOUTH LANDFILL RI/FS

SURFACE WATER FOR GROSS ALPHA AND BETA RADIATION

TABLE 7-2

COMBE FILL SOUTH LANDFILL
GROSS ALPHA AND BETA ANALYSES

1985

SAMPLE No.	WPW025	WPW013	WPW04	WPW023	WPW03	WPW02	S-3	S-4	D-2
RESIDENT No.	50	51	02	48	03	04			
DATE	8/22/85	9/25/85	9/25/85	8/22/85	9/25/85	9/25/85	8/29/85	9/4/85	8/28/85
Gross Alpha	2.7+/-1.1	LT 0.8	2.0+/-1.1	1.4+/-0.9	2.0+/-1.1	2.4+/-1.0	13+/-12	13+/-7.8	LT 0.8
Gross Beta	5.8+/1.7	LT 0.8	4.0+/-2.0	3.1+/-1.5	4.0+/-2.0	9.2+/-2.0	LT 5.1	4.8+/-7.7	2.5+/-1.6

SAMPLE No.	D-3	D-6	W-7	RSURFW02	L-2	L-3
NAME			UPSTREAM BLACK R.	E. BR. TROUT BK.	LEACHATE SEEP 2	LEACHATE SEEP 3
DATE	9/4/85	8/29/85	8/13/85	10/17/85	10/17/85	10/17/85
Gross Alpha	2.3+/-1.4	0.9+/-1.8	LT 0.8	LT 1.0	LT 1.0	30+/-17
Gross Beta	2.6+/-1.6	3.5+/-1.8	LT 0.8	6.4+/-1.7	21+/-2.7	240+/-24

Comments: LT indicates less than
All readings are in picocuries/liter

The highest gross alpha concentration in any potable well was 2.7 ± 1.1 pCi/l (resident No. 50) and the highest gross beta concentration was 9.2 ± 2.0 pCi/l (resident No. 04), both below their respective MCLs.

Leachate seep L-3, located between shallow wells S-3 and S-4, had the highest gross alpha and beta concentrations measured on-site of 30 ± 17 pCi/l and 240 ± 24 pCi/l, respectively. This data is consistent with the 1981 URWA study, which found the headwaters of the East Branch of Trout Brook to have the highest gross beta contamination. At the same time, however, total radiation readings (near well D-8) at the land surface were at or below background levels for the site and no significant gamma peaks were found in well D-8. These findings, coupled with the fact that the leachate seep emerges from the waste pile/saprolite layer above bedrock, and that the nearby shallow wells S-3 and S-4 had elevated gross alpha levels, point to the possibility of a man-made radioactive source at the landfill in the vicinity of L-3. However, additional radioactive investigations are needed to confirm this possibility, as well as to confirm the contribution from any natural radioactivity source.

CHAPTER 8

PUBLIC HEALTH ASSESSMENT

8.1 INTRODUCTION

The previous chapters of this report have described the physical and chemical characteristics of the air, soil, surface water, and groundwater in and near the Combe Fill South landfill and the impacts of the site on these media. This chapter assesses the significance of landfill-generated contaminants to public health.

Guidance for the preparation of this assessment came primarily from the Draft Superfund Public Health Evaluation Manual (18 December 1985) prepared by ICF Incorporated for the EPA Office of Emergency and Remedial Response and the Office of Solid Waste and Emergency Response. The methodologies described in this manual were modified as required to reflect the needs and limitations of this study site. Worksheets prepared in support of the public health assessment are included in Appendix DD.

The assessment of the present (baseline) public health impacts associated with the Combe Fill South landfill involved five basic steps:

- Selection of indicator chemicals
- Estimation of exposure point concentrations of indicator chemicals
- Estimation of human intakes of indicator chemicals
- Assessment of toxicity of indicator chemicals
- Characterization of risks of indicator chemicals

8.2 SELECTION OF INDICATOR CHEMICALS

As described in previous chapters, about 65 acres of the 115-acre property owned by the Combe Fill Corp. at the Combe Fill South site are known to contain landfilled wastes at depths up to 80 ft. After continuous operation from 1971 to 1981, the landfill closed in November 1981. During this time, citations were issued to the operators of the landfill for failure to properly operate and maintain the site. Nearby residents have complained of odors and pollution of surface and groundwater by the landfill. Although illegal (and perhaps hazardous) dumping activities were suspected to have taken place, there is no conclusive evidence to indicate that such activities occurred.

Sampling and analysis of air, soils, surface waters, and groundwaters made before and during this RI study have identified 85 chemicals (measured at concentrations above their method detection limit) on and near the site. Appendix T summarizes and characterizes all the priority organic pollutants, some non-priority organic pollutants, and tentatively identified halogenated organics found on and near the landfill; Appendix U summarizes and characterizes all inorganic priority pollutants. Since it is impractical to evaluate the public health implications of this many chemicals, a subset of these chemicals, identified as indicator chemicals, were selected for complete evaluation of their public health impacts.

Indicator chemicals are those that pose the greatest potential public health risk at a particular site and should represent the most toxic, mobile and persistent chemicals discharged by the site, as well as those present in the greatest quantities. Important chemical characteristics used in this selection process include toxicological class and severity, site concentration, volatility, water

solubility, sorption potential, biodegradation (or conversely bioaccumulation), and physical/chemical/biological removal processes.

Table 8-1 characterizes the nine final indicator chemicals selected for evaluation at the Combe Fill South landfill site. The compounds in Table 8-1 are generally listed in order of their toxicological severity within their toxicological class (some compounds are listed as both potential carcinogens and noncarcinogens) starting with potential carcinogens. This order is somewhat modified to reflect the greater importance of those compounds found in groundwaters in and near the site because groundwater is the major contaminant pathway at the Combe Fill South landfill. The worksheets prepared as part of the indicator chemical selection process are provided in Appendix DD and include the assumptions used in this selection process.

During the first iteration of the public health assessment and evaluation process at Combe Fill South landfill, arsenic, a priority pollutant metal, was selected as an indicator chemical for landfill-generated contamination because of its significant carcinogenic potency and its occurrence in the soils/wastes on the landfill. However, as described in Chapters 4 and 5, this landfill-related arsenic remains in the soils on the site and does not apparently contribute to either groundwater or surface water contamination. Concentrations of arsenic in off-site potable wells are about the same as concentrations in on-site shallow and deep monitoring wells and leachate. These concentrations meet all federal and state drinking, groundwater, and surface water standards and all federal and state criteria and advisories except for the federal ambient water quality criteria, adjusted for drinking water (see Appendices T through Z). Arsenic was also not measured as a landfill-generated air pollutant. Since ingestion of water, particularly groundwater, and inhalation of air are considered to be the major contaminant exposure pathways, and since landfill-

TABLE 8-1

INDICATOR CHEMICALS

Combe Fill South Landfill

CHEMICAL	CAS NUMBER	TOXICOLOGICAL CLASS	WATER SOLUBILITY (mg/l)	VAPOR PRESSURE (mmHg)	HENRY'S LAW CONSTANT (atm-m^3/moles)	ORGANIC PARTITION COEFFICIENT, Koc
Chloroform	67-66-3	PC	8.2×10^3	1.51×10^2	2.87×10^{-3}	31
Benzene	71-43-2	PC, NC	1.75×10^3	9.52×10^1	5.59×10^{-3}	83
Tetrachloroethylene	127-18-4	PC, NC	1.5×10^2	1.78×10^1	2.59×10^{-2}	364
1,2-Dichloroethane	107-06-2	PC, NC	8.52×10^3	6.4×10^1	9.78×10^{-4}	14
Trichloroethylene	79-01-6	PC, NC	1.1×10^3	5.79×10^1	9.1×10^{-3}	126
Nickel	7440-02-0	PC, NC	-	0.0	-	-
Toluene	108-88-3	NC	5.35×10^2	2.81×10^1	6.37×10^{-3}	300
1,1-Dichloroethane	75-34-3	NC	5.5×10^3	1.82×10^2	4.31×10^{-3}	30
Methylene Chloride	75-09-2	PC, NC	2.0×10^4	3.62×10^2	2.03×10^{-3}	8.8

related arsenic has not been demonstrated to occur in these matrices, arsenic was eliminated from the final set of indicator chemicals evaluated for the public health impacts.

