US EPA Contract No. 68-W9-0024

ARCS II

FINAL

REMEDIAL INVESTIGATION REPORT
FOR
PORT WASHINGTON LANDFILL

Town of North Hempstead
Nassau County, New York

REMEDIAL PLANNING ACTIVITIES AT SELECTED UNCONTROLLED HAZARDOUS SUBSTANCE DISPOSAL SITES WITHIN EPA REGION II

(NY, NJ, PR, VI)

WAS 003 0001 F

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Town of North Hempstead
Nassau County, New York

EPA Contract No. 68-W9-0024
Work Assignment No. 006-2L78
Document Control No. 7720-006-RI1-RT-BBLK

Prepared for:

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Region II
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June 1989

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REMEDIAL PLANNING ACTIVITIES AT SELECTED UNCONTROLLED HAZARDOUS SUBSTANCE DISPOSAL SITES WITHIN EPA REGION II
(ARCS II)

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Final

Remedial Investigation Report for the Port Washington Landfill Town of North Hempstead, NY

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EXECUTIVE SUMMARY

Section 1.0

- The Port Washington landfill is located in the northwestern portion of Nassau County, New York. The Landfill is located on a 139 acre lot, owned and operated by the Town of North Hempstead (TNH). The lot contains a 54 acre inactive landfill section (L-4) and an active landfill section (L-5). Of the 54 acres denoted as the L-4 parcel, 33 acres were the subject of landfilling activities. It is this presently inactive parcel and the residential community situated to the west of the site which are the primary subjects of this Remedial Investigation report.

- Landfilling activities at L-4 were initiated in March 1974 and terminated in July 1983. The site is presently uncapped but is underlain by a PVC liner and a contiguous clay liner. Leachate which is collected is pretreated at the site and discharged to a local publicly-owned treatment works (POTW). Due to liner installation problems during the early operations of L-4, it has been reported by the Nassau County Department of Health that between 10 and 20 million gallons of leachate were discharged to the environment between 1974 and 1977.

- During the winters of 1979, 1980 and 1981, furnace "puff-backs" occurred at homes near the Landfill. These explosions were believed to have been caused by methane gas migrating from the Landfill and entering the residences through cracks in the floor slabs. As a result, remedial measures were undertaken by the TNH. These included installation of a passive gas venting system, an active gas venting system utilizing blowers, and a gas combustion unit in addition to a series of off-site landfill gas monitoring wells.

- Also in 1981, several volatile organic compounds (1,2-dichloropropane, 1,1,1-trichloroethane, and tetrachloroethene) were discovered in the Port Washington Water District's Southport well. The well was subsequently placed on "reserved" status. This well is located 1,300 feet hydraulically upgradient from the L-4 landfill. Resampling of the well showed the presence of vinyl chloride. Subsequently, the Southport well was placed on "restricted" status and it has remained closed for public water supply purposes since June 1981.

- In 1982, ambient air testing of the passive vents at L-4 by EPA revealed the presence of methane and other gases including vinyl chloride; tetrachloroethene; 1,1-dichloroethane, 1,1,1-trichloroethane and ethyl benzene. In late 1982, the L-4 portion of the Port Washington Landfill was placed on EPA's National Priorities List.

- While the Southport well was in use, the natural hydraulic gradient in the Upper Glacial Aquifer from the southwest to northeast was reversed, causing a westward migration of chlorides associated with former gravel washing activities in the site vicinity. When the Southport well was shut off, the natural northeastern gradient returned, causing a reduction in chloride concentrations in monitoring wells to the west of L-4. Contrary to the chlorides, however, the concentrations of volatile organics in the ground water west of the site have been continually fluctuating, showing no signs of decreasing, and actually increasing in some instances. Therefore, the closing of the Southport well does not appear to have significantly affected the migration of volatile organic compounds. This implies that the contamination found west of the Landfill and at the Southport well may be related to the migration of landfill gas.

Section 2.0

- The active landfill gas management system is comprised of twenty-eight steel vents, a series of PVC plastic vents tied into the main header system, a blower house, and a horizontal combustion unit. This system is designed to create a vacuum curtain along the western and southwestern border of the L-4 landfill to preclude the off-site migration in the subsurface of gases associated with the Landfill.

- The active landfill gas management system is supplemented by a passive system comprised of a series of concrete cisterns and a number of PVC vents located along the southwestern and western perimeter of L-4.

- Field activities undertaken by the REM II and the EPA-Environmental Response Team (EPA-ERT) in association with the study of landfill gas migration and control at the L-4 site included:

    - a physical inspection of the active venting system
    - measurement of well head vacuum and temperature conditions
    - measurement of primary gases at the well heads
    - analysis of condensate formed in the main gas header
    - installation of four off-site landfill gas monitoring wells
    - pressure probe well installation and unit vent performance testing
    - landfill surface emission rate measurements (flux boxes)
    - analysis of landfill gas concentrations in eleven off-site monitoring wells
    - collection and analysis of soil samples from each of the four newly installed off-site landfill gas monitoring wells
    - soil gas survey of the area south of L-4
    - sampling and analysis of outdoor ambient air in the residential neighborhood to the west of L-4.

- Dynamic testing of the active vent system employing a variety of blower and vent valve settings was unable to be performed because only one blower was found to be operating at the time these tests were to be performed by the REM II team (design calls for six blowers to be operating).

- Well head gas flow rates were unable to be determined because of the inability of the equipment employed (pitot tubes) to work effectively at the flow levels induced with only one blower operating.

- It was observed that the most likely period of landfill gas migration occurred when positive pressures were recorded at the landfill gas monitoring wells. Such conditions occurred during periods of "diving" or sustained low barometric pressure conditions.

Section 3.0

- A landfill gas management system was installed by the town of North Hempstead in response to a series of "puff-backs" in residences to the west of L-4 in 1979-1981 presumably caused by a buildup of methane gas. Since the completion of the gas control system in late 1983, "puff-backs" have not occurred. Methane has, however, been detected by EPA's - Environmental Response Team (ERT) to the south of the L-4 site where the gas management system does not extend.

- The design number of blowers to be operating is six. During the REM II team's field work in 1987 and 1988, three blowers were typically operating and on occasion only one blower was operating.

- Some of the active steel vents (Nos. 119 through 127) were observed to be disconnected from the active gas management system.

- Topographic low points exist on the main header line. These low points tend to collect condensate thus causing blockage and surging of the vacuum in the main pipes.

- The gas extraction vents are subject to flooding and sedimentation conditions which can significantly reduce the number of vent slots available for gas entrapment and thus reduce the system's capability to prevent the off-site migration of landfill gas.

- There are numerous vacuum leaks in the active venting system.

- One blower operating was sufficient to effect negative pressures at each of the steel vents connected to the active gas management system.

- When no blowers were operating, >100% of the lower explosive limit (LEL) was recorded in the well heads of the active venting system. When one blower was turned on, substantial reductions in the % LEL were recorded.

- Compounds detected in on-site landfill gas vents (active and passive) include:

  vinyl chloride
  benzene
  chlorobenzene
  1,1-dichloroethane
  trichloroethene
  1,1-dichloroethene
  1,2-dichloroethane
  trans-1,2-dichloroethene
  1,1,2,2-tetrachloroethane
  tetrachloroethene and
  1,1,1-trichloroethane

- Only small quantities of several volatile organic compounds were detected in condensate drained from the active vent manifold system. Two of the compounds detected in the condensate (benzene and chlorobenzene) were also detected in the on-site landfill gas.

- The horizontal combustion unit (HCU) is designed to operate with a fuel supply of 20 to 25 percent methane and at a temperature of 1600 °F. The HCU manufacturer indicates that at such an operating temperature a destruction and removal efficiency of volatile organics of 99.99% can be achieved. Operator logs from the TNH indicate that there are instances when the percent methane concentration and HCU operating temperature drops below the manufacturer's recommendations. It may therefore be presumed that design destruction and removal efficiencies are not achieved in the HCU during those periods.

- Landfill gases begin to migrate in the subsurface to the west of the active venting system in the vicinity of TNH-4 within several hours of shutting down in the blower system.

- It appears than when three blowers are operating, the existing gas management system prevents to a significant degree the off-site migration of methane to those areas where landfill gas monitoring wells are situated (generally west and southwest of the L-4 site). However, the operation of three blowers does not prevent the excursion of methane off-site in those areas not under the influence of the gas management system (i.e., to the south of L-4) nor is it certain that methane does not migrate off-site into areas (generally north of L-4) not presently monitored by the landfill gas wells. Additionally, the operation of three blowers does not prevent the migration of volatile organic compounds off-site.

- Of the three active vents able to be tested, each was capable of achieving a sphere of influence extending at least 50 feet radially from the vent with but three or less blowers operating.

- Compounds emanating from the surface of L-4, as measured by flux boxes include:

  vinyl chloride
  trans-1,2-dichloroethene
  tetrachloroethene
  trichloroethene
  xylene
  toluene
  1,1-dichloroethene
  1,1-dichloroethane
  chloroform
  1,1,1-trichloroethane
  benzene
  chlorobenzene

  These compounds, for the most part, are the same ones detected in the on-site gas vents.

- Soil samples collected during the installation of four off-site landfill gas monitoring wells revealed only trace amounts of but three compounds (toluene, tetrachloroethene and 2-butanone).

- Landfill gas containing volatile organic compounds was detected in the subsurface at all of the landfill gas monitoring wells to the south and southwest of L-4. It appear that the gas preferentially migrates in those areas monitored by medium and deep probes. Compounds detected in the off-site landfill gas monitoring wells were:

  1,1-dichloroethane
  trichloroethene
  1,1,1-trichloroethane
  1,1-dichloroethene
  tetrachloroethene
  chloroform
  trans-1,2-dichloroethene
  vinyl chloride
  1,2-dichloroethane
  1,1,2,2-tetrachloroethane
  1,2-dichloropropane
  benzene

- Viewing the contaminants detected at the Southport well, in the off-site landfill gas (LFG) wells, and at the L-4 landfill itself, it is apparent that a correlation exists. Of the 4 compounds detected in the ground water at the Southport well, 3 of these compounds were detected in the off-site LFG wells and 3 were detected in the venting system at L-4 itself. Similarly, of the 12 compounds detected in the off-site LFG wells, 9 of these compounds were also detected in surface emissions from L-4 and 10 were detected in the L-4 vent system.

- An ambient air sampling event performed by EPA-ERT in the vicinity of Wakefield Avenue, which monitored for seven volatile organic compounds associated with the L-4 landfill, did not conclusively demonstrate the presence of these compounds in the residential neighborhood.

Section 4.0

- Field activities undertaken by the REM II team in association with the hydrogeological investigation of the L-4 site included:

  - installation of eleven off-site ground water monitoring wells

- collection of split-spoon soil samples during installation of the ground water and landfill gas monitoring wells
- geophysical logging of the three deepest ground water monitoring wells
- permeability testing of the Raritan Clay
- "slug" testing of various water-bearing zones to determining insitu permeabilities
- pump testing of the Stonytown well and associated water level monitoring
- performance of a topographic survey
- measurements of water table elevations
- three rounds of ground water sampling

Section 5.0

- The stratigraphy underlying the Port Washington landfill consists of the:

  Upper Glacial Aquifer
  Upper Magothy Formation
  Lower Magothy Formation
  Raritan Clay Member
  Lloyd Sand Member
  Bedrock

- The Magothy Formation is the primary public water supply aquifer for most of Long Island and a significant aquifer in the Port Washington area.
- The Upper Glacial aquifer is the most important formation controlling ground water flow and contaminant transport at the Port Washington Landfill. It is used for public and private water supply throughout Manhasset Neck.
- Two bands of glacial till within the Upper Glacial Aquifer significantly impact the ground water flow system beneath the Landfill. Where the till does not exist the aquifer is fairly transmissive.

Conversely, where the till is present the aquifer has measurably lower permeabilities.

- Very little organic contamination was found in split-spoon soil samples collected during off-site landfill gas and ground water monitoring well installation.

- In the study area, the prevailing hydraulic gradient in the Upper Glacial Aquifer is from southwest to northeast. Beneath the Port Washington landfill, however, the gradient flattens considerably and changes to have a mainly northern orientation.

- The Raritan Clay acts as an effective aquitard restricting flow from the Lloyd Sand upward to the Magothy Formation, and vice versa.

- At the Southport well, the configuration of the till above the well screen forces it to pull water from both the north and from beneath the Port Washington Landfill out of the Magothy Formation and from the Upper Glacial Aquifer.

- The Port Washington aquifer (which replaces the Raritan Clay several thousand feet north of the Port Washington Landfill) acts as a local ground water sink for the water-bearing zones which overlie it. This is an important component of the ground water flow regime and impacts the migration of contaminants beneath and in the immediate vicinity of the Landfill.

- Historic ground water data in the vicinity of the Landfill suggests the following trends:

  - organic contamination has existed in the ground water west of L-4 since 1981, and perhaps earlier;

  - organic contamination appears to be most severe in the upper part of the Upper Glacial Aquifer west of the Landfill;

  - elevated chloride concentrations in the shallow ground water system west of the Landfill have dissipated since the Southport well has stopped pumping; and

  - most of the organic contaminants found in the leachate have been detected west of the Landfill in the TNH monitoring wells.

- The shallow ground water wells show the highest levels of contamination.

- The contamination detected west of the Landfill in the Upper Glacial Aquifer contains similar volatile organic constituents found historically in the landfill leachate.

- Historical chloride data illustrates that a trend of decreasing observed concentrations had been occurring at monitoring wells west of the Landfill. The origin of the chloride is speculated to be associated with past gravel washing operations. This data is important for two reasons. First, where the chloride concentrations appear to be dissipating west of the Landfill, the organic constituents are not. In some aspects, this is expected given that the organic constituents adsorb to the soil particles and are generally much slower moving than conventional constituents. However, the persistence of volatile organic constituents at elevated concentrations west of the Landfill indicates the presence of some source or sources continuing to impact water quality in this area. Second, although volatile organic constituents were detected at the Southport well causing its closing, inorganic constituents such as chloride were never detected above background concentrations. Since the organic constituents detected in the Southport well move slower through the ground water than chloride, the contamination observed at the Southport does not appear to have traveled from the Landfill to the well solely through the ground water.

- Rainfall percolate stripping volatile organic gases residing in the vadose zone is a viable mechanism explaining the historical volatile organic contamination detected at the Southport well.

- Elevated levels of volatile organic contamination detected in the ground water just west of L-4 indicates that some source of contamination along the western boundary of the landfill must persist.

- Ground water flow simulations made to better characterize the organic contamination detected in the Upper Glacial Aquifer west of the Landfill indicate that the migration of elevated levels of volatile organic contamination is generally to the northwest and downward through the Upper Glacial Aquifer into the Magothy Formation. If left unchanged, the existing flow field may carry the organic contaminants downward into the Port Washington Aquifer and perhaps the Lloyd Aquifer. This migratory route should be examined further to determine the extent of contamination and its potential impacts.

- Inorganic contamination consistent with the landfill leachate quality appears to be emanating from the eastern side of L-4 as evidenced by the detection of conventional water quality contaminants in EPA 103. This inorganic plume is migrating nearly due north and can potentially migrate into the lower water-bearing zones given the existing ground water flow field configuration.

Section 6.0

- Three sources of contamination have historically existed in the Port Washington study area including:
    - landfill leachate;
    - vapor phase volatile organics originating at the Landfill; and
    - salt water originating from the sand and gravel soil washing operations.

- The historical direction of ground water flow beneath the Landfill when the Southport was in operation was from the east to west (especially when irrigation pumping also occurred at the NHCC). Since the Southport well was removed from service due to volatile organic contamination, the ground water now flows from the southwest to the north and northeast beneath the Landfill.

- The most significant impacts from the historical sources have been identified as the build-up of methane and other volatile organic vapors in homes adjacent to the Landfill and the migration of volatile organic constituents into the Southport well which was used for public drinking water.

- Three sources of ground water contamination apparently continue to persist. These are:
  - vapor phase volatile organic constituents in the unsaturated zone which are available to be stripped by rainfall percolate and carried to the saturated zone;
  - concentrated volatile organic "condensate" localized near TNH-10/9 and TNH6; and
  - landfill leachate.

- The organic constituents present in the saturated and unsaturated zones are believed to create passive sources of contamination due to partitioning phenomenon characteristic of such contaminants. These passive sources could persist in the subsurface far into the future.

- The subsurface vapor phase organic constituents appear to impact the existing ground water quality and may impact the air quality in homes west of the Landfill.

- All of the sources listed above can potentially impact the quality of water extracted at the Southport well with the concentrated organic contamination perhaps having the greatest impact, and the inorganic contaminants contained in the landfill leachate perhaps only influencing the water quality at the well under increased pumping scenarios (e.g., dry seasons when the Southport well and North Hempstead Country Club irrigation wells are pumping simultaneously). Also, other area water wells could be impacted. The Stonytown well and the Hewlett wells are potentially at risk in that during certain pumping conditions their zones of capture could extend into an area persently receiving volatile organic contamination. Additionally, the Bar Beach well could be at risk in the future given the present south to north migration pathway in the area of elevated volatile organic contaminants.

- If wells are placed east of the Landfill for the purposes of water supply, most, if not all, of these sources may impact the extracted ground water quality. However, the chloride remnants from the soil washing operations will most probably exclude any water extracted from the upper water bearing zones from potable usage.

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Section 1

1.0 SITE BACKGROUND INFORMATION

The purposes of this section of the Remedial Investigation (RI) Report are to describe the objectives and format of the RI report, to review the history of the site and to present an explanation of the regional environmental setting of the study area. A general discussion on the occurrence of landfill leachate and gases is also presented.

1.1 REMEDIAL INVESTIGATION OBJECTIVES AND REPORT FORMAT

The Port Washington Landfill Remedial Investigation (RI) Report has been prepared for the U.S. Environmental Protection Agency (EPA) in part under Work Assignment No. 113-2L78.6 of EPA Contract No. 68-01-6939, Performance of Remedial Response Activities at Uncontrolled Hazardous Waste Sites (REM II) and in part under Work Assignment No. 006-2L78 of EPA Contract No. 68-W9-0024, Remedial Planning Activities at Selected Uncontrolled Hazardous Substance Disposal Sites Within EPA Region II (ARCS II). The purposes of this investigation were to:

- Investigate the presence of hazardous substances in the ground water, soil, landfill gas and offsite soil gas as previously reported by the Town of North Hempstead, its consultants and by the EPA and its consultants.
- Collect data to estimate the existing degree and extent of contamination present.
- Evaluate the landfill as a potential source of contamination.
- Evaluate in current and future use scenarios any potential health risks of contaminants detected in the study area which are site-related.
- Gather pertinent information required to develop and evaluate alternatives to remediate any environmental or public health problems identified in the RI.

The format of the RI Report is as follows:

Section 1 - The remaining parts of this section present the history and environmental setting of the project area as well as the nature of the contamination as understood prior to performance of the RI. Additionally, the mechanisms of landfill leachate and gas generation are discussed.

Sections 2 and 4 - These sections of the report describe the investigative methodologies applied, respectively, for landfill gas and ground water data acquisition studies.

Sections 3 and 5 - These sections present the data collected and an analysis of this data from, respectively, the landfill gas and ground water studies.

Section 6 - This section synthesizes the results of all of the data and analysis into a conceptual model which estimates the nature and extent of the contamination at the Port Washington site as well as describes the mechanisms for contaminant generation and travel in the study area.

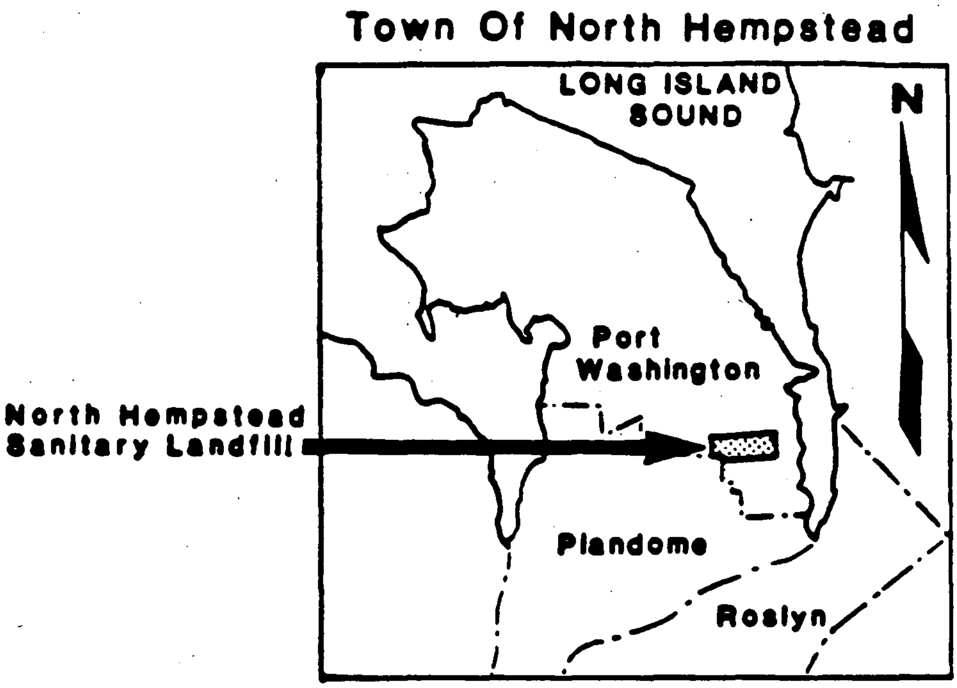
Section 7 - This section presents the baseline Public Health Evaluation which is an assessment of the endangerment to public health, welfare and the environment in the study area based on the analytical results of the remedial investigation as presented in sections 3, 5 and 6. Section 7 has been bound as a separate volume of the RI report.

1.2 SITE CHARACTERISTICS

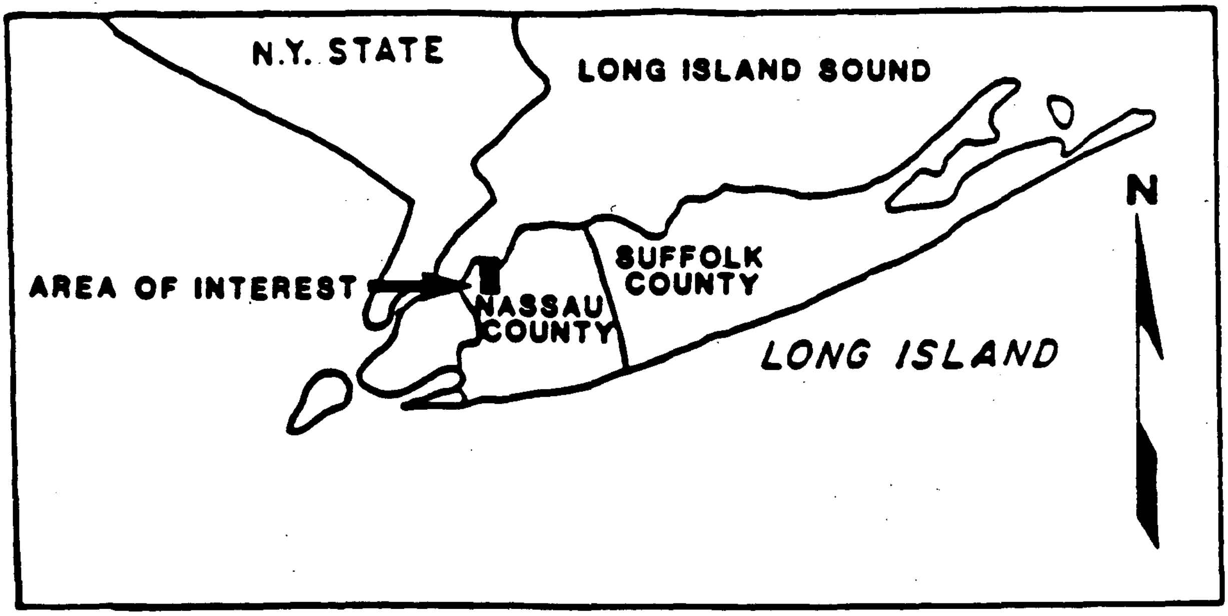
1.2.1 SITE LOCATION

The Port Washington Landfill is located in the northwestern portion of Nassau County, NY. as shown in [redacted]. It is situated on the eastern portion of Manhasset Neck and is bordered as follows: on the east by Hempstead Harbor; on the west by residences and the North Hempstead Country Club golf course; on the south by an industrial park; and on the north by an active sand and gravel quarry. [redacted] presents a detail of the region.

The landfill is located on a 139 acre lot, owned and operated by the Town of North Hempstead (hereinafter referred to as "the Town" or "TNH"). This



LOCATION MAP



KEY PLAN

Not to Scale

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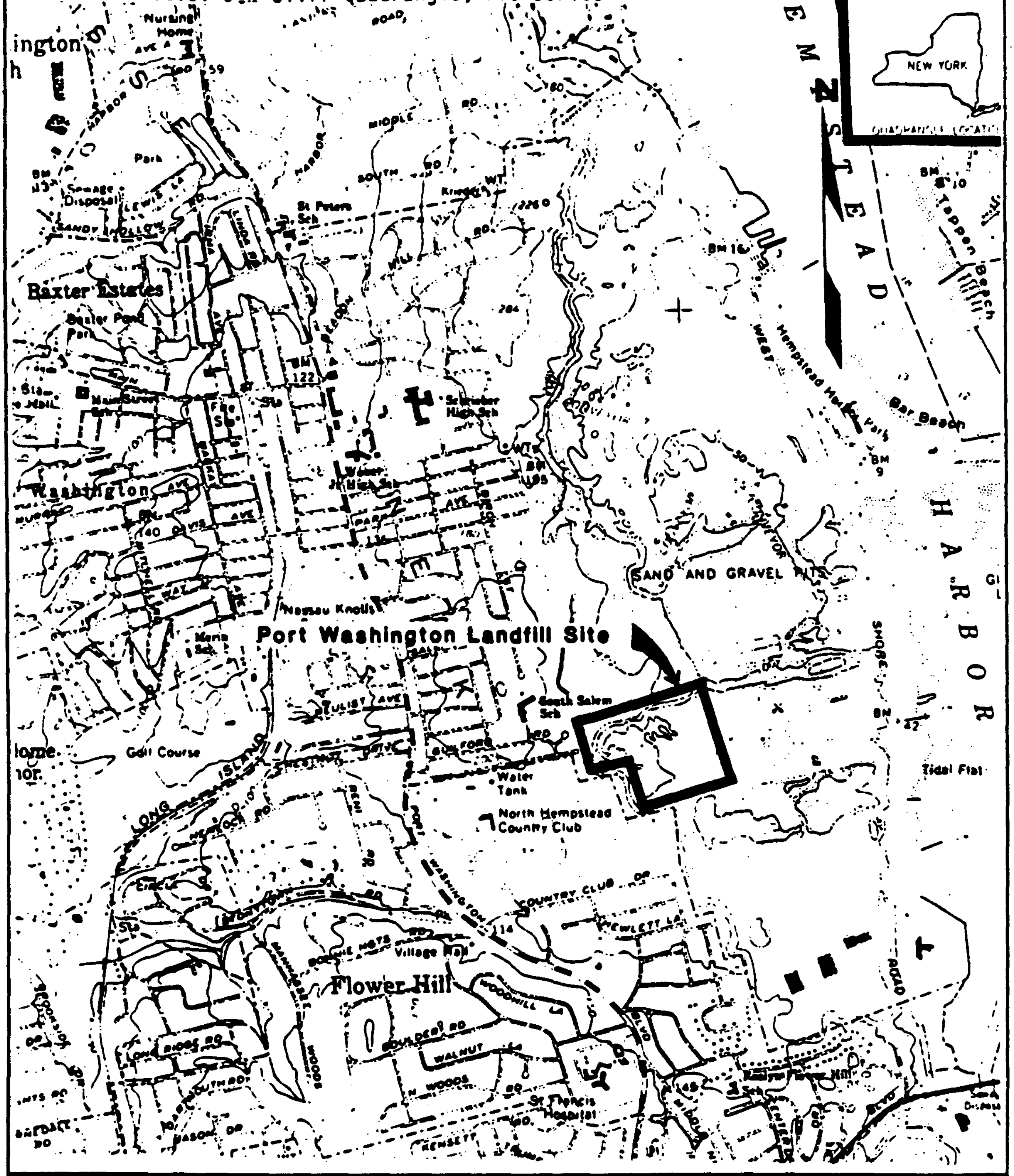
Figure 1

Area Location Ma

Port Washington Landfill, Port Washington, New Y



Source: U.S.G.S. Sea Cliff Quadrangle, 7.5 series

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Figure 1-2

Site Location Map

Port Washington Landfill, Port Washington, New York

parcel contains two landfilled areas separated by a vacant area. L-4 is a 54 acre inactive landfill section on the western portion of the property and L-5 is an active landfill comprised of two approximately 18 acre sections on the eastern portion of the property. The intermediate vacant area is about 50 acres in extent. The L-4 landfill and the residential area to the west of the site constituted the primary focus of this investigation. The site parcels are shown in Figure 1-3. Additional information concerning construction and operation of the L-4 landfill is contained in Section 1.3.6.

1.2.2 SITE HISTORY

Prior to the Town of North Hempstead's purchase of the property, the site area was used as a sand and gravel mining operation that began in the 1880's. When the area was used for sand and gravel mining, sea water was used in the washing process. After the mining operation had terminated, and prior to development by the Town, the All-American Sand and Gravel Corporation used this area as a landfill primarily for construction debris which was reported to include concrete, wood and miscellaneous solid wastes such as metal drums (Miller, 1973). The land was purchased by the Town for use as a sanitary landfill in 1973.

Four ground water monitoring wells (TNH 1,2,3 and 4) were installed at the site by Geraghty & Miller (the Town's consultants) prior to construction of the landfill. These well locations and other monitoring wells in existence at the initiation of the RI are shown in [illegible]4. These wells were installed to provide a baseline of ground water quality conditions. Initial sampling of these wells by Geraghty & Miller (G&M) in June 1973 indicated elevated levels of dissolved solids. This was attributed by G&M to the use of sea water as wash water by the previous owner and to waste disposal activity prior to the Town's purchase of the property. No organics analysis of ground water samples was performed prior to the construction of the landfill.

The initial design of the landfill called for placement of a clay liner between the refuse and the native soil. Due to installation problems and

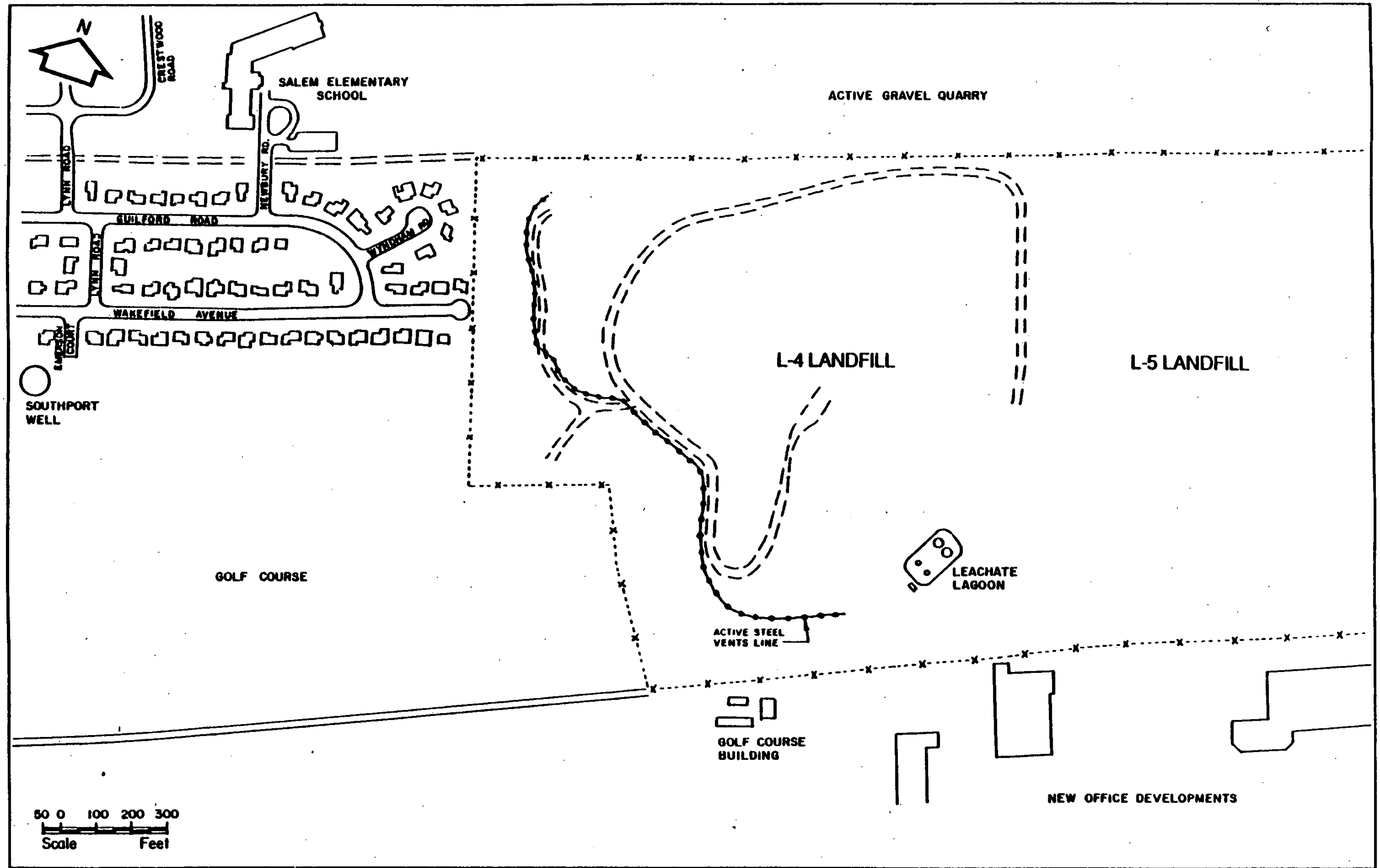

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Figure 1-3

Study Area

Port Washington, Nassau County, New York

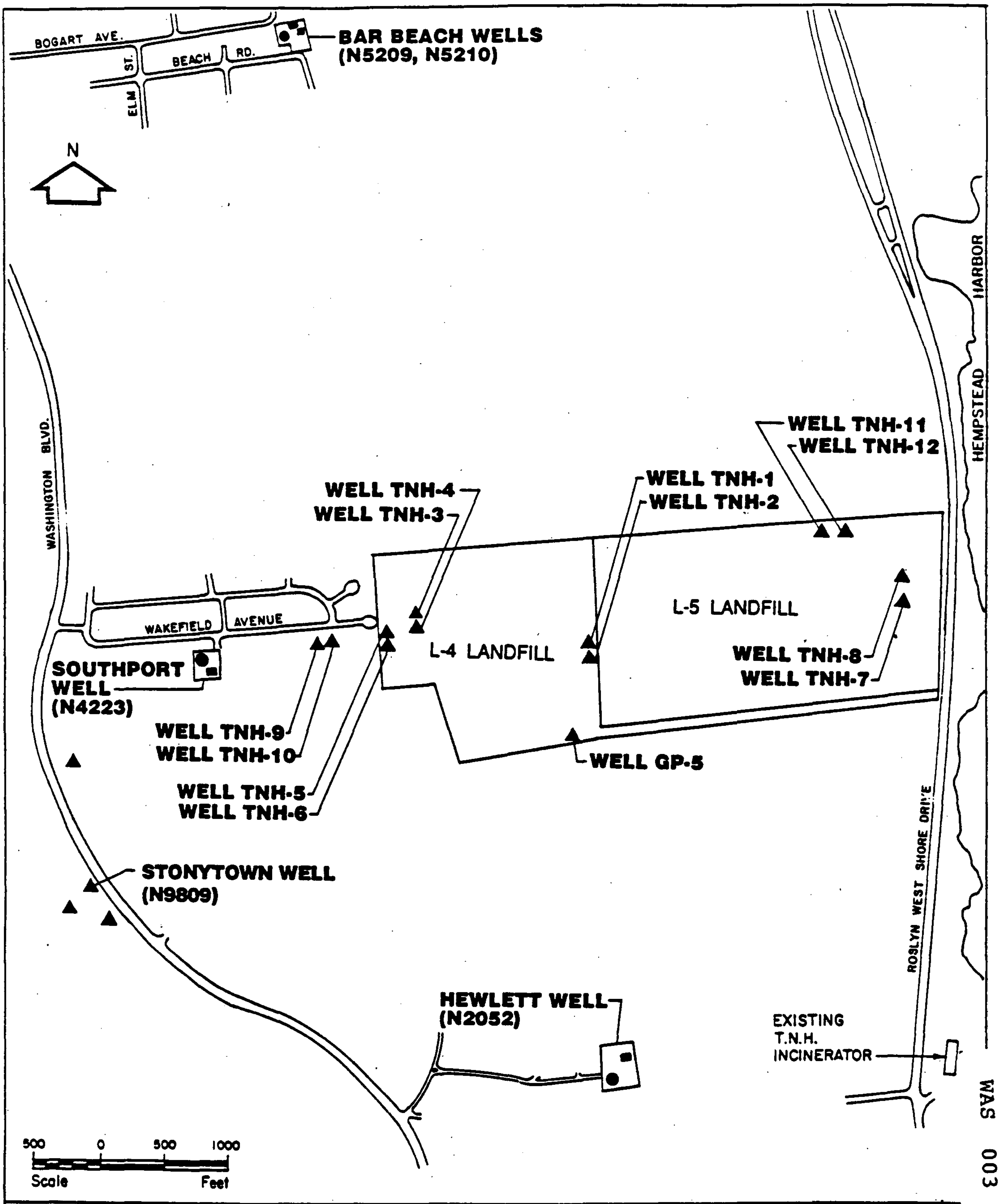

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Figure 1-

Groundwater Monitoring and Supply Wells
Existing at the Initiation of the Remedial Investigatio

Port Washington Landfill, Port Washington, New York

inclement weather, a 20-mil PVC liner was not installed until January 1974. Initially this liner covered an area of four acres.

Landfilling at L-4 began on March 4, 1974 with the disposal of incinerator residue, residential and commercial refuse and construction rubble. In September 1974, the Nassau County Department of Health (NCDOH) indicated in a report that provisions for removing leachate had not been installed at the landfill and consequently the leachate had accumulated to a depth of 5 feet and threatened to flow over the plastic liner. In July 1975, complaints of odors from the L-4 site were first recorded by the NCDOH. Also in July 1975, the NCDOH reported that leachate was present in areas of the landfill beyond that portion protected by the liner. This occurrence was presumed to be due to the lack of an adequate means to dispose of excessive leachate that had built up thus causing an overflow from the liner. In March 1976, a leachate treatment system was started and was comprised of a receiving lagoon with mechanical aerators. The lagoon effluent was chlorinated and subsequently discharged back onto the L-4 landfill through a series of sprinkler heads.

In June 1977, the NCDOH reported that leachate continued to escape from L-4 because the liner remained incomplete. Also, in June 1977, testing of several monitoring wells at the landfill by NCDOH indicated contamination by organic and inorganic constituents. In September 1977, the leachate treatment system discharge was hooked up to the Port Washington sewer system. In 1979, as the operation of the landfill expanded, TNH-3 and TNH-4 were abandoned and sealed, and replaced by TNH wells 5 and 6. Eventually, the liner in the L-4 section was expanded to cover a total of 29 acres. In addition to the PVC bottom liner, clay material was placed between the refuse and the sand and gravel cliffs on the west side of the site. A sand blanket with drains was installed between the PVC liner and the refuse to collect the leachate produced by the landfill.

During the winters of 1979, 1980 and 1981, furnace "puff-backs" occurred at homes near the landfill. These explosions were sufficiently severe to necessitate calls to the fire department. It was believed that gases were migrating from the landfill and entering the homes through the slab floors.

In 1981, extensive air monitoring of both the ambient and subsurface air was performed in the area by the NCDOH and the Nassau County Fire Commission. The ambient air monitoring demonstrated that methane levels exceeded lower explosive limits in several homes. In-ground readings indicated the presence of methane along the western boundary of L-4 as well as out into the North Hempstead Country Club (see figure 1-[illegible]). As a result, several remedial measures at L-4 were undertaken by the Town. Beginning in July 1981, these included installation of a passive gas venting system, an active gas venting system utilizing blowers, and a gas combustion unit. A chronology of events associated with the landfill gas monitoring control efforts by the Town of North Hempstead is presented in table 1-1.

Also in 1981, volatile organic contaminants (1,2-dichloropropane; 1,1,1-trichloroethane, and tetrachloroethylene), were discovered in the Port Washington Water District's (PWWD) Southport Well during testing on February 26 by the NCDOH. The well was subsequently placed on "reserve" status. This well is located 1,300 feet to the west and hydraulically upgradient from the L-4 landfill (see figure 1-6). The PWWD well was subsequently resampled on May 19, 1981 and June 9, 1981. These samples showed the presence of vinyl chloride at 37 and 48 parts per billion, respectively. On June 12, 1981 the Southport Well was placed on "restricted" status. On June 18, 1981 the NCDOH resampled the well but did not detect any volatile organics. Nevertheless, the well remained "restricted" (i.e. closed). Additional ground water monitoring wells (TNH-7, TNH-8, TNH-9, TNH-10, TNH-11, and TNH-12) were installed between the landfill and Southport Well in November 1981.

Between July and October 1982, the EPA's Field Investigation Team (FIT) performed air testing at the landfill. The results were included in a Task Report entitled "Town of North Hempstead L-4 Landfill (Port Washington Landfill), Final Report" dated December 1, 1982 (Fred C. Hart Associates, Inc.). The findings indicated methane and other gases (including vinyl chloride; toluene; tetrachloroethylene; trans 1,2-dichloroethylene; 1,1-dichloroethane; 1,1,1-trichloroethane; and ethylbenzene) were being emitted from the landfill vents. This methane gas and associated compounds were reported as being capable of migrating up to several hundred feet in the

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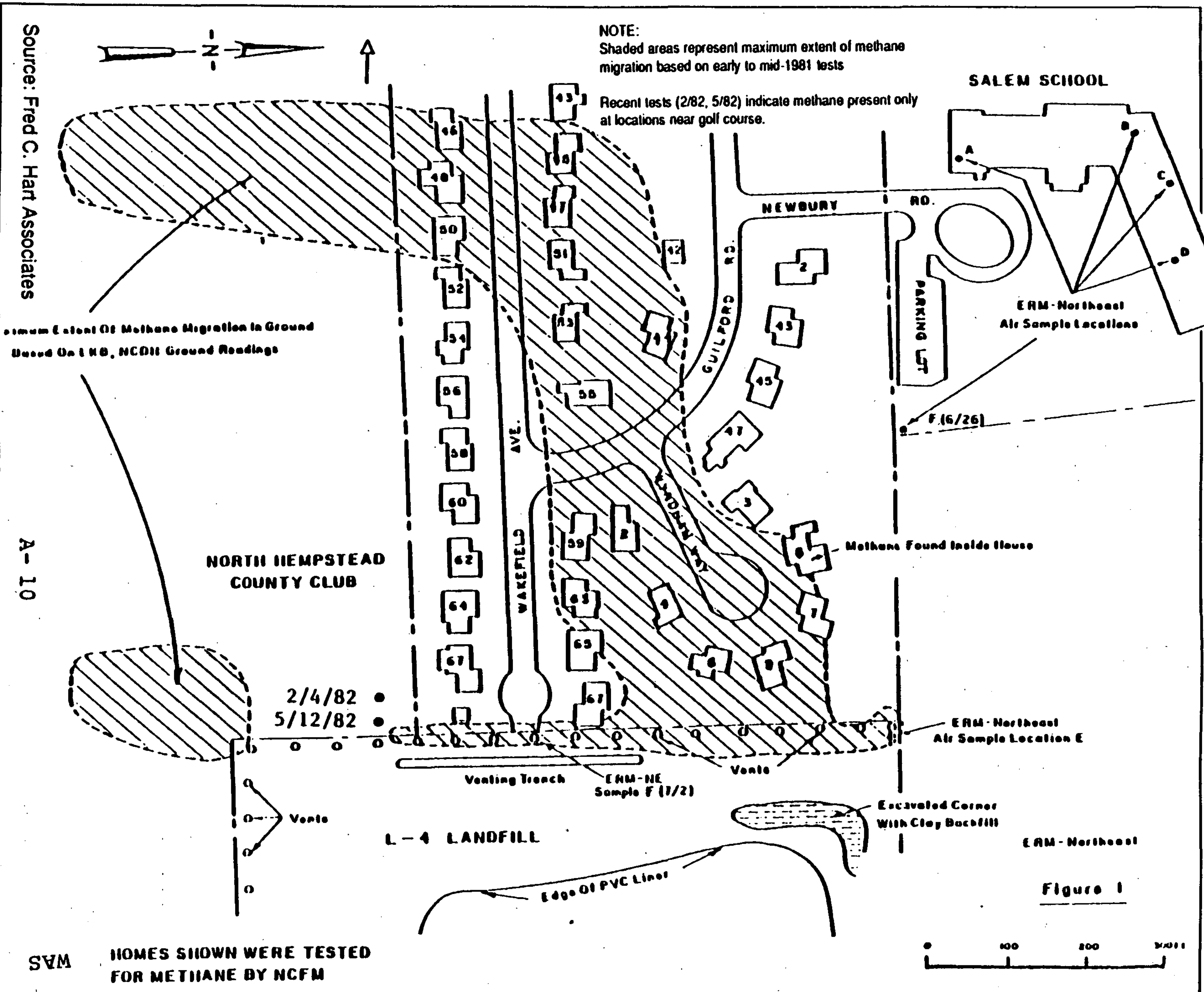
Source: Fred C. Hart Associates

A- 10



Fig

In-Ground Methane Mig
Prior to Installation of the Active Venting Sy
Port Washington Landfill, Port Washington, Ne

TABLE 1-1*

CHRONOLOGY OF EVENTS
LANDFILL GAS MONITORING AND CONTROL EFFORTS UNDERTAKEN BY THE TOWN OF NORTH HEMPSTEAD

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1. 1981 and Earlier. Plastic vent wells were installed to the west of the L-4 Landfill between the edge of refuse and property line. Initially, these were allowed to vent passively. Later, blowers were connected to the plastic vents to actively extract migrating gas.

2. July 1981. Twenty-eight steel vent wells were installed in refuse, along the west perimeter of the L-4 Landfill. Their purpose was to provide a more permanent alternative to the plastic vents in controlling off-site gas migration. Initially, these were allowed to vent passively to the atmosphere, with the bulk of gas control provided by the plastic vents above.

3. January 1982 through May 1982. Connective header line and blower system for the above steel vents was designed. This system was to transform the steel vents cited above into an active extraction system, and to remove the need for plastic vents to control off-site gas migration. This construction project was put out to bid during May 1982.

4. October 1982 through September 1983. A total of 9 LFG series monitoring wells were installed off-site to monitor any migrating landfill gases. Seven wells were located to the west of the L-4 Landfill to detect migrating gases from this site. Two wells were placed to the north and east of the proposed L-5 Landfill site to detect any migrating gases from that facility.

5. December 6, 1982 through December 14, 1982. Short-term pump tests were performed by SCS Engineers on the majority of steel vents. Field results and conclusions were documented in a report entitled "Landfill Gas Test Results, Port Washington Landfill, Town of North Hempstead, New York", dated December 1982.

   The report documented that the steel vent system as designed, and with all 8 blowers operational, likely could not deliver the design flow of 214 cfm per well. However, the report also demonstrated that a flow of 100 cfm per well could be delivered. Computations in the report indicated that a flow of only 25 cfm per well should be sufficient to control migrating gases, based on an assumed average generation rate in the vicinity of each well. Thus, the report concluded that the system provides four-fold more extraction than that required.

TABLE 1-1*
(continued)

This report also addressed the presence of water and sediment accumulations in selected vents.

6. March 1983. Pump-out of water and sediment accumulations was performed on selected steel vents.

7. April 29, 1983. Official monitoring of LFG series wells was initiated. First monitoring period spanned from April 29, 1983 through May 19, 1983.

8. Fall 1982 through November 1983. Header line and blower system for permanent steel vent gas extraction system was constructed.

9. November 30, 1983 through December 18, 1983. Start-up and fine tuning of steel vent gas extraction control system was initiated. During this period, baseline conditions were established.

10. December 19, 1983 through January 1984. Blowers for the new steel vent extraction system first became operational on December 19, 1983. Fine tuning of the gas extraction system was then performed by adjusting valves at the individual steel vents. Optimum steel vent operating conditions were established, and the system demonstrated to provide gas control under normal weather conditions.

11. February 1984 through April 1984. Though optimum operating conditions for the steel vent system had been established, and gas control provided under most weather conditions, some excursions of gas were detected under extreme barometric conditions. It was established that the steel vent system could not control gas excursions under these extreme conditions, even with all 8 blowers operating. Thus, during this two month period, selected off-site plastic vents were reactivated, and allowed to extract gas in combination with the steel vent system. This combination of steel and plastic vents was later demonstrated to provide gas control even under extreme barometric variations. Operating conditions (number of blowers and valve settings) were firmly established at this point and the initial fine tuning effort was concluded.

12. October 17, 1984 and October 18, 1984. Maintenance was performed on selected LFG series monitoring wells which were found to be in questionable condition.

TABLE 1-1*
(continued)

13. October 19, 1984 and October 20, 1984. Further testing of the combined steel and plastic vent extraction control system was performed to demonstrate that the ideal operating conditions established early in 1984 were still valid at this point 6 months later. Some adjustments to valve settings was made.

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*Information taken from correspondence to the Town of North Hempstead Department of Public Works from SCS Engineers dated September 19, 1985.

(556)

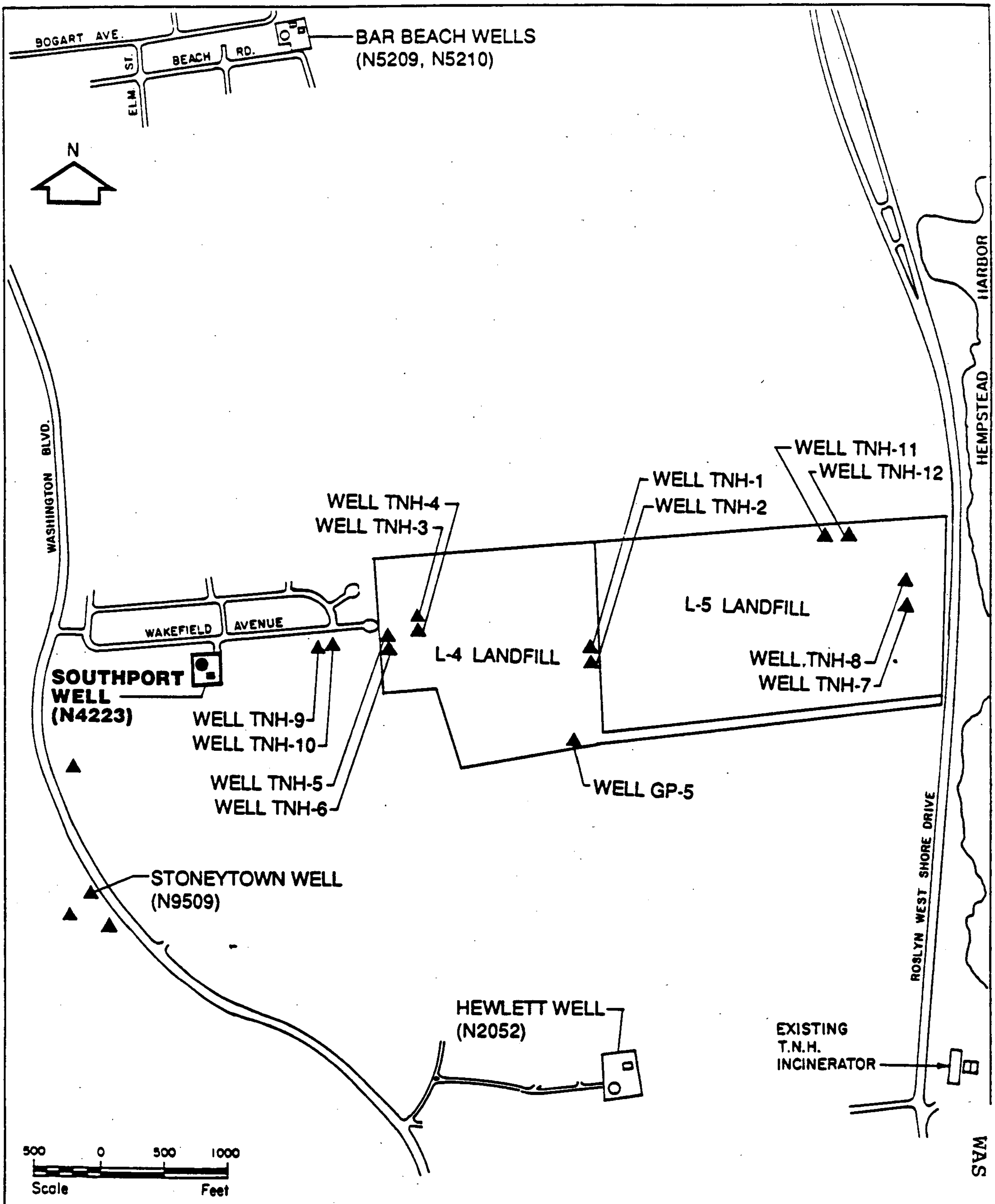

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Figure

Location of Southport W

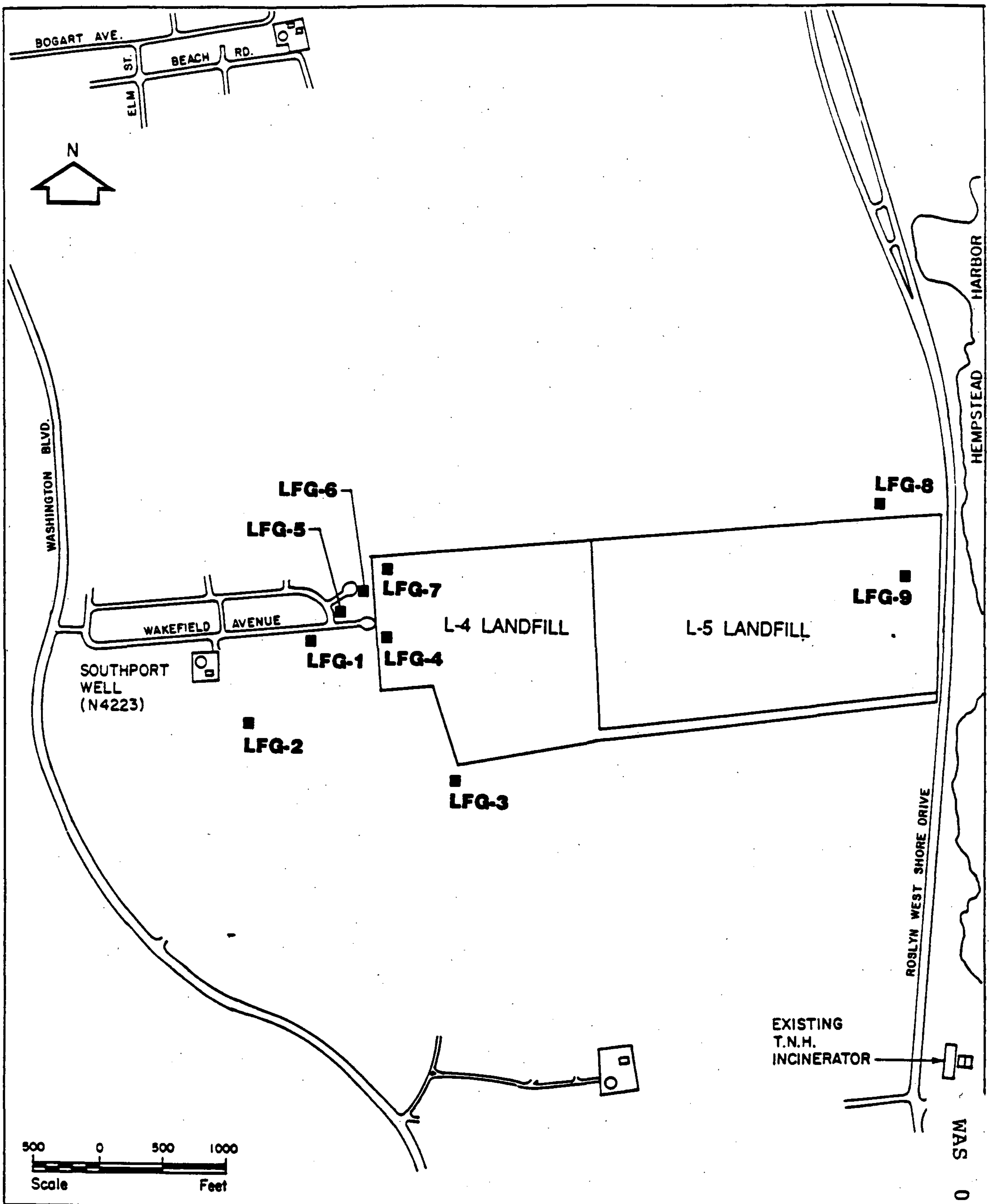
Port Washington Landfill, Port Washington, New Y

ambient air into the residential area under certain meteorological conditions. On December 20, 1982, in response to concerns about contamination in the area, the L-4 portion of the Port Washington site was placed on EPA's National Priorities List (NPL). The Southport Well has since remained closed.

The Town installed landfill gas (LFG) wells (LFG-1 through LFG-7) to monitor subsurface gases (see figure 1-7) between October 1982 and September 1983. Disposal operations ceased at the L-4 landfill on July 21, 1983. From that date on, disposal operations consisting of compacted and uncompacted residential and commercial/industrial refuse were instead performed at the L-5 landfill and continue to this date as does monitoring of both the landfill gas wells and the ground water monitoring wells. A section of the L-5 landfill property situated in the center of the site is presently not in use.

Between the initiation of landfilling activities by the TNH on March 4, 1974 and the cessation of such activities on July 21, 1983, the Town of North Hempstead is reported to have placed approximately 260,000 tons per year of material in the L-4 landfill. The fill consisted of residential, commercial and industrial refuse, construction debris and incinerator residue. The disposal of oil and gasoline saturated soil and properly packed asbestos was also permitted by the New York State Department of Environmental Conservation (NYSDEC) on several occasions in the history of L-4 operations (NUS Corporation, 1984). There were also unconfirmed and undocumented reports by residents in the area of the disposal of drummed liquid wastes at the landfill.

In June 1984, NUS Corporation, under contract to EPA, prepared a Remedial Action Master Plan (RAMP). In May 1985, CDM was requested by EPA to evaluate the site under the REM II contract. CDM submitted a Work Plan in October 1985 and a Project Operations Plan in November 1986. The Work Plan was revised in June 1987 to reflect changes necessitated by the newly promulgated Superfund Amendments and Reauthorization Act (SARA). This Remedial Investigation report constitutes the first major deliverable identified in the Work Plan.



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Figur

Landfill Gas Monitoring W
Existing at the Initiation of the Remedial Investiga
Port Washington Landfill, Port Washington, New

1.2.3 LANDFILL GAS AND LEACHATE GENERATION

Prior to a discussion of the contamination problem at the Port Washington site as it existed at the initiation of RI, it is important for the reader to have a general understanding of the mechanisms of landfill gas and leachate generation.

Landfills are affected by their environment and, in turn, can affect the environment. To understand these phenomena requires a understanding of how landfills undergo physical, chemical and biological action and how this produces a product capable of offsite effects.

When landfills are "uncapped" (as is the case of the Port Washington Landfill) or are subject to intermittent wetting such as during rainfall events, water can enter a landfill, come into contact with landfill materials, dissolve organic and inorganic substances and transport them outside the landfill. Of course, this can be controlled by appropriate surface, side and bottom landfill controls (i.e., caps, liners, drains). When uncontrolled, the entering liquid leaves the landfill in a number of possible ways: as leachate (leakage); as vapor (evaporation); and as drainage (if collected). The quantities of entering water leaving the fill can be estimated using various water balance formulations that account for the physical, geohydrologic, surface hydrologic and weather conditions at the location of interest.

The quality of leachate is reflective of the material (refuse) it is in contact with. Household refuse, for example, typically yields a leachate containing sodium, potassium, chloride, sulfates and nitrogen components. A listing of typical compounds and their range of concentration in a typical municipal landfill leachate is given in [redacted] It should be noted that other constituents besides these common organics and inorganics are often found in landfill leachate. These include compounds related to solvents, oils, cleaning compounds, degreasing compounds, pesticides etc. that result from household refuse and/or commercial and industrial wastes. Examples of such compounds are listed below (Brow and Donnelly, 1988):

TABLE 1-2

TYPICAL MUNICIPAL LANDFILL LEACHATE CONSTITUENTS*

Leachate	Range	Average (high side)
COD (mg/l)	1,000-100,000	10,000
BOD_5 (mg/l)	1,000-50,000	10,000
TOC (mg/l)	1,000-10,000	5,000
TDS (mg/l)	1,000-20,000	10,000
TVS (mg/l)	1,000-30,000	---
NH_4 - N (mg/l)	100-1,000	500
Org - N (mg/l)	10-1,000	100
$NO_3 + NO_2$ (mg/l)	0.1-10	1
TK - N (mg/l)	10-1,000	100
P - Total (mg/l)	0.1-100	1-10
PO_4 (inorg) (mg/l)	---	10
Fe (mg/l)	10-1,000	100-1,000
Na (mg/l)	50-10,000	500
K (mg/l)	50-4,000	500
CL (mg/l)	100-4,000	500
SO_4 (mg/l)	10-1,500	100
Ca (mg/l)	100-10,000	500
Mg (mg/l)	20-200	100
Mn (mg/l)	1-50	10
Zn (mg/l)	0.1-400	1-10
Cu (mg/l)	0.01-10	0.5
Cd (mg/l)	0.001-1	0.05

TABLE 1-2
(continued)

TYPICAL MUNICIPAL LANDFILL LEACHATE CONSTITUENTS*

Leachate	Range	Average (high side)
pH (units)	4-7	5-7
Specific Conductivity (μ mho/ml)	2,000-8,000	5,000

*Taken from "Leachate from Municipal Landfills, Production and Management", Noyes Publications, by J.C.S. Lu., B. Eichenberger, R.J. Stearns; Pollution Technology Review No. 119

(540)

- acetone
- benzene
- bromoform
- carbon tetrachloride
- chloroform
- dichlorobenzene
- ethanol
- hexane
- methylethylketone
- phenol
- tetrachloroethane
- tetrachloroethylene
- trichloroethylene
- vinyl chloride
- toluene
- xylene

Municipal landfills, where refuse containing large amounts of organic materials (e.g., paper and food wastes) are dumped, compacted and covered with soil, typically generate a variety of gaseous by-products. Since air cannot penetrate a well compacted and covered landfill, aerobic microorganisms, which require oxygen for life, rapidly use all of the available oxygen supply. Anaerobic bacteria, which require an oxygen-free environment, then thrive, accomplishing most of the organic degradation in the landfill. The products of this decomposition are primarily carbon dioxide and methane gas. Since carbon dioxide is soluble in water, some is likely to leach out of the landfill in a dissolved form. On the other hand, methane, which is less soluble and lighter than air, usually remains in a gaseous phase and tends to migrate out of the landfill. This gas migration can be a problem in the immediate vicinity of a landfill primarily because of the methane content. Methane, in concentrations of 5 percent to 15 percent with oxygen in the air, forms an explosive combination.

Theoretically, one kilogram of wet refuse can yield between 47 and 270 liters of methane. Because of the heat in the landfill (up to 110°F average) resulting from anaerobiosis, landfill gas is typically laden with moisture and other gaseous products. This gas may condense into water droplets upon contacting cooler soils surrounding the landfill should such gas have the opportunity to migrate. Landfill gas components typically include (Emcon Associates, 1980):

Methane (CH_4): 50-70%
Carbon dioxide (CO_2): 30-50%
NH_3, H_2S, other gases: Trace

In summary, it should be noted that landfills can produce gaseous and liquid constituents and that the rate and extent of their production are a function of a number of phenomena including weather, geology, geohydrology, time since placement of the refuse, landfill depth, compaction density, waste composition, moisture and temperature.

1.2.4 CONTAMINATION PROBLEM DEFINITION

Prior to the performance of the REM II team's remedial investigation (RI) activities at the Port Washington site, an extensive amount of ground water, leachate, landfill gas and ambient air monitoring had been performed by other investigators. The following sections discuss each medium individually and describe the nature and extent of the contamination as it was understood by CDM prior to the initiation of the RI.

Ground Water

From 1979 to 1981, while the Southport Well was in operation, concentrations of chlorides in wells TNH-5 and TNH-6 (see figure 1-4) were in the range of 1,500 milligrams per liter (mg/l) and 80 mg/l, respectively. These wells are located hydraulically upgradient from the L-4 site. When the Southport Well ceased pumping in July 1981, chloride concentrations in all of these wells began dropping. In October 1984, TNH-6 had dropped to background levels (10 to 22 mg/l). In January 1985, chlorides in TNH-5 had dropped to 34 mg/l. Apparently, while the Southport Well was in use, the hydraulic gradient was reversed causing a westward migration of chlorides. When the Southport Well was shut off, the natural northeastern gradient returned, carrying the chlorides toward Hempstead Harbor.

The concentrations of the volatile organic compounds revealed a much different trend. The same volatile organic compounds present in the landfill leachate were detected in TNH-6, TNH-9, and TNH-10. Tetrachloroethylene, 1,1,1-trichloroethane, cis/trans-1,2 dichloroethylene, and 1,1 dichloroethane were detected in wells TNH-6 and TNH-10 between 1983 and 1985. Well TNH-9 (placed in the same location as well TNH-10 but screened 30 feet deeper) contained levels of 1,1-dichloroethane, cis/trans-1-2-dichloroethylene, and 1,1,1-trichloroethane. Meanwhile, levels of volatile organics in wells TNH-7, TNH-8, TNH-11, and TNH-12 (eastern portion of landfill) were seldom observed above detection limits. Contrary to the chlorides, however, the concentrations of the volatile organics have been continually fluctuating, showing no signs of decreasing, and actually increasing in some instances. Therefore, the closing of the Southport Well does not appear to have affected the migration of these compounds and implies that the contamination found at the Southport is related to the migration of landfill gas.

Leachate

The surface of the L-4 landfill is not capped. Therefore, infiltration of precipitation occurs directly through the landfill surface and runoff from the surrounding uplands also enters the landfill. The leachate produced from the L-4 site has been shown to be high in dissolved solids (chloride, sulfates, sodium, calcium, Kjeldahl Nitrogen and ammonia nitrogen) as is typical of landfill leachate. However, several volatile organic compounds have also been detected in the raw leachate with maximum concentrations listed in table 1-3. These compounds have also been detected in the air and the ground water immediately west of the site.

Surface Water

Since the direction of ground water flow beneath the landfill is northeastward, toward Hempstead Harbor, surface water could be receiving contaminants from the L-4 landfill. At the initiation of the RI field activities, however, no surface water or sediment samples had been collected from the Harbor to ascertain the presence or absence of L-4 contaminants.

TABLE 1-3

CONCENTRATIONS OF SELECTED CONTAMINANTS IN LEACHATE FROM THE PORT WASHINGTON LANDFILL*

Compound	Max. concentration (ppb)
1,1-dichloroethane	660
cis/trans-1,2-dichloroethylene	1,300
1,1,1-trichloroethane	320
trichloroethylene	420
vinyl chloride	100
1,1,2,2-tetrachloroethane	1,500
tetrachloroethylene	650

*Data from Exhibit M, Town of North Hempstead - Ground Water Monitoring, Organic Chemical Laboratory Analyses, Maximum Concentrations, Henderson & Casey, P.C., Westbury, New York.

(OVERHEAD/601)

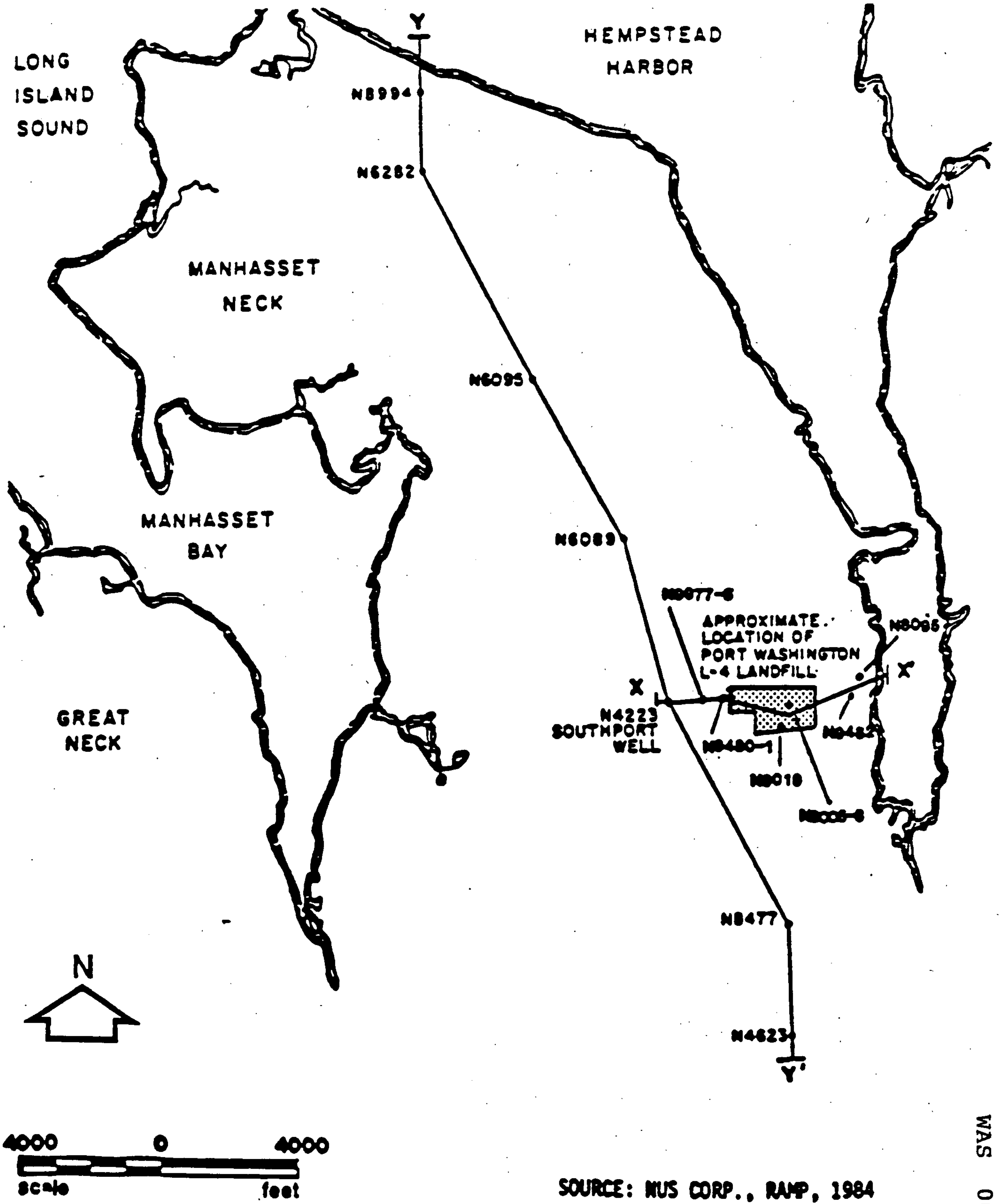
Landfill Gas

Since the beginning of 1983, an extensive amount of landfill gas monitoring has been performed at the Port Washington L-4 site. The gas has been shown to be principally composed of methane and carbon dioxide resulting from the decomposition of organic matter but it has also included various volatile organics. The primary sources for landfill gas data since 1983 have been SCS Engineers (the Town's Consultants) and H2M (a laboratory under contract to SCS). The landfill gas wells shown in figure 1-7 historically have been used to monitor the presence and migration of landfill gases. Results of landfill gas analysis prior to 1984 showed the presence of volatile organic compounds in the soils surrounding the site. At that time, the methane concentrations in LFG-4 along the western perimeter of the L-4 site often exceeded the lower explosive limit of methane. Also, investigation of the nearby homes and ambient air in the vicinity of the landfill by the NCDOH and the Nassau County Fire Commission indicated that methane was migrating from the landfill. Therefore, to remediate the migration of gas, a gas collection system was installed along the western perimeter of the L-4 site. The system became operational in late 1983 with final operational adjustments being completed in early 1984.