8.3 ESTIMATION OF EXPOSURE POINT CONCENTRATIONS OF INDICATOR CHEMICALS

The next step in the public health evaluation process is the identification of exposure pathways from release sources to exposed populations. Table 8-2 summarizes the major exposure pathways at the Combe Fill South landfill. Figure 8-1 shows the location of potential release sources at the site.

Volatilization of contaminants from soil surfaces, leachate seeps, and contaminated surface water with subsequent transport by air to the population surrounding the landfill is one of the possible exposure pathways at Combe Fill South landfill. As demonstrated by the ISCLT air modeling (Appendix A) conducted for this site, there is little directional preference in the long-term movement and concentration of contaminants emanating from the landfill. Therefore, the entire residential population within about 0.5 miles of the site perimeter was assumed to be equally at risk from airborne contaminants. Location No. 45, a day care facility 2500 ft to the southeast of the landfill, has been identified as a separate sensitive population. Contaminant exposure points and populations are shown in Figure 8-2.

Leaching of chemicals from contaminated soils and wastes to the groundwater, which is subsequently used as a source of potable water in the vicinity of the landfill is probably the most important contaminant transport medium for the Combe Fill South landfill. The residents on the western half of Schoolhouse Lane, 2400 ft northeast of the landfill, are the most significantly exposed population for this contamination. Other exposed populations are within 0.5 miles of the perimeter of the landfill and are located

TABLE 8-2 (Page 1 of 2)

MATRIX OF POSSIBLE EXPOSURE PATHWAYS

Combe Fill South Landfill

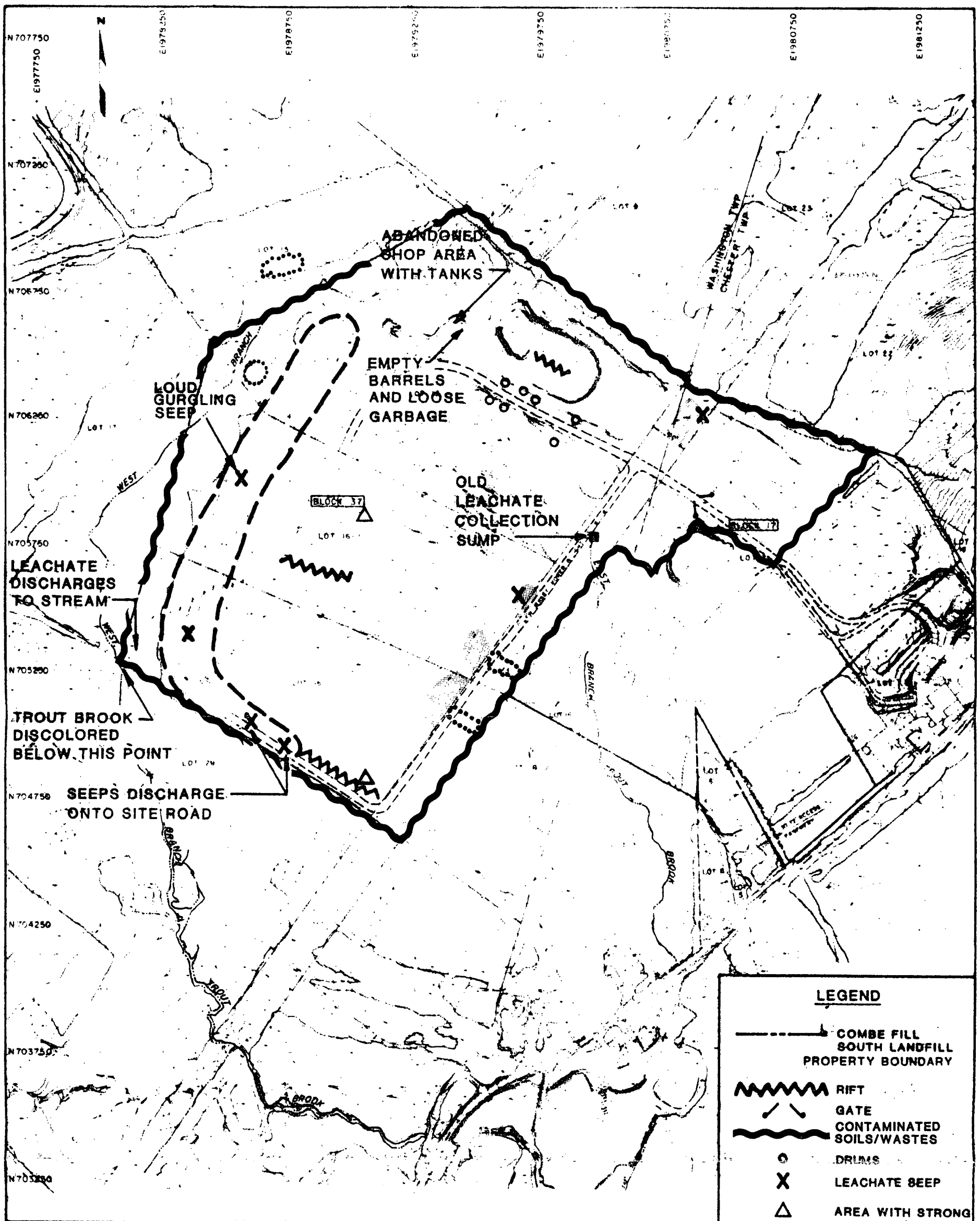
RELEASE TRANSPORT/MEDIUM	RELEASE SOURCE/MECHANISM	EXPOSURE POINT	EXPOSURE ROUTE	NUMBER OF PEOPLE EXPOSED	COMMENTS
Air	Contaminated soils, leachate seeps, surface water/Volatilization	0.5 mi radius of site perimeter	Inhalation	170	24-hr exposure
	(As above)	Day Care Center	(As above)	60	Sensitive population
Groundwater	Contaminated soils and waste/Leaching	Western half of Schoolhouse Lane, 2400 ft NE of landfill	Ingestion, dermal, inhalation	30	Significant exposure point
	(As above)	About 0.5 mi to NE, E, & S of landfill perimeter to Trout Brook, Parker Road, and Unnamed tributary	(As above)	70 (excludes 30 from western Schoolhouse Lane)	Residents only
	(As above)	Day Care Center	(As above)	60 (not included in residential population)	Sensitive population

TABLE 8-2 (Page 2 of 2)

MATRIX OF POSSIBLE EXPOSURE PATHWAYS

Combe Fill South Landfill

RELEASE TRANSPORT/MEDIUM	RELEASE SOURCE/MECHANISM	EXPOSURE POINT	EXPOSURE ROUTE	NUMBER OF PEOPLE EXPOSED	COMMENTS
Surface Water	Contaminated groundwater/ Streamflow recharge and leachate seeps	Hacklebarney State Park ~1.5 mi downstream of landfill	Ingestion (water), ingestion (fish), dermal	30 (per yr)	Possible but not likely ingestion of water by park visitors; possible but unlikely dermal exposure from stream wading; possible ingestion of fish having bioaccumulated contaminants. Short-term exposure only
	Contaminated soils/ Runoff	(As above)	(As above)		
Soils	Contaminated surface soils/Leaching and runoff	Hacklebarney State Park 1.5 mi downstream of landfill	Ingestion of fish exposed to contaminated stream sediments	(part of above population)	Possible but not probable long-term route
	Contaminated surface soil/Tracking	On-site	Dermal	7	Short-term exposure



Lawler, Matusky & Skelly Engineers
Environmental Science & Engineering Consultants
One Blue Hill Plaza
Pearl River, New York 10965

COMBE FILL SOUTH LANDFILL
REMEDIAL INVESTIGATION/
FEASIBILITY STUDY

F. C. wright associates, inc.
earth resources consultants
harrisburg pennsylvania

POSSIBLE CHEMICAL
RELEASE SOURCES

FIGURE 8-1

Lawler, Matusky & Skelly Engineers
Environmental Science & Engineering Consultants
One Blue Hill Plaza
Pearl River, New York 10965

r. e. wright associates, inc.
earth resources consultants
harrisburg pennsylvania

COMBE FILL SOUTH LANDFILL
REMEDIAL INVESTIGATION / FEASIBILITY STUDY

500 0 5
SCALE APPROX

CONTAMINANT EXPOSURE LOCATIONS

FIGURE 8-2

sky & Skelly Engineers
cience & Engineering Consultants
ne Blue Hill Plaza
River, New York 10965

ht associates, inc.
sources consultants
pennsylvania

COMBE FILL SOUTH LANDFILL
REMEDIAL INVESTIGATION / FEASIBILITY STUDY

500 0 500 1000 FEET
SCALE APPROX.

CONTAMINANT EXPOSURE LOCATIONS

FIGURE 8-2

toward Trout Brook, Parker Road, and the unnamed tributary to the north. Location No. 45, a day care center, is again separately listed as a sensitive population because it uses a private well for its potable water supply. These exposed populations are shown in Figure 8-2.

Neither surface waters nor soils are considered to be major contaminant release or transport media. Possible but unlikely exposure from surface waters and soils include:

- Ingestion of, or dermal exposure to, water in Trout Brook at Hacklebarney State Park. The stream is not a potable water source for the Park and would therefore be used only as an incidently source of drinking water during use of park facilities. Trout Brook is too shallow for swimming activities, but fisherman and children may wade in the stream and may inadvertently ingest some of the water.

  -al (wrong in draft, too)

- Ingestion of fish exposed to contaminants in the waters and sediments of Trout Brook is possible, but species of trout (the principal game fish) are stocked annually and will have no opportunity to bioaccumulate contaminants.

- Because there is no physical barrier to prevent access to the landfill it is possible that people may walk onto the site and have direct physical contact with contaminated surface soils and water. However, the off-the-road location of the landfill seems to partly isolate it from the general public. This somewhat isolated location and its distance from the closet residences suggest that it is unlikely that children younger than six years would venture onto the site and ingest contaminated soil or leachate.

Exposure concentrations were calculated for each exposure point along the most likely contaminant pathways (i.e., air inhalation, groundwater ingestion, and surface water ingestion) using a combination of monitoring data collected during the RI, environmental contaminant modeling, and previous sampling data. These calculated

exposure concentrations represent contaminant releases from the landfill alone, i.e., background concentrations have been subtracted. Two exposure concentrations, a "best" estimate and an "upper-bound," have been estimated for each contaminant in each exposure pathway. These estimated exposure point concentrations are summarized in Tables 8-3 through 8-6.

The four primary contaminant exposure locations evaluated for the Combe Fill South landfill include:

- The residents of the western half of Schoolhouse Lane. These residents are assumed to be exposed to landfill contaminants via inhalation of the air, ingestion of groundwater as the principal potable water source, and occasional ingestion of the surface waters of the unnamed tributary.

- The day care center where the children are exposed to landfill contaminants in the air and in the groundwater, their potable water source. Occasional ingestion of surface waters from nearby Trout Brook is also assumed to be an exposure pathway for this sensitive population.

- The other residents within approximately a 0.5-mile radius of the landfill perimeter to the north, east, and southeast of the landfill (as bordered by Schoolhouse Lane, Parker Road, and Trout Brook). These residents are exposed to contaminants in the air and in the groundwater. Occasional ingestion of the surface waters of Trout Brook is also considered to be a possible exposure pathway for this population.

- Recreational users of Hacklebarney State Park along Trout Brook located about 1.5 miles downstream of the landfill. These park users are exposed on a short-term basis to contaminants in the air and in surface waters (assumed to be incidentally ingested).

Information on the population distribution within a 5 mile radius of the site is given in Chapter 2 section 2.1.1 of this report;

TABLE 8-3

WESTERN SCHOOLHOUSE LANE
EXPOSURE POINT CONCENTRATIONS OF
INDICATOR CHEMICALS

Combe Fill South Landfill

CHEMICAL	CONCENTRATIONS[a] "BEST" TO "UPPER-BOUND"		
	AIR (mg/m^3)	SURFACE WATER[b] (mg/l)	GROUND WATER (mg/l)
Chloroform	.00007 - .005	0	.0291 - .182
Benzene	.00072 - .048	0	0 - .126[c]
Tetrachloethylene	.00035 - .015	0	.00167 - .00994
1,2-Dichloroethane	0	0	.0037 - .00938[c]
Trichloroethylene	.00024 - .015	0	.00093 - .0284[c]
Nickel	0 - .000008	0	.005 - .01
Toluene	.00212 - .087	0	0 - 0.0042
1,1-Dichloroethane	0	0	0 - .0032
Methylene Chloride	.0004 - .0004	0	0 - .210

[a]Only those concentrations attributable to landfill. Does not include background.

[b]Unnamed tributary.

[c]Concentration exceeds applicable or relevant and appropriate criteria, Table 8-7.

TABLE 8-4

DAY-CARE CENTER
EXPOSURE POINT CONCENTRATIONS OF
INDICATOR CHEMICALS

Combe Fill South Landfill

CHEMICAL	CONCENTRATIONS[a] "BEST" TO "UPPER-BOUND"		
	AIR (mg/m^3)	SURFACE WATER[b] (mg/l)	GROUND WATER (mg/l)
Chloroform	.00007 - .005	0	0 - .040
Benzene	.00072 - .048	0	0
Tetrachloethylene	.00035 - .015	0	0 - .005
1,2-Dichloroethane	0	0	0
Trichloroethylene	.00024 - .015	0	0
Nickel	0 - .000008	0	0 - .005
Toluene	.00212 - .087	0	0
1,1-Dichloroethane	0	0	0
Methylene Chloride	.0004 - .0004	.00078 - .0014	0 - .014

[a]Concentrations attributable to landfill alone. Does not include background.

[b]At Trout Brook.

TABLE 8-5

WITHIN 0.5 MILES TO NORTH, EAST, AND SOUTH OF THE LANDFILL
EXPOSURE POINT CONCENTRATIONS OF INDICATOR CHEMICALS

Combe Fill South Landfill

CHEMICAL	CONCENTRATIONS[a] "BEST" TO "UPPER-BOUND" AIR (mg/m^3)	SURFACE WATER[b] (mg/l)	GROUND WATER (mg/l)
Chloroform	.00007 - .005	0	.00066 - .0697
Benzene	.00072 - .048	0	0 - .0011
Tetrachloethylene	.00035 - .015	0	0 - .0067
1,2-Dichloroethane	0	0	0 - .0185[c]
Trichloroethylene	.00024 - .015	0	.00413 - .010[c]
Nickel	0 - .000008	0	.0017 - .01
Toluene	.00212 - .087	0	0 - .0042
1,1-Dichloroethane	0	0	0
Methylene Chloride	.0004 - .0004	.00078 - .0014	.00051 - .210

[a]Concentrations attributable to landfill alone. Does not include background.

[b]At Trout Brook.

[c]Concentration exceeds applicable or relevant and appropriate criteria, Table 8-7.