Ambient Air

The indoor ambient air quality of selected homes along Wakefield Avenue and Guilford Drive in the vicinity of L-4 was assessed by the Nassau County Department of Health in 1981 and 1982. Vinyl chloride and benzene were detected in some cases at concentrations exceeding the New York State Acceptable Ambient Level (AAL). Concentrations of tetrachloroethylene, 1,1,1-trichloroethane and toluene were also evidenced but in levels less than the AAL.

In 1981 and 1982, the Nassau County Fire Commission monitored indoor and outdoor air for methane along Wakefield Avenue, Guilford Drive and Wyndham Way. The Commission's March 1981 tests revealed the presence of potentially explosive conditions in eleven of the thirty-seven homes tested. From 1981 to 1983 EPA's Field Investigation Team (FIT) also monitored in



SOURCE: NUS CORP., RAMP, 1984

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Figure

Location of Geologic Cross-Sec

Port Washington, Nassau County, Nev

TABLE 1-4

MAJOR GROUND WATER PUMPING WELLS IN THE STUDY AREA

Well	Depth	Year Constructed	Formation	Rating (gallons per minute)
Southport	330 ft.	1954	Magothy	700
Stonytown	532 ft.	1981	Lloyd	1,350
Hewlett	331 ft.	1947	Magothy	750
Hewlett	334 ft.	1955	Magothy	750
NHCC	265 ft.	1952	Upper Glacial	1,000
NHCC	255 ft.	1971	Upper Glacial	1,000
Bar Beach	300 ft.	1956	Upper Glacial	800

(539)

the same locations for methane. Methane was detected by the FIT in certain homes. Measurements of methane concentrations in the ambient air surrounding the L-4 site have also been conducted from 1981 to the present by the Nassau County Department of Health (NCDOH). The combustible gas (% methane) measurements performed by NCDOH since 1984 have been zero in the ambient air.

1.3 ENVIRONMENTAL SETTING AND SITE FEATURES

The present topography, geology, hydrogeology, meteorology, ground water use, ground water balance, and land use of the L-4 site and surrounding area are described in this section. Also, design features of L-4 are presented as currently understood.

1.3.1 TOPOGRAPHY

The current land surface elevation at the L-4 landfill varies from approximately 50 feet MSL at the eastern section of the landfill to approximately 160 feet MSL at the western border. The landfilling of material was initiated at about elevation 30 feet above mean sea level (MSL). The final topography of the L-4 landfill is pending approval of a landfill closure plan. The topography at the golf course west of the landfill consists of rolling hills varying from elevations of 150 to 200 feet MSL. Further east of the L-4 landfill, L-5 landfill elevations may extend above 150 feet MSL. The topography of the L-4 and L-5 parcels is mapped on an annual basis by the Town of North Hempstead.

1.3.2 GEOLOGY

The regional geology of the Port Washington Landfill and vicinity has been discussed extensively in earlier investigations by Swarzenski (1963), Kilburn (1979) and NUS Corp. (1984). This section of the RI report presents a summary of the past regional investigations. However, the reader is referred to Section 5.1 for a review and discussion of the local stratigraphy in the immediate vicinity of the Port Washington landfill.

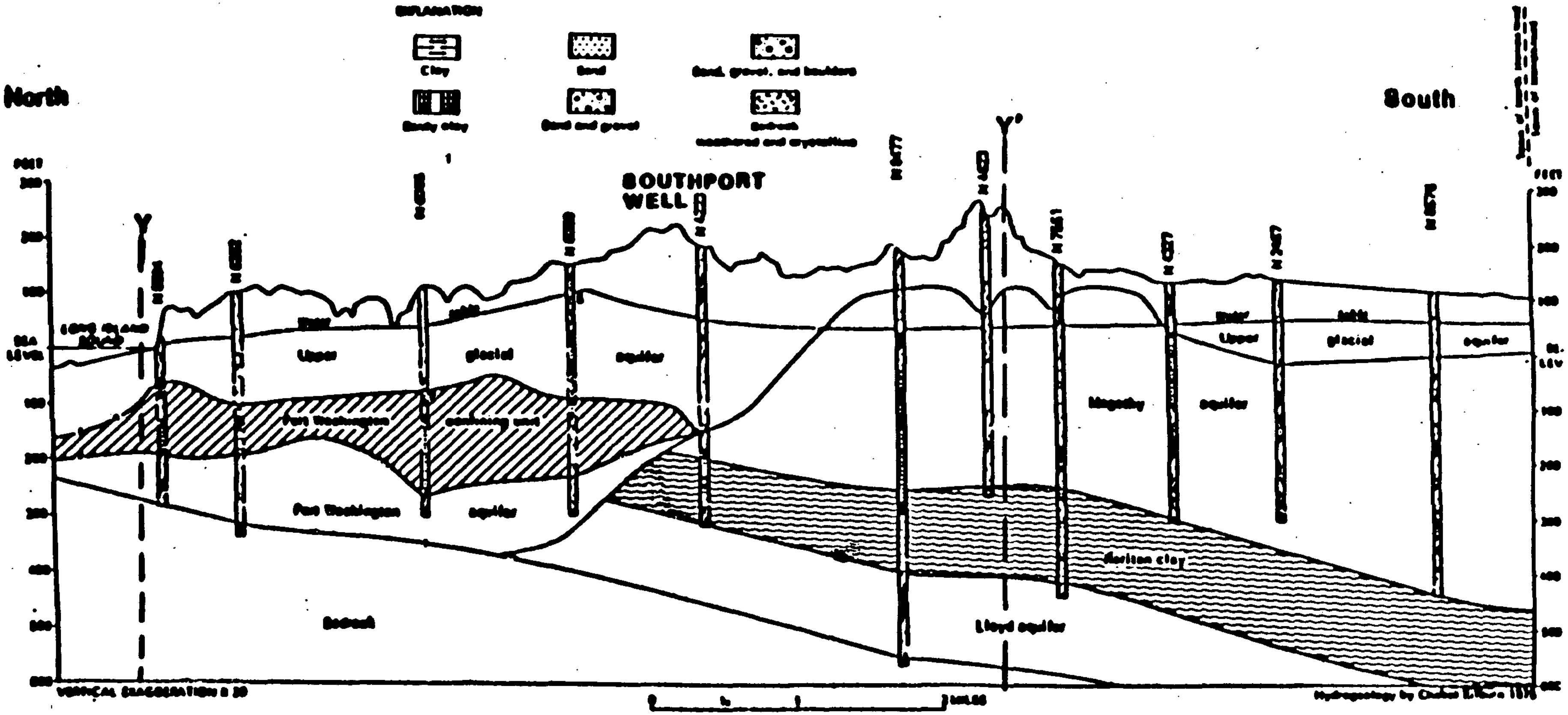
The Town of Port Washington is located in the Atlantic Coastal Plain physiographic province. Strata directly underlying the site are composed of unconsolidated glacial gravel, sand, silt and clay of Pleistocene age. Sediments below the Pleistocene glacial deposits in the southern portion of Manhasset Neck consist of marine and continental Cretaceous age clay, silt and sand of the Magothy Formation. Underlying this is the Raritan Formation. The Raritan is locally composed of two units, an upper clay member and the lower Lloyd Sand. The Raritan Formation is underlain by lower Paleozoic and/or Precambrian metamorphic bedrock. The Magothy and Raritan Formation may have locally been removed by erosion and filled in with Pleistocene glacial deposits.

Underlying the Pleistocene glacial deposits in the northern portion of Manhasset Neck are extensive deposits of Upper Cretaceous and Pleistocene clays and silts, followed by deposits of sands and gravels. These units comprise the Port Washington Confining Unit and the Port Washington Aquifer respectively. The Port Washington Aquifer is underlain by bedrock. A north-south trending geologic cross-section of the Manhasset Neck is presented in [redacted] and an east-west cross-section through the landfill is presented in [redacted] The approximate location of these sections is shown in [redacted]

1.3.3 HYDROGEOLOGY

The regional hydrogeology of the Manhasset Neck is centered around alternating layers of aquifers (i.e. Upper Glacial, Magothy, Lloyd) and aquitards (i.e. Raritan, Port Washington Confining Unit). The aquifers are the zones through which the most significant amounts of ground water flow, and therefore, these are the zones which are tapped for public water supply. Aquitards, on the other hand, are significant as barriers to vertical flow of ground water, generally separating the aquifers in a "layered-cake" arrangement.

Beneath the landfill at L-4, the Upper Glacial aquifer represents the uppermost water-bearing zone. The Magothy aquifer immediately underlies the Upper Glacial, with the Lloyd aquifer below separated from the Magothy



*The Port Washington Landfill is located approximately 1,300 feet east of the Southport Well

Source: Kilburn, 1979

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Figure 1-8

North-South Geologic Cross-Section of Manhasset Neck

Port Washington, Nassau County, New York

WEST - EAST GEOLOGIC CROSS - SECTION

(Geologic contacts based on information by Henderson and Casey, and Chabot Kilburn)

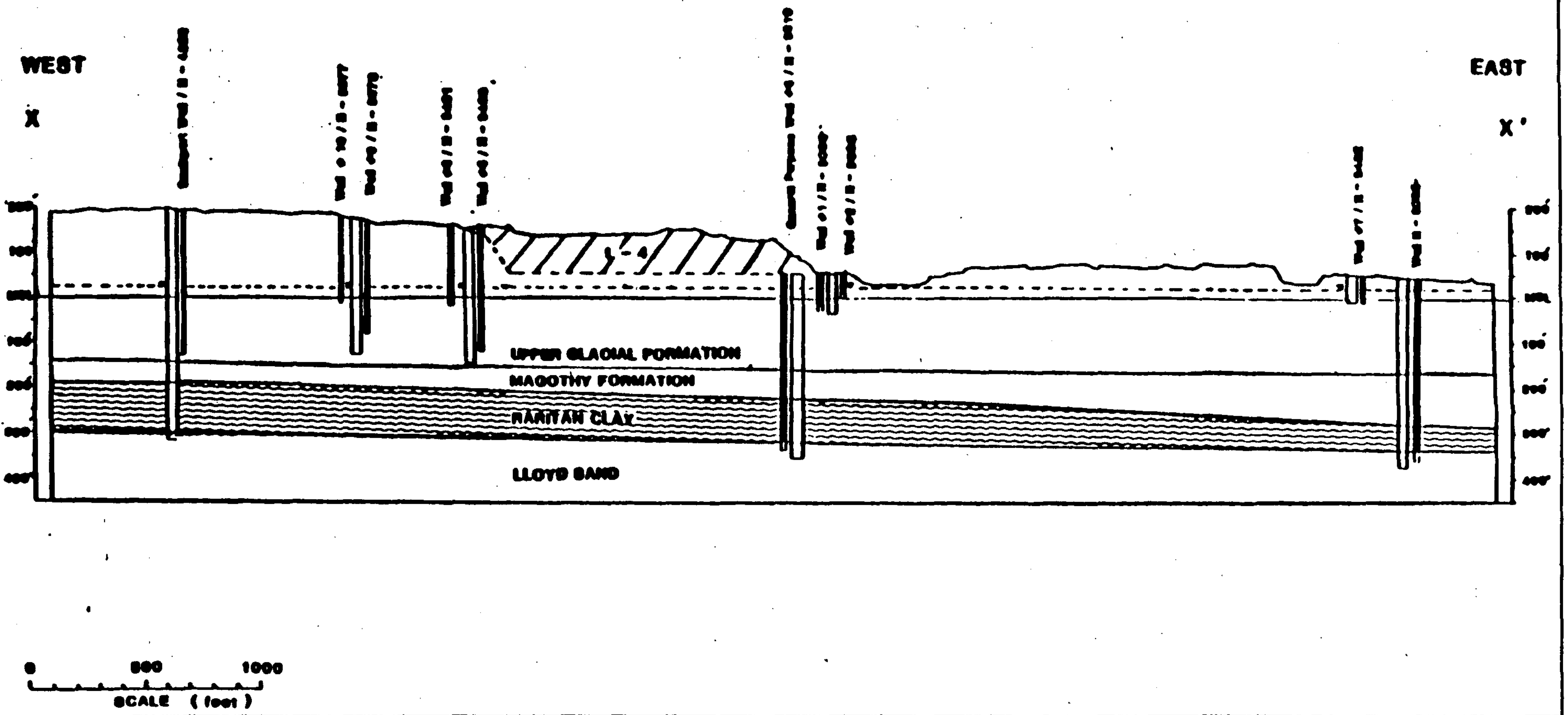

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Figure 1-9

West-East Geologic Cross-Section

Port Washington, Nassau County, New York

by the Raritan aquitard. The Lloyd aquifer is the assumed bottom of the ground water flow system given that it overlies the bedrock. To the north, the Magothy, Raritan, and Lloyd have been replaced by the Port Washington Confining Unit and Aquifer. All of the aquifers described above are utilized locally for public water supply.

The Upper Glacial aquifer which generally flows from west to east beneath the landfill carries water from the crown of the peninsula to Hempstead Harbor (an extension of Long Island Sound). The Magothy aquifer, which has similar flow characteristics, also discharges into Hempstead Harbor. The Lloyd aquifer, on the other hand, is insulated from the local surface water bodies by the Raritan clay such that waters contained in this unit can migrate beneath Hempstead Harbor and Manhasset Harbor. According to the USGS (1987), the waters in the Lloyd Aquifer flow from east to west beneath the Landfill discharging regionally into Manhasset Harbor and Long Island Sound. The Port Washington aquifer also has a regional flow component which allows for some water to flow beneath the water bodies bordering the peninsula.

The most significant users of ground water in the area are the Port Washington Water District (PWWD) and the North Hempstead Country Club (NHCC). Several PWWD production wells are potentially affected by Landfill operations including the Southport, Stonytown, and Hewlett wells, as well as the Bar Beach Road well to the north of the site. The characteristics of these wells are presented in [redacted]. Additionally, the NHCC has two irrigation wells located along Port Washington Blvd. The details associated with these two wells are also presented in table 1-4.

The Southport well is located 1,300 feet due west and hydraulically upgradient from the Port Washington landfill. It was constructed in 1954 and was utilized for public water supply until June 12, 1981 (see section 1.2.2). It was suspected at the time that the cone of influence created when the Southport Well was pumping reached eastward towards the landfill and intercepted ground water from beneath the site. The Stonytown well was constructed 3,000 feet southwest and hydraulically upgradient from the landfill and brought on line to replace the lost yield caused by the closing of the Southport. However, the annual pumping rate at this location was reduced in 1982 to limit its cone of influence as a safeguard against possible contamination migrating to the well from the Port Washington landfill. Subsequently, in 1987 a permit from NYSDEC was issued authorizing increased annual pumpage for the Stonytown well; however, water level and water quality monitoring requirements were also increased as an additional safeguard.

Throughout this time period, irrigation pumping has continued on the NHCC grounds. Withdrawals have been estimated to be as high as 1,000 gallons per minute (gpm) during the summer months. This ground water extraction may have significant impacts on the ground water flow field beneath the landfill, especially given the proximity of the local water supply pumping. It should be noted that no ground water quality data has been obtained from the water pumped from the irrigation wells.

1.3.4 METEOROLOGY

The local climate is described based on data recorded at Brookhaven National Laboratory (41 miles east of the site) and La Guardia Airport (approximately 11 miles west-southwest of the site). The REM II team, however, did install a meteorological recording station at the Port Washington landfill to record micro-meteorological conditions during the course of remedial investigation activities. This station is further described in Section 2.6 and real-time meteorological results are discussed more fully in section 3.0.

Climate - The climate of central Long Island is representative of the humid continental type that is affected by the passing of air masses governed by large-scale circulation patterns. These general patterns are modified by regional topographic features. The Appalachian and Adirondack Mountains lying to the west tend to form a shelter belt for intense weather systems approaching from the west. The open ocean and bay areas to the east, south and north also tend to modify weather systems in the study area. Localized weather features, such as sea-breeze circulations, can cause minor influence on the climate in the immediate vicinity of the site.

Temperature - The largest influence on the regional temperature pattern is the Atlantic Ocean to the south and Long Island Sound to the north. The average annual temperature is 50°F. Winter temperatures are milder than mainland areas at similar latitudes because of the moderating influence of the surrounding warmer water surfaces. During the summer, afternoon temperatures are moderated by local sea breezes and water influence. The coldest month of the year is January with a mean monthly temperature of 24°F while the hottest month is July with a mean monthly temperature of 73°F.

Precipitation - Annual precipitation in the study area is produced from moisture originating in the Gulf of Mexico and the southeastern portions of the North American continent, the open water areas of Long Island Sound and the Atlantic Ocean and moisture from the west central region of the continent which is carried by the prevailing westerlies.

The average annual rainfall at the LaGuardia Airport recording station from 1973 to 1984 was 42 inches. This is primarily rainfall with a limited amount of the total precipitation recorded as snowfall.

Most precipitation in the winter months is produced by low pressure systems that form to the south and intensify as they move northeastward. As storm systems move off the coast in the Mid-Atlantic region, they occasionally stall and thereby influence weather in the Long Island area for several days. Significant amounts of snowfall are produced when these systems are accompanied by near freezing temperatures. Snow occurs between October and April with an average seasonal amount of 31 inches. In the summer, precipitation is associated with the passage of fronts and convective showers. Localized heavy precipitation may result from squall lines and intense thunderstorms produced by frontal passages.

The prevailing westerly winds of the mid-latitudes dominate general air movements in the area. During the winter season, polar air masses dominate the region, and the wind has a more northerly component. In the summer months, tropical air masses dominate and a strong southerly component is present. The average annual wind speed recorded at JFK International Airport is 13 miles per hour. Wind speeds generally increase in the winter season and decreases in the summer. This change coincides with the movement of the mid-latitude jet stream. Maximum gusts also occur during winter, when the surface pressure gradients are often greatest.

1.3.5 HYDROLOGIC MASS BALANCE

This section presents an overview of the water budget, or hydrologic mass balance, for the study area. The importance of the water budget is associated with the determination of water volumes which pass through the flow system. Of specific interest are the volumes of water migrating through the ground beneath the landfill. This information is important for use in modeling the ground water flow regime presented in Appendix A.

Under normal conditions the water budget can be defined by the following components:

- precipitation (inflow);
- recharge into the ground (outflow);
- evapotranspiration (outflow); and
- runoff (outflow)

However, the intensive use of ground water on Long Island, in general, and in the vicinity of the landfill, in particular, greatly complicates the water budget as presented in such simple terms. Although precipitation remains as the only overall inflow component, the shallow ground water system has inflow components including not just recharge but return flow linked to leaking sewer lines, irrigation practices, leaching field seepage, artificial recharge, and local soil washing operations, as well.

In addition, outflows from the shallow ground water flow system complicate the simplified water budget. The relevant ground water outflows include pumping discharges, discharges at springs, and downward leakage from the shallow aquifer into deeper regional flow systems.

The following section of this report evaluates each of the water balance components defined in both the simplified (overall) hydrologic budget and the ground water budget.

Overall Hydrologic Mass Balance

Again, the basic components of the hydrologic mass balance are precipitation as inflow and evapotranspiration, runoff, and ground water recharge as outflow.

As previously discussed, precipitation in the Port Washington area averages about 42 inches annually. Of this, approximately 45 to 50 percent recharges into the subsurface (Swarzinski, 1961), approximately 45 to 50 percent is lost to evapotranspiration, and up to five percent is lost as streamflow or direct surface water runoff (Steenhuis, 1985).

There are significant seasonal variations associated with this mass balance. Although limited records exist for the area, it is suggested that during the summer months net evapotranspiration is nearly equal to total rainfall (Steenhuis (1985)), and during the winter months evapotranspiration is negligible. However, the total loss accounts for approximately 45 to 50 percent of the total outflow from the system or about 20 inches per year.

Precipitation, on the other hand, does not vary significantly with season. Although late summer is sometimes dry, this same period often produces the most intense rainfall events.

Runoff is insignificant in the overall scheme of losses, such that its seasonal variation is unimportant.

Ground Water Balance

Although precipitation ultimately is the source of water coming into the surface and ground water systems, there are various components of the ground water system which can be uniquely identified. These are return flow, artificial recharge, and water accumulated due to soil washing operations. (Note that water introduced to the shallow aquifers during soil washing operations at the local gravel pits, although it may be sizable, is local by nature and occurred prior to 1974. It therefore has not been incorporated into this mass balance.)

Return flow is typically water that enters the ground water system through irrigation, pipe leakage, or leaching fields. It is called return flow because the origin of these types of water is solely from the ground water aquifers and it is returned as percolation adding to the total recharge. Estimates for the total volume of return flow in the study area caused by irrigation are no more than 1 inch per year with local variability. Pipe leaks and leaching field return flow may be considerable in the vicinity of the landfill due to the fact that between 40 and 60 percent of the Port Washington residences are unsewered. Using an average consumption of approximately 3 million gallons per day (MGD) for the Port Washington area, approximately one half could be returned to the ground by return flow. Over a 14 square mile area, this rate would account for approximately 2 inches of recharge a year. Therefore, upwards of 3 inches of return flow may enter the ground water flow system, annually.

Artificial recharge which is usually associated with air conditioning cooling operations and has widespread use across most of Long Island, is not practiced in the Port Washington area.

Based on these observations and analyses total average annual inflow into the ground water flow system is estimated to range from 24 to 26 inches per year over the study area.

Evapotranspiration, runoff, and recharge are the most significant outflows from the surface water flow system. However, in the subsurface, pumping discharges, spring discharges, and downward leakage into regional aquifers impact the volume of ground water.

Public water supply pumpage plays a major role in the ground water balance. Pumping within the study area by the PWWD (10 wells), Plandome (3 wells) and Manhasset-Lakeville Water district (1 well) totals approximately 3 MGD, of which the vast majority is extracted from above the Raritan Clay. Limited pumping also occurs for private consumption at numerous interests on the peninsula, however, the golf courses represent the heaviest users. The NHCC wells are rated at 1,000 gpm and produce upwards of 60 million gallons of water over 6 months in the summer.

Ground water discharges into surface water bodies are almost solely associated with discharges into Hempstead Harbor and Manhasset Neck in the vicinity of Port Washington. Hempstead Harbor is the sole recipient of the ground water which flows beneath the landfill. Estimates of this volume ranges from 40,000 to 100,000 gallons per day. (All of the water carried by the Upper Glacial and Magothy water bearing zones (horizontally) discharges into this salt water body).

The vertical component of flow through the water-bearing zones above the Raritan induce flux downward into the Lloyd aquifer. It should be noted that an upward flow component across the Raritan occurs mainly beneath the major water bodies such as Manhasset Bay and Hempstead Harbor. The next flux across the Raritan is downward from the Magothy to the Lloyd.

1.3.6 CONSTRUCTION AND OPERATION OF THE L-4 LANDFILL

As previously discussed, the Port Washington L-4 landfill site occupies a total of approximately 54 acres. Of this, the disposal area consists of 33 acres, with the remainder being access roadways and the interim leachate treatment facility. Prior to filling, the bottom of the site was approximately 30 feet above mean sea level (MSL) (Lockwood, Kessler & Bartlett, 1974). Currently, the top elevation of the landfill is approximately 180 feet MSL sloping to 155 MSL at the western perimeter of the landfill. The sides are steeply sloping to approximately 55 feet MSL at the toe of the landfill.

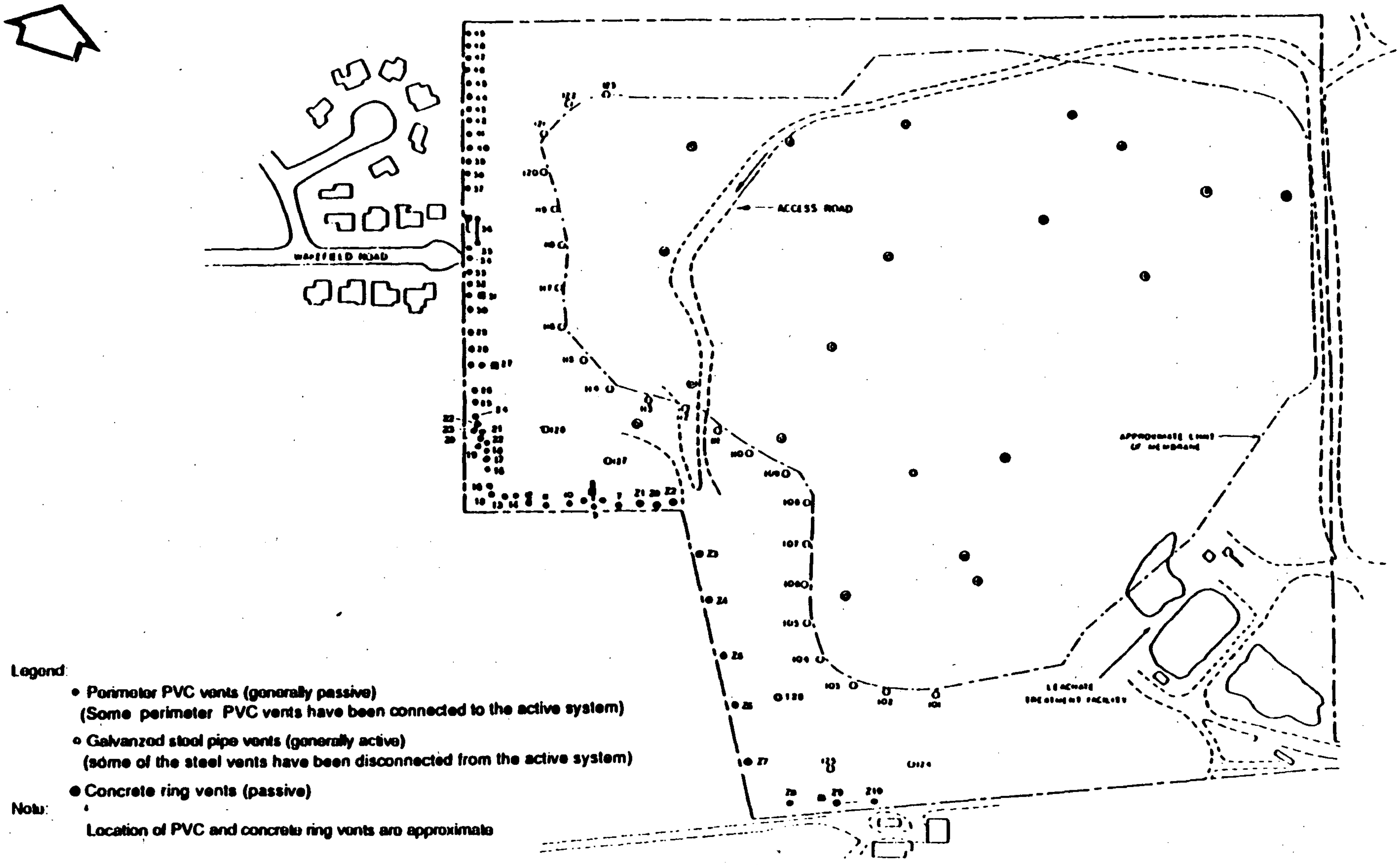
During construction in 1974, a 20-mil PVC liner was installed on 4 acres of the site. A leachate collection system consisting of collection pipelines in a sandbed was placed directly upon the liner. As operations continued, both the PVC liner and the leachate collection system were extended until the liner reached a final area of 29 acres. Details as to how the liner systems were bonded together during expansion are unknown.

The western perimeter of the landfill abuts against steep sand cliffs which were a remnant of the former All-American Sand and Gravel Corporation's sand and gravel excavation. To prevent the off-site migration of landfill-generated gases, a clay barrier was placed between the fill material and the sand cliffs during construction of the fill. In addition to this, twenty-three vents constructed of perforated concrete leaching rings, 6 feet in diameter, were installed on-site during its construction to vent the landfill gases to the atmosphere. These concrete vents (cisterns) extend from the bottom to the top of the landfill and are currently filled with crushed stone.

Additional vents were installed into the fill in the form of twenty-eight galvanized steel "active" vents along the perimeter of the PVC liner, and numerous PVC "passive" vents in native soil along the western fenceline of the landfill (see [redacted] Landfill gases are designed to be extracted from the active vents by a system of blowers located southeast of the leachate treatment lagoon. The extracted gases are then designed to be conveyed to a combustion unit near the landfill entrance and burned. The passive vents allow subsurface landfill gas to vent to the ambient air in the absence of any mechanical inducement.

A gravel filled trench was also reported to be installed by the Town along a portion of the western site perimeter near Wakefield Avenue. This trench was reported to be about 500 feet long, 3 feet wide and 6 to 7 feet deep. The purpose of this trench was to act as a passive venting system for migrating landfill gases.

Further details concerning the existing gas management system are presented in Section 2.0.



Legend:

- ● Perimeter PVC vents (generally passive)
  (Some perimeter PVC vents have been connected to the active system)
- ○ Galvanized steel pipe vents (generally active)
  (some of the steel vents have been disconnected from the active system)
- ● Concrete ring vents (passive)

Note:

Location of PVC and concrete ring vents are approximate

Source: Fred C. Hart Associates (1982)/SCS Engineers (1987)

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Figure 1-11

Gas Management System Layout

Port Washington Landfill, Port Washington, New York

1.3.7 SURROUNDING LAND USE AND DEMOGRAPHY

Land use in the area surrounding the Port Washington site is mixed. Residential use dominates in the northwest area outside L-4. A residential development is located 50 feet from the landfill, and the presently unoccupied Salem School (part of the development) is located within 700 feet. Recreational land use in the site area occurs directly west and southwest of the landfill in the form of the North Hempstead Country Club. A public beach (Bar Beach) is also situated approximately one mile north of the eastern entry to the site. A commercial office complex and warehouses (the Seaview properties) are located directly south of the site. Further to the south and along Shore Road are garden apartments. To the north, is the Cow Bay Sand and Gravel Quarry. Across Hempstead Harbor to the east are the towns of Roslyn Harbor and Glenwood Landing which are primarily residential.

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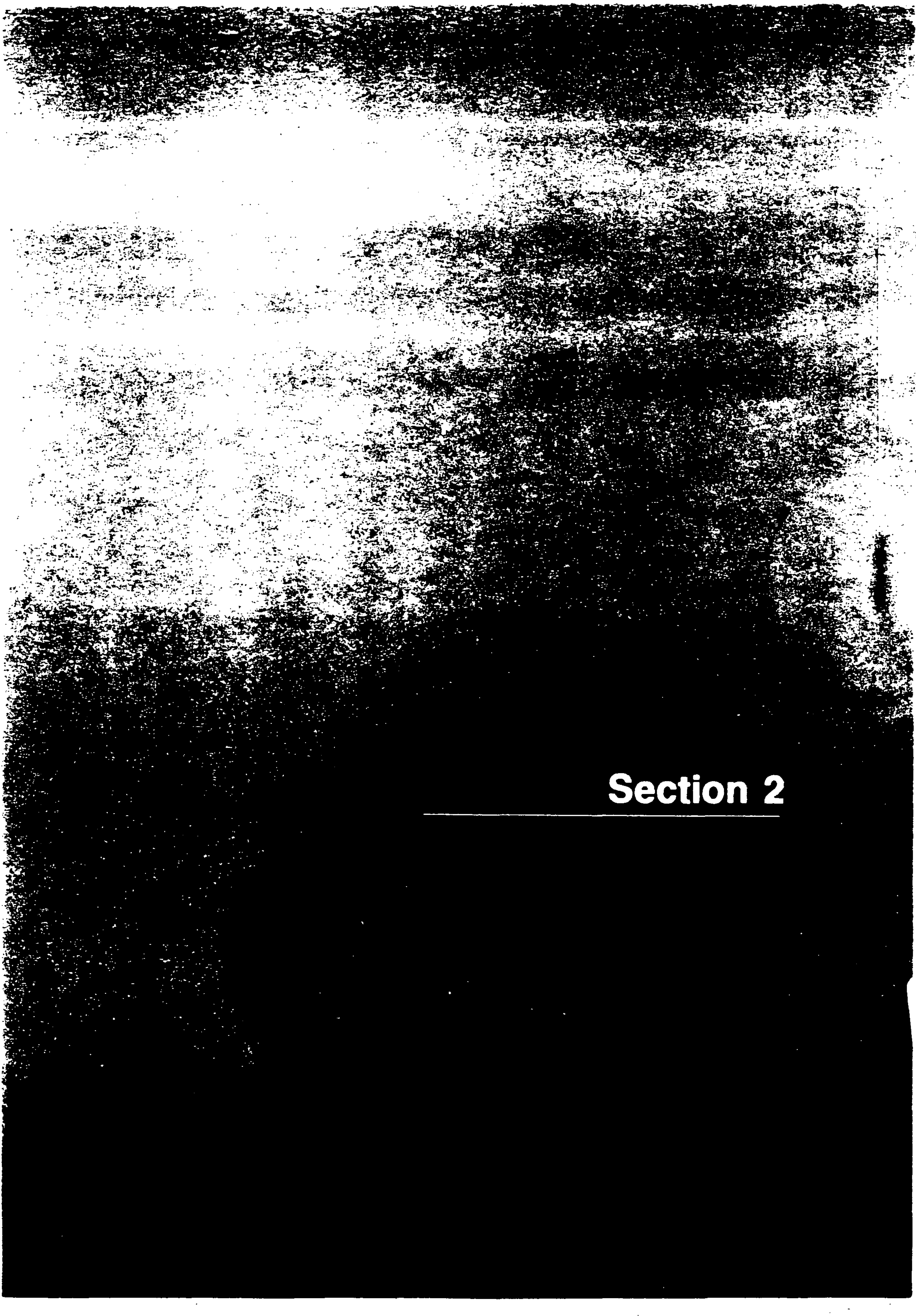


Section 2

2.0 REMEDIAL INVESTIGATION ACTIVITIES

LANDFILL GAS AND AIR QUALITY

In section 1.0, background information on the Port Washington Landfill site was provided. The purpose of section 2.0 is to describe the procedures and methodologies used to define and assess landfill gas (LFG) generation, transport and management at the site. Specific objectives of the LFG gas work included:

- determine if subsurface migration of gases occurs from the landfill to offsite areas,
- assess the effectiveness of the existing gas venting system in preventing landfill gas migration offsite under different seasonal conditions
- determine whether landfill gas may be impacting indoor and ambient air quality in the immediate environs of the landfill.

Gas migration control and monitoring facilities have been installed at the Landfill at different periods since before 1981 in an attempt to mitigate gas movement from the Landfill to a primary area of concern---the residential properties west of the landfill and the Salem School. Another emerging area of concern is the area south of the Landfill where an industrial complex has rapidly developed over the past few years. This area has most recently been investigated by the EPA Environmental Response Team (ERT). (See Section 2.4.1).

The various gas control facilities that have been installed on and around the L-4 landfill by the Town of North Hempstead include:

- Twenty-three (23) passive concrete vents (cisterns)
- A passive vent trench (reported to be approximately 500 ft. long, 3 feet wide and 6 to 7 feet deep) along the landfill fenceline perpendicular to Wakefield Avenue
- Twenty-eight (28) steel vents which are connected to the "active" gas removal system

- "Passive" plastic vents (some of which are connected to the active gas removal system)
- Blower house and Horizontal Combustion Unit (HCU)

These facilities are currently in operation at the site and are located as shown in figure 2-1.