TABLE 8-6

TROUT BROOK AT HACKLEBARNEY STATE PARK
EXPOSURE POINT CONCENTRATIONS OF
INDICATOR CHEMICALS

Combe Fill South Landfill

CHEMICAL	CONCENTRATIONS[a] "BEST" TO "UPPER-BOUND"		
	AIR (mg/m^3)	SURFACE WATER[b] (mg/l)	GROUND WATER (mg/l)
Chloroform	.00007 - .005	0	NA
Benzene	.00072 - .048	0	NA
Tetrachloethylene	.00035 - .015	0	NA
1,2-Dichloroethane	0	0	NA
Trichloroethylene	.00024 - .015	0	NA
Nickel	0 - .000008	0	NA
Toluene	.00212 - .087	0	NA
1,1-Dichloroethane	0	0	NA
Methylene Chloride	.0004 - .0004	.00078 - .0014	NA

[a]Concentrations attributable to landfill alone. Does not include background.

[b]Trout Brook at entrance to Hacklebarney State Park.

NA - Not applicable to exposure scenario.

other sensitive populations in the study area are described in Table 2-1, pg. 2-1B1 of this report.

Exposure concentrations of air contaminants were calculated using a combination of air modeling and site sampling data. The ISCLT air modeling performed for this landfill calculated concentrations of total volatile contaminants at various distances from the landfill. "Best-estimate" concentrations of individual volatile contaminants were calculated by multiplying the total ISCLT calculated concentration by the proportion of the constituent to the total RI measured concentration. "Best-estimate" concentrations of metals were based on actual QA/QC corrected RI measurements (i.e., on-site minus upwind concentrations). "Upper-bound" concentrations were assumed to be equal to the single QA/QC corrected worst-day RI sampling conditions (on-site minus upwind).

Exposure concentrations of chemicals in groundwater were obtained from the results of the RI program and previous sampling information. "Best-estimate" concentrations were assumed to equal the concentration of chemicals actually measured during the RI in the potable wells associated with the exposure point. Background concentrations of chemicals in groundwater were assumed to equal zero, thus all measured concentrations were attributed to the landfill. "Upper-bound" estimates for the potable wells at the end of Schoolhouse Lane were assumed to be equal to the average concentrations measured in the monitoring wells D-2 and DW-4 located upgradient in the groundwater flow path leading to these wells. The "upper-bound" estimates of groundwater contaminants impacting the day care center were assumed to equal the concentrations measured in a previous sampling of the center that were higher than those measured during the RI. The "upper-bound" estimates for the remainder of the exposed population was assumed to be equal to the highest concentration of the contaminant as measured during the RI in the

potable wells at the western end of Schoolhouse Lane or as measured in previous residential sampling efforts, whichever was greater.

Exposure concentrations for surface water locations were also obtained from the results of the RI and previous sampling information. "Best-estimate" concentrations at surface water locations were assumed to equal the average of the RI concentrations at that location (minus the RI background station concentration) or the average of previous sampling concentrations (minus the previous background concentration at the upstream Black River station). "Upper-bound" concentrations were assumed to equal the maximum concentration of the constituent (as measured either during the RI or during previous samplings) minus the appropriate background concentrations.

In Table 8-7 the nine indicator chemicals are characterized according to their applicable, or relevant and appropriate requirements. Applicable, or relevant and appropriate requirements include federal drinking water maximum contaminant levels (MCLs), national ambient air quality standards (NAAQS) and the federally-approved NJ water quality standards (FW-2 standards for local waters, see Chapter 5). Table 8-7 also lists other federal and state standards, criteria, advisories, and guidance including:

- Federal ambient water quality criteria (adjusted for drinking water only)
- EPA drinking water health advisories (HEAs)
- NJ groundwater quality standards (for GW-2 waters)
- Federal recommended maximum contaminant levels (RMCLs) in drinking water

These standards and criteria, as well as acceptable daily intakes (ADIs) and preliminary protective concentration limits (PPCLs), are

TABLE 8-7

APPLICABLE, OR RELEVANT AND APPROPRIATE STANDARDS AND OTHER FEDERAL AND STATE STANDARDS, CRITERIA, AND ADVISORIES

Combe Fill South Landfill

	APPLICABLE OR RELEVANT AND APPROPRIATE			OTHER FEDERAL AND STATE STANDARDS CRITERIA AND ADVISORIES			
CHEMICAL	FED. DRINKING WATER STDS MCL (mg/l)	NJ SURFACE WATER STD FW-2 (mg/l)	NATIONAL[a] AMBIENT AIR STANDARD (mg/m^3)	FED. AMBIENT WATER QUALITY CRITERIA, DRINKING ONLY (mg/l)	NJ GROUNDWATER STANDARDS GW-2 (mg/l)	FED. DRINKING WATER RECOMMENDED LIMITS RMCL (mg/l)	EPA DRINKING WATER HEALTH ADVISORIES (mg/l)[b]
Chloroform	NS	NS		0 (.00019)[c]	NS	NS	NS
Benzene	.005	NS		0 (.00067)[c]	NS	0	.00035
Tetrachloroethylene	NS	NS		0 (.00088)[c]	NS	NS	.0007
1,2-Dichloroethane	.005	NS		0 (.00094)[c]	NS	0	.00095
Trichloroethylene	.005	NS		0 (.0028)[c]	NS	0	.0028
Nickel	NS	NS		.0154	NS	NS	.35[d]
Toluene	NS	NS		15	NS	2	10.1[d]
1,1-Dichloroethane	NS	NS		Insufficent data	NS	NS	NS
Methylene Chloride	NS	NS		0 (.00019)[c]	NS	NS	.05

[a]The NAAQS has no standards for the indicator chemicals.

[b]Referenced concentration for 10^6 increased cancer risk for 70 kg adult unless otherwise stated.

[c]Numbers in ( ) are concentrations corresponding to 10^6 increased cancer risk, although target criteria is zero.

[d]Lifetime exposure concentration for 10 kg adult.

NS - No standard, criteria or advisories.

summarized for all constituents found at greater than detection limits on and near the site in Appendices V through Z.

As seen in Table 8-3, along the western half of Schoolhouse Lane the "upper-bound" estimates of benzene, 1,2-dichloroethane, and trichloroethylene exceed the federal MCL for drinking water. Both the "best" and "upper-bound" estimates of three indicator chemicals (chloroform, tetrachloroethylene, and 1,2-dichloroethane) exceeded the federal ambient water quality criteria (adjusted for drinking water only); the "upper-bound" estimates of another three chemicals (benzene, trichloroethylene, and methylene chloride) also exceeded the ambient water quality criteria. Of the four indicator chemicals at this exposure point for which there are recommended maximum concentration limits (RMCLs) in drinking water, three (benzene, 1,2-dichloroethane, and trichloroethylene) had concentrations that exceeded the RMCL. Finally, EPA drinking water health advisories were exceeded by benzene ("upper-bound" estimate only), tetrachloroethylene ("best" and "upper-bound" estimates), and the "upper-bound" estimates for 1,2-dichloroethane and trichloroethylene.

At the day care center the "upper-bound" estimates for chloroform, tetrachloroethylene, and methylene chloride in groundwater all exceed the federal ambient water quality criteria (adjusted for drinking water only). The "upper-bound" concentrations for tetrachloroethylene also exceeds the EPA drinking water health advisory.

Other residents within about 0.5 miles of the landfill to the northeast, east, and southeast are part of the third exposure point scenario. "Upper-bound" groundwater estimates of trichloroethylene and 1,2-dichloroethane exceed drinking water MCLs. Of the eight chemicals having ambient water quality criteria only methylene chloride has concentrations that exceed criteria in both surface waters and groundwaters at this exposure point. All RMCLs except

that for toluene are exceeded by the "upper-bound" estimates. All surface and groundwater concentrations are below the EPA drinking water health advisories.

For the fourth exposure point at Hacklebarney State Park, only air and surface water concentrations are considered to be relevant sources of landfill contamination. Although no relevant standards are exceeded at this exposure point, the concentration of methylene chloride exceeds the ambient water quality criteria.