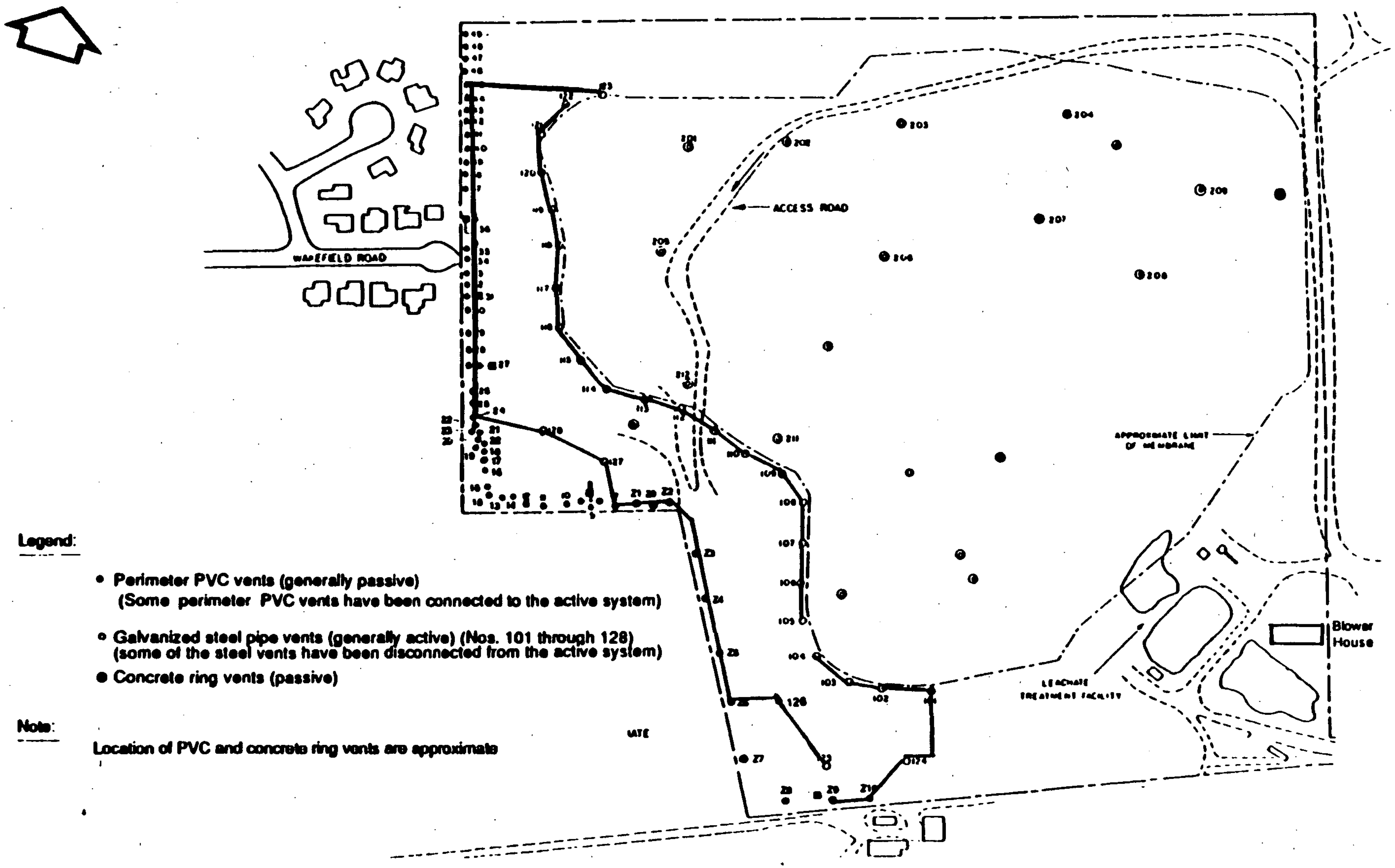
In addition to these aforementioned control facilities, the Town of North Hempstead has also installed the following for gas migration monitoring purposes:

- Landfill gas monitoring wells
- RCRA probes.

The active gas management system associated with the L-4 landfill consists of the combined operation of perimeter (plastic vent) wells and the in-landfill (steel vent) wells. As of November 1987, a total of 36 extraction wells were reported to be operating as part of the active system. Eight of these wells were plastic vent perimeter wells and 28 were steel vent wells. (Although it should be noted that steel vent well Nos. 124, 125 and 126 were disconnected at that time.) Approximately 40 passive plastic vents are situated on the western perimeter of the site which are not connected to the active extraction system.

The on-site steel vent wells are constructed of 10-inch diameter steel pipe, with slotted perforations for most of their depth. Extracted gas flows from each well toward the blower house via an 18-inch main header line or laterals mode of polyethylene (PE) pipe. The perimeter plastic wells are constructed of 6-inch PVC pipe.

The blower house is located at the base of the L-4 landfill and is equipped to accommodate eight blowers (six operating, two spare). Although design operating conditions call for six blowers to be operating, since 1984 the landfill gas extraction system has been operated on anywhere from one to four blowers. The HCU was added to the extraction system in 1984. The purpose of the HCU is to combust and destroy collected landfill gas,



Legend:

- Perimeter PVC vents (generally passive)
  (Some perimeter PVC vents have been connected to the active system)
- ○ Galvanized steel pipe vents (generally active) (Nos. 101 through 128)
  (some of the steel vents have been disconnected from the active system)
- ● Concrete ring vents (passive)

Note:

Location of PVC and concrete ring vents are approximate

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Figure 2-1

Gas Management System Layout

Port Washington Landfill, Port Washington, New York

resulting in negligible or not detectable discharges of volatile organic compounds. The HCU is a high-temperature, thermal incinerator designed to operate continuously at approximately 1600°F. Supplemental fuel (propane) is available at the site for start-up procedures, and to maintain operational temperatures and flame stability, if required.

To meet the study objectives, the remedial investigation LFG work conducted by the REM II team was divided into six tasks:

- Assessment of the performance of the existing gas venting system (Section 2.1)
- Pressure probe installation and unit vent performance testing (Section 2.2)
- Landfill gas surface emission rate testing (Section 2.3)
- Landfill gas monitoring well installation and sampling (Section 2.4)
- Ambient air quality evaluation (Section 2.5)
- Meteorological data collection (Section 2.6)

The specific purposes and methodologies used in each of these field efforts are described in the following sections.

2.1 PERFORMANCE ASSESSMENT OF EXISTING SYSTEM

The existing landfill gas venting system was designed to collect landfill gas produced in the Port Washington landfill and prevent any such gases from migrating in a westerly direction from the Landfill to nearby residential properties. The components of the gas venting system presently include: a combination of passive (plastic and concrete) and active (plastic and steel) vents, a vent manifold system (header pipes), eight blowers and a horizontal combustion unit (HCU).

The active and passive venting system was to be evaluated by the REM II team to determine if the system, under current operating conditions, was providing an effective barrier to the westerly migration of landfill-generated gases, horizontally into and through the surrounding soils. This evaluation was to be performed in a twofold manner: (1) inspection/analysis of the Town of North Hempstead's operating logs, design/as-built drawings and specifications; and, (2) performance of field testing.

The REM II team's field system assessment program was designed, as stated in the Work Plan, to collect field data which would be relevant to the assessment of the venting system as currently operated by the Town. The methodologies and associated work elements planned to collect this data are described below and included ten (10) subtasks which, in aggregate, were to allow for system assessment. Further details concerning these field activities are included in Addendum No. 6 to the Project Operations Plan dated July 1988.

2.1.1 INSPECTION OF EXISTING SYSTEM

Several inspections of the gas venting system along the western boundary of the L-4 site were performed during the period of December 1986 through August 1988. During these inspections, observations were made of the physical condition of the system as well as its design and operation.

A detailed on-site inspection of the system was performed between July 14 and July 22, 1988, during which period other vent system data acquisition tasks were performed. During the inspections, physical characteristics of the system were noted to discern active and passive vents. In addition, observation of leaks at manifold joints and fittings and condensate presence in pipes were noted. These observations also included the physical manner of connection of each vent to the main header line; that is, whether the connections were inverted upwards or downwards thus indicating which vent connections were possible sinks for condensate collection. During the inspection of the system, topographic low points on the main header line which were also possible sources of condensate collection and discharge were noted. The results of these physical observations are recorded in section 3.1.1.

2.1.2 CATEGORIZATION OF VENTS

As a first step in understanding the physical operation of the venting system, the vents of concern on the western perimeter of the Landfill were categorized by the REM II team into two classes based on their design basis and our understanding of their actual performance.

The design basis referred to the intended purpose of the vents, that is, either passive (not connected to the blower system) or active (connected to the blower system). The results of this categorization are listed in table 3-1.

2.1.3 RECORDING POSITION OF THE VENT VALVES

In order to determine under what conditions the active vents normally operated, the REM II team conducted a baseline survey of the venting system as it existed in late July 1988 before the start of dynamic testing of the system. It was determined that each active vent is equipped with a valve with a set of eight notches numbered 1 to 8 (fully opened to fully closed, respectively). The position of each valve setting was recorded at the start of the baseline survey (see table 3-1) to determine the degree of opening of each valve prior to initiating dynamic testing. Subsequent to establishing the baseline conditions, dynamic testing of the system was to begin and include three stages of blower operation (i.e. no blowers operating, three blowers operating and six blowers operating) in conjunction with three stages of valve settings at each blower stage. Unfortunately, this dynamic testing was unable to be performed because only one blower was operational. As a compromise, only one-half of the proposed dynamic testing program was attempted. Namely, the REM II team attempted to ascertain what effect changes in the vent valve settings would have on the individual well head pressures. With only one blower operating, however, the changes noted in pressure were so slight that it could not be determined if they were attributable to changing the valve settings or to surging conditions in the pipeline. Accordingly, dynamic testing of the system was halted without obtaining the desired information.

2.1.4 MEASURING WELL HEAD VACUUM

In order to determine the effectiveness of each vent in drawing a vacuum and hence its ability to be an effective component of a gas migration management system, well head vacuum measurements were taken at each steel and plastic vent that had a port. The port was, typically, a 1/4-inch hole drilled by Town representatives at the top of the vent. A pressure gauge was used to measure the well head vacuum when the venting system was "on" (i.e. one blower operating) and when the system was "off" (i.e. all blowers turned off). The measurements taken were recorded and the data that resulted is presented in section 3.1.2 (table 3-3). Again, it was originally intended to measure well head vacuum under a variety of blower operating conditions. However, because only one blower was operating this investigation was limited to measurement in just a "system on" and "system off" mode.

2.1.5 MEASURING TEMPERATURE OF THE GASES AT THE WELL HEAD

Temperature was intended to be measured at each active vent to provide an indication of those areas of the Landfill where the refuse was readily decomposing. This information might also provide indications of smoldering landfill fires. This information was considered useful to obtain as an aid in assessing what improvements to the existing system, if any, might be necessary.

The temperature of the gases at the vents was also initially intended to be measured each time there was an adjustment to the vent valves or blower operations so as to detect any effect changes in the operation of the system may have on this variable. Instead, temperatures were only recorded in the "system on"/"system off" mode. The results are discussed in section 3.1.2.

2.1.6 MEASURING GENERAL PROPERTIES OF THE GASES AT THE WELL HEAD

To secure an initial understanding of the general characteristics of the vent gases, field measurements of the primary gases (nitrogen, oxygen, methane and carbon dioxide) were performed at the well head utilizing an organic vapor analyzer, a photoionization detector, and a combustible gas indicator. A discussion of these results is included in Section 3.1.3.

The concentrations of the primary gases in extracted landfill gas is used to assess the "proper" withdrawal rate of a vent. If too large a vacuum is applied to a vent, ambient air will be drawn from the landfill surface, through the refuse, and into the vent. This is undesirable for two reasons:

1. High withdrawal rates, with air breakthrough from the surface of the landfill, can lead to subsurface landfill fires;
2. The extracted landfill gas may be too dilute in methane, due to air infiltration, to support combustion in the HCU unless a supplemental fuel source is utilized.

Gas samples were also taken from selected steel vents (No. 103, No. 116 and No. 122), a plastic vent (vent No. Z), a concrete cistern and at the inlet of blower No. 8 for EPA Contract Laboratory Program (CLP) analysis. The samples were collected in "SUMMA" canisters and analyzed for the primary gases as well as volatile organic compounds. These results are presented in Section 3.1.3.

2.1.7 DETERMINING WELL HEAD GAS FLOW RATE

Well head gas flow rates were to be measured in each active vent during the dynamic testing program previously described so that this current operating information could be compared to SCS Engineer's design specifications and an indication of the effectiveness of the existing gas venting system drawn. Pitot tubes were used to measure well head flow rates. The pitot tubes employed were not effective in measuring well head flow rates due to surging in the header line, condensation of moisture from the gases onto the pitot tube, and the fact that only one blower was operating thus producing a low level of flow. Pitot tubes work more effectively at flow levels higher than those encountered in the field. As a result, gas flows were not able to be measured.

2.1.8 SAMPLING CONDENSATE

Because subsurface gas readings at EPA LFG well No. 202, as later discussed, were found to be high during the initial stages of this field investigation, it was postulated that a possible cause of these elevated readings could be condensate draining or leaking onto the ground from a nearby low point in the main header system. Accordingly, condensate was collected from the pipeline leading directly to plastic vent (Z), next to EPA LFG well no. 202 as well as from four drain points on the header line and the condensate manhole by the blower house (see figure 2-27.) The condensate was analyzed by a CLP laboratory for volatile organics. The results are discussed in section 3.1.4.

2.1.9 SAMPLING OF GASES AT BLOWERS INLET/OUTLET

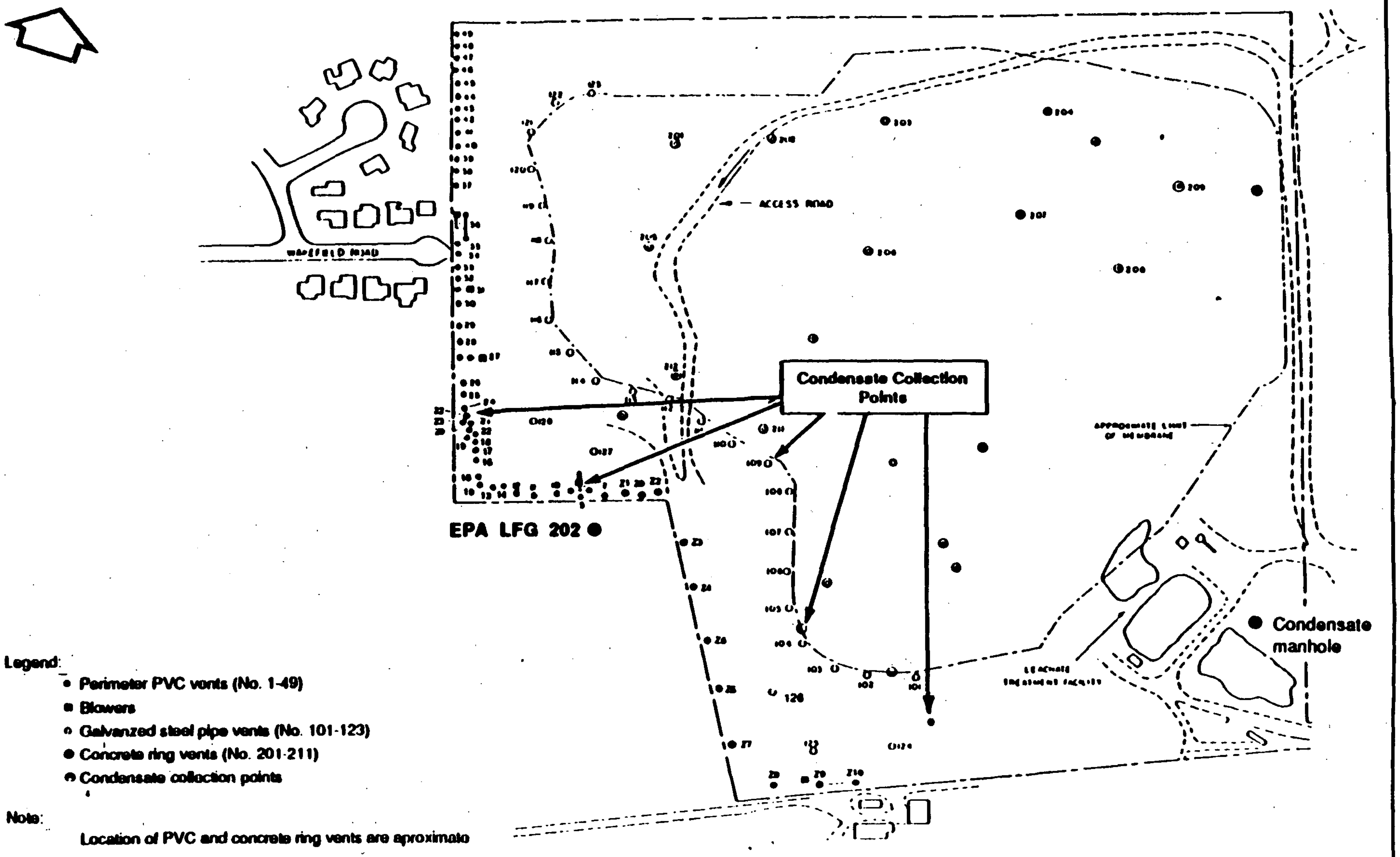
Gases were sampled at the inlet of the blowers to characterize the composite gas stream being extracted from the vent system and to determine whether the venting system extracted enough methane to run the HCU at its design efficiency. The results are presented in Section 3.1.5.

2.1.10 MONITORING OF THE WELLS OUTSIDE THE LANDFILL

To assure no unsafe excursions of gases to the west of the Landfill during the dynamic vent system assessment program, combustible gas measurements were taken at wells EPA LFG-201, EPA LFG-202, TNH-3, TNH-4 and TNH-8. When increasing levels were noted during the time period when the blower was turned off, these were reported to Town representatives who then returned the single operational blower to service. These measurements are reported in section 3.1.6.

2.2 PRESSURE PROBE WELL INSTALLATION AND UNIT VENT PERFORMANCE TESTING

The primary objective of this task was to assess the "sphere of influence" of the active vents when the venting system was on and hence its potential efficiency in creating a barrier or "vacuum curtain" to prevent gas migration to the area west of L-4. The "sphere of influence" of a single vent



Note:

Location of PVC and concrete ring vents are aproximate

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environmental engineers, scientists, planners & management consultants

Figure 2-2

Condensate Collection Points

Port Washington Landfill, Port Washington, New York

was to be described at different system operating (i.e. vent vacuum) levels which were to be effected by varying the number of blowers in operation and the vent discharge valve setting. That is, this task was to be performed in conjunction with the system performance assessment task described in subsection 2.1 above.

To accomplish the task, the following had to be performed:

- select desired active vent
- install pressure probes at desired vent
- install/operate transducers and data loggers
- measure well head pressure at varying blower and discharge valve settings.

These tasks are further described in the following sections. The results of the sphere of influence testing are discussed in section 3.2.

2.2.1 SELECTION OF DESIRED VENT

Because the purpose of this task was to delineate the "sphere of influence" about a vent, the objective initially was to select a vent that had a good potential to operate appropriately over a range of vacuum conditions. Based upon information in the 1982 SCS report, vent No. 116 was selected because of the high percent of methane detected in the vent under static conditions and its ability to generate an acceptable flow of gas at the well head vacuums applied by SCS. Vent No. 116 was also selected because it possessed the attribute of being located almost directly west of L-4 in line with Wakefield Avenue, that is, an area of primary interest.

2.2.2 INSTALLATION OF PRESSURE PROBES

Five pressure probe well sites were originally selected at radial distances of 25, 50 and 75 feet away from steel vent no. 116 and at different orientations (i.e. compass directions) from vent No. 116. The orientations were established to allow for a better approximation of the two-dimensional extent of the zone of influence at vent No. 116. The choice of these distances was related to the design sphere of influence as discussed by SCS

Engineers (1982). SCS indicated that, in most cases, the radius of influence generated by the design flow in a vent should be more than sufficient to accommodate a radius of influence equal to half the well spacing. With most steel vents being spaced 75 feet on center, this means that at the depth of the well perforations a radius of influence of only about 40 feet is required to effect a continuous vacuum curtain to curtail gas excursions off-site.

The location of one pressure probe well site at an originally planned distance of 100 feet away from the vent No. 116 was ultimately changed because of concerns that the PVC liner beneath L-4 would be penetrated if drilling were performed to the originally proposed depths at the various locations. The maximum probe depths and also the sites of the pressure probe wells were reconsidered and finally established as shown in table 2-1. The pressure probe sites around vent No. 116 are shown on figure 2-3.

Three pressure probes were installed at different depths below grade at each pressure probe site. Thus, a total of 15 individual locations were monitored. The depths were established during the project planning stage but were modified as necessary during the field drilling operation based on soil conditions and other physical conditions encountered. The main physical condition, notwithstanding refusal, that influenced the positions of the pressure probes was the presence of perched water. It was necessary to place the screened probe section at a depth and location outside of any perched water, otherwise the probe would be ineffective.

Drilling of the five pressure probe wells was performed by Environmental Drilling Inc. of Mt. Arlington, NJ. Drilling started in late February 1988 and was completed by early March 1988 with all the fifteen probes installed in the five pressure probe well sites. Split spoon samples were collected from the bottom of each borehole and revealed the presence of municipal refuse, thus demonstrating that the integrity of the liner was not breached. During the drilling, two well locations were abandoned due to the presence of water at various depths below grade. These locations were sealed with a mixture of bentonite and cement.

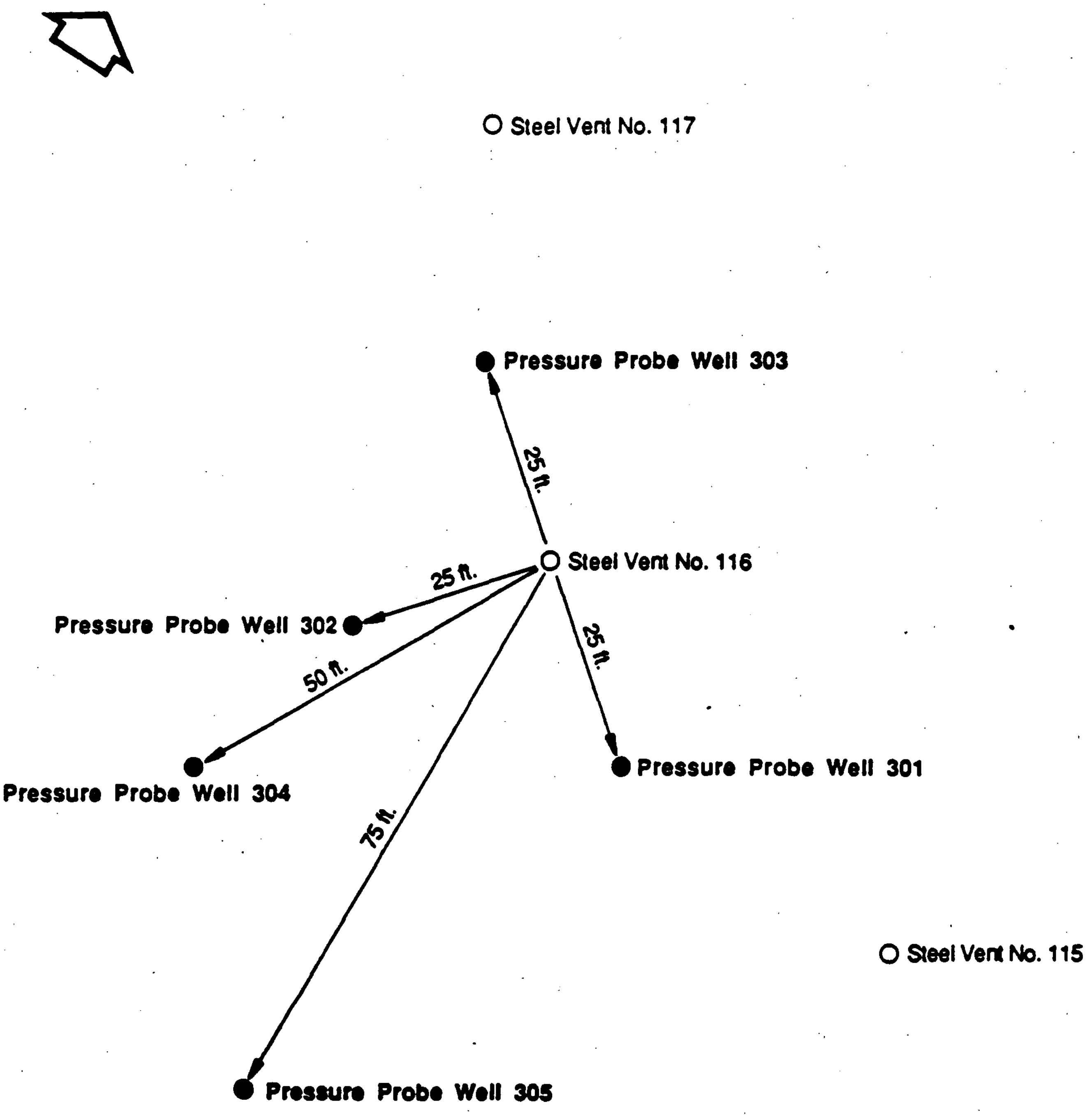
TABLE 2-1

PRESSURE PROBE ELEVATIONS

Pressure Probe well	Distance from Vent No. 116	Orientation from Vent No. 116	Elevation of Top of Well (MSL)	Pressure Probe #	Probe Elev. (MSL)*	Depth below ground surface*
301	25 ft.	Southeast	162.56	A	138.98	23.58
				B	118.98	43.58
				C	101.98	60.58
302	25 ft.	Southwest	159.55	A	139.97	19.58
				B	124.97	34.58
				C	110.97	48.58
303	25 ft	North	160.96	A	137.38	23.58
				B	117.38	43.58
				C	100.38	60.58
304	50 ft	West	158.59	A	145.01	13.58
				B	135.01	23.58
				C	121.01	37.58
305	75 ft	Southwest	158.87	A	145.29	13.58
				B	135.29	23.58
				C	125.29	33.58

* = Depth measured to the bottom of the probe

(588)



Not to scale

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Figu

Pressure Probe Well Locat

Port Washington Landfill, Port Washington, New

Temperature elements were installed at depths of 50 feet and 5 feet in probes No. 301 and No. 303, respectively. As-built drawings for the pressure probe wells are provided in Appendix B.

2.2.3 INSTALLATION OF TRANSDUCERS

Differential pressure transducers were installed on each probe to ascertain changes in vacuum intensity under different system operating levels. The scale of the differential pressure transducers was calibrated from -5 to +5 psi, thereby covering the possible range of differential pressures that could be expected in the field under normal conditions. Four dataloggers were used to record data from the fifteen differential pressure transducers and two temperature probes. Logger #1 was connected to pressure probe well EPA 301 with 3 transducers (one transducer at each pressure probe) and one temperature probe installed at 50 feet from grade. Logger #2 was connected to EPA pressure probe wells 302 and 303, with six transducers and one temperature probe. Logger #3 was connected to EPA pressure probe well 304 with three transducers, and logger #4 was connected to EPA pressure probe well 305 with three transducers. The dataloggers were programmed to scan the sensors at 10 second intervals and output one minute averages to the storage units for subsequent downloading to an IBM computer.

2.3 LANDFILL SURFACE EMISSION RATE MEASUREMENTS

For uncapped landfills, gas produced during routine decomposition of the solid waste can be emitted through the surfaces of the landfill. Because L-4 is not capped, it could be expected that surface emissions occur at the Landfill surface. This information is important both for baseline Public Health Evaluation (PHE) purposes (Section 7.0) and for use in the design of a landfill cap and associated horizontal gas migration controls. To develop estimates of surface emission rates, a flux box measurement approach was used.

Flux boxes are designed to capture the gases escaping from a surface enclosed by the area of the flux box. During the performance of this task, the methodology employed was two-staged, as follows:

- Preliminary surface survey and flux sampling station selection
- Surface flux emission measurements (over several different seasons).

Each of these items are described below.

2.3.1 PRELIMINARY SURFACE SURVEY AND STATION SELECTION

The surface of the Landfill (L-4) was gridded using 100 feet between grid stations. Areas which were inaccessible (such as the Landfill side slopes) were not used in this survey. An organic vapor analyzer was used to measure the concentration of total volatile organics at each grid node. During this operation, the tip of the probe of the organic vapor analyzer was inserted through a perforated hole in a semi-spherical enclosure with a diameter of approximately 2 inches. The probe tip was inserted and sealed into this semi-sphere such that when the open end of the enclosure was placed over the ground surface, the probe tip (and the OVA) would be directly reading the concentration of VOCs emitted through the ground surface without being affected by dispersion due to wind.

The results of this preliminary survey were plotted and different zones of volatile emissions were established. Based on these results, ten (10) flux box sampling stations were chosen. These ten stations were selected to cover the range of concentrations encountered during the preliminary survey.

2.3.2 FLUX BOX MEASUREMENTS

Flux box measurements were performed during three different periods. The first measurements were done between December 1987 and January 1988, the second set of measurements were done in March 1988, and the third round of measurements were taken in September 1988. Detailed descriptions of the methodology used in the flux measuring operation is contained in the Project Operation Plan; a brief description is given below.

A flux box was placed at a selected station for the measurement with the collar pushed into the ground. The attachments to the flux box (thermometer and pressure release valve) were positioned in place. The sweep gas (certified to be ultra high purity air) was connected to the inlet valve of the flux box with a flow meter placed in-line between sweep gas cylinder and flux box. The sweep gas was turned on at a flow rate of one liter per minute. A minimum elapsed period of five minutes was allowed for the flux box to come to equilibrium before connecting the sampler and "SUMMA" canister to the unit.

The flow controller of the sampler was set at one liter per minute and the canister was filled at this flow rate to avoid a build-up of pressure inside the flux box. The gas sample collected in the "SUMMA" canister was sent to the CLP laboratory for analyses. The target compounds were the same as the target compounds of the gas samples from the landfill gas (LFG) monitoring wells and included all priority pollutants and methane. The emission rate was calculated based on the flow rate of the sweep gas and the concentration of the different contaminants. This method is described in Klenbusch (1986).

The flux box was cleaned between sampling locations and then dried in an oven at 105°C for a minimum period of one hour. All teflon tubes were discarded after each sampling station and all fittings were cleaned with high purity grade methanol in an ultrasonic cleaner.

The sampling method described above was utilized during the second gas sampling campaign (March 1988). During the first and third campaigns, no sweep gas was used and instead samples were collected to just quantify the concentrations of gases being emitted through the landfill surface. The results of the flux box sampling program are presented and discussed in Section 3.3.

2.4 INSTALLATION/SAMPLING OF OFF-SITE EPA LFG WELLS

As described in the Work Plan, EPA and its contractors believed that the number and location of off-site TNH landfill gas wells that existed at the

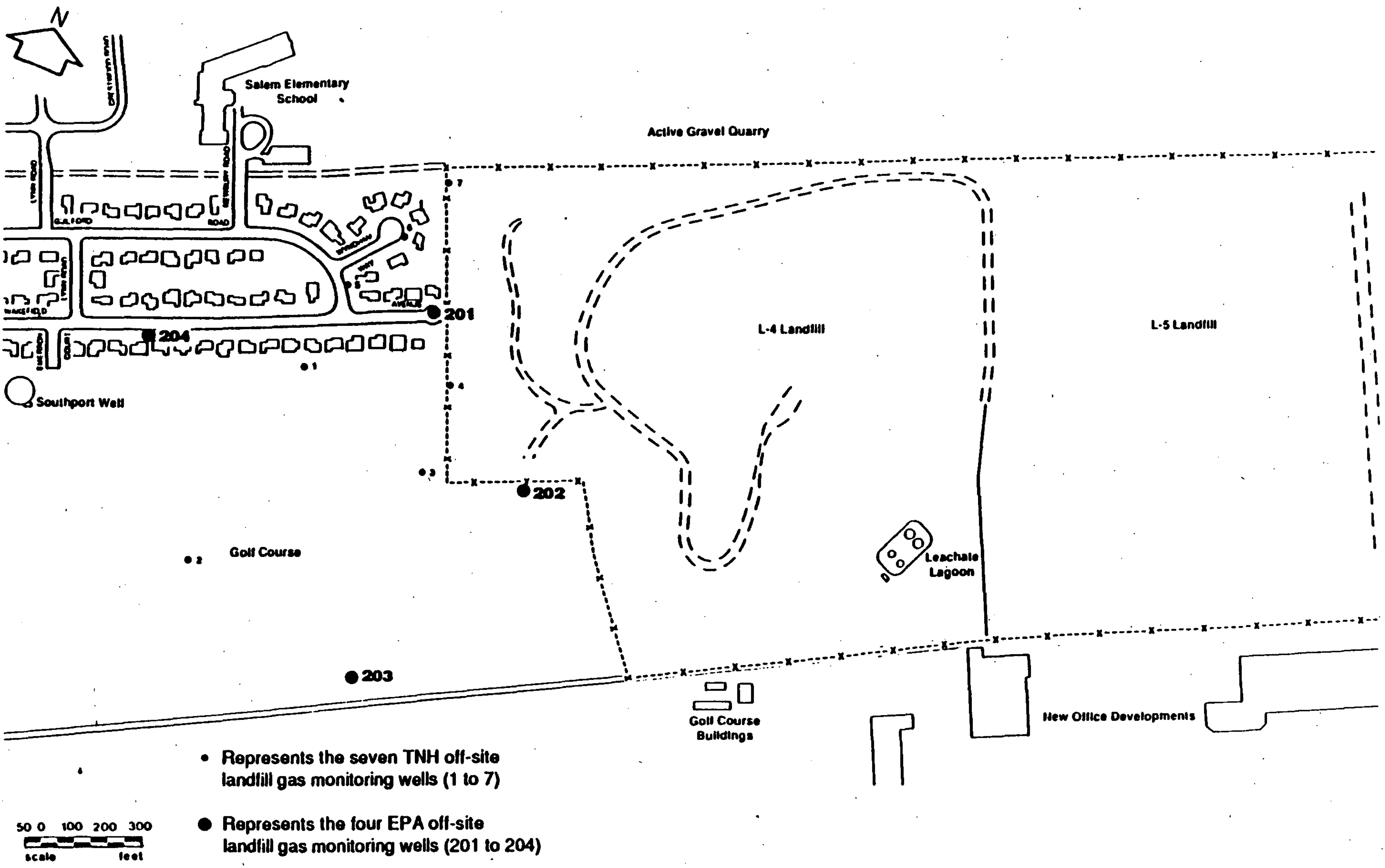
Port Washington site required supplementation. The purpose of installing additional LFG wells therefore was to allow for a more complete delineation of the direction and extent of any landfill gas flow offsite and to allow for estimating gradients of gas travel.

The REM II team's subcontractor, Hydro Group. Inc. of Smithtown, N.Y., initiated the drilling and installation of the landfill gas (LFG) monitoring wells in April 1987. All four monitoring wells were installed between April 4 and October 28, 1987 at the locations indicated in figure 2-4. Gas monitoring well EPA LFG-201 was placed in a location along the western border of the L-4 fill between the Town of North Hempstead's existing gas wells LFG-4 and LFG-7. This location was chosen for three reasons:

- to provide additional information on landfill gas concentrations as they varied north to south along the western boundary of L-4
- to provide a monitoring point west of the sphere of influence of the active venting system, and
- to provide a monitoring point within the area of concern - the residential area.

Gas monitoring well EPA LFG-202 was located to provide more information on the southern extent of any landfill gas migration immediately adjacent to the Landfill. Gas monitoring wells EPA LFG-203 and EPA LFG-204 were placed near ground water monitoring wells EPA-106/EPA-110 and EPA-105, respectively, to provide information concerning any possible correlation between VOC's in subsurface air and the ground water. Furthermore, gas monitoring wells EPA LFG-203 and EPA LFG-204 were located to provide more information on the extent of potential migration of subsurface gas phase VOC's to the west and southwest of the L-4 fill. All four LFG wells were drilled using hollow stem auger methods. A typical LFG well is shown in [redacted] Each of the LFG wells was equipped with four gas sampling probes at multiple depths (see [redacted]

During the drilling operation, four sets of soil samples were collected from each well for subsequent laboratory analysis. Each set consisted of three sample containers - one each for volatile organics, base neutral



- Represents the seven TNH off-site landfill gas monitoring wells (1 to 7)

● Represents the four EPA off-site landfill gas monitoring wells (201 to 204)

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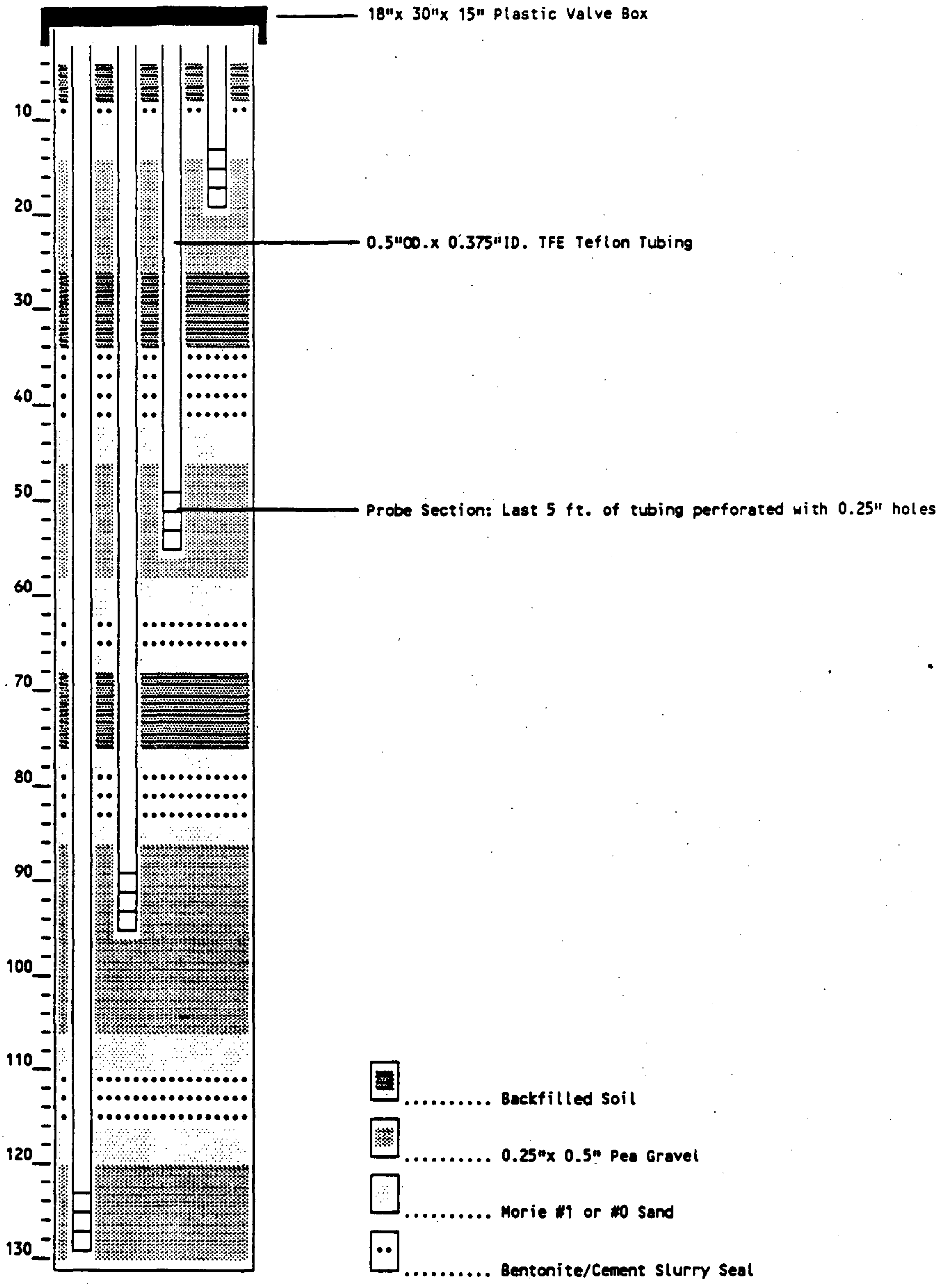
Figure 2-4

Location of Landfill Gas Monitoring Wells

Port Washington Landfill, Port Washington, New York



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Figu

Typical EPA LFG Well Constr

Port Washington Landfill, Port Washington, N

TABLE 2-2

EPA LFG WELL
GAS SAMPLING PROBE DEPTHS

Well No.	*Elevation (MSL)	+Gas Probe Depths (ft. below grade)			
		A'	A	B	C
201	155.93	23	50	90	115
202	152.91	34	65	95	125
203	153.64	10.5	34.5	97	115
204	199.69	20	55	95	129

*Elevation is measured from MSL to a point on the well valve box.

+Probe depth is measured at the bottom of the tubing (bottom of perforated probe section). The "screened" interval is therefore from this depth to 5 ft. above.

(544)

acids/extractables, and metals/cyanides. The four sets of samples were taken at varying depths within each well as noted on table 2-3 and were collected using a split spoon sampler lined with either teflon or stainless steel tubes. Once the sampler was brought up to the ground surface, the tubes were immediately capped with teflon liners and placed in an iced cooler for sample preservation. The samples were later sent to an EPA-CLP laboratory for analysis.

Additional sample cores were collected from EPA LFG Wells 201 and 202 to help characterize the geologic formations and to determine the proper placement of the gas monitoring probes. These samples, along with any excess soil remaining in the spoon containing the analytical samples, were placed in marked plastic "Ziploc" bags. The headspace in the bag was then analyzed after approximately 10 minutes using the OVA and/or HNu meter.

Each soil sample was classified by a REM II field geologist and entered into a dedicated field note book and soil boring log (see Appendix C).

Gas samples were collected from certain of the previously existing Town of North Hempstead and newly installed LFG wells. Construction data on the TNH wells and typical construction detail are given respectively on table 2-4 and figure 2-6. These samples were then analyzed for volatile organic contaminants (VOC) and methane in order to characterize qualitatively and quantitatively the nature and extent of the subsurface vapors. Additionally, data gathered during the sampling event was used to determine the representativeness and accuracy of LFG data collected by the Town. A summary location table of all these LFG wells is presented in table 2-5.

Three rounds of LFG well sampling were performed by the REM II team in order to characterize possible temporal and seasonal variations in the offsite migration of landfill gases. The sampling campaigns were performed during the following periods:

- December 1987 - January 1988
- March 1988
- August - September 1988

TABLE 2-3

LFG WELL SOIL SAMPLE DEPTHS

	Sample interval (ft. below grade)			
Well number	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4
201	20-24	50-55	110-112	127-130
202	20-24	50-55	100-104	130-134
203	19-20.5	49-50.5	84-90.5	114-115.5
204	20-24	50-54	95-99	125-129

(543)

TABLE 2-4

*TNH LFG WELL CONSTRUCTION SUMMARY

Well No.	Approximate Ground Surface Elevation (MSL)	Water monitoring screen depth (ft. B.G.)		Gas probe depths (ft. B.G.)		
		Bottom	Top	A	B	C
1	173	150	148	25	88	147
2	160	135	130	9	59	104
3B	160	145	140	10	75	130
3C	160	---	---	10	75	---
4A	155	141	136	51	81	121
4B	155	---	---	10	---	---
5	172	160	155	20	80	145
6	177	165	160	18	78	143
7	168	155	150	14	84	139
8	56	35	30	11	25	33
9	48	30	25	14	21	26

*Data is taken from the report from SCS Engineers to the Town of North Hempstead dated September 1983, and titled "Engineering Report on Well Installations-As-Built Data for Wells LFG-1 through LFG-9."

B.G. = Below Grade

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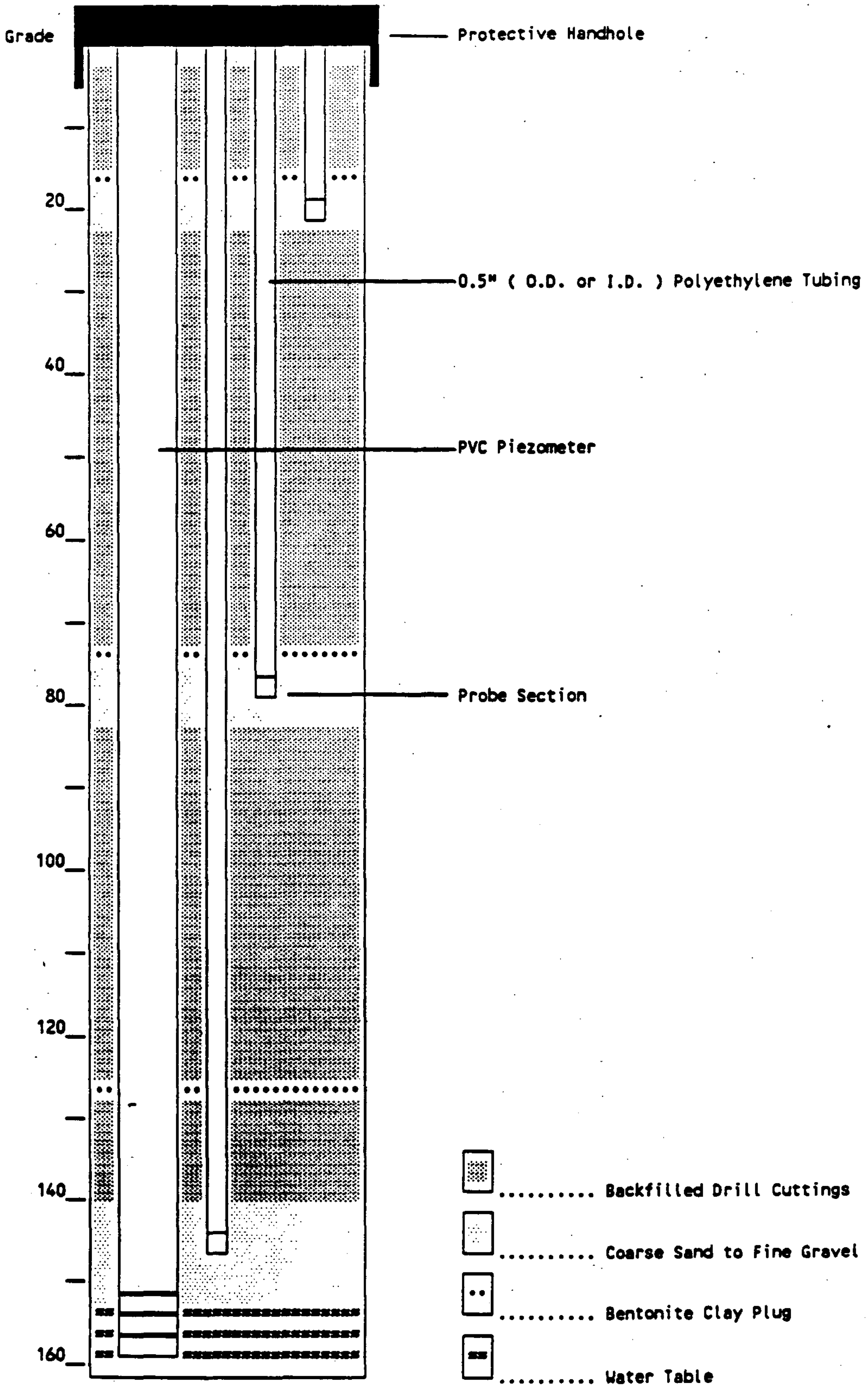

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Figure 2

Typical Town LFG Well Constructi

Port Washington Landfill, Port Washington, New Y

TABLE 2-5

LFG WELL SUMMARY

Well Number	Approximate Distance to Edge of Refuse (ft.)	Location
EPA-201	80	Opposite 67 Wakefield Ave.
EPA-202	80	North Hempstead County Club 13th Tee
EPA-203	820	North Hempstead County Club 17th Tee
EPA-204	990	Opposite 40 Wakefield Ave.
TNH-1	500	Back of 54 Wakefield Road
TNH-2	1,050	North Hempstead County Club
TNH-3	200	North Hempstead County Club
TNH-4	50	Port Washington Landfill
TNH-5	450	Guilford Road - by Wyndham and Wakefield
TNH-6	300	Opposite 6 Wyndham Way
TNH-7	200	Port Washington Landfill

EPA = LFG well installed by the U.S. Environmental Protection Agency

TNH = LFG well installed by the Town of North Hempstead

(overhead/557)

A fourth round of sampling was completed by the EPA - Environmental Response Team in early 1989. The results of this sampling event will be released as a supplemental report as soon as the laboratory analyses are available.

SUMMA canister sampling was employed for the LFG well sampling. This technology employs a specially polished, cleaned, and evacuated stainless steel canister that allows for the collection of a gaseous (air) sample without the loss of trace VOC's through interaction with the container surface. The canister can then be delivered to a laboratory for analysis.

By agreement between the TNH and the EPA regarding the collection of "split" LFG samples, the Town's consultant (H2M) collected consecutive samples along with the REM II team. Due to the differing sampling methodologies employed (H2M used Tenax traps while the REM II team used SUMMA canisters), simultaneous split samples were not possible. The time period between sample collection by the REM II team and the Town's consultant varied from several minutes to several days.

Sampling events were constrained to periods when appropriate conditions existed, that is, when a positive pressure was recorded at the LFG probes. It was observed that this usually existed during periods of "diving" or sustained low barometric pressure conditions. Thus, the term of each sampling campaign was affected by the duration and severity of appropriate positive pressure or barometric pressure conditions.

During these diving barometric pressure conditions, the LFG probe pressures were strongly positive and remained so for a longer period of time than if the weather situation were changing at a slower rate. If the low barometric pressure persisted, the soil pressure at the probe depth would eventually come into equilibrium with the ambient pressure, thereby resulting in a zero differential well pressure. Based on these observations, it is apparent that differential well pressure is a function of time, current barometric pressure, previous barometric pressure, and the rate of change between the two (also further observations indicate that it is a function of depth). As a direct result of this dependency on the weather, sampling was interrupted several times when the well pressures turned negative.

2.4.1 SUPPLEMENTARY SOIL GAS SURVEY

Since the initial Work Plan preparation in 1985, commercial property development south of the Landfill has occurred. Whereas the original LFG program focused on gas transport to the residential area to the west of L-4, it was judged prudent by EPA to perform a soil gas survey in the commercial tract area using the resources of EPA's Environmental Response Team (ERT) to evaluate the possibility of gas migration from L-4 into this locale. The program, performed on September 21, 1988 included the following:

- establishment of a transect adjacent and parallel to the fence separating the southern boundary of the Landfill from the commercial area
- establishment of 13 sampling locations along the transect
- establishment of a grid perpendicular to the transect which included 16 additional sampling locations
- screening each sampling location with an HNu photoanalyzer, an organic vapor analyzer, and a combustible gas indicator
- sampling at selected stations for analysis by a Photovac gas chromatograph

All samples were analyzed for benzene, toluene, xylene, trichloroethylene, tetrachloroethylene, ethylbenzene, vinyl chloride, total organics and methane. The results are presented in section 3.4.4 and ERT's full report is included as Appendix D.

A review of the blower operating logs maintained by the TNH during this period revealed that the HCU was not operational on the two days prior to ERT's test. This situation was reported to be caused by a lack of electrical power to the HCU resulting from contractor's working on the power lines. The blowers and HCU were not re-started until 8:45 AM on the morning of ERT's testing program. The three blowers remained operational throughout that day until 3:50 PM at which time they were again shut down. The blowers and HCU then remained shut down until 1:30 PM on the following day.

2.5 AMBIENT AIR QUALITY EVALUATION

The activities performed under this task included:

- Reviewing the existing ambient air data (by the REM II team)
- Sampling of the outdoor ambient air (TAGA Sampling by EPA ERT)
- Evaluating RCRA Probe Data (by the REM II team)

2.5.1 REVIEW OF THE EXISTING AIR QUALITY DATA

Data on both indoor and outdoor ambient air quality at and around the Port Washington Landfill site have been collected since 1981. The data includes the following surveys:

- Nassau County Department of Health: from February 3 to April 27, 1981.
- EPA air monitoring: July 7 to October 5, 1982.
- Nassau County Department of Health: March to August 1983.
- Nassau County Department of Health: March 6 to April 10, 1984.

The REM II team reviewed this data for the purpose of designing the remedial investigation activities, particularizing the compounds of concern in the ambient air, and as an aid in performing the Public Health Evaluation.

The basic finding from the review was that during the pre-1983 period, gases were found to be migrating outside the Landfill towards the west (Wakefield Avenue and Guilford Road environs). A typical example of this was the puff-back of oil burners in the winter of 1981. It was observed that there was a correlation between puff-backs and weather condition.

Typically, puff-backs occurred on a rainy and windy day. This weather pattern is indicative of falling barometric pressures. It could therefore be concluded that the most appropriate times to sample the off-site landfill gas wells were during periods of falling barometric pressure.

2.5.2 AMBIENT AIR QUALITY SAMPLING (TAGA)

As part of the remedial investigation effort, EPA's Environmental Response Team (ERT) performed ambient air sampling at Port Washington to assist in determining any effects of off-site emissions originating from the Port Washington landfill on the local air quality. The air assessment study was designed to monitor the presence of target compounds at upwind and downwind locations of the Landfill; through neighborhoods adjacent to, and removed from, the Landfill; and by stationary and mobile modes of operation.

This sampling strategy was thought to incorporate the variables that would maximize the likelihood of observing the target compounds as well as distinguishing the contribution of the landfill from the upwind location. The target compounds selected for monitoring were:

- 1,1,1-Trichloroethane
- 1,1-Dichloroethane
- Benzene
- Tetrachloroethene
- Trichloroethene
- Toluene
- Vinyl Chloride

Data were collected for the period of September 27 through September 29, 1988 through the use of EPA's mobile Trace Atmospheric Gas Analyzer (TAGA) van. Monitoring in both the mobile and stationary modes was conducted. A study of a portion of the Landfill's perimeter with flexible Teflon sampling line was also performed. The areas traversed by the TAGA van included:

- Guilford Road
- Wakefield Avenue
- Wyndham Way
- Salem School parking lot

- Lynn Road
- 99 Seaview Boulevard parking lot
- Osprey Court
- Seaview Boulevard
- West Shore Drive

One sampling operation with a Teflon sampling hose was conducted at the cul-de-sac at the east end of Wakefield Avenue. Two hundred feet of Teflon hose was uncoiled and stationary data acquisitions were performed every 50 feet along a portion of the Landfill's perimeter fence. EPA-ERT's conclusions are reproduced in section 3.5 of this report. Complete data results and sampling methodologies may be found in EPA-ERT's report "TAGA Analysis Ambient Air in the Vicinity of the Landfill at Port Washington, New York", December 1988 (See Appendix E).

2.5.3 RCRA PROBE DATA

The RCRA probes are a series of twenty-eight 1/2-inch and 1-inch PVC pipes installed by the Town of North Hempstead in 1981 near the western perimeter of L-4, along Wakefield Drive, Wyndham Way, and on portions of the North Hempstead County Club. Each probe consists of pipe installed to a depth of approximately 5 feet with the intended purpose of serving as a monitoring point for the off-site migration of combustible gas from L-4. The Town monitors these probes on a monthly basis. This monitoring program is also known as TNH's "Off-Site Program" or the "RCRA Inventory." The REM II team examined the records of the Off-Site Program dating from 1981 to ascertain the history of movement of combustible gas to the west from L-4. Our review of this data indicated that the presence of combustible gas has been consistently reported as "Not Detected" at these probes.

2.6 METEOROLOGICAL STATION INSTALLATION

A meteorological station was installed to measure wind speed and direction, ambient air temperature, soil temperatures at three different depths and barometric pressure. Wind speed and wind direction information was gathered for use in the risk assessment analysis. Barometric pressure information led to insights into landfill gas emission rates and provided an indication as to the most appropriate times to monitor landfill gas migration. Soil and air temperatures were recorded so they could be related to frost cover conditions at the Landfill. Data recording for all sensors was via a datalogger with solid state memory modules. This system was configured so that it was compatible with an IBM personal computer which was used to retrieve data.

Physical site characterization and field maps were reviewed in the choice of the location for the meteorological station. The parameters that were considered in the choice of location were:

- o Direction of true north for calibration of the wind direction indicator.
- o Topographic and structural relief of the area to minimize diffusion conditions.
- o Accessibility to the meteorological station.

The site chosen for the meteorological station is shown on figure 2-7. This was the highest point at the Landfill and was clear of large objects or terrain features that could significantly affect wind flow patterns or cause shading effects on the radiation and humidity sensors. It was an area that was accessible, and therefore aided the data collection and retrieval process. A summary of the data collected by the meteorlogical station is available in Appendix F.

2.7 CONCLUSIONS

The active and passive venting system at the L-4 site was to be evaluated by the REM II team to determine if the system, under current operating conditions, was providing an effective barrier to the westerly migration of landfill-generated gases through the subsurface.

To perform this task, the REM II team intended to conduct a physical inspection of the gas management facilities; measure well head vacuums, gas temperatures, flow rates and general properties of the gases; sample condensate; install pressure probes; measure unit vent performance; conduct Landfill surface emission rates and install and sample additional landfill

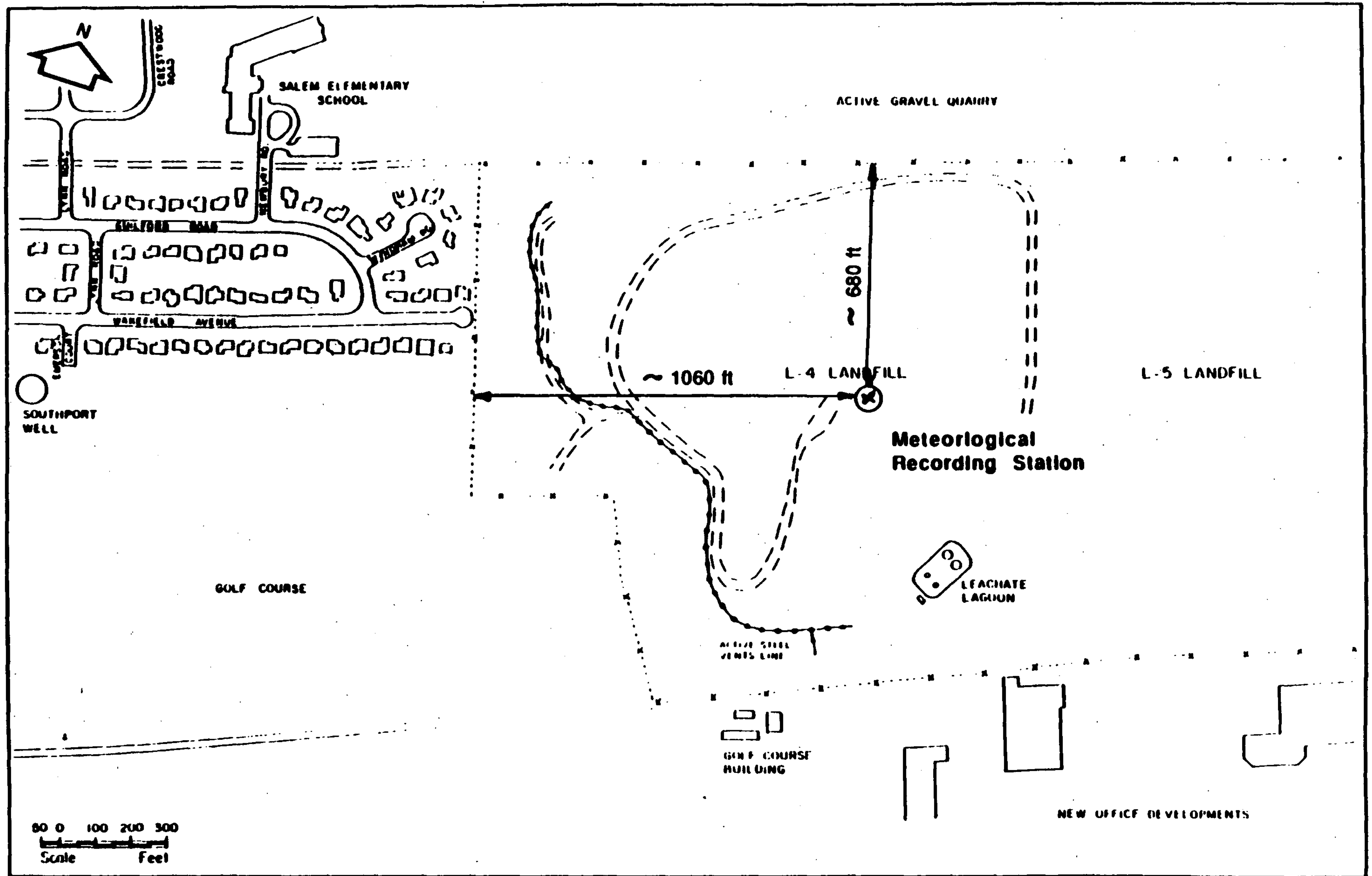

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Figure 2-7

Meteorlogical Recording Station Location

Port Washington Landfill, Port Washington, New York

gas monitoring wells. Unfortunately, not all of these tasks could be completed as designed because only one of the six available blowers was operational at the time of the system assessment. Design operating conditions require that six blowers be operating. Despite these vent system assessment difficulties, however, valuable information was obtained concerning the nature and extent of subsurface gas migration and the present physical and operational state of the existing gas management facilities. This information is presented in the following section.

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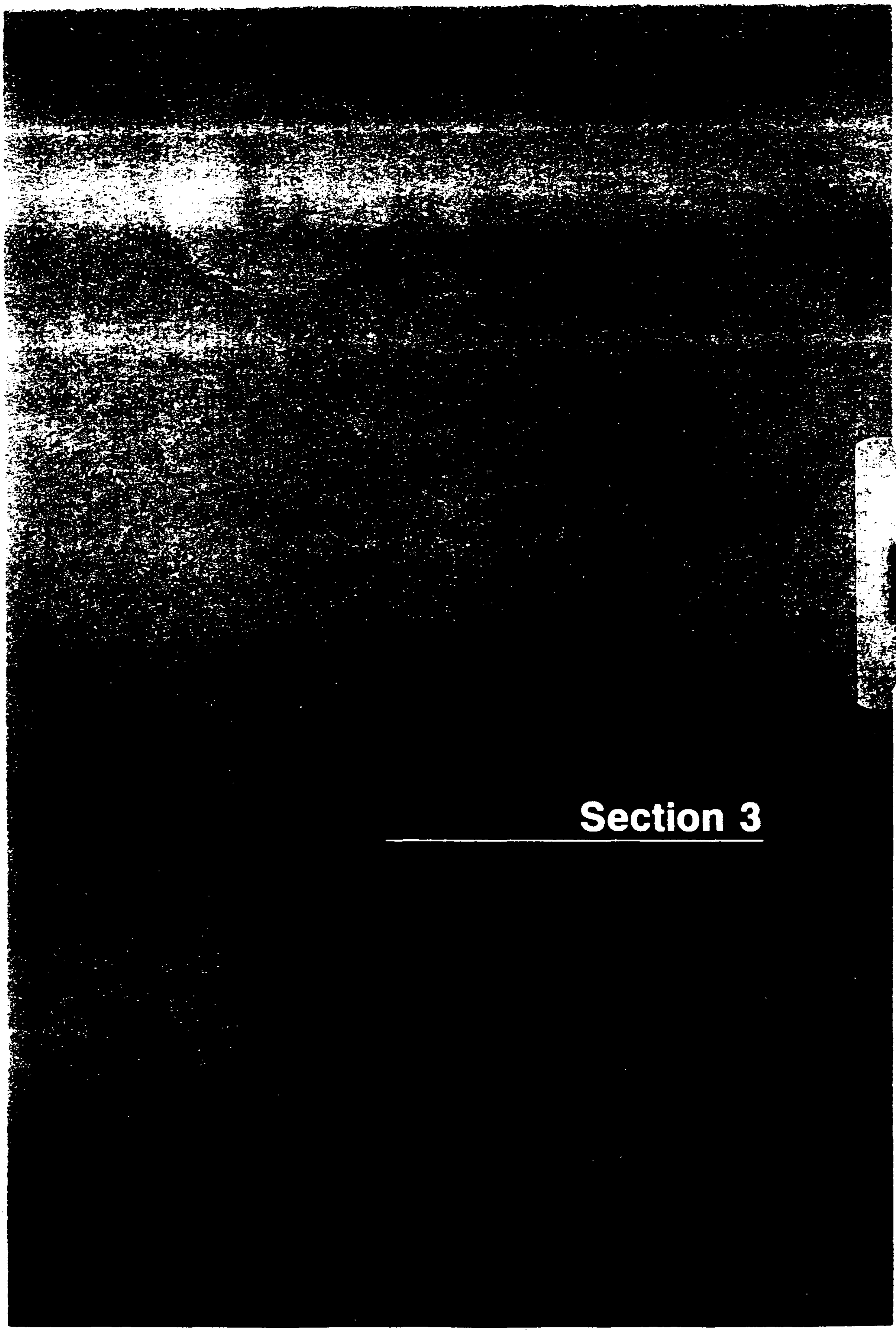


Section 3

3.0 DATA RESULTS AND ANALYSIS
LANDFILL GAS AND AIR QUALITY INVESTIGATION

The purpose of this chapter is to present the results of the various landfill gas-related field investigations described in section 2.0. The results of these investigations are presented as follows:

- evaluation of the performance of the existing landfill gas control system; (Section 3.1)
- determination of the zone of influence of a selected active vent; (section 3.2)
- estimation of surface flux emissions of landfill gases; (section 3.3)
- determination of the presence and extent of landfill gases offsite; (section 3.4)
- evaluation of the ambient air quality at the Landfill and vicinity; (section 3.5) and
- establishment of a microclimatological data base at the Landfill (section 3.6)

In section 6.0, the data presented herein is correlated with data from the ground water investigations discussed in section 5.0 to develop a conceptual model of contaminant migration from the Landfill.

3.1 GAS VENT SYSTEM ASSESSMENT

Municipal wastes were disposed and buried in cells at L-4 starting in 1974. Methane was reported to have migrated off-site as soon thereafter as 1977 and "puff-backs" occurred, presumably caused by methane build-ups, in residences along Wakefield Avenue in 1979, 1980 and 1981. Due to these occurrences, the Town of North Hempstead installed a venting system in the western portion of the landfill to control the subsurface migration of gases off-site. The chronology of events associated with the venting system were previously outlined in table 1-1. Since the installation of the venting system, "puff-backs" have not been observed. However, methane has been detected to the south of the L-4 and L-5 parcels by the EPA-Environmental Response Team (ERT) (see section 3.4) and at landfill gas well TNH-4 which is an on-site well located to the west of the active system. Additionally, volatile organic constituent vapors have been detected in the unsaturated zone beneath both the residential community and the North Hempstead Country Club. This situation exists despite the presence of the subsurface gas extraction system (see section 3.4).

The components of the venting system and the field tasks conducted to evaluate their performance have been described in section 2.0. The following section therefore presents the data and results associated with each of the gas system assessment field tasks.

Based on the December 1982 SCS report, the design operating condition for the vent system is for six blowers to be operating. These blowers are designed to deliver a sufficient vacuum to the venting system well heads such that subsurface gases that may otherwise migrate west of the Landfill are instead captured. During the course of the REM II team's remedial investigation activities in 1987 and 1988, however, it appeared that only between one and three blowers were typically operating. The TNH's operating procedure as observed by REM II team personnel appeared to be that the system was initially started-up with three blowers on line. After a few hours the third blower was shut down, presumably because a reduction in methane content at the inlet to the horizontal combustion unit (HCU) was observed and continued operation of the third blower threatened to dilute the inlet gases to the HCU such that a flare could no longer be maintained and thus thermal destruction of the waste gases would be incomplete. In essence it appeared that the number of blowers operating was balanced against the amount of methane observed at the inlet to the HCU such that a flare was maintained. Operation of fewer than the design number of blowers raises questions about whether the vacuum delivered to the active vents is sufficient to prevent the movement of subsurface gases off-site. This is particularly true at those vents furthest from the blowers since these vents would experience the greatest reduction in observed vacuum due to system head losses.

Since only one blower was operational during the task of system assessment, the REM II team's field evaluations were conducted during a period of time when the venting process was at less than design conditions. Therefore, the data collection and resulting assessment were necessarily limited from that originally envisioned in the Work Plan. Nonetheless, the individual subtask components of the system assessment were conducted on the venting facilities "as-is" to the extent feasible.

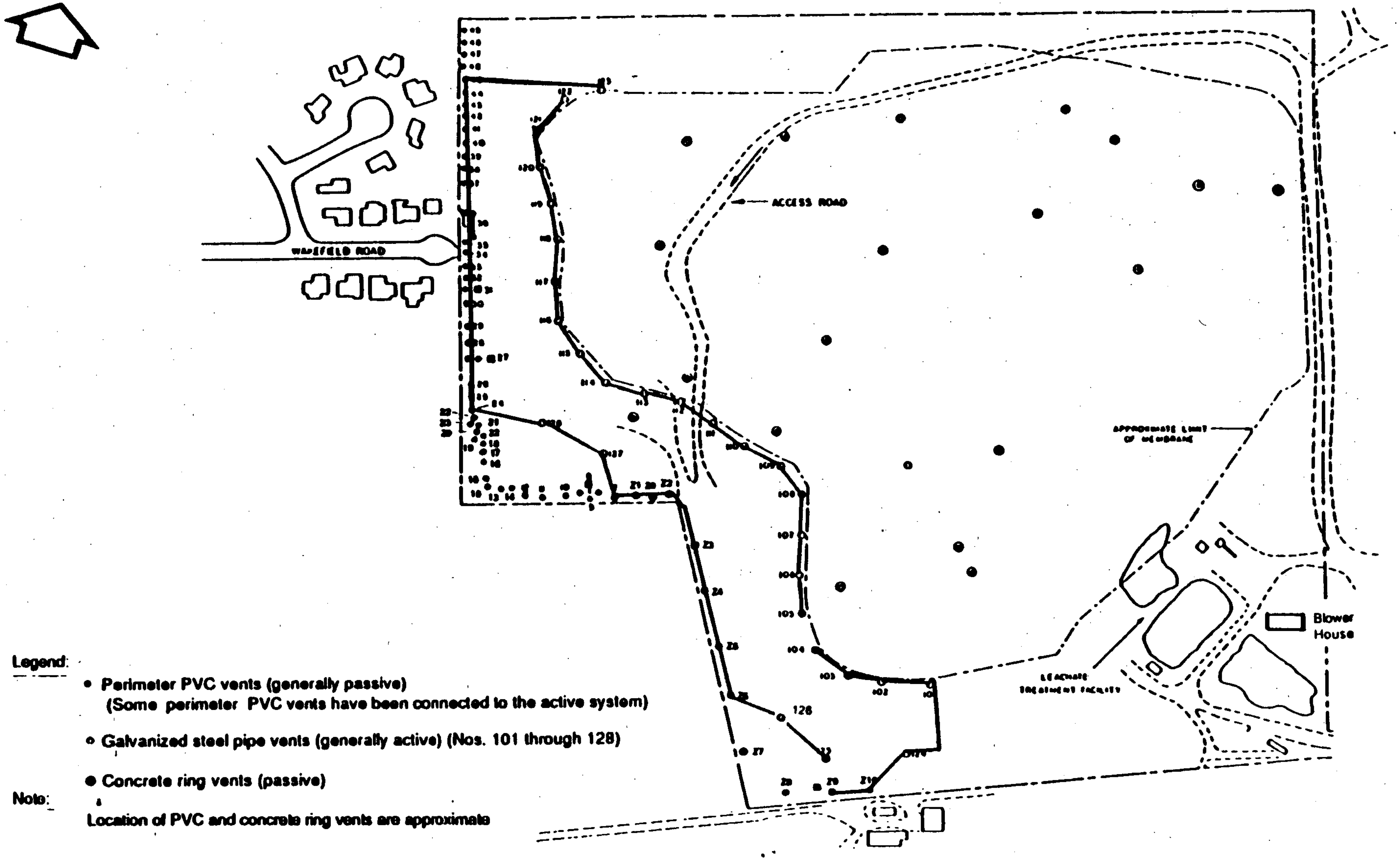
The specific subtask components were as follows:

- visual inspection of the vent system physical condition;
- observation and recording of the active vent valve settings and measurements of well head vacuum and temperature;
- measurement of gas composition and methane content during vent system operation;
- sampling and analysis of condensate;
- sampling and analysis at the inlet of the operating blower; and
- monitoring for the presence of subsurface landfill gas west of the venting system.

The existing landfill gas venting system is shown in Figure 3-[illegible]. Three materials of construction (steel, plastic and concrete) have been used in the venting system. The steel vents have generally being referred to as active vents, while the concrete vents have been referred to as passive vents. On the Landfill, some plastic vents are connected to the active system, and therefore can be categorized as active vents. The plastic vents which are not connected to the active system continue to perform a role of passive venting.