8.4 ESTIMATION OF CHEMICAL INTAKES

Applying standard values of adult and child body weights, water ingestion and air inhalation to the "best" and "upper-bound" exposure point concentration estimates described previously, average daily intakes of landfill generated contaminants were then calculated. Intakes were calculated for three primary modes of exposure: ingestion of groundwater as the normal source of potable water, inhalation of air, and occasional drinking of surface waters during recreational activities. The pathways for which contaminant exposures were quantified at selected exposure points are listed in Table 8-8.

Tables 8-9 through 8-12 summarize the calculated daily intakes of each of the indicator chemicals at the referenced exposure points. Except for the recreational drinking of surface waters, all intake calculations assume that subchronic intakes can be approximated by the "upper-bound" concentration estimates and chronic intakes can be estimated with the "best" concentration estimate at the exposure point. Intakes of surface water were assumed to be always ocassional (subchronic) and were based on the best estimate of the exposure point concentration but assuming only half the average daily water ingestion for an adult or child.

TABLE 8-8

QUANTIFIED PATHWAYS CONTRIBUTING TO TOTAL EXPOSURE

Combe Fill South Landfill

EXPOSURE POINT	QUANTIFIED EXPOSURE PATHWAYS	COMMENTS
1. Residents on western half of Schoolhouse Lane (Significant exposure point)	Groundwater ingestion	
	Air inhalation	
	Surface water ingestion at Unnamed Tributary	Short-term exposure only
2. Day Care Center (Sensitive population)	Groundwater ingestion	Chronic exposure but at half daily intake rate
	Air inhalation	
	Surface water ingestion at Trout Brook	Short-term exposure only
3. Other residents to Northeast, East, and South within about 0.5 mile of site	Groundwater ingestion	
	Air inhalation	
	Surface water ingestion at West Branch of Trout Brook	Short-term exposure only
4. Recreational uses of Hacklebarney State Park (1.5 miles south of landfill	Air inhalation	Short-term exposure only
	Surface water ingestion of Trout Brook	Short-term exposure at half normal daily intake
	(Fish ingestion)	(Not quantified)

TABLE 8-9

DAILY INTAKE CALCULATIONS OF INDICATOR CHEMICALS
WESTERN HALF OF SCHOOLHOUSE LANE

Combe Fill South Landfill

INDICATOR CHEMICALS	DAILY INTAKES (mg/kg/day)							
	SUBCHRONIC DAILY INTAKE (SDI)				CHRONIC DAILY INTAKE (CDI)			
	GW	SW	TOTAL ORAL	AIR	GW	SW	TOTAL ORAL	AIR
Chloroform	5.28×10^{-3}	0	5.28×10^{-3}	1.45×10^{-3}	8.44×10^{-4}	NA	8.44×10^{-4}	2.03×10^{-5}
Benzene	3.65×10^{-3}	0	3.65×10^{-3}	0.0139	0	NA	0	2.09×10^{-4}
Tetrachloroethylene	2.88×10^{-4}	0	2.88×10^{-4}	4.35×10^{-3}	4.84×10^{-5}	NA	4.84×10^{-5}	1.02×10^{-4}
1,2-Dichloroethane	1.07×10^{-4}	0	1.07×10^{-4}	0	2.72×10^{-4}	NA	2.72×10^{-4}	0
Trichloroethylene	8.24×10^{-4}	0	8.24×10^{-4}	4.35×10^{-3}	2.70×10^{-5}	NA	2.70×10^{-5}	6.96×10^{-5}
Nickel	2.9×10^{-4}	0	2.9×10^{-4}	2.32×10^{-6}	1.45×10^{-4}	NA	1.45×10^{-4}	0
Toluene	1.22×10^{-4}	0	1.22×10^{-4}	0.0252	0	NA	0	6.15×10^{-4}
1,1-Dichloroethane	9.28×10^{-5}	0	9.28×10^{-5}	0	0	NA	0	0
Methylene chloride	6.09×10^{-3}	0	6.09×10^{-3}	1.6×10^{-4}	0	NA	0	1.16×10^{-4}

GW = Groundwater
SW = Surface water
Oral = Groundwater + surface water
NA = Not applicable

TABLE 8-10

DAILY INTAKE CALCULATIONS OF INDICATOR CHEMICALS
DAY CARE CENTER

Combe Fill South Landfill

INDICATOR CHEMICALS	DAILY INTAKES (mg/kg/day)							
	SUBCHRONIC DAILY INTAKE (SDI)				CHRONIC DAILY INTAKE (CDI)			
	GW	SW	TOTAL ORAL	AIR	GW	SW	TOTAL ORAL	AIR
Chloroform	2×10^{-3}	0	2×10^{-3}	2.5×10^{-3}	0	NA	0	3.5×10^{-5}
Benzene	0	0	0	0.024	0	NA	0	3.6×10^{-4}
Tetrachloroethylene	2.5×10^{-4}	0	2.5×10^{-4}	7.5×10^{-3}	0	NA	0	1.75×10^{-4}
1,2-Dichloroethane	0	0	0	0	0	NA	0	0
Trichloroethylene	0	0	0	7.5×10^{-3}	0	NA	0	1.2×10^{-4}
Nickel	2.5×10^{-4}	0	2.5×10^{-4}	4×10^{-6}	0	NA	0	0
Toluene	0	0	0	0.0435	0	NA	0	1.06×10^{-3}
1,1-Dichloroethane	0	0	0	0	0	NA	0	0
Methylene chloride	7×10^{-4}	3.9×10^{-5}	7.39×10^{-4}	2×10^{-4}	0	NA	0	2×10^{-4}

GW = Groundwater
SW = Surface water
Oral = Groundwater + surface water
NA = Not applicable

TABLE 8-11

DAILY INTAKE CALCULATIONS OF INDICATOR CHEMICALS
OTHER RESIDENTS WITHIN 0.5 MILES TO NORTH, EAST, AND SOUTH OF SITE

Combe Fill South Landfill

INDICATOR CHEMICALS	DAILY INTAKES (mg/kg/day)							
	SUBCHRONIC DAILY INTAKE (SDI)				CHRONIC DAILY INTAKE (CDI)			
	GW	SW	TOTAL ORAL	AIR	GW	SW	TOTAL ORAL	AIR
Chloroform	2.02×10^{-3}	0	2.02×10^{-3}	1.45×10^{-3}	1.91×10^{-5}	NA	1.91×10^{-5}	2.03×10^{-5}
Benzene	3.19×10^{-5}	0	3.19×10^{-5}	0.0139	0	NA	0	2.09×10^{-4}
Tetrachloroethylene	1.94×10^{-4}	0	1.94×10^{-4}	4.35×10^{-3}	0	NA	0	1.02×10^{-4}
1,2-Dichloroethane	5.37×10^{-4}	0	5.37×10^{-4}	0	0	NA	0	0
Trichloroethylene	2.9×10^{-4}	0	2.9×10^{-4}	4.35×10^{-3}	1.20×10^{-4}	NA	1.20×10^{-4}	6.96×10^{-5}
Nickel	2.9×10^{-4}	0	2.9×10^{-4}	2.32×10^{-6}	4.93×10^{-5}	NA	4.93×10^{-5}	0
Toluene	1.22×10^{-4}	0	1.22×10^{-3}	0.0252	0	NA	0	6.15×10^{-4}
1,1-Dichloroethane	0	0	0	0	0	NA	0	0
Methylene chloride	6.09×10^{-3}	1.09×10^{-5}	6.101×10^{-3}	1.16×10^{-4}	1.48×10^{-5}	NA	1.48×10^{-5}	1.16×10^{-4}

GW = Groundwater
SW = Surface water
Oral = Groundwater + surface water
NA = Not applicable