3.1.1 VISUAL INSPECTION

A detailed visual inspection of the vent system was carried out by REM II team personnel between July 14 and July 22, 1988 and the observations recorded are shown in Table 3-1. A large number of these observations indicate that air leaks in the system have been a frequent problem and that



Legend:

- ● Perimeter PVC vents (generally passive)
  (Some perimeter PVC vents have been connected to the active system)
- ○ Galvanized steel pipe vents (generally active) (Nos. 101 through 128)
- ● Concrete ring vents (passive)

Note:
Location of PVC and concrete ring vents are approximate

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Figure 3-1

Landfill Gas Venting System Plan View

Port Washington Landfill, Port Washington, New York

TABLE 3-1

VISUAL OBSERVATIONS OF THE VENT SYSTEM DURING BASELINE SURVEY

Vent No.	Vent Type	Design Condition	Current Condition	Valve Setting	Notes
01	S	A	A	4	Leak in lateral pipe line and the main header particularly at the 90° elbow where the pipe was repaired
02	S	A	A	5	Small leak in PVC lateral pipe connecting main header line to the well and 90° elbow
103	S	A	A	3	Leak in PVC lateral pipe to the well. Observed water surging.
104	S	A	A	7	Major condensate blockage causing surging. Pipe weld is cracked at the joint.
105	S	A	A	3	Stainless steel pipe clamp leaking at the joint
106	S	A	A	4	
07	S	A	A	5	
08	S	A	A	8	Well valve cannot be fully closed.
109	S	A	A	NR	
0	S	A	A	6	PVC lateral to well is noticeably leaking.
1	S	A	P	4	Disconnected from active system
112	S	A	A	4	Valve cannot be completely closed. Gases leaking from the vent to the ambient air.
3	S	A	A	5	
114	S	A	A	6	Condensate blockage caused surgin in the lateral pipes.
115	S	A	A	6	Vacuum leak in 6-inch PVC pipe

TABLE 3-1
(continued)

VISUAL OBSERVATIONS OF THE VENT SYSTEM DURING BASELINE SURVEY

Vent No.	Vent Type	Design Condition	Current Condition	Valve Setting	Notes
116	S	A	A	8	
117	S	A	A	8	
118	S	A	A	8	
119	S	A	P	NR	Disconnected from active system
120	S	A	P	NR	Disconnected from active system
121	S	A	P	NR	Disconnected from active system
22	S	A	P	NR	Disconnected from active system
123	S	A	P	NR	Disconnected from active system
124	S	A	P	1	Disconnected from active system
25	S	A	P	NR	Disconnected from active system
26	S	A	P	1	Disconnected from active system
27	S	A	P	2	Disconnected from active system
128	S	A	A	8	Significant air leak at the lateral main line to the plastic vents. Currently this joint is covered with duct tape.

OTES:

1. Observations recorded between July 14 and July 22, 1988.
   There are 23 concrete cisterns on-site which also comprise part of the vent system. These cisterns act as passive vents.
3. Perimeter plastic vents were designed to act as passive vents. A number of these vents have since been connected to the active system.
4. Vent valve settings: (1=open; 8=closed), NR=no reading.
5. S = Steel construction.
   A = Active vent.
   P = Passive vent or shut off from system vacuum

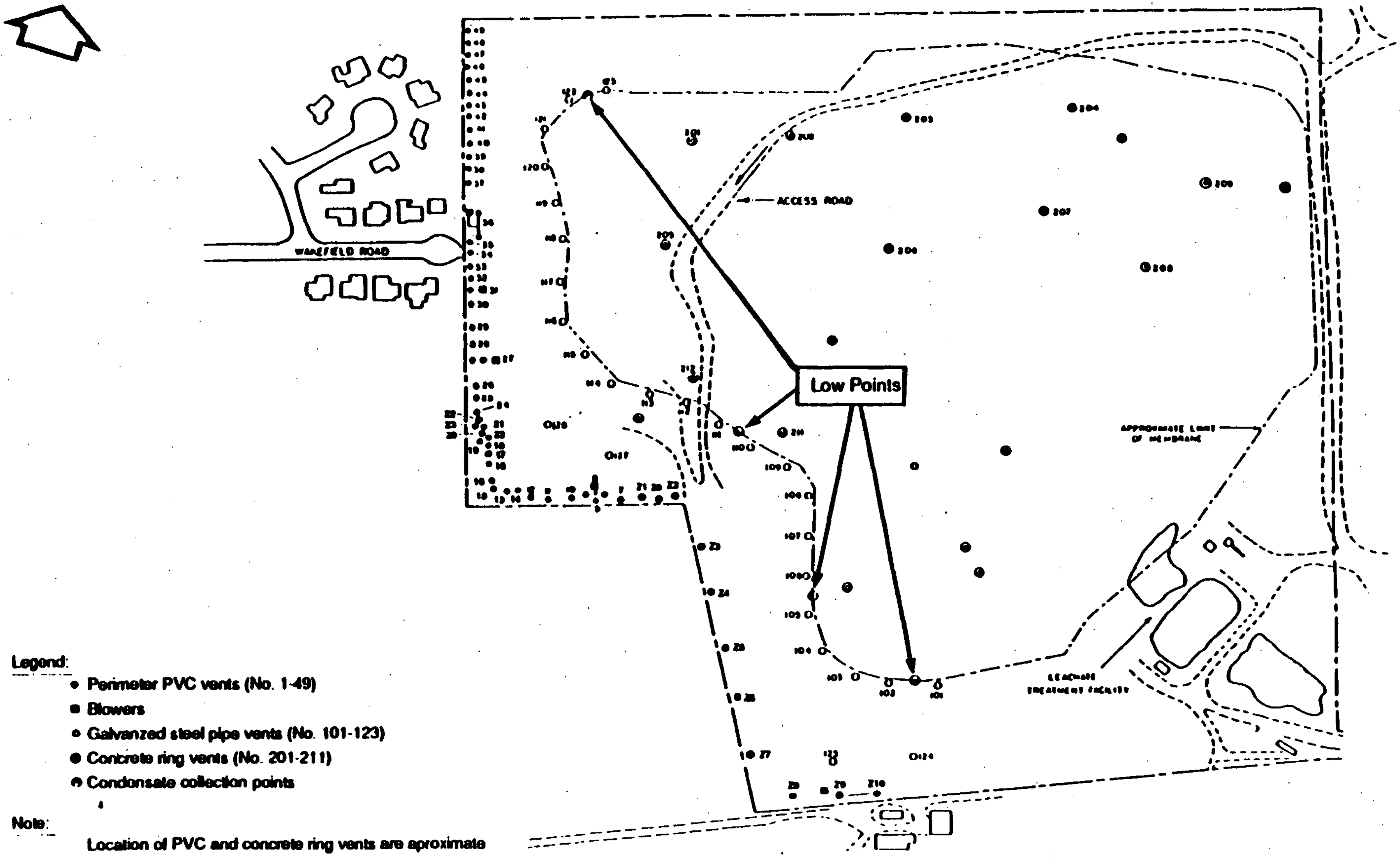
the leaks have been "mended" by the TNH with the use of duct tape. In the field it was observed that the duct tape was inappropriate to effect repairs since this material could not provide the type of tight seal necessary where significant negative pressures must be maintained.

The active venting system was designed to provide a complete barrier to gas migration on the western sector of the Landfill. Some of the vents (No. 119 through No. 127), however, were observed to be disconnected from the active system. In addition, some of the vent valves were closed thereby reducing their ability to withdraw gases from the subsurface.

Some of the vents that were disconnected from the system are in the northwestern sector of the Landfill (nos. 119 to 123) and therefore that area may be assumed to have no active "curtain" or barrier to the migration of gases. It was therefore expected that gases may migrate from the Landfill through that sector to the residential area west of the Landfill. This hypothesis was later supported by the field data as depicted in section 3.4 where the analysis of the monitored gases in the offsite areas of the Landfill are discussed.

It was also noted that topographic low points exist on the main header line as shown on [redacted]2. These low points tend to collect condensate thus causing blockage and surging of the vacuum in the main pipes. Additionally, condensate which collects in the plastic vent header is available, due to differences in elevation, for discharge back into plastic vent No. 22 and plastic vent Z(1). As these two vents are located beyond the limits of the plastic liner, volatile organic compounds from the Landfill may be being transported outside the Landfill at these locations.

In addition to the visual observations, [redacted]ased upon TNH data) indicates that many of the vents are subject to sedimentation conditions and flooding. For example, vent No. 101 was reported to contain about 25 feet of sediment in December 1982 and vent No. 103 contained 27 feet of sediment. Furthermore, as of July 1988, vent No. 101 contained enough water to block 96 percent of the available vent slots used to capture landfill gas. Conditions such as these can significantly reduce the number



Note:
Location of PVC and concrete ring vents are aproximate

CDM

Figure 3-2

Topographic Low Points on Main Header

Port Washington Landfill, Port Washington, New York

TABLE 3-2

SEDIMENTATION CONDITIONS IN THE STEEL VENTS

Vent	Top of Vent (ft. MSL)	Grade Elevation (ft. MSL)	Top of Slots (ft. MSL)	Elevation of Bottom of Vent Slots (ft. MSL)	Dec. 1982 Water Levels (ft. MSL)	Dec. 1982 Sediment Levels (ft. MSL)	March 1988 Water Levels (ft. MSL)	July 1988 Water Levels (ft. MSL)
101	180	170	160	60	86	85	111	156
102	180	170	160	60	84	84	114	116
103	180	168	158	60	88	87	NR	148
104	175	165	155	60	90	70	117	117
105	175	162	152	65	86	72	115	NR
106	175	161	151	65	91	71	131	131
107	170	161	151	65	90	80	117	115
108	170	161	151	70	93	76	115	115
109	170	161	151	70	91	76	127	116
110	170	161	151	70	110	75	122	119
111	175	162	152	75	NR	NR	128	131
112	175	163	153	75	NR	NR	123	130
113	175	168	158	75	120	93	NR	132
114	180	170	160	75	121	95	138	137
115	180	168	158	75	125	95	154	NR
116	175	165	155	75	113	92	136	143
117	175	165	155	75	115	91	140	141
118	175	164	154	75	108	85	NR	103
119	165	155	145	75	92	87	102	102
120	145	135	125	75	88	86	98	101
121	135	125	115	75	98	97	108	107
122	120	112	102	75	85	84	100	98
123	110	100	90	75	Dry	75	97	97
124	180	170	160	120	Dry	128	NR	NR
125	180	170	160	110	NR	NR	NR	NR
126	175	165	155	110	121	120	NR	NR
127	170	158	148	135	Dry	135	NR	NR
128	170	158	148	125	NR	NR	NR	NR

TABLE 3-2
(continued)

SEDIMENTATION CONDITIONS IN THE STEEL VENTS

Notes:

1. NR = No reading.
2. Based on data received from the Town of North Hempstead. See "Landfill Gas Test Results, Port Washington Landfill," prepared by SCS Engineers (December 1982). See also as-built drawings and correspondence dated August 16, 1988 from SCS Engineers to the Town of North Hempstead.

(572)

of vent slots available for gas entrapment in the steel vent pipes and impact the system's capability to prevent off-site migration of gases. While it is unknown whether the vents have been cleaned out since March 1983 (see table 1-1), it is important to note the vent system's susceptibility to sedimentation and flooding and the resulting need for routine maintenance to alleviate or prevent such conditions.

Based on the visual inspection performed, the following conclusions about the performance of the venting system can be drawn:

- The number of blowers required to be operating (six) to develop the design gas flow rate in each active vent were not observed to be operational. Instead, typically only three blowers were operating and during the REM II team's gas system assessment only one blower was operating.
- There are many leaks at joints along the pipeline.
- Some of the vents have historically been subject to sedimentation and flooding conditions. These problems are presumed to impact the ability of the system to develop an effective barrier to off-site gas migration.
- Some of the "active" vents have been disconnected from the active system.
- Condensate can collect within the system at low points thus causing blockage and surging in the main pipes. In some locations, condensate is available to be transported back into some of the perimeter plastic vents which are located outside the limits of the Landfill liner.

3.1.2 VENT VALVE SETTINGS AND MEASUREMENTS OF WELL HEAD VACUUMS AND TEMPERATURE

Two settings of the venting system were carried out in this task, and the effects of these settings on well head pressures and temperatures of the gases from the vents are depicted in [redacted] The two settings were:

- A static condition with the venting system off, and all the valve positions in the operating positions as were currently maintained by the Town of North Hempstead, and
- A dynamic condition with the venting system on, and the valves at the same positions as they were in the static condition.

TABLE 3-3

WELL HEAD PRESSURE AND TEMPERATURE

	Venting system off - July 16, 1988			Venting system on - July 21,1988 (1 blower operating)		
Vent No.	Time	Pressure (inches of H_2O)	Temp (°F)	Time	Pressure (inches of H_2O)	Temp (°F)
101	11:56	+0.20	**	21:49	-2.50	130
102	11:37	+0.00	**	**	-2.20	151
103	13:18	+0.35	110	**	-1.10	133
104	13:40	+0.04	112	22:24	-2.40	125
105	**	**	**	22:35	-1.60	**
106	14:38	+0.20	94	22:42	-2.20	89
107	14:51	+0.02	117	22:46	-2.10	122
108	15:01	0.03	106	22:50	-2.20	112
109	**	**	**	**	**	**
110	15:45	+0.20	90	22:59	-1.80	100
111	16:05	+0.07	90	**	**	**
112	16:16	+0.20	90	23:08	-2.00	73
113	16:35	+0.12	87	23:14	-2.10	72
114	08:24	+0.17	**	23:20	-2.00	72
115	18:36	+0.15	80	23:25	-2.00	**
116	18:54	+0.17	89	20:00	-2.00	77
117	19:06	+0.17	80	20:32	**	**
118	19:30	+0.14	**	**	**	**
119	**	**	**	18.12	+0.03	85
120	**	**	**	18:20	+0.01	87
121	**	**	**	18:38	+0.04	81
122	**	**	**	**	**	**
123	**	**	**	**	**	**
124	11:10	+0.25	92	12:10	+0.25	92
125	12:37	+0.10	95	12:37	+0.10	95
126	14:09	+0.35	96	14:09	+0.35	96
127	16:51	+0.03	86	16:51	+0.03	86
128	17:17	+0.12	88	17:07	+0.12	88

** - no reading taken.

Table 3-3 depicts that virtually all the active gas vents showed positive readings at the well head when the system was off. This positive pressure can be attributed to the build-up of landfill gases from refuse decomposition.

The range in positive pressures were from 0.03 to 0.35 inches of water. These positive pressures were quickly reduced to negative values when the system was turned on (i.e., one blower operating). This indicates that a single blower operating can produce a vacuum at the active vents.

Of interest, however, is the fact that the pressures when measured in vents No. 119 to No. 128 still showed the same positive pressures even though the system was on. This indicates that vents No. 119 through No. 128 were not affected by the blower system and confirms the visual observation reported in section 3.1.1 that this series of vents is disconnected from the active venting system.

The data obtained for the temperature of the gases leaving the vents did not reveal any trends from which a conclusion could be drawn. In some cases the temperature increased when the vent system was turned on and in some cases the temperature decreased under this operating condition. It is interesting to note, however, that the temperature of the gases exiting vent Nos. 124 through 127, unlike the other vents, did not vary when the system was turned on. This is to be expected given that these vents are disconnected from the active system.

3.1.3 GENERAL PROPERTIES OF THE GASES FROM THE ACTIVE VENTS

In assessing the quality of the gases collected by the venting system, four major constituents were examined by the REM II team. These constituents, generally referred to as primary gases, are methane, carbon dioxide, nitrogen and oxygen.

Methane is the main constituent of gas produced in a municipal or sanitary landfill operating under anaerobic conditions (i.e. in an environment without oxygen). Methane typically makes up 50 to 60 percent of the gases produced. Analysis of the methane content in conjunction with the other primary gases can provide insight into how well a gas extraction system is operating. For instance, a lower methane content accompanied by a high nitrogen content indicates severe air entrainment into the landfill. This condition could cause degeneration of the methanogenic bacteria that decomposes the refuse and a return to aerobic conditions (i.e., in the presence of oxygen) within the landfill. Therefore, methane and nitrogen are very good indicators of the decomposition processes within a landfill.

Carbon dioxide is the next major constituent of most landfill gases and together with methane should account for 90 to 98 percent of the gases generated from a landfill operating under typical anaerobic conditions. Carbon dioxide is produced as a by-product of methanogenesis of bacterial decay as the organic matter within the landfill is decomposed. In a landfill undergoing aerobic decomposition, carbon dioxide is the primary gas produced.

Nitrogen generally is not present in landfill gases at any appreciable level because the typical process of decomposition is anaerobic. When high levels of nitrogen are found in landfill gases, it is generally indicative of either air intrusion into the landfill or leaking gas collection lines. This condition is caused in most cases by a venting system that induces air to move into the landfill. Operating a gas vent system in this manner should be done carefully, and the extent of air infiltrating the landfill controlled diligently as fires could result in the landfill due to spontaneous combustion of refuse in the presence of the oxygen drawn into the landfill. Ideally, the level of residual nitrogen in landfill gases should be kept to a minimum.

Similarly, the oxygen content in a landfill should be low under normal anaerobic operating conditions. A level less than 1 percent is typically recommended for good landfill operations. High oxygen levels introduced anywhere in the system, whether through entrainment from the landfill surface or directly into the gas system header, can create flammable conditions.

The primary gases discussed above are not considered to be harmful to humans, although methane, residual nitrogen from aerobic decomposition, and carbon dioxide all have asphyxiating properties. Instead, their relative concentrations at each vent provides an indication as to the operating efficiency and performance of the vent. Volatile organic compounds (VOC's), on the other hand, are of importance for human toxicity. Therefore VOC's were sampled at selected active and passive vents and analyzed for in addition to the primary gases. The results of this portion of the remedial investigation are described below.

Primary Gases

Methane was measured at the Port Washington site in the well heads of all the steel vents during a period when no blowers were operational and when one blower was operational. When no blowers were operational measurements detected methane at greater than 100 percent of the lower explosive limit (LEL) in the well head (see table 3-4). The lower explosive limit is defined as a 5 percent concentration of methane in air. However, when the single blower came on, the vacuum created resulted in a substantial reduction in methane content (see [redacted]). This could indicate that either:

- a breakthrough of ambient air from the landfill surface down into the gas well occurs when the blower system is turned on thus mixing and diluting the methane concentrations, or
- the active vent system is successful in removing methane gas and the landfill does not produce enough methane to continuously supply quantities extracted.

At steel vent Nos. 110, 112, 113, 114, 115, 116 and 117 the percent methane was reduced more than 75 percent. These vents also had the greatest reduction in measured well head temperatures. The vents to the north (Nos. 119, 120, 121, 122 and 123) were not connected to the active system and since no vacuum was created, no change in methane content was expected (which is consistent with the data collected at Nos. 121, 122 and 123). Vent Nos. 102, 104, 105, 106, 107, 109 and 118 did not experience a significant reduction in methane content despite the evidence of a vacuum being induced at these vents by the operation of a single blower. This may indicate that

TABLE 3-4

PRIMARY GAS MEASUREMENTS AT THE ACTIVE VENTS WHEN THE VENT SYSTEM WAS OFF*

Vent No.	Pressure (inches of H_2O)	Temperature (° F)	% LEL	Methane (%)	CO_2 (%)	N (%)	O (%)
101	+0.20	NR	>100	NR	NR	NR	NR
102	0.0	NR	>100	46.6	32.7	19.6	1.1
103	+0.35	110	>100	48.0	40.7	11.0	0.2
104	+0.04	112	>100	55.0	42.9	1.9	0.1
105	+0.23	122	>100	55.6	41.8	2.5	0.1
106	+0.20	94	>100	53.0	40.6	5.8	0.5
107	+0.20	117	>100	55.4	42.6	1.8	0.0
108	+0.03	106	>100	NR	NR	NR	NR
109	+0.40	82	>100	60.5	43.7	2.8	0.1
110	+0.20	90	>100	58.4	41.4	0.1	0.1
111	+0.07	90	>100	44.8	33.4	11.7	10.1
112	+0.20	90	>100	59.5	39.3	1.1	0.1
113	+0.20	87	>100	61.5	38.3	0.1	0.1
114	+0.17	NR	>100	61.9	37.2	0.6	0.1
115	+0.15	80	>100	60.8	38.9	0.2	0.1
116	+0.17	89	>100	60.3	38.5	1.0	0.1
117	+0.17	80	>100	59.6	40.3	0.1	0.0
118	+0.14	NR	>100	61.6	38.1	0.2	0.1
119	NR	NR	NR	NR	NR	NR	NR
120	NR	NR	NR	NR	NR	NR	NR
121	NR	NR	NR	5.5	2.4	70.6	21.3
122	NR	NR	NR	1.0	1.2	45.2	52.4
123	NR	NR	NR	0.6	0.4	77.4	21.6
124	+0.25	92	>100	NR	NR	NR	NR
125	+0.10	95	>100	NR	NR	NR	NR
126	+0.35	96	>100	54.3	45.0	0.5	0.2
127	+0.03	86	>100	59.9	39.7	0.3	0.1
128	+0.12	88	>100	59.2	40.0	0.7	0.1

* = No blovers operating. July 16, 1988
NR = No reading vas taken in the field

TABLE 3-5

PRIMARY GAS MEASUREMENTS AT THE ACTIVE VENTS WHEN THE VENT SYSTEM WAS ON*

Vent No.	Pressure (inches of H_2O)	Temperature (°F)	% LEL	Methane (%)	CO_2 (%)	N (%)	O (%)
101	-2.50	130	46	55.8	43.7	0.3	0.1
102	-2.20	151	52	51.8	41.1	6.8	0.2
103	-1.10	133	50	NR	NR	NR	NR
104	-2.40	125	45	54.8	42.1	2.9	0.1
105	-1.60	NR	52	51.8	39.8	7.3	1.1
106	-2.20	89	48	49.7	38.1	12.0	0.2
107	-2.10	122	10	51.2	39.1	8.6	1.0
108	-2.20	112	55	55.4	42.4	2.0	0.1
109	NR	NR	NR	57.3	40.0	2.6	0.1
110	-1.80	100	17	19.8	26.8	51.7	1.6
111	NR	NR	NR	NR	NR	NR	NR
112	-2.00	73	7	14.6	13.6	60.1	11.7
113	-2.10	72	6	6.4	11.5	68.9	11.0
114	-2.00	72	8	21.9	19.0	52.9	6.1
115	-2.00	NR	2	3.5	12.1	78.4	5.9
116	-2.00	77	14	20.4	21.4	55.8	2.4
117	NR	NR	NR	16.3	17.1	58.2	8.3
118	NR	NR	NR	53.8	35.4	10.6	0.2
119	+0.03	85	60	59.9	36.8	2.8	0.2
120	+0.01	87	65	6.5	4.1	68.7	20.6
121	+0.04	81	40	4.4	2.6	71.7	21.3
122	NR	NR	NR	1.0	1.2	45.2	52.4
123	NR	NR	NR	0.6	0.4	77.4	21.6
124	+0.25	92	>100	57.7	43.7	2.5	0.1
125	+0.10	95	>100	55.3	44.3	0.3	0.1
126	+0.35	96	>100	3.2	6.1	74.0	16.6
127	+0.03	86	>100	NR	NR	NR	NR
128	+0.12	88	>100	NR	NR	NR	NR

* = One blower operating. July 18, 1988.
NR = No reading was taken in the field.

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higher concentrations of methane are produced in the vicinity of these vents than in those areas (like vent no. 110) where methane concentrations were substantially decreased by the blower system coming on or it may indicate that the vacuum being applied by a single blower at vent locations 102, 104, 105, 106 etc. is insufficient to effectively capture the methane being produced by the landfill in these locations.

Vents Nos. 110 and 112 to 117 showed low methane content when the system was on, as shown in table 3-5. The nitrogen content measured at these same vents was elevated and approaching ambient air concentrations. This may indicate that these vents are pulling too high a volume of air into the landfill. This situation could possibly alter the landfill's anaerobic status in these areas. Additionally, these vents have higher quantities of oxygen and lower quantities of carbon dioxide than do the other functioning gas wells. Oxygen can only be supplied by ambient air due to the nature of the decomposition of the refuse.

Because of the ratio of oxygen to carbon dioxide, the high concentration of methane and lack of nitrogen detected, it can be concluded that vents No. 101 to No. 109 are operating satisfactorily, while vents No. 110 and No. 112 to No. 117 are pulling too much air. This air entrainment could kill anaerobic bacteria, slow down the production of methane, and hence impact the operation of the HCU. More importantly, however, the air entrainment in this area gives rise to concerns about the potential for subsurface fires.

Volatile Organics

Gases from vents No. 103, No. 116, No. 122, No. Z, a concrete cistern and the inlet to blower No. 8 were also sampled using SUMMA canisters and analyzed by the EPA Environmental Response Team (ERT) for volatile organic compounds. These results are presented in [illegible]

From this table it can be seen that a number of volatile organic compounds are associated with landfill gas from the L-4 site. The compounds having the highest concentrations include:

TABLE 3-[illegible]

VOLATILE ORGANIC ANALYSES FROM ON-SITE GAS VENTS

Compound	Active Vents				Passive Vents			
	Vent No. 103 (B0747)	Vent No. 116 (B0742)	Vent No. 116 (dup) (B0739)	Vent No. 122 (B0732)	Vent No. Z (B0744)	Concrete Cistern (B0804)	Concrete Cistern (dup) (B0794)	Blower Inlet (B0734)
Vinyl chloride	51.5	19.9	27.5	5.34	642	343	348	71.0
Chloroform	1.58U	1.58U	1.30U	1.58U	1.58U	1.58U	1.58U	1.58U
Methylene chloride	1.46U	1.46U	1.87	1.46U	1.46U	3.29	2.95	13.7
1,1-dichloroethene	9.88	0.92U	0.76U	0.92U	20.7	7.64	7.78	12.9
1,1-dichloroethane	8.50	8.69	8.76	0.8U	325	13.3	12.6	32.0
1,2-dichloroethane	35.6	1.94	1.65	0.98U	5.14	1.87	1.75	8.63
Trans 1,2-dichloroethene	22.5	2.55	2.55	0.89U	9.28	19.0	19.4	24.5
Bromodichloromethane	1.55U	1.55U	1.27U	1.55U	1.55U	1.55U	1.55U	1.55U
Trichloroethene	16.9	2.20	1.86	1.27	38.2	6.48	6.00	21.5
1,1,2,2-tetrachloroethane	70.8	12.70	1.32U	29.4	1.6U	1.6U	1.6U	68.6
1,1,1-trichloroethane	1.31U	1.31U	1.08U	1.31U	13.6	1.31U	1.31U	3.29
Tetrachloroethene	67.2	6.69	5.98	1.78	53.6	18.2	17.4	59.8
Carbon tetrachloride	2.08U	2.08U	1.71U	2.08U	2.08U	2.08U	2.08U	2.08U
1,1,2-trichloroethane	4.58	1.52U	1.25U	1.52U	1.52U	1.52U	1.52U	4.09
Benzene	143	86.3	77.3	3.66	127	58.1	49.6	151
Chlorobenzene	151	123	113	3.06U	153	3.06U	60.8	160

NOTES:

U = Undetected at the detection limit shown.

All concentrations in parts per billion on a volume per volume basis.

(686)

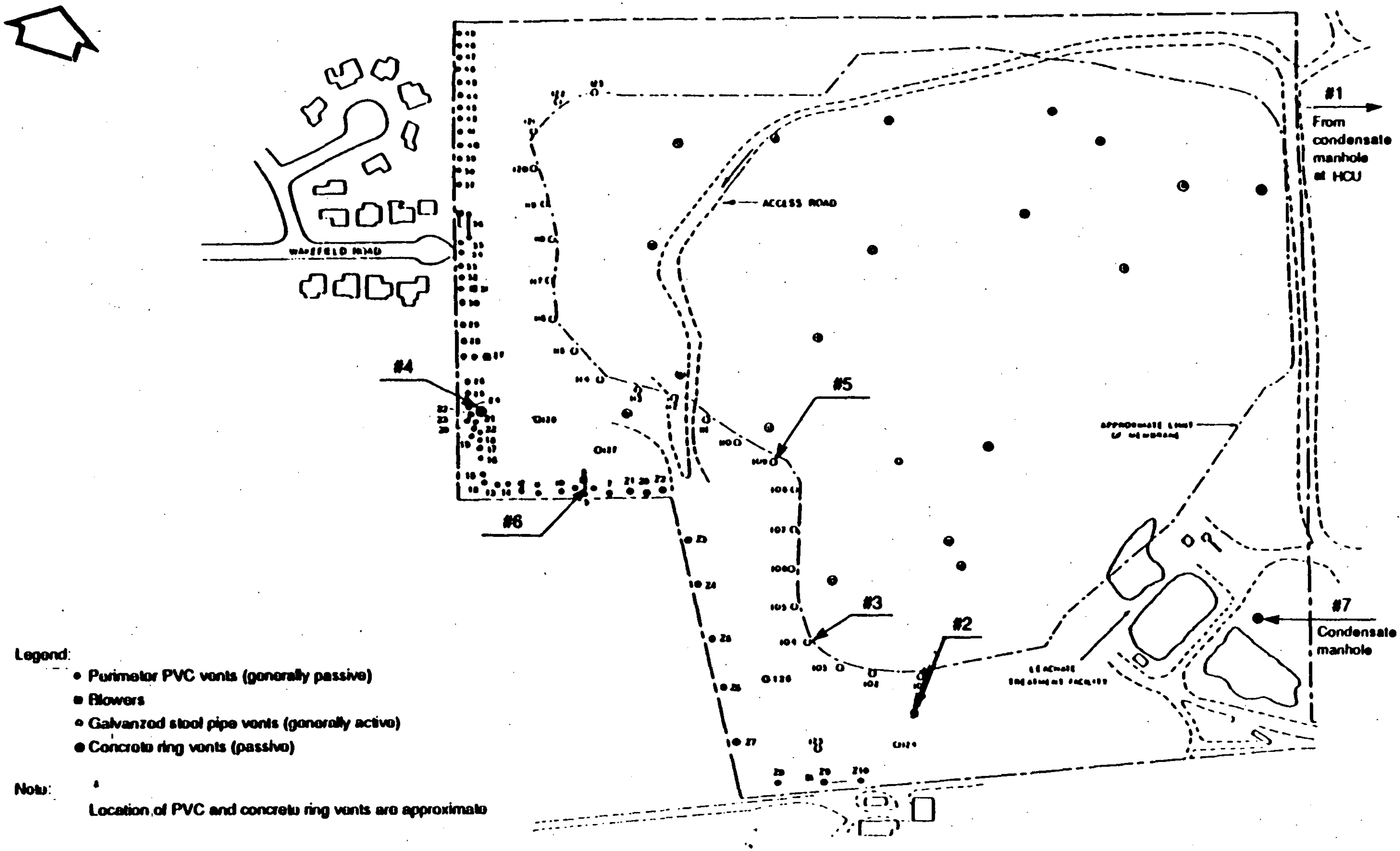
- vinyl chloride
- benzene
- chlorobenzene
- 1,1-dichloroethane
- trichloroethene
- 1,1-dichloroethene
- 1,2-dichloroethane
- trans 1,2-dichloroethene
- 1,1,2,2-tetrachloroethane
- tetrachloroethene

The importance of this data, in addition to their use in the Public Health Evalution (see section 7.0) is that these compounds serve as a "fingerprint" of the Port Washington landfill. That is, subsurface gases in the off-site areas which contain these compounds may be presumed to be associated with migrating landfill gas. As will be seen in section 3.4, eight of the ten above-referenced chemical constituents have in fact been detected in subsurface gases off-site.

3.1.4 SAMPLING AND ANALYSIS OF CONDENSATE

Condensate was collected from the vent manifold system as described in section 2.1.8 and analyzed for volatile organics. Condensate sampling points are shown on [redacted]. Condensate can best be described as vapors which have condensed to a liquid phase. Typically the primary component of condensate is water, however, other landfill gases may be absorbed by this medium. The results of the condensate analyses are presented in [redacted] From this table it is apparent that with the exception of acetone and 2-butanone only small quantities of several volatile organics were detected in the condensate. The constituents detected were:

- acetone
- 1,2-dichloroethene
- benzene
- 4-methyl-2-pentanone
- toluene
- 2-butanone
- chlorobenzene
- ethylbenzene
- xylene (total)



Legend:
- ● Perimeter PVC vents (generally passive)
- ■ Blowers
- ○ Galvanized steel pipe vents (generally active)
- ● Concrete ring vents (passive)

Note:
Location of PVC and concrete ring vents are approximate

Source: Fred C. Hart Associates (1982)

CDM

Figure 3-3

Condensate Sampling Locations

Port Washington Landfill, Port Washington, New York

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ants

TABLE 3-7

CONDENSATE ANALYSES

Sample #	1	2	3		4		5	6		7	
				Field Blank		Trip Blank			BT 264		
Sample I.D.	BR 821	BT 257	BT 258	BT 259	BT 260	BT 261	BT 262	BT 263	Dup	BT 265	BT 266
Compound											
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	ND	ND	ND	ND	ND	2 J	ND	ND	ND	ND	ND
Acetone	15,000	2,900 J	ND	ND	560	ND	630	2,100 J	2,900	11,000	12,000
Carbon Disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethene (total)	ND	ND	24	ND	21 J	ND	47	64 J	49 J	ND	ND
Chloroform	ND	ND	ND	ND	ND	4 J	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Butanone	4,600 J	1,600 J	FQA	FQA	87 J	FQA	200 J	ND	79 J	3,400 J	3,200 J
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	160 J	ND	ND	ND
Carbon Tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Acetate	FQA	ND	ND	ND	FQA	ND	FQA	ND	FQA	FQA	FQA
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	5	ND	ND	ND	20 J	ND	ND	ND	ND
trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	ND	ND	35	ND	ND	ND	61	ND	ND	ND	ND
2-Hexanone	ND	ND	11 J	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	12	ND	17 J	ND	45	ND	ND	ND	ND
Chlorobenzene	ND	ND	5	ND	ND	ND	ND	ND	16 J	ND	ND
Ethylbenzene	ND	ND	13	ND	ND	ND	44	ND	ND	ND	ND
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Xylene (total)	ND	ND	16	ND	ND	ND	54	ND	ND	ND	ND

FQA - Failed Quality Assurance.
J - Estimated Value.

BT 264 is a duplicate sample of BT 263
BT 266 is a duplicate sample of BT 265
All concentrations are in (ug/l)

Of these, the reader will recall that two compounds (benzene and chlorobenzene) were also found in emissions from the on-site gas vents (section 3.1.3).

It should also be noted again that at vent Z condensate is available to drain directly back into this vent which is located outside of the existing liner system. Such an occurrence may provide a contaminant load on the ground water flow system near LFG 202. A condensate sample from the gas header in this vicinity (sample #6) indicated the presence of acetone; 1,2-dichloroethene; and 1,1,1-trichloroethane. Concentrations of 1,2-dichloroethene and 1,1,1-trichloroethane have been detected in the ground water at LFG 202.

3.1.5 SAMPLING AND ANALYSIS AT THE BLOWERS

Gas samples were collected in July 1988 from both the inlet and outlet of the blowers to aid in the overall gas system assessment. During this subtask, as with all other gas vent assessment subtasks, only one blower was operating. The gas samples were analyzed for the primary gas constituents. The results are shown in table 3-8:

TABLE 3-8

PRIMARY GAS CONCENTRATION AT THE BLOWER INLET AND OUTLET

Sample Location	Methane (%)	CO_2(%)	N(%)	O(%)
Blower inlet	30.3	24.7	38.6	6.4
Blower outlet	30.4	24.7	38.0	6.9

Several items should be noted with respect to this data. First, the oxygen content at the blower is relatively high. Recall that a level less than 1 percent is typically recommended. The elevated levels of oxygen may be the result of leaks in the vent system as noted in table 3-1 or the result of air entrainment through the landfill surface. Second, the manufacturer of the HCU (John Zink, Co.) reports that a 20 to 25% concentration of methane is required for proper operation of this equipment and that at concentrations less than this a supplemental fuel should be used. The manufacturer reports that with this concentration of methane and an operating temperature of 1600 °F, a destruction/removal efficiency (DRE) of 99.99% can be achieved for volatile organics. Given a measured operating concentration of 30 percent methane, the HCU appears to have been capable of achieving the design destruction and removal efficiency at the time of the REM II team's remedial investigation in July 1988. However, it has been reported by the Town that during the period of the REM II team's first and second round of landfill gas well sampling in December 1987 and March 1988, during which time three blowers were operating as opposed to only one in July 1988, the methane content at the HCU was but 15.8% and 17.8%, respectively (see table 3-[illegible]). There is no evidence that a supplemental fuel was used during these periods of low methane concentrations. From these cases it is apparent that as the well head vacuum is increased by increasing the number of blowers operating, more ambient air is drawn into the venting system thereby depressing or diluting the methane content. A methane content this low, in the absence of any supplemental fuel, may decrease the operating temperature of the HCU below its design of 1600 °F thereby reducing the DRE. Operating temperatures below the 1600°F recommended were in fact recorded by the TNH during this time period (table 3-9). Additionally, under conditions where the methane content is this low, "flame-outs" of the HCU can occur thereby allowing collected landfill gas to vent directly to the atmosphere.

3.1.6 MONITORING OF ON-SITE AND OFF-SITE WELLS FOR METHANE GAS

As a preventive and safety measure during the course of the vent system assessment work, field monitoring of combustible and organic vapors was performed by the REM II team at locations along the western perimeter of L-4. Specifically, landfill gas wells TNH-3, TNH-4 and TNH-7 were monitored as were EPA LFG 201 and EPA LFG 202. [illegible] 3-10 presents the combustible gas data collected at these locations on July 20 and July 21, 1988.

TABLE 3-9

OPERATIONAL DATA FOR THE HORIZONTAL COMBUSTION UNIT (HCU)

Methane Content at Inlet:	Frequency of Methane Reading Observed					Average
	0%	10-12%	12.1-15%	15.1-18%	18.1-21%	
December 1987	1	7	27	79	4	15.80%
March 1988	-0-	2	1	87	25	17.82%

Combustion Temperature:	Frequency of Temperature Reading Observed						Average
	0°C	<1000°C	1001-1200°C	1201-1400°C	1401-1600°C	>1601°C	
December 1987	3	6	13	23	30	43	1482°C
March 1988	1	1	2	11	46	54	1571°C

Oxygen Content at Inlet:	Frequency of Oxygen Content Recorded					Average
	0%	<5%	5.1-8.0%	8.1-12.0%	12.1-16.0%	
December 1987	1	1	5	32	71	13.5%
March 1988	40	3	2	11	46	10.8%

Carbon Dioxide Content at Inlet:	Frequency of Carbon Dioxide Content Recorded						Average
	0%	<5%	5.1-8.0%	8.1-12.0%	12.1-16.0%	>16.1%	
December 1987	1	1	49	64	1	2	9.0%
March 1988	-0-	-0-	22	75	15	3	10.6%

Note:

- In March 1988, of the 744 hours available for the HCU to operate, it was recorded as operating for 500 of these hours, or 67% of the time. On only one day was the HCU not operating at all. The percent of hours per day the HCU operated during March 1988 is recorded as follows:

0-4 hrs/day = 3%
5-8 hrs/day = 7%
9-12 hrs/day = 0%
13-16 hrs/day = 33%
17-20 hrs/day = 37%
21-24 hrs/day = 20%

- Three blowers were reported as operational during December 1987 and March 1988. These periods correspond with the REM II team's first two rounds of landfill gas sampling.

TABLE 3-10

COMBUSTIBLE GAS MEASUREMENTS DURING SYSTEM ASSESSMENT

LFG Vent	July 20 Methane (% LEL)	July 20 Oxygen (%)	July 21 Methane (% LEL)	July 21 Oxygen (%)
201 A'	-0-	21	-0-	19
201 A	-0-	19.5	-0-	19
201 B	-0-	11	1	10
201 C	-0-	21	-0-	14.5
202 A'	3	15	3	16
202 A	-0-	17	-0-	17
202 B	-0-	17	-0-	16
202 C	1	15.5	-0-	15
3 A	-0-	19.5	-0-	19
3 B	-0-	21	-0-	19.5
3 C	-0-	21	-0-	21
4 A	-0-	21	>100	-0-
4 B	-0-	21	20	4.5
4 C	-0-	19.5	60	14
7 A	-0-	15	-0-	15
7 B	-0-	19.5	-0-	19
7 C	-0-	20	-0-	19

Notes:

1. Gas vent system was "on" (one blower operating) on July 20, 1988. Gas vent system was "off" (no blowers operating) on July 21, 1988.
2. The designations A', A, B and C next to the LFG vent number refer to the gas probe location within the LFG well.

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Inspection of table 3-10 indicates:

- Between July 20 and July 21 (when the system was turned off) the percent LEL methane concentrations stayed essentially constant at wells EPA LFG 201 and 202 as well as at TNH-3 and TNH-7.
- At well TNH-4, combustible gas levels rose from zero up to greater than 100 percent of the LEL. Oxygen levels followed a reverse trend (as one would expect) from between 19.5 and 21 percent to between zero and 14 percent.

This data indicates that landfill gases begin to migrate to the west of the gas vent system in the vicinity of TNH-4 within a matter of hours upon shutting down the blower system. Because the single operational blower was returned to operation once the excursion of gases was found to have breached the control facilities, the extent and pervasiveness of landfill gases migrating into areas where other LFG monitoring wells were located under a "no blowers operating" condition could not be assessed. Conversely, the effective vacuum created by one blower operating appears to be significant enough to prevent explosive levels of methane (above 5% LEL) from migrating off-site in those areas where the active venting system currently exists and where monitoring points are currently placed.

On-site and off-site landfill gas wells were also sampled and analyzed for methane during the first and third gas sampling campaigns. (Due to laboratory problems, methane was not analyzed for during the second round). These results are presented in [redacted] As can be seen, methane was detected on only one occasion (at TNH-4). Based upon these three rounds of data it appears that when three blowers are operating, the gas management system prevents to a significant degree the off-site migration of methane to those areas where landfill gas monitoring wells are situated. However, the operation of three blowers does not prevent the excursion of methane off-site in those areas not under the influence of the gas management system (see section 3.4.4 on EPA-ERT's supplemental gas survey) nor is it certain that methane does not migrate off-site into areas not presently monitored by the landfill gas wells. Additionally, the operation of three blowers does not prevent the migration of VOCs off-site (see section 3.4).

TABLE 3-11

METHANE ANALYSIS OF LANDFILL GAS SAMPLES

	Round ——>	1	2	3
Well No.	Det. Limit (ppmv) ——>	500	50	2.5
TNH LFG-1	(off-site)	ND	NA	ND
TNH LFG-2	(off-site)	ND	NA	ND
TNH LFG-3	(off-site)	ND	NA	ND
TNH LFG-4	(on-site)	ND	NA	81,621*
TNH LFG-5	(off-site)	ND	NA	ND
TNH LFG-6	(off-site)	ND	NA	ND
TNH LFG-7	(on-site)	ND	NA	ND
EPA LFG-201	(on-site)	ND	NA	ND
EPA LFG-202	(off-site)	ND	NA	ND
EPA LFG-203	(off-site)	ND	NA	ND
EPA LFG-204	(off-site)	ND	NA	ND

* Value found at probe A (shallow probe). Value is reported in ppmv.

ND - Not Detected.

NA - Not Analyzed.

Operating Conditions:

Round 1 - 3 blowers operating
Round 2 - 3 blowers operating
Round 3 - 3 blowers operating

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3.1.7 CONCLUSIONS

The following conclusions can be drawn based upon the tasks performed during the vent system assessment:

- Fewer than the design number of blowers were operational during the course of the REM II team's remedial investigation activities.
- The physical condition of the active vent system is deteriorated as evidenced by pervasive leaks of ambient air into the system, patchwork repairs utilizing duct tape, and vent valves which cannot be fully opened or closed.
- "Active" vents nos. 119 through 123, located in the northwestern portion of L-4, have been disconnected from the active system. Therefore, that area of the site may be assumed to have no active barrier to the migration of subsurface gases. These vents continue to function as passive vents.
- "Active" vents Nos. 124 through 127 have also been disconnected from the active vent system and presently function as passive vents.
- Condensate accumulation at low points in the header system result in blockage and surging of the vacuum at various vents.
- Sedimentation and flooding in the active gas vents may be reducing the effectiveness of the vents in capturing subsurface gases.
- The horizontal combustion unit (HCU) appears to be operated at times below the manufacturer's recommendations for methane content (20% to 25%) without supplementing the fuel supply to the HCU. As a result, design operating temperatures (1600 °F) at times are not achieved thereby potentially reducing the HCU's destruction and removal efficiency of landfill gas constituents including volatile organic compounds.
- Although operating in a deteriorated mode, the system with even just one blower operating apparently prevents a significant migration of <u>methane</u> off-site to areas monitored by the EPA and TNH landfill gas wells to the west of L-4; however, if the system is turned off (no blowers operating) methane begins to move west of the gas management system in a matter of hours and the possibility exists that the pre-1983 condition of puff-backs may occur at the residential properties west of the landfill.
- Explosive levels of methane are migrating off-site to the south of the Port Washington landfill in an area not under the influence of the current gas management system and not monitored by the EPA and TNH landfill gas wells.

3.2 PRESSURE PROBE AND UNIT VENT PERFORMANCE TESTING

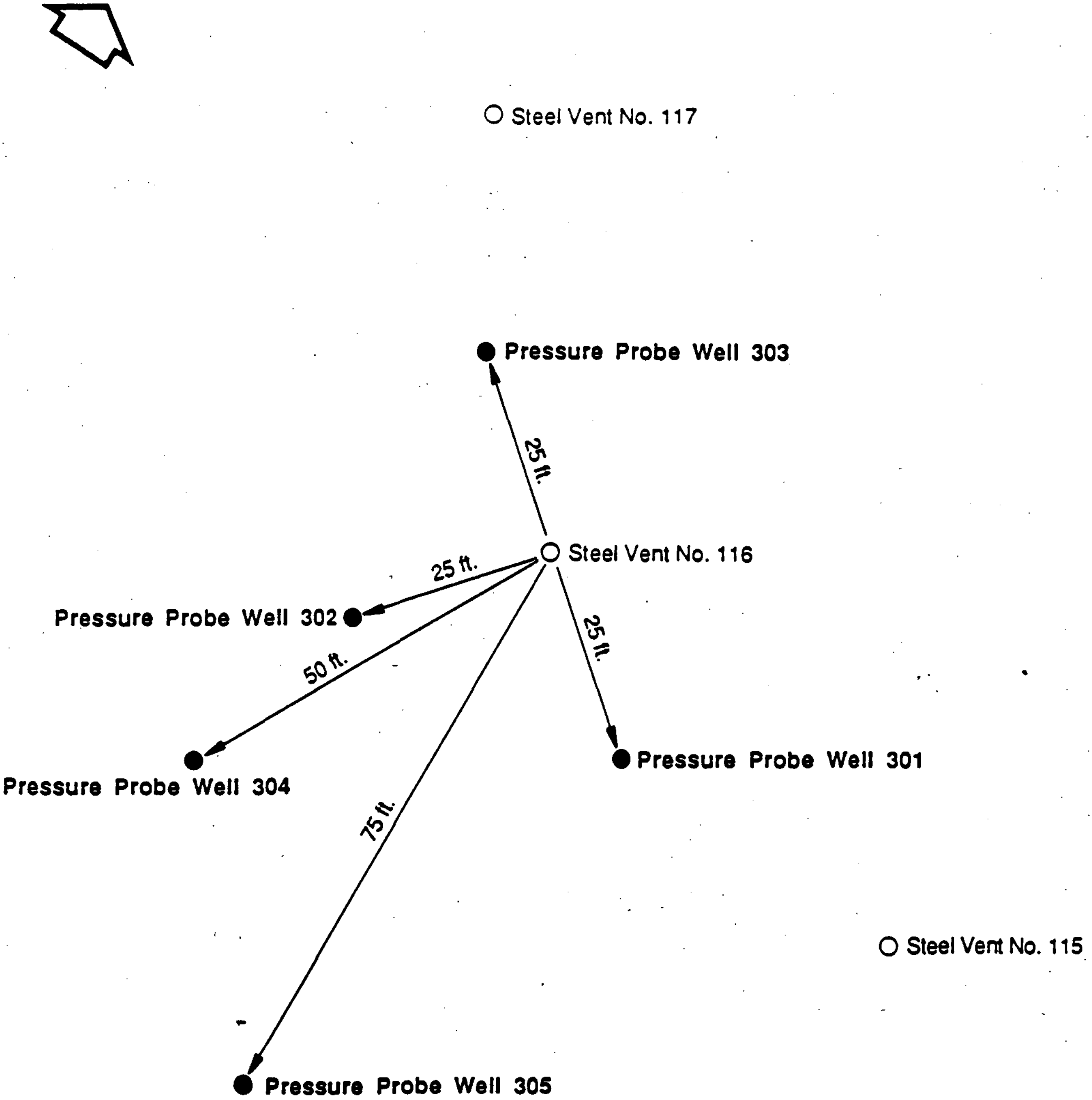
A pressure probe test was performed to determine the "sphere of influence" of an active vent under current operating conditions. This information was considered to be useful in assessing the capability of the active venting system in creating a barrier or "vacuum curtain" to the migration of subsurface gases into the off-site area.

To effect this test five pressure probe wells were installed in March 1988 around vent No. 116. Vent No. 116 was chosen based on its effective performance as stated in the SCS (1982) report. The pressure probe wells were installed 25, 50 and 75 feet from vent No. 116 in various directions as shown in figure 3-4. Pressure probe wells No. 301, No. 302, and No. 303 were all located 25 feet away and in the southeast, southwest and north directions respectively. Pressure probe well No. 304 was fifty feet away and in a southwest direction, and pressure probe well No. 305 was installed seventy five feet away in a southwest direction. Pressure probe wells were not installed to the east of the venting system header pipeline due to two main reasons:

- The access road and steep terrain to the east of vent No. 116 precluded installation of a pressure probe well
- The primary interest in gas migration was to the west of the vent toward the residential area rather than to the east of the vent.

The depths of the different probes in each well was stated on table 2-1.

The pressure probes were used to collect continuous soil pressure data during different phases of blower operation. Therefore the impact of a vacuum being drawn on vent No. 116 was continuously monitored by the pressure probes. Even though the resulting data as presented characterizes only a single active vent under specific circumstances of vent and blower configuration, the data does indicate the presence of a sphere of influence in the subsurface around vent No. 116 imparted by the vacuum extraction process.



Not to scale

CDM
environmental engineers, scientists
planners & management consultants

Fi 4

Pressure Probe Well Lo is

Port Washington Landfill, Port Washington, rk

The results from pressure probe wells No. 301, No. 302, No. 303 and No. 304 show that the pressure probes responded to changes in pressures induced by the operation of vent No. 116. Pressure probe well No. 305 showed very little effect (if any) caused by the operation of vent No. 116.

There are two explanations for this lack of an effect at pressure probe well No. 305:

- Well No. 305 may have been installed in a cell of the refuse which was not pneumatically connected to the sphere of influence of vent No. 116.
- Vent No. 116 may not have a sphere of influence extending up to seventy five feet.

The data obtained from the five pressure probe wells clearly shows that there is an influence on the pressure probe wells caused by the operation of vent No. 116. When the blower system was on (vacuum or negative pressure in vent No. 116) the pressure measured by the transducers was negative, and this pressure was reversed when the vent system was turned off. Between one and three blowers were reported to be operational during the course of the pressure probe testing.

It can be concluded that a "sphere of influence" could be effected at vent No. 116 and that this vacuum condition would assist in providing a barrier for reducing gas migration from the landfill to the west. Further, it can be concluded that the radius of influence of vent No. 116 is at least fifty feet in that pressure probe well No. 304 (a distance of fifty feet from vent No. 116) showed an effect whereas pressure probe well No. 305 (at a distance of 75 feet) did not. In that it is reported that most of the steel vents are spaced at a distance of 75 feet on center, a radius of influence of 40 feet will provide for some overlapping between active vents.

To supplement the pressure probe tests, a unit vent performance test was also performed to determine the "curtain" effect of active vent Nos. 101 and 103. The results are listed in [redacted] Here it can be observed that as the valve setting on vent no. 101 was gradually opened, the pres-

TABLE 3-12

SPHERE OF INFLUENCE TESTS ON VENT NOS. 101 AND 103

Time of reading	No. 101 Vent valve setting	No. 101 Well pressure (in. of H_2O)	No. 102 Well pressure (in. of H_2O)	Time of reading	No. 103 Vent valve setting	No. 102 Well pressure (in. of H_2O)
1603	8	+1.50	***	0537	8	+0.90
1620	8	+1.50	+1.10	0540	8	+0.90
1621	8	+1.50	+1.00	0541	6	+0.90
1623	8	+0.90	+1.00	0542	4	+0.90
1627	6	**	+1.00	0543	2	**
1630	8	**	+0.20	0546	2	+0.20
1631	8	**	+0.10	0547	2	+0.00
1632	6	**	+0.00	0548	2	-0.10
1639	6	-10.00	-0.30	0600	2	-0.20

Notes:

1. Steel vent #102 was fully closed during these tests.
2. Vent settings: (1 = fully Open 8 = fully Closed).
3. ** = Reading not taken.
4. One blower was operating during those tests.

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sure in vent No. 101 dropped and eventually became negative. Simultaneously, as the valve setting on vent no. 101 was being opened, the pressure in vent No. 102 correspondingly dropped until its pressure was negative too. The conclusion to be drawn is that the influence of vent No. 101 is capable of extending or overlapping well No. 102 (located a distance of approximately 75 feet away) at some elevation in the landfill. In other words, a curtain or barrier to subsurface migration exists between vents 101 and 103 at some depth within the landfill.

A similar test was run on vent No. 103. Again the vent valve setting on vent No. 103 was opened. A corresponding drop in well head pressure was recorded at vent no. 102 located approximately 75 feet away. The conclusion again to be drawn is that the "curtain" effect of vent No. 103 extends at least up to vent No. 102 at some elevation in the landfill.

It was the REM II team's original intention to proceed to test each active vent in the above described manner; however, the relatively low head vacuums obtained at vents progressively further removed from the blower system (probably due to one blower being operational and the large number of air leaks in the system) coupled with a shut-down of the blower system by TNH personnel during the latter portions of the assessment program, prevented the continuation of this task.

3.3 SURFACE FLUX EMISSIONS FROM THE LANDFILL

An estimate of the surface emissions from the landfill surface was performed using flux boxes at ten locations on the landfill. The locations are shown in [redacted] The ten stations were chosen after a field survey was carried out on the landfill surface at grid intervals of 100 feet, as discussed in section 2.3.

Three rounds of flux box measurements were performed. One each in December 1987 - January 1988, March 1988 and September 1988. During the second round of surface emission measurements, some of the station locations were modified slightly to afford sampling of areas with cracks in the landfill

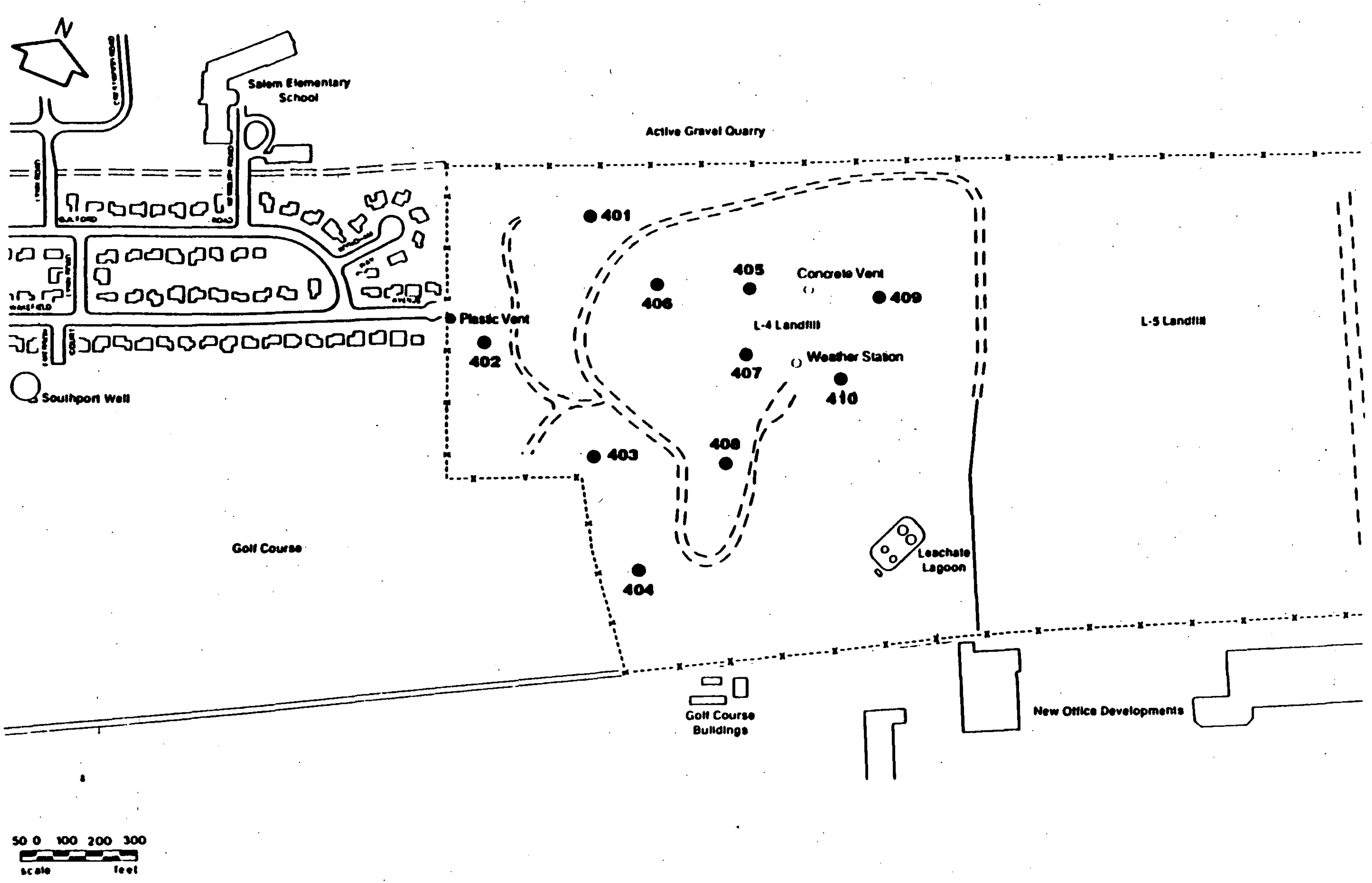

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Figure 3-5

Approximate Location of Flux Box Stations

Port Washington Landfill, Port Washington, New York

surface. The stations utilized in round two were repeated in the third round of surface emission testing.

The samples obtained from each flux box were sent to a CLP laboratory for analysis. The analytical results from the first round of sampling which passed EPA QA/QC procedures are shown in table 3-13. As can be seen, only one (flux box station 402) of ten samples collected passed EPA QA/QC procedures and this sample only showed the presence of acetone. This may be due to the high detection limits reported by the laboratory. Round 2 flux box data achieved better results. From this data, presented on table 3-14 it can be seen that during round 2 the gases emitted from the landfill surface were fewer in quantity and concentration than the volatile organic compounds detected in the active and passive vents (section 3.1.3). However, the values obtained at station #407 (crack on the landfill surface near the meteorological station) showed that a variety of compounds were being emitted from this area including vinyl chloride, trans-1,2-dichloroethene, tetrachloroethene, trichloroethene, xylene and toluene. Round 3 flux box data is presented in table 3-15. A review of this table shows that surface emissions were detected at all but three flux box sampling stations (No. 401, No. 402, No. 404) although once again the major surface emissions from the landfill were emanating from flux box location No. 407. This flux box was placed over a "crack" in the landfill surface approximately 3 inches wide and 18 inches long. The depth of the crack could not be determined. The compounds detected at the other flux box locations besides #407 are generally much fewer in number and concentration although flux box location #410 in the center of L-4 also appears to have elevated levels of surface emissions. Also of interest is to note the compounds which appear relatively consistently in round 3 regardless of flux box location. Compounds falling into this classification are:

Compound	# of Stations Detected
benzene	7
vinyl chloride	6
tetrachloroethene	6
trans-1,2-dichloroethene	5

TABLE 3-13
Flux Box Data (Round 1)

Sample Location Sample Number	FB402 Sp41	FB2 Sp35
Volatiles		
Vinyl Chloride	ND	ND
Chloroform	ND	ND
Bromoform	ND	ND
Methylene Chloride	ND	ND
Acetone	9254	ND
2-Butanone	ND	ND
Chloroethane	ND	ND
Chloromethane	ND	ND
Bromomethane	ND	ND
1,1-Dichloroethene	ND	ND
1,1-Dichloroethane	ND	ND
1,2-Dichloroethane	ND	ND
Trans-1,2-Dichloroethene	ND	ND
Bromodichloromethane	ND	ND
Dibromochloromethane	ND	ND
Trichloroethene	ND	ND
1,1,1-Trichloroethane	ND	ND
1,1,2-Trichloroethane	ND	ND
Trichlorofluoromethane	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND
Tetrachloroethene	ND	ND
Carbon Tetrachloride	ND	ND
1,2-Dichloropropane	ND	ND
cis-1,3-Dichloropropene	ND	ND
Trans-1,3-Dichloropropene	ND	ND
2-Chloroethylvinylether	ND	ND
4-Methyl-2-Pentanone	ND	ND
Acrolein	ND	ND
Acrylonitrile	ND	ND
Toluene	ND	ND
Benzene	ND	ND
Chlorobenzene	ND	ND
Ethylbenzene	ND	ND
Tot Xylene	ND	ND

Reported as ppb on a volume per volume (v/v) basis.
FB2 is a field blank.
FB402 is a flux box from sampling station 402.
Refer to the appendices for analytical detection limits.

TABLE 3-14
Flux Box Data (Round 2)

Sample Location Sample Number	FB401 Sp49	FB402 Sp45	FB403 Sp46	FB404 Sp43	FB405 Sp50	FB406 Sp53	FB406 DI53	FB407 Sp48	FB407 DI48
Chloromethane	7 U	3 U	7 U	6 U	6 U	7 U	13 U	10 UJ	1920 U
Bromomethane	4 U	4 U	4 U	3 U	3 U	4 U	7 U	6 UJ	1020 U
Vinyl Chloride	6 U	5 U	6 U	4 U	5 U	166 E	113	20700 E	20500
Chloroethane	5 U	5 U	6 U	4 U	5 U	5 U	10 U	8 UJ	1500 U
Methylene Chloride	Fqa	Fqa	Fqa	Fqa	Fqa	Fqa	Fqa	5770 E	Fqa
Acetone	Fqa	Fqa	Fqa	Fqa	Fqa	Fqa	Fqa	3160 E	Fqa
Carbon Disulfide	2 U	2 U	2 U	2 U	2 U	2 U	4 U	3 UJ	632 U
1,1-Dichloroethene	2 U	2 U	2 U	2 U	2 U	2 U	4 U	355 E	501 U
1,1-Dichloroethane	2 U	2 U	2 U	2 U	2 U	1 J	1 J	1470 E	490 U
Trans-1,2-Dichloroethene	2 U	2 U	2 U	2 U	1 U	37	36	15000 E	6760
Chloroform	1 U	1 U	2 U	1 U	1 U	2 U	3 U	2 UJ	407 U
1,2-Dichloroethane	2 U	2 U	2 U	1 U	2 U	2 U	3 U	3 UJ	490 U
2-Butanone	Fqa	Fqa	3 UJ	Fqa	Fqa	Fqa	Fqa	2550 E	Fqa
1,1,1-Trichloroethane	1 U	1 U	1 U	1 U	1 U	3	3	833 E	109 J
Carbon Tetrachloride	1 U	1 U	1 U	1 U	1 U	1 U	2 U	2 UJ	316 U
Vinyl Acetate	2 UJ	2 UJ	2 UJ	2 U	2 UJ	2 UJ	4 UJ	3 UJ	559 UJ
Bromodichloromethane	1 U	1 U	1 U	1 U	1 U	1 U	2 U	2 UJ	297 U
1,2-Dichloropropane	2 U	2 U	2 U	1 U	1 U	2 U	3 U	140 E	429 U
Trans-1,2-Dichloropropane	2 U	2 U	2 U	1 U	1 U	2 U	3 U	2 UJ	437 U
Trichloroethene	1 U	1 U	1 U	1 U	1 U	2	2 J	4840 E	1180
Dibromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	2 U	1 UJ	233 U
1,1,2-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	3 U	2 U	364 U
Benzene	2 U	2 U	2 U	2 U	2 U	2 U	4 U	3 UJ	123 J
cis-1,3-Dichloropropene	2 U	2 U	2 U	1 U	1 U	2 U	3 U	2 UJ	437 U
2-Chloroethylvinylether	2 UJ	2 UJ	2 UJ	1 UJ	1 UJ	2 UJ	3 UJ	3 UJ	453 UJ
Bromoform	1 U	2 U	1 U	1 U	1 U	1 U	1 U	1 UJ	192 U
4-Methyl-2-Pentanone	2 UJ	2 UJ	2 UJ	1 UJ	2 UJ	2 UJ	3 UJ	3 UJ	481 UJ
Hexanone	2 UJ	2 UJ	2 UJ	1 UJ	2 UJ	2 UJ	3 UJ	3 UJ	481 UJ
Tetrachloroethene	1 U	1 U	1 U	1 U	1 U	19	18	8780 E	3370
1,1,2,2-Tetrachloroethane	1 U	1 U	1 U	1 U	1 U	1 U	2 U	2 UJ	29 U
Toluene	2 U	2 U	2 U	2 U	Fqa	Fqa	Fqa	3 U	4440
Chlorobenzene	2 U	2 U	2 U	1 U	2 J	2 U	3 U	2 UJ	429 U
Ethylbenzene	2 U	2 U	2 U	2 U	1	2 U	3 U	3 UJ	2 UJ
Styr		2 U	2 U	1 U	1 U	2 U	3 U	3 UJ	462 U
Tol		2 U	2 U	1 U	3 U	2 U	3 U	3 UJ	725

TABLE 3-14
Flux Box Data (Round 2)
(continued)

Sample Location Sample Number	FB408 Sp51	FB408d Sp52	FB409 Sp42	FB409d Sp47	FB410 Sp55	Blank Sp44	Con Vent Sp54	PL Vent Sp40
Chloromethane	8 U	7 U	6 U	7 U	8 U	7 U	7 U	8 U
Bromomethane	4 U	4 U	3 U	4 U	4 U	4 U	4 U	4 U
Vinyl Chloride	6 U	6 U	5 U	6 U	6 U	6 U	51	6 U
Chloroethane	6 U	6 U	5 U	6 U	6 U	6 U	6 U	6 U
Methylene Chloride	Fqa	Fqa	Fqa	Fqa	Fqa	25	2 U	2 U
Acetone	Fqa	Fqa	Fqa	Fqa	Fqa	15	Fqa	Fqa
Carbon Disulfide	3 U	2 U	2 U	2 U	3 U	2 U	3 U	3 U
1,1-Dichloroethene	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,1-Dichloroethane	2 U	2 U	2 U	2 U	3 U	2 U	2 U	2 J
Trans-1,2-Dichloroethene	2 U	2 U	2 U	2 U	2 U	2 U	3 U	2 U
Chloroform	2 U	2 U	1 U	2 U	2	2 U	2 U	3 UJ
1,2-Dichloroethane	2 U	2 U	2 U	2 U	2 U	2 U	1 U	2 U
2-Butanone	Fqa	Fqa	2 UJ	3 UJ	Fqa	3 J	Fqa	Fqa
1,1,1-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	2 U	2 U
Carbon Tetrachloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Vinyl Acetate	2 UJ	2 UJ	1 U	2 UJ	2 UJ	2 UJ	3 UJ	2 UJ
Bromodichloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloropropane	2 U	2 U	1 U	2 U	2 U	2 U	2 U	2 U
Trans-1,2-Dichloropropane	2 U	2 U	1 U	2 U	2 U	2 U	2 U	2 U
Trichloroethene	2 U	1 U	2 U	1 U	2 U	1 U	2 U	2 U
Dibromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	1 U	1 U	2 UJ	1 U	1 U	1 U	2 U	2 U
Benzene	2 U	2 U	1 U	2 U	1 U	2 U	3 U	3 U
cis-1,3-Dichloropropene	2 U	2 U	2 UJ	2 U	2 U	2 U	2 U	2 U
2-Chloroethylvinylether	2 U	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 UJ	2 U
Bromoform	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
4-Methyl-2-Pentanone	2 UJ	2 UJ	1 U	2 UJ	2 UJ	2 UJ	2 UJ	2 U
Hexanone	2 UJ	2 UJ	2 U	2 UJ	2 UJ	2 UJ	2 UJ	2 U
Tetrachloroethene	1	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Toluene	2 U	2 U	2 U	2 U	Fqa	3	Fqa	2 U
Chlorobenzene	2 U	2 U	1 U	2 U	10	2 U	2 U	2 U
Ethylbenzene	2 U	2 U	2 U	2 U	38	2 U	13	2 U
Styrene	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
	2 U	2 U	2 U	2 U	71	2 U	29	2 U

otherwise.

U = indicates compound was analysed for, but not detected at the value shown.

J = indicates that the value was estimated.

B = indicates that the analyte was found in the blank.

E = indicates that the concentration of the analyte exceeded the

TABLE 3-15
Flux Box Data (Round 3)

Sample Location Sample #	#401 040	#402 036	#403 009	#404 011	#405 044	#406 049	#406 023	#407 045	#407 001	#408 054	#409 047	#410 027
Vinyl Chloride	0.93 U	0.93 U	0.93 U	0.93 U	10.5	47.0	0.93 U	320	20.9	4.05	4.02	133
1,1 Dichloroethene	0.76 U	0.76 U	0.76 U	0.76 U	0.92 U	0.92 U	0.76 U	167	83.0	0.92 U	0.92 U	1.19
Methylene Chloride	5.05	7.26	8.36	7.70	11.6	9.75	2.3	14.6 U	553	9.13	1.90	22.6
Trans - 1,2-Dichloroethene	0.73 U	0.73 U	0.73 U	0.73 U	2.75	2.08	0.73 U	159	125	2.92	0.89 U	27.7
1,1-Dichloroethane	0.66 U	0.66 U	0.66 U	0.66 U	0.8 U	5.13	0.66 U	408	326	0.8 U	0.8 U	37.2
Chloroform	1.30 U	1.30 U	1.30 U	1.30 U	1.58 U	1.58 U	1.75	1.58 U	2.91	1.58 U	1.59	1.58 U
1,1,1-Trichloroethane	1.08 U	1.08 U	1.08 U	1.08 U	1.31 U	1.31 U	1.08 U	80.4	76.9	1.31 U	1.31 U	1.82
Carbon Tetrachloride	1.71 U	1.71 U	1.71 U	1.71 U	2.08 U	2.08 U	1.71 U	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U
Benzene	1.25 U	1.25 U	2.33	1.25 U	23.1	42.9	1.25 U	293	242	26.6	2.82	149
1,2-Dichloroethane	0.81 U	0.81 U	0.81 U	0.81 U	0.98 U	0.98 U	0.81 U	283	0.98 U	0.98 U	0.98 U	5.55
Trichloroethene	0.73 U	0.73 U	0.73 U	0.73 U	0.89 U	1.33	0.73 U	0.89 U	86.1	0.89 U	0.89 U	3.48
Bromodichloromethane	1.27 U	1.27 U	1.27 U	1.27 U	1.55 U	1.55 U	1.27 U	1.55 U	1.55 U	1.55 U	1.55 U	1.55 U
1,1,2-Trichloroethane	1.25 U	1.25 U	1.25 U	1.25 U	1.52 U	1.52 U	1.25 U	1.52 U	1.52 U	1.52 U	1.52 U	1.52 U
Tetrachloroethene	0.81 U	0.81 U	0.81 U	0.81 U	0.99	6.77	1.15	113	48.1	1.23	3.85	10.9
Chlorobenzene	2.52 U	2.52 U	2.52 U	2.52 U	4.93	110	2.52 U	34.7	26.4	3.06 U	3.06 U	106
1,1,2,2-Tetrachloroethane	1.32 U	1.32 U	1.32 U	1.32 U	1.6 U	1.6 U	2.68	1.6 U	1.6 U	1.6 U	5.33	133

All co me per volume basis
U = n at the detection limit indicated

Elevated concentrations of the following compounds were detected during round 3 flux box sampling:

- vinyl chloride
- 1,1-dichloroethene
- 1,1-dichloroethane
- 1,2-dichloroethane
- trans 1,2-dichloroethene
- trichloroethene
- tetrachloroethene
- benzene
- chlorobenzene
- 1,1,1-trichloroethane

Again, it can be seen that the chemicals detected in the surface flux are, for the most part, the same ones detected in the on-site gas vents. All of the chemicals listed above were detected at both of these locations.