TABLE 8-12

DAILY INTAKE CALCULATIONS OF INDICATOR CHEMICALS
TROUT BROOK AT HACKLEBARNEY STATE PARK

Combe Fill South Landfill

INDICATOR CHEMICALS	DAILY INTAKES (mg/kg/day)							
	SUBCHRONIC DAILY INTAKE (SDI)				CHRONIC DAILY INTAKE (CDI)			
	GW	SW	TOTAL ORAL	AIR	GW	SW	TOTAL ORAL	AIR
Chloroform	NA	0	0	2.03×10^{-5}	NA	NA	NA	NA
Benzene	NA	0	0	2.09×10^{-4}	NA	NA	NA	NA
Tetrachloroethylene	NA	0	0	1.02×10^{-4}	NA	NA	NA	NA
1,2-Dichloroethane	NA	0	0	0	NA	NA	NA	NA
Trichloroethylene	NA	0	0	6.96×10^{-5}	NA	NA	NA	NA
Nickel	NA	0	0	0	NA	NA	NA	NA
Toluene	NA	0	0	6.15×10^{-4}	NA	NA	NA	NA
1,1-Dichloroethane	NA	0	0	0	NA	NA	NA	NA
Methylene chloride	NA	1.09×10^{-5}	1.09×10^{-5}	1.16×10^{-4}	NA	NA	NA	NA

GW = Groundwater
SW = Surface water
Oral = Groundwater + surface water
NA = Not applicable

Groundwater ingestion by the children attending the day care center was assumed to be chronic but intakes were calculated using only half the normal water ingestion rate for a child because it was assumed that the child lived outside of the groundwater impact area. On the other hand, all inhalation intakes were calculated using the total daily inhalation volume on the assumption that the child lived within the air impact area. Air inhalation contaminant intakes by recreational users of Hacklebarney State Park were based on total daily air inhalation volumes for adults and best estimate exposure concentration but were assumed to be of short-duration (subchronic) as is recreational water ingestion.

8.5 TOXICITY ASSESSMENT

The next step in the public health assessment process is the evaluation of the toxicity of the indicator chemicals. Toxicity is evaluated in three ways:

- Acceptable intake for subchronic (AIS) exposure of noncarcinogens, expressed in mg/kg of body weight/day
- Acceptable intake for chronic (AIC) exposure of noncarcinogens, expressed in mg/kg of body weight/day
- Carcinogenic potency factor (CPF) for potential carcinogens, expressed as a lifetime cancer risk, mg/kg of body weight/day, or $(mg/kg/day)^{-1}$. This factor is an estimated upper 95% confidence limit of the carcinogenic potency of a chemical.

AIS and AIC values are calculated from ADIs developed by the EPA Office of Research and Development and from Health Effects Assessment (HEAs) documents prepared by the EPA Environmental Criteria and Assessment Office. CPFs are also provided in the HEAs and by the EPA Carcinogenic Assessment Group. The acceptable intakes and carcinogenic potency factors for inhalation and ingestion of the

chemical indicators at the Combe Fill South landfill are summarized in Table 8-13. Site-specific factors that may affect the generic toxicity values summarized in Table 8-13 include:

- The presence of a sensitive population. A sensitive population, the day care center, a nursery and day-care facility with a student population of 60 children, is located about 0.5 miles to the southeast of the site. This population is primarily exposed to contaminants in the air and in the groundwater, the potable water source.

- Exposure uncertainties. Such nonqualified minor exposure pathways such as ingestion of fish, ingestion of on-site soils, and dermal adsorption from air or water, represent uncertainties regarding subchronic levels of exposures, particularly to surface waters.

- The quality and quantity of site-specific exposure data. For the Combe Fill South landfill study, the overall data adequacy is believed to be sufficiently detailed to allow reasonable assessment and the QA/QC associated with the data was acceptable. However, as mentioned in previous discussions, much of the RI data was collected during a time of abnormally low precipitation (and consequently low leachate production and low surface water flows). Therefore, the site data may not appropriately reflect site impacts under normal rainfall conditions. Additional "normal weather" site data information would be helpful in fine-tuning the evaluation of public health impacts from the site.

- The percentage of site chemicals explicitly evaluated. The nine indicator chemicals chosen for evaluation at the Combe Fill South site represent approximately 10% of the total number of compounds, measured at concentrations above their detection limits, on and near the landfill.

8.6 RISK CHARACTERIZATION OF INDICATOR CHEMICALS

In the final step of the baseline public health evaluation process comparisons are made between projected and acceptable intakes for noncarcinogenic chemicals and between projected and target risks

TABLE 8-13

CRITICAL TOXICITY VALUES FOR INDICATOR CHEMICALS

Combe Fill South Landfill

CHEMICAL	NONCARCINOGENIC AIS (mg/kg/day)	NONCARCINOGENIC AIC (mg/kg/day)	CARCINOGENIC POTENCY FACTOR $(mg/kg/day)^{-1}$	EPA WEIGHT OF EVIDENCE RATING
Inhalation Route				
1. Chloroform	NV	NV	NV	B2
2. Benzene	NV	NV	2.6×10^{-2}	A
3. Tetrachloroethylene	NV	NV	1.7×10^{-3}	B2
4. 1,2-Dichloroethane	NV	NV	NV	B2
5. Trichloroethylene	NV	NV	4.6×10^{-3}	B2
6. Nickel	NV	1.2	1.2	A
7. Toluene	NV	NV	-	-
8. 1,1-Dichloroethane	1.38	1.4×10^{-1}	-	-
9. Methylene chloride	NV	NV	6.3×10^{-4}	B2
Ingestion Route				
1. Chloroform	NV	NV	7.0×10^{-2}	B2
2. Benzene	NV	NV	4.45×10^{-2}	A
3. Tetrachloroethylene	NV	2×10^{-2}	5.1×10^{-2}	B2
4. 1,2-Dichloroethane	NV	NV	6.9×10^{-2}	B2
5. Trichloroethylene	NV	NV	1.1×10^{-2}	B2
6. Nickel	2×10^{-2}	1×10^{-1}	NV	D
7. Toluene	4.3×10^{-1}	2.9×10^{-1}	-	-
8. 1,1-Dichloroethane	1.2	1.2×10^{-1}	-	-
9. Methylene chloride	NV	5×10^{-2}	NV	B2

NV = No value given.
\- = Chemical not listed.
AIS = Acceptable intake, subchronic.
AIC = Acceptable intake, chronic.
EPA Weight of Evidence Rating = Rating group for evaluating carcinogenicity of chemical in decreasing order of evidence of carcinogenicity from A, B1, B2, C, D, E.

for carcinogenic chemicals. General chemicals are evaluated as both carcinogenic and noncarcinogenic where human carcinogenicity has not yet been fully established.

Tables 8-14 through 8-17 summarize the development of the subchronic and chronic hazard indices for noncarcinogenic indicator chemicals at each of the four exposure points selected for evaluation. A chronic or subchronic hazard index is calculated by summing the ratios of projected:acceptable daily intakes for each chemical for both inhalation and oral routes of exposure. Summing the inhalation and oral route ratios provides a total chronic or subchronic hazard index for the exposure point. Only those indicator chemicals with published AIS or AIC values were included in these hazard index calculations. Where an oral AIS or AIC was available for a chemical but not an inhalation AIS or AIC, a second hazard index calculation (shown in parentheses) was made using oral AIS values for the inhalation route.

As seen in Tables 8-14 through 8-17, none of the calculated hazard indices (oral, inhalation, or total) exceed unity for any exposure location. Therefore, it is probable that the landfill does not result in any subchronic or chronic noncarcinogenic health hazards.

Carcinogenic risks associated with the landfill are evaluated in Tables 8-18 through 8-20. Chronic daily intakes for inhalation and oral routes are multiplied by the respective CPF to develop a route specific risk for each potential carcinogen. The CPF is an upper 95% confidence limit on the probability of cancerous response per unit intake of a chemical over a lifetime. When multiplied by the estimated daily estimated intake, the CPF provides an estimate of the incremental cancer risk associated with intake of the specific chemical.

TABLE 8-14

NONCARCINOGENIC HAZARD INDICES
WESTERN HALF OF SCHOOLHOUSE LANE

Combe Fill South Landfill

	SUBCHRONIC HAZARD INDEX					
	INHALATION			ORAL		
CHEMICAL	SDI	AIS	SDI:AIS	SDI	AIS	SDI:AIS
Nickel	2.32×10^{6}	(.02)[a]	(.00012)[b]	3.9×10^{-4}	.02	.0145
Toluene	.0252	(.43)[a]	(0.5860)[b]	1.22×10^{-4}	.43	.000284
1,1-Dichloroethane	0	1.38	0	9.28×10^{-5}	1.2	.000077
Total			0(.05872)[b]			.01486
Subchronic Total Hazard Index = 0.01486 (0.07358)[b]						

	CHRONIC HAZARD INDEX					
	INHALATION			ORAL		
CHEMICAL	CDI	AIC	CDI:AIC	CDI	AIC	CDI:AIC
Tetrachloroethylene	1.02×10^{-4}	(.02)[a]	(.005)[b]	4.84×10^{-5}	.02	.0024
Nickel	0	1.2	0	1.45×10^{-4}	.1	.0015
Toluene	6.15×10^{-4}	(.29)[a]	(.0021)[b]	0	.29	0
1,1-Dichloroethane	0	.14	0	0	.12	0
Methylene chloride	1.16×10^{-4}	(.05)[a]	(.0023)[b]	0	.05	0
Total			0(.0094)[b]			.0039
Chronic Total Hazard Index = .0039						

[a]Inhalation AIS or AIC assumed to equal oral AIS or AIC.
[b]Calculated using assumed inhalation AIS or AIC
SID = Subchronic daily intake, mg/kg/day.
AIS = Acceptable intake subchronic, mg/kg/day.
SDI:AIS = Ratio of SDI to AIS.
CDI = Chronic daily intake, mg/kg/day.
AIC = Acceptable intake chronic, mg/kg/day.
CDI:AIC = Ratio of CDI to AIC.

TABLE 8-15

NONCARCINOGENIC HAZARD INDICES
DAY CARE CENTER

Combe Fill South Landfill

	SUBCHRONIC HAZARD INDEX					
	INHALATION			ORAL		
CHEMICAL	SDI	AIS	SDI:AIS	SDI	AIS	SDI:AIS
Nickel	4×10^{-6}	(.02)[a]	(.0002)[b]	7.5×10^{-4}	.02	.0125
Toluene	.0435	(.43)[a]	(.1012)[b]	0	.43	0
1,1-Dichloroethane	0	1.38	0	0	1.2	0
Total			0(.1014)[b]			0(.0125)
Subchronic Total Hazard Index = .0125 (.1139)[b]						

	CHRONIC HAZARD INDEX					
	INHALATION			ORAL		
CHEMICAL	CDI	AIC	CDI:AIC	CDI	AIC	CDI:AIC
Tetrachloroethylene	1.75×10^{-4}	(.02)[a]	(.0088)[b]	0	.02	0
Nickel	0	1.2	0	0	.1	0
Toluene	1.06×10^{-3}	(.29)[a]	(.0037)[b]	0	.29	0
1,1-Dichloroethane	0	.14	0	0	.12	0
Methylene chloride	2×10^{-4}	(.05)[a]	(.004)[b]	0	.05	0
Total			0(.0165)[b]			0
Chronic Total Hazard Index = 0(.0165)						

[a]Inhalation AIS or AIC assumed to equal oral AIS or AIC.
[b]Calculated using assumed inhalation AIS or AIC
SID = Subchronic daily intake, mg/kg/day.
AIS = Acceptable intake subchronic, mg/kg/day.
SDI:AIS = Ratio of SDI to AIS.
CDI = Chronic daily intake, mg/kg/day.
AIC = Acceptable intake chronic, mg/kg/day.
CDI:AIC = Ratio of CDI to AIC.

TABLE 8-16

NONCARCINOGENIC HAZARD INDICES
RESIDENTS WITHIN 0.5 MILE TO THE NORTH, SOUTH, AND EAST OF LANDFILL

Combe Fill South Landfill

	SUBCHRONIC HAZARD INDEX					
	INHALATION			ORAL		
CHEMICAL	SDI	AIS	SDI:AIS	SDI	AIS	SDI:AIS
Nickel	2.32×10^{-6}	(.02)[a]	(.00012)[b]	3.81×10^{-4}	.02	.0191
Toluene	.0252	(.43)[a]	(.0586)[b]	2.542×10^{-3}	.43	.0059
1,1-Dichloroethane	0	1.38	0	0	1.2	0
Total			0(.0587)[b]			.01734
Subchronic Total Hazard Index = .01734 (.07604)[b]						

	CHRONIC HAZARD INDEX					
	INHALATION			ORAL		
CHEMICAL	CDI	AIC	CDI:AIC	CDI	AIC	CDI:AIC
Tetrachloroethylene	1.02×10^{-4}	(.02)[a]	(.0051)[b]	0	.02	0
Nickel	0	1.2	0	4.93×10^{-5}	.1	.000493
Toluene	6.15×10^{-4}	(.29)[a]	(.0021)[b]	0	.29	0
1,1-Dichloroethane	0	.14	0	0	.12	0
Methylene chloride	1.16×10^{-4}	(.05)[a]	(.0023)[b]	1.48×10^{-5}	.05	.000296
Total			0(.0095)[b]			.00079
Chronic Total Hazard Index = .00079 (.0103)						

[a]Inhalation AIS or AIC assumed to equal oral AIS or AIC.
[b]Calculated using assumed inhalation AIS or AIC
SID = Subchronic daily intake, mg/kg/day.
AIS = Acceptable intake subchronic, mg/kg/day.
SDI:AIS = Ratio of SDI to AIS.
CDI = Chronic daily intake, mg/kg/day.
AIC = Acceptable intake chronic, mg/kg/day.
CDI:AIC = Ratio of CDI to AIC.

TABLE 8-17

NONCARCINOGENIC HAZARD INDICES
TROUT BROOK AT HACKLEBARNEY STATE PARK

Combe Fill South Landfill

	SUBCHRONIC HAZARD INDEX					
	INHALATION			ORAL		
CHEMICAL	SDI	AIS	SDI:AIS	SDI	AIS	SDI:AIS
Nickel	0	(.02)[a]	(0)[b]	0	.02	0
Toluene	6.15×10^{-4}	(.43)[a]	(.00143)[b]	0	.43	0
1,1-Dichloroethane	0	1.38[a]	0	0	1.2	0
Total			0(.00143)[b]			0
Subchronic Total Hazard Index = 0 (.00143)[b]						

CHRONIC HAZARD INDEX

Not Applicable.
(No chronic daily intakes assumed for recreational users at this exposure point.)

[a]Inhalation AIS or AIC assumed to equal oral AIS or AIC.
[b]Calculated using assumed inhalation AIS or AIC
SID = Subchronic daily intake, mg/kg/day.
AIS = Acceptable intake subchronic, mg/kg/day.
SDI:AIS = Ratio of SDI to AIS.
CDI = Chronic daily intake, mg/kg/day.
AIC = Acceptable intake chronic, mg/kg/day.
CDI:AIC = Ratio of CDI to AIC.

TABLE 8-18

CALCULATION OF RISK FROM POTENTIAL CARCINOGENS
WESTERN HALF OF SCHOOLHOUSE LANE

Combe Fill South Landfill

CHEMICAL	EXPOSURE ROUTE	CDI (mg/kg/day)	CARCINOGENIC POTENCY FACTOR $(mg/kg/day)^{-1}$	ROUTE SPECIFIC RISK	TOTAL CHEMICAL SPECIFIC RISK
Chloroform	Inhalation	2.03×10^{-5}	-	(1×10^{-6})	5.9×10^{-5}
	Ingestion	8.44×10^{-4}	7.0×10^{-2}	5.9×10^{-5}	(6×10^{-5})
Benzene	Inhalation	2.09×10^{-4}	2.6×10^{-2}	5×10^{-6}	5×10^{-6}
	Ingestion	0	4.45×10^{-2}	0	
Tetrachloroethylene	Inhalation	1.02×10^{-4}	1.73×10^{-3}	1.735×10^{-7}	2.65×10^{-6}
	Ingestion	4.48×10^{-5}	5.1×10^{-2}	2.47×10^{-6}	
1,2-Dichloroethane	Inhalation	0	-	0	1.88×10^{-5}
	Ingestion	2.72×10^{-4}	6.9×10^{-2}	1.88×10^{-5}	
Trichloroethylene	Inhalation	6.96×10^{-5}	4.6×10^{-3}	3.2×10^{-7}	6.17×10^{-7}
	Ingestion	2.70×10^{-5}	1.1×10^{-2}	2.97×10^{-7}	
Nickel	Inhalation	0	1.2	0	0
	Ingestion	1.45×10^{-4}	-	(1.74×10^{-4})	(1.74×10^{-4})
Methylene chloride	Inhalation	1.16×10^{-4}	6.3×10^{-4}	7.3×10^{-8}	7.3×10^{-8}
	Ingestion	0	-	0	
TOTAL INCREMENTAL RISK					8.614×10^{-5} (2.611×10^{-4})

Numbers in ( ) based on assumption that carcinogenic risk is the same for inhalation and ingestion for specific compounds.

TABLE 8-19

CALCULATION OF RISK FROM POTENTIAL CARCINOGENS
DAY CARE CENTER

Combe Fill South Landfill

CHEMICAL	EXPOSURE ROUTE	CDI (mg/kg/day)	CARCINOGENIC POTENCY FACTOR $(mg/kg/day)^{-1}$	ROUTE SPECIFIC RISK	TOTAL CHEMICAL SPECIFIC RISK
Chloroform	Inhalation	3.5×10^{-5}	-	(2.45×10^{-6})	0
	Ingestion	0	7.0×10^{-2}	0	(2.45×10^{-6})
Benzene	Inhalation	3.6×10^{-4}	2.6×10^{-2}	9.36×10^{-6}	9.36×10^{-6}
	Ingestion	0	4.45×10^{-2}	0	
Tetrachloroethylene	Inhalation	1.75×10^{-4}	1.73×10^{-3}	2.98×10^{-7}	2.98×10^{-7}
	Ingestion	0	5.1×10^{-2}	0	
1,2-Dichloroethane	Inhalation	0	-	0	0
	Ingestion	0	6.9×10^{-2}	0	0
Trichloroethylene	Inhalation	1.2×10^{-4}	4.6×10^{-3}	5.52×10^{-7}	5.52×10^{-7}
	Ingestion	0	1.1×10^{-2}	0	
Nickel	Inhalation	0	1.2	0	0
	Ingestion	0	-	0	
Methylene chloride	Inhalation	2×10^{-4}	6.3×10^{-4}	1.26×10^{-7}	1.26×10^{-7}
	Ingestion	0	-	0	
TOTAL INCREMENTAL RISK					1.03×10^{-5} (1.279×10^{-5})

Numbers in ( ) based on assumption that carcinogenic risk is the same for inhalation and ingestion for specific compounds.

TABLE 8-20

CALCULATION OF RISK FROM POTENTIAL CARCINOGENS
WITHIN 0.5 MILE TO THE NORTH, EAST, AND SOUTH OF LANDFILL

Combe Fill South Landfill

CHEMICAL	EXPOSURE ROUTE	CDI (mg/kg/day)	CARCINOGENIC POTENCY FACTOR $(mg/kg/day)^{-1}$	ROUTE SPECIFIC RISK	TOTAL CHEMICAL SPECIFIC RISK
Chloroform	Inhalation	2.03×10^{-5}	-	(1.421×10^{-6})	1.337×10^{-6}
	Ingestion	1.91×10^{-5}	7.0×10^{-2}	1.337×10^{-6}	(2.758×10^{-6})
Benzene	Inhalation	2.09×10^{-4}	2.6×10^{-2}	5.434×10^{-6}	5.434×10^{-6}
	Ingestion	0	4.45×10^{-2}	0	
Tetrachloroethylene	Inhalation	1.02×10^{-4}	1.73×10^{-3}	1.73×10^{-7}	1.73×10^{-7}
	Ingestion	0	5.1×10^{-2}	0	
1,2-Dichloroethane	Inhalation	0	-	0	0
	Ingestion	0	6.9×10^{-2}	0	
Trichloroethylene	Inhalation	6.96×10^{-5}	4.6×10^{-3}	3.2×10^{-7}	1.64×10^{-6}
	Ingestion	1.2×10^{-4}	1.1×10^{-2}	1.32×10^{-6}	
Nickel	Inhalation	0	1.2	0	0
	Ingestion	4.93×10^{-5}	-	(5.916×10^{-5})	(5.916×10^{-5})
Methylene chloride	Inhalation	1.16×10^{-4}	6.3×10^{-4}	7.3×10^{-8}	7.3×10^{-8}
	Ingestion	1.48×10^{-5}	-	(9×10^{-9})	(8.2×10^{-8})
TOTAL INCREMENTAL RISK					8.65×10^{-6} (1.15×10^{-5})

Numbers in ( ) based on assumption that carcinogenic risk is the same for inhalation and ingestion for specific compounds.

Where carcinogenic potency factors were available for only one intake route of a chemical, the total chemical and exposure location incremental risk was calculated in two ways:

- Using only the intake route for which a potency factor was available
- Using the established potency factor for one intake route to calculate the incremental risks associated with the second route. The results of this alternate calculation are presented in parentheses in Tables 8-18 through 8-20.

Route specific risks (inhalation and oral) are combined to calculate total chemical-specific incremental cancer risks. These chemical-specific incremental risks are then combined to obtain a total incremental risk of cancer from potential carcinogens at the exposure point.

Because carcinogenic risks are evaluated on the basis of chronic exposures, no carcinogenic risk has been calculated for the recreational users of Trout Brook in Hacklebarney State Park. Their exposure to the landfill generated chemicals is assumed to be only occasional, i.e., a few days per year.

The total incremental risks at the exposure locations as described in Tables 8-18 through 8-20 are:

- Western half of Schoolhouse Lane:
  8.61×10^{-5}
- Day care center:
  1.03×10^{-5}
- Within 0.5 miles to north, east, and south of landfill:
  8.65×10^{-6}

This risk ranking is supported by the other site evaluation data discussed in Chapters 4, 5, and 6.

8.7 UNCERTAINTIES

Several of the uncertainties regarding data collection and adequacy have been discussed in previous chapters and in Sections 8.5 and 8.6 of this chapter. To summarize, these major uncertainties include:

- Unquantified minor exposure pathways. Ingestion of fish, ingestion of on-site soils, and dermal adsorption from air and water have not be evaluated in this risk assessment. en
- Quality and quantity of measured data. Since much of the RI data used for the carcinogenic risk assessment was collected during a time of abnormally low precipitation (and consequently low leachate production and low surface water flows), the site data may not appropriately reflect site impacts under normal rainfall conditions.
- Estimates of groundwater plume movement. As discussed in Chapter 4, although the boundaries and possible direction of movement of contaminated groundwater have been estimated based on an evaluation of environmental conditions measured during the RI, the rate of contaminant movement has not been estimated.

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