The flux box data from round 2 was used to calculate surface flux rates for the volatile organic compounds from the landfill. These flux rates are shown in table 3-16. Flux rates are used to portray the data in terms of concentrations of chemical released to the ambient air per unit area of the landfill surface per unit time. Data in this format is utilized in conducting the baseline Public Health Evaluation (section 7.0).

In the interpretation of the data presented above, it should be noted that there are also surface cracks (similar to those evidenced at flux box station #407) on the sides of the landfill which may be venting volatile organic compounds to the ambient air. Flux measurements were not taken at these sideslopes due to the physical dangers involved in setting up a flux box on the sideslopes, which in some cases were 1:1. Therefore the estimated flux presented in table 3-16 should be treated as conservative, and the actual total emission from the landfill surface should be expected to be greater.

TABLE 3-16
Flux Emission Rate from the Landfill Surface During Round 2

	Flux Box I.D. No.									
Compound	401	402	403	404	405	406	407	408	409	410
Vinyl Chloride	-	-	-	-	-	5.78 E+03	1.05 E+06	-	-	-
Methylene Chloride	-		-	-	-	-	4.01 E+05	-	-	-
Acetone	-	-	-	-	-	-	1.50 E+05	-	-	-
1,1-Dichloroethene	-	-	-	-	-	-	2.81 E +04	-	-	-
1,1-Dichloroethane	-	-	-	-	-	8.09 E+01	1.19 E+05	-	-	-
trans-1,2-Dichloroethene	-	-	-	-	-	2.93 E +03	5.36 E+05	-	-	-
Chloroform	-	-	-	-	-	-	-	-	-	1.95 E+02
2-Butanone	-	-	-	-	-	-	1.50 E+05	-	-	-
1,1,1-Trichloroethane	-	-	-	-	-	3.27 E+02	1.19 E+04	-	-	-
1,2-Dichloropropane	-	-	-	-	-	-	1.29 E+04	-	-	-
Trichloroethene	-	-	-	-	-	2.15 E+02	1.27 E+05	-	-	-
Benzene	-	-	-	-	-	-	7.86 E+03	-	-	-
Tetrachloroethene	-	-	-	-	-	2.58 E+03	4.57 E+05	1.36 E+02	-	-
Chlorobenzene	-	-	-	-	1.84 E+02	-	-	-	-	9.21 E+02
Ethylbenzene	-	-	-	-	8.68 E+01	-	-	-	-	3.30 E+03
xylenes (Total)	-	-	-	-	-	-	-	-	-	6.17 E+03

"—" Emission rate is 0.00 E+0

r square meter per day

rd conditions of P=1 atmosphere and T=70 F

3.4 LANDFILL GAS MONITORING DATA

3.4.1 BACKGROUND

Four landfill gas monitoring wells were installed at the Port Washington site by the REM II team. The installation of these wells was described in section 2.4. These wells are numbered EPA LFG 201 to EPA LFG 204. Information about these wells is provided in tables 3-17 and 3-18. Figure 3-6 shows the locations of these monitoring wells.

All of the newly installed landfill gas monitoring wells were located to the west of the landfill because this was the major area of concern. Prior to the installation of the active venting system this portion of the study area was reported to have experienced methane gas migration from the landfill.

Each EPA LFG well was fitted with four probes located at different depths. in the well. The probes were labeled A' (generally ten to thirty-five feet below grade); A (thirty-five to sixty-five feet); B (ninety to one hundred feet); and C (one hundred and fifteen to one hundred and thirty feet). Detailed descriptions, specifications, boring logs and 'as-builts' are contained in Appendix G.

The Town of North Hempstead landfill gas wells were designed to serve in a complimentary role of ground water level measurement. This facility for ground water level measurement was incorporated into only one of the landfill gas monitoring wells constructed by the REM II team (EPA LFG 202). The need for water level measurements in the other EPA wells (LFG 201, LFG 203 and LFG 204) was not considered to be of prime importance as the ground water monitoring wells installed by the REM II team (EPA #101 to EPA #111) provided this capability.

3.4.2 SOIL DATA FROM THE WELL INSTALLATION

Soil samples were collected using split spoon liners during the installation of the EPA LFG wells and forwarded to the CLP laboratory for analysis.

TABLE 3-17

WELL LOCATION SUMMARY

Well Number	Approximate Distance to Edge of Refuse (ft)	Location
EPA LFG-201	80	Opposite 67 Wakefield Avenue
EPA LFG-202	80	North Hempstead County Club 13th Tee
EPA LFG-203	820	North Hempstead County Club 17th Tee
EPA LFG-204	990	Opposite 40 Wakefield Avenue
TNH-1	500	Back of 54 Wakefield Avenue
TNH-2	1,050	North Hempstead County Club
TNH-3	200	North Hempstead County Club
TNH-4	50	Port Washington Landfill
TNH-5	450	Guilford Road - by Wyndham and Wakefield
TNH-6	300	Opposite 6 Wyndham Way
TNH-7	200	Port Washington Landfill

(634)

TABLE 3-18

WELL CONSTRUCTION ELEVATIONS - AS-BUILT DATA

ELEVATIONS (FT. MSL)

LFG Well No.	Ground Water Table (MSL)	Top of Screen Elevation (MSL)	Gas Probe Elevations** (MSL)				Ground Surface Elevation (MSL)
			A′	A	B	C	
EPA 201	-	-	132	105	65	40*	155
EPA 202	23	14	119	88	58	28	153
EPA 203	-	-	142	118	56	38	153
EPA 204	-	-	180	145	105	71	200
TNH 1	22	25	-	148	85	26	173
TNH 2	41	30	-	151	101	56	160
TNH 3	28	20	-	150	85	30	160
TNH 4	33	19	-	104	74	34	152
TNH 5	19	17	-	152	92	27	172
TNH 6	24	17	-	159	99	34	177
TNH 7	19	18	-	154	84	29	168

"-" = Not applicable.

* = Probe was inoperable

** = Elevation is reported at bottom of probe

(631)

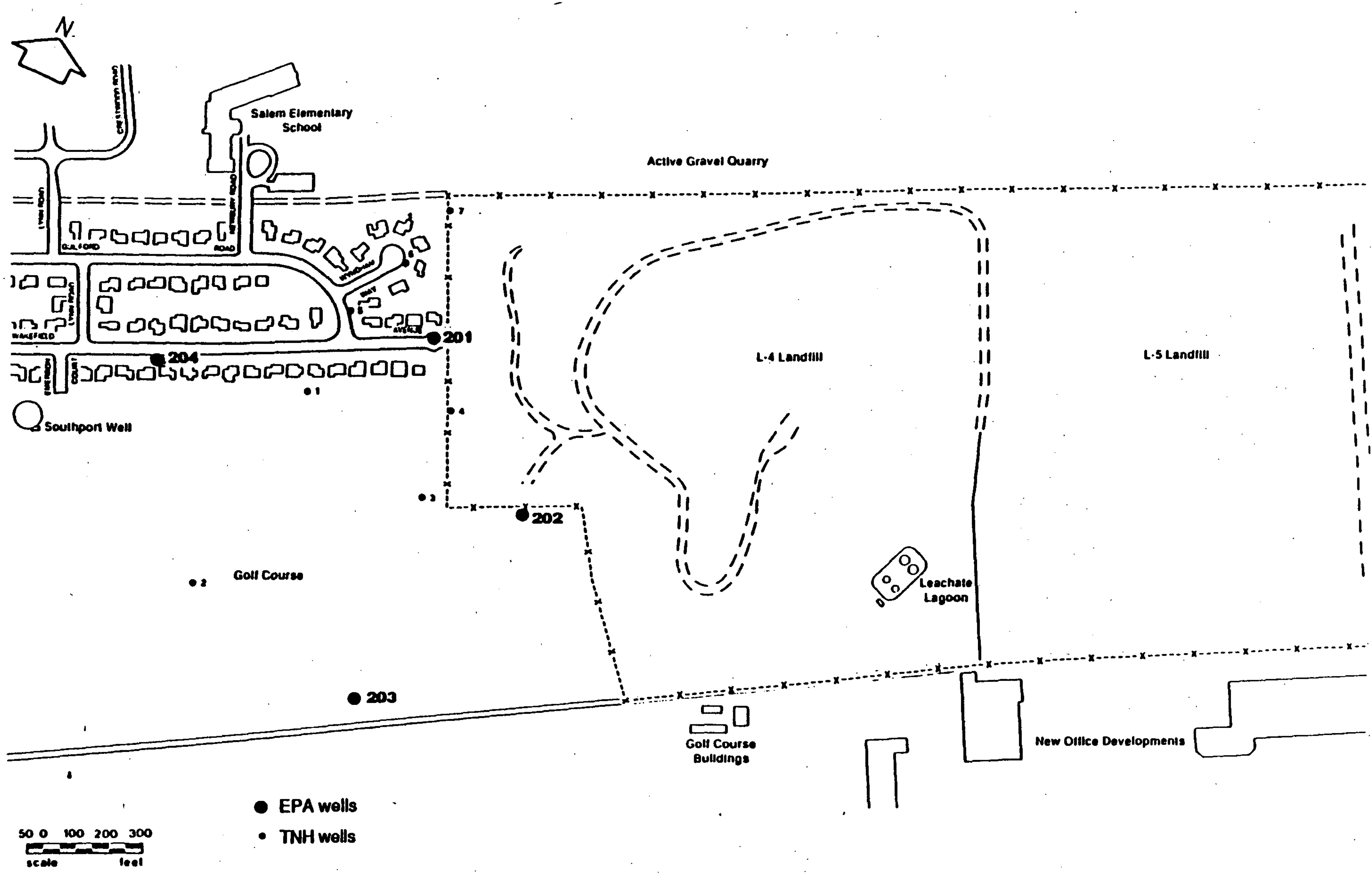

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Figure 3-6

Location of Landfill Gas Monitoring Wells

Port Washington Landfill, Port Washington, New York

The results of these analyses are presented in table 3-19. Additional samples were collected via split-spoon and field screened for headspace characteristics using an HNu and OVA (see section 4.1.1). The data from these field analyses were used to develop the boring logs which are presented in Appendix H.

The primary purpose of these samples was to determine if contaminants, specifically volatile organics, were present on off-site soil particles. A review of table 3-20, however, shows that in only a very limited number of cases were any volatile organics detected in the soil samples and when a compound was detected it was at very low levels, usually at or below the detection limit. This necessitated only estimated values being reported. Interestingly, the HNu and OVA results indicated the presence of volatile organic compounds in the headspace associated with these samples.

3.4.3 GAS SAMPLING AND ANALYSIS

Landfill gas samples were collected from eleven landfill gas monitoring wells. Some wells were installed by the Town of North Hempstead (TNH #1 to TNH #7) and some were installed by the EPA (LFG 201 to LFG 204). As previously discussed, samples from these locations have been collected to date on three different occasions by the REM II team. The analytical results of these efforts are presented on figures 3-[illegible] to 3-22. Table 3-23 summarizes all of this data by depicting only those compounds which were detected and the respective locations where the compounds were found. Appendix I contains the raw data collected during all three rounds of landfill gas sampling.

Figure 3-[illegible] (inclusive) represents a display of some of the landfill gas data from rounds 1,2 and 3. The figures are "dot plots" of the concentrations of the various chemical compounds detected. The larger the "dot" the larger the concentration as denoted in the figure key. Six different chemicals have been chosen to be depicted in this manner:

- o trichloroethene
- o 1,1,1-trichloroethane

TABLE 3-19

ANALYTICAL RESULTS FROM SOIL SAMPLES COLLECTED DURING INSTALLATION OF EPA LFG 201 TO EPA LFG 204

Well No.	Sampling Interval Below Grade (ft.)	Results	% Moisture Content
EPA LFG 201	20 to 24	No volatile organic compounds detected	15
	50 to 54	No volatile organic compounds detected	8
	100 to 104	No volatile organic compounds detected	14
	126 to 130	No volatile organic compounds detected	12
EPA LFG 202	29 to 34	Toluene detected at a concentration of 2J	13
	60 to 65	Toluene detected at a concentration of 5J	13
	90 to 95	No volatile organic compounds detected	15
	120 to 125	Tetrachloroethene detected at a concentration of 2J Toluene detected at a concentration of 2J	10
EPA LFG 203	10.5 to 15.5	No volatile organic compounds detected	9
	29.5 to 34.5	No volatile organic compounds detected	6
	92 to 97	No volatile organic compounds detected	10
	110 to 115	No volatile organic compounds detected	12
EPA LFG 204	15 to 20	No volatile organic compounds detected	15
	50 to 55	No volatile organic compounds detected	2
	90 to 95	No volatile organic compounds detected	2
	124 to 129	2-butanone detected at a concentration of 10J	1

Notes:

All concentrations are reported in ug/kg.

J = Estimated concentration.

TABLE 3-20
Landfill Gas Monitoring Well Results (Round 1)

Sample Location Sample Number	6A Sp29	6C Sp31	7A Sp18	7B Sp19	201D Sp02	202A Sp04	203B Sp22	203C Sp23	204A Sp07
Volatiles									
Vinyl Chloride	FQA	FQA	FQA	FQA	FQA	FQA	FQA	FQA	FQA
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	FQA	FQA	FQA	FQA	FQA	FQA	FQA	FQA	FQA
2-Butanone	FQA	FQA	FQA	FQA	FQA	FQA	FQA	FQA	FQA
Chloroethane	FQA	FQA	FQA	FQA	FQA	FQA	FQA	FQA	FQA
Chloromethane	FQA	FQA	FQA	FQA	FQA	FQA	FQA	FQA	FQA
Bromomethane	FQA	FQA	FQA	FQA	FQA	FQA	FQA	FQA	FQA
1,1-Dichloroethene	ND	ND	ND	FQA	ND	ND	FQA	ND	FQA
1,1-Dichloroethane	ND	ND	ND	ND	ND	385	ND	25	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND	119	24	ND	ND
1,1,1-Trichloroethane	ND	ND	152	ND	ND	612	198	194	79
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	FQA	FQA	FQA	FQA	FQA	FQA	FQA	FQA	FQA
	ND	ND	ND	ND	ND	ND	FQA	ND	ND

TABLE 3-20
Landfill Gas Monitoring Well Results (Round 1)

(continued)

Sample Location Sample Number	6A Sp29	6C Sp31	7A Sp18	7B Sp19	201D Sp02	202A Sp04	203B Sp22	203C Sp23	204A Sp07
Tetrachloroethene	31	14J	ND	ND	123	614	478	123	131
Carbon Tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	FQA
2-Chloroethylvinylether	ND	FQA	FQA	FQA	FQA	ND	FQA	FQA	ND
4-Methyl-2-Pentanone	ND	FQA	FQA	FQA	FQA	ND	FQA	FQA	ND
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	FQA
Acrylonitrile	ND	FQA	ND	ND	ND	FQA	72JB	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tot Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND

All concentrations are shown in parts per billion on a volume by volume basis. Values have been rounded to nearest whole number.
Only data which has passed EPA data validation procedures are shown.
ND = not detected. Refer to the appendices for individual sample detection limits.
B = compound was detected in blanks
J = estimated value
FQA = Failed quality assurance

TABLE 3-21
Landfill Gas Monitoring Well Results (Round 2)

Sample Location Sample Number	1A Sp13	1B Sp14	1C Sp16	2A Sp17	2B Sp18	2C Sp19	3A Sp20	3B Sp21	3C Sp22	4A Sp23	4B Sp24	4C Sp26
Volatiles												
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	2J	ND	ND	ND	ND	ND	3	ND	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	ND	ND	ND	ND	Fqa	229	ND	Fqa	ND	ND	ND	ND
Acetone	Fqa	Fqa	Fqa	Fqa	Fqa	Fqa	Fqa	Fqa	Fqa	Fqa	Fqa	Fqa
2-Butanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	2	ND	ND	1J	ND	2J	ND	ND	ND	ND
1,1-Dichloroethane	ND	5	27	ND	ND	9	ND	16	7	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,2-Dichloroethene	ND	ND	17	ND	ND	2	ND	22	5	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	2	5	ND	ND	2	ND	6	ND	ND	ND	ND
1,1,1-Trichloroethane	5	70	83	3	10	101	2	72	6	ND	Fqa	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	Fqa	ND	ND
Tetrachloroethene	15	101	81	Fqa	Fqa	30	Fqa	89	Fqa	ND	20	Fqa
Carbon Tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethylvinylether	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-Pentanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acrylonitrile	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tot Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 3-21
Landfill Gas Monitoring Well Results (Round 2)

(continued)

Sample Location Sample Number	5A Sp27	5B Sp28	5C Sp29	6A Sp30	6B Sp31	6C Sp32	7A Sp33	7B Sp34	7C Sp36	201B Sp01	201C Sp02	202A Sp3/4
Volatiles												
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	1J	ND	3	ND	ND	ND	8
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	Fqa	ND	ND	ND	ND	ND	ND	ND	Fqa	ND	ND	ND
Acetone	Fqa	Fqa	Fqa	ND	Fqa	Fqa	Fqa	166	Fqa	Fqa	Fqa	Fqa
2-Butanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	1J	ND	ND	ND	10
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	54	ND	2J	ND	129
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	68
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	1	ND	ND	ND	ND	ND	ND	ND	ND	34
1,1,1-Trichloroethane	Fqa	Fqa	Fqa	Fqa	370	Fqa	Fqa	692	Fqa	10	24	258
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	Fqa	Fqa	Fqa	Fqa	500	22	Fqa	62	Fqa	14	16	292
Carbon Tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	ND	2	ND	ND	ND	ND	ND	ND	ND	ND	10
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethylvinylether	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-Pentanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acrylonitrile	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tot Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

TABLE 3-21
Landfill Gas Monitoring Well Results (Round 2)

(continued)

Sample Location Sample Number	202B Sp05	202C Sp06	203A Sp07	203B Sp08	203C Sp09	204A Sp10	204B Sp11	204C Sp12	Blank Sp39	Blank Sp37	Blank Sp38
Volatiles											
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	6	ND	ND	1J	ND	1J	4	ND	ND	ND
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	Fqa	ND	ND	ND	ND	ND	ND	ND	68	Fqa	87
Acetone	Fqa	Fqa	Fqa	Fqa	Fqa	613	Fqa	Fqa	169	Fqa	14
2-Butanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	9	31	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	74	326	ND	11	12	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,2-Dichloroethene	21	10	ND	ND	4	ND	ND	ND	ND	ND	ND
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	14	25	ND	9	6	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	310	226	ND	90	68	23	25	46	18	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	208	129	Fqa	105	76	75	53	74	2	1J	1J
Carbon Tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	ND	2J	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trans-1,3-Dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-Chloroethylvinylether	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-Pentanone	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acrolein	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acrylonitrile	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tot Xylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

r billion on a volume per volume basis.
andices for individual sample detection

Fqa = failed assurance quality
J = estimated value

Values shown have been rounded to nearest whole number.

TABLE 3-22
Landfill Gas Monitoring Well Results (Round 3)

Sample Location Sample Number	1A 060	1B 056/059	1C 058	2A 028	2B 018	2C 041	3A 033	3B 003	3C 015	4A 048	4B 010/029	4C 024
Compounds												
Vinyl Chloride	0.93 U	0.93 U	0.93 U	0.93 U	0.93 U	0.93 U	1.13 U	0.93 U	0.93 U	6.04	1.13 U	0.93 U
1,1-Dichloroethene	0.76 U	0.70	3.33	0.76 U	0.76 U	0.76 U	0.92 U	1.13	0.76 U	0.92 U	1.09	0.76 U
Methylene Chloride	1.20 U	1.20 U	2.23	1.20 U	1.20 U	1.20 U	1.46 U	1.20 U	1.65	1.37	1.29	1.20 U
Trans - 1,2-Dichloroethene	0.73 U	0.73 U	0.73 U	0.73 U	0.73 U	0.73 U	0.89 U	0.73 U	0.73 U	1.00	0.89 U	0.73 U
1,1-Dichloroethane	0.66 U	3.73	26.1	0.66 U	0.66 U	3.08	0.8 U	5.94	3.32	8.23	2.12	0.66 U
Chloroform	1.30 U	2.07	1.30 U	1.30 U	1.30 U	1.64	1.58 U	1.3 U	1.30 U	1.58 U	1.58 U	1.30 U
1,1,1-Trichloroethane	21.8	64.95	87.1	2.18	1.08 U	36.4	1.31 U	26.6	3.50	1.31 U	22.3	1.08 U
Carbon Tetrachloride	1.71 U	1.71 U	1.71 U	1.71 U	1.71 U	1.71 U	2.08 U	1.71 U	1.71 U	2.08 U	2.08 U	1.71 U
Benzene	1.25 U	1.25 U	1.25 U	1.25 U	1.25 U	1.25 U	1.51 U	1.25 U	1.25 U	4.03	1.51 U	1.25 U
1,2-Dichloroethane	0.81 U	0.81 U	0.81 U	0.81 U	0.81 U	0.81 U	0.98 U	0.81 U	0.81 U	0.98 U	0.98 U	0.81 U
Trichloroethene	0.73 U	1.07	2.96	0.73 U	0.73 U	0.73 U	0.89 U	1.64	0.73 U	0.89 U	0.89 U	0.73 U
Bromodichloromethane	1.27 U	1.27 U	1.27 U	1.27 U	1.27 U	1.27 U	1.55 U	1.27 U	1.27 U	1.55 U	1.55 U	1.27 U
1,1,2-Trichloroethane	1.25 U	1.25 U	1.25 U	1.25 U	1.25 U	1.25 U	1.52 U	1.25 U	1.25 U	1.52 U	1.52 U	1.25 U
Tetrachloroethene	40.0	116	91.4	3.33	2.78	10.3	3.17	45.1	3.50	5.44	38.99	0.81 U
Chlorobenzene	2.52 U	2.52 U	2.52 U	2.52 U	2.52 U	2.52 U	3.06 U	2.52 U	2.52 U	3.06 U	3.06 U	2.52 U
1,1,2,2-Tetrachloroethane	1.32 U	1.32 U	1.32 U	1.32 U	1.32 U	1.32 U	1.6 U	1.32 U	1.32 U	19.85	1.6 U	1.32 U

TABLE 3-22
Landfill Gas Monitoring Well Results (Round 3)

(continued)

Sample Location Sample Number	5A 026	5B 030	5C 019	6A 050	6B 052	6C 037	7A 017	7B 020	7C 038	201B 007
Compounds										
Vinyl Chloride	0.93 U	0.93 U	0.93 U	0.93 U	0.93 U	0.93 U	1.13 U	1.13 U	1.13 U	1.13 U
1,1-Dichloroethene	0.76 U	0.76 U	0.76 U	0.76 U	0.76 U	0.76 U	0.92 U	9.01	0.92 U	0.92 U
Methylene Chloride	1.20 U	1.20 U	1.20 U	1.20 U	1.42	1.51	1.46 U	2.66	1.46 U	1.46 U
Trans - 1,2-Dichloroethene	0.73 U	0.73 U	0.73 U	0.73 U	0.73 U	0.73 U	0.89 U	0.89 U	0.89 U	0.89 U
1,1-Dichloroethane	0.66 U	1.96	0.66 U	0.66 U	0.66 U	0.66 U	0.8 U	26.3	0.8 U	1.22
Chloroform	1.30 U	2.14	1.30 U	1.48	1.30 U	1.30 U	1.58 U	3.00	1.58 U	1.58 U
1,1,1-Trichloroethane	1.12	52.4	4.86	3.78	16.5	7.52	1.31 U	252	10.0	14.4
Carbon Tetrachloride	1.71 U	1.71 U	1.71 U	1.71 U	1.71 U	1.71 U	2.08 U	2.08 U	2.08 U	2.08 U
Benzene	1.25 U	1.25 U	1.25 U	1.25 U	1.25 U	1.25 U	1.61	1.51 U	1.51 U	1.51 U
1,2-Dichloroethane	0.81 U	5.34	0.81 U	0.81 U	0.81 U	0.81 U	0.98 U	29.7	0.98 U	0.98 U
Trichloroethene	0.73 U	0.73 U	0.73 U	0.73 U	0.73 U	0.73 U	0.89 U	0.89 U	0.89 U	0.89 U
Bromodichloromethane	1.27 U	1.27 U	1.27 U	1.27 U	1.27 U	1.27 U	1.55 U	1.55 U	1.55 U	1.55 U
1,1,2-Trichloroethane	1.25 U	1.25 U	1.25 U	1.25 U	1.25 U	1.25 U	1.52 U	1.52 U	1.52 U	1.52 U
Tetrachloroethene	3.60	40.7	7.21	21.0	17.8	19.4	9.62	89.7	8.04	15.0
Chlorobenzene	2.52 U	2.52 U	2.52 U	2.52 U	2.52 U	2.52 U	3.06 U	3.06 U	3.06 U	3.06 U
1,1,2,2-Tetrachloroethane	1.32 U	1.32 U	1.32 U	1.32 U	1.32 U	1.32 U	1.6 U	1.6 U	1.6 U	1.6 U

TABLE 3-22
Landfill Gas Monitoring Well Results (Round 3)
(continued)

Sample Location Sample Number	201C 042	202A 014	202B 032	202C 039	203B 043	203C 002	204A 035	204B 022	204C 031	Blank 051
Compounds										
Vinyl Chloride	1.13 U	1.13 U	1.13 U	1.13 U	1.13 U	1.13 U	1.13 U	1.13 U	1.13 U	0.93 U
1,1-Dichloroethene	1.98	18.8	16.0	17.8	8.36	6.10	0.92 U	0.92 U	0.92 U	0.76 U
Methylene Chloride	1.46 U	14.9	16.0	3.73	3.12	3.52	1.46 U	1.46 U	1.46 U	50.5
Trans - 1,2-Dichloroethene	0.89 U	0.89 U	0.89 U	0.89 U	0.89 U	0.89 U	0.89 U	0.89 U	0.89 U	0.73 U
1,1-Dichloroethane	0.8 U	72.1	60.2	138	8.75	12.9	0.8 U	0.8 U	0.8 U	0.66 U
Chloroform	1.58 U	6.85	5.67	6.46	3.51	3.01	1.58 U	1.58 U	2.83	1.30 U
1,1,1-Trichloroethane	41.85	147	144	1.31 U	57.5	72.7	19.6	12.5	21.7	1.08 U
Carbon Tetrachloride	2.08 U	2.08 U	2.08 U	1.49	2.08 U	2.08 U	2.08 U	2.08 U	2.08 U	1.71 U
Benzene	1.51 U	1.51 U	1.56	1.86	1.51 U	1.62	1.51 U	1.51 U	1.51 U	1.25 U
1,2-Dichloroethane	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.81 U
Trichloroethene	0.89 U	14.3	8.79	10.5	5.65	5.24	0.89 U	0.89 U	0.89 U	0.73 U
Bromodichloromethane	1.55 U	1.55 U	1.55 U	1.55 U	1.55 U	1.55 U	1.55 U	1.55 U	1.55 U	1.27 U
1,1,2-Trichloroethane	1.52 U	1.52 U	1.52 U	1.52 U	1.52 U	1.52 U	1.52 U	1.52 U	1.52 U	1.25 U
Tetrachloroethene	18.5	73.8	117.4	49.8	104	105	28.9	44.6	62.7	0.81 U
Chlorobenzene	3.06 U	3.06 U	3.06 U	3.06 U	3.06 U	3.06 U	3.06 U	3.06 U	3.06 U	2.52 U
1,1,2,2-Tetrachloroethane	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	1.32 U

All results are in parts per billion on a volume per volume basis.
oted. Refer to the appendices for individual sample detection limits.

TABLE 3-23
Summary of Landfill Gas Well Data for Rounds 1, 2, and 3

Compound Detected	Well I.D.	Round 1 Shallow Probe	Round 1 Medium Probe	Round 1 Deep Probe	Round 2 Shallow Probe	Round 2 Medium Probe	Round 2 Deep Probe	Round 3 Shallow Probe	Round 3 Medium Probe	Round 3 Deep Probe
1,1-Dichloroethane	TNH-1					5	27		4	26
	TNH-2						9			3
	TNH-3					16	7		6	3
	TNH-4							8	2	
	TNH-5								2	
	TNH-7					54			26	
	LFG-201					2 J			1	
	LFG-202	385			129	74	326	72	60	138
	LFG-203		25			11	12		9	13
Trichloroethene	TNH-1					2	5		1	3
	TNH-2						2			
	TNH-3					6			2	
	TNH-5						1			
	LFG-202	119			34	14	25	14	9	10
	LFG-203	24				9	6		6	5
1,1,1-Trichloroethane	TNH-1				5	70	83	22	65	87
	TNH-2				3	10	101	2		36
	TNH-3				2	72	6		27	3
	TNH-4								22	
	TNH-5							1	52	5

TABLE 3-23
Summary of Landfill Gas Well Data for Rounds 1, 2, and 3
(continued)

Compound Detected	Well I.D.	Round 1 Shallow Probe	Round 1 Medium Probe	Round 1 Deep Probe	Round 2 Shallow Probe	Round 2 Medium Probe	Round 2 Deep Probe	Round 3 Shallow Probe	Round 3 Medium Probe	Round 3 Deep Probe
1,1,1-Trichloroethane (continued)	TNH-6					370		4	16	8
	TNH-7	152				692			252	10
	LFG-201					10	24		14	42
	LFG-202	612			258	310	226	147	144	
	LFG-203	198	194			90	68		58	73
	LFG-204	79			23	25	46	20	12	22
1,1-Dichloroethene	TNH-1						2		1	3
	TNH-2						1 J			1
	TNH-3					2 J			1	
	TNH-4								1	
	TNH-7					1 J			9	
	LFG-201									2
	LFG-202				10	9	31	19	16	18
	LFG-203								8	6
Tetrachloroethene	TNH-1				15	101	81	40	116	91
	TNH-2						30	3	3	10
	TNH-3					89		3	45	3
	TNH-4					20		5	39	
	TNH-5							4	41	7
		31		14 J		500	22	21	18	19

TABLE 3-23
Summary of Landfill Gas Well Data for Rounds 1, 2, and 3
(continued)

		Round 1			Round 2			Round 3		
Compound Detected	Well I.D.	Shallow Probe	Medium Probe	Deep Probe	Shallow Probe	Medium Probe	Deep Probe	Shallow Probe	Medium Probe	Deep Probe
Tetrachloroethene (continued)	TNH-7					62		10	90	8
	LFG-201		123			14	16		15	19
	LFG-202	614			292	208	129	74	117	50
	LFG-203	478	123			105	76		104	105
	LFG-204	131			75	53	74	29	45	63
Chloroform	TNH-1					2 J			2	
	TNH-2									2
	TNH-3					3				
	TNH-5								2	
	TNH-6						1 J	1		
	TNH-7					3			3	6
	LFG-202				8		6	7	6	3
	LFG-203						1 J		4	3
	LFG-204					1 J	4			
Trans-1,2-Dichloroethene	TNH-1						17			
	TNH-2						2			
	TNH-3					22	5			
	TNH-4							1		
	LFG-202				68	21	10			
	LFG-203						4			
								6		

TABLE 3-23
Summary of Landfill Gas Well Data for Rounds 1, 2, and 3
(continued)

Compound Detected	Well I.D.	Round 1			Round 2			Round 3		
		Shallow Probe	Medium Probe	Deep Probe	Shallow Probe	Medium Probe	Deep Probe	Shallow Probe	Medium Probe	Deep Probe
1,2-Dichloroethane	TNH-5								5	
	TNH-7								30	
1,1,2,2-Tetrachloroethane	TNH-4							20		
1,2-Dichloropropane	TNH-5						2			
	LFG-202				10		2 J			
Benzene	TNH-4							4		
	TNH-7							2		
	LFG-202								2	2
	LFG-203									2
Carbon Tetrachloride	LFG-202									1

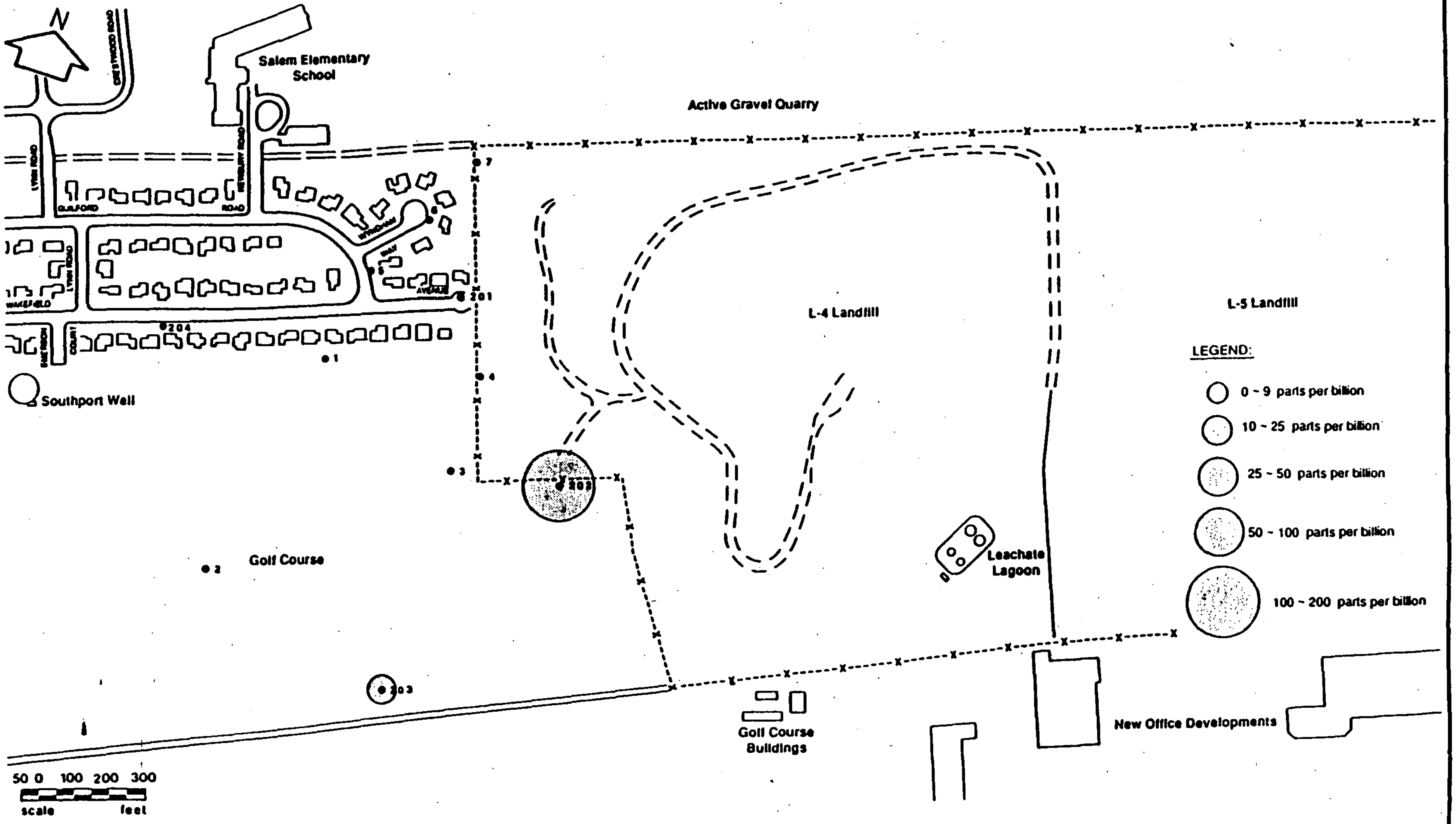
Notes:

1. All concentrations are in parts per billion on a volume per volume basis. Values have been rounded to the nearest whole number.
2. Only those data points showing detectable concentrations are depicted. Acetone and Methylene Chloride are not shown.
3. J = estimated value

FIGURE 3-7

DOT PLOTS OF SUBSURFACE GAS DETECTED IN THE OFF-SITE AREAS

(Note: Figure 3-7 is comprised of 57 individual figures which follow)



CDM

scientists,

nts

Figure 0-0

Trichloroethene
Round 1 (Shallow)

Port Washington Landfill, Port Washington, New York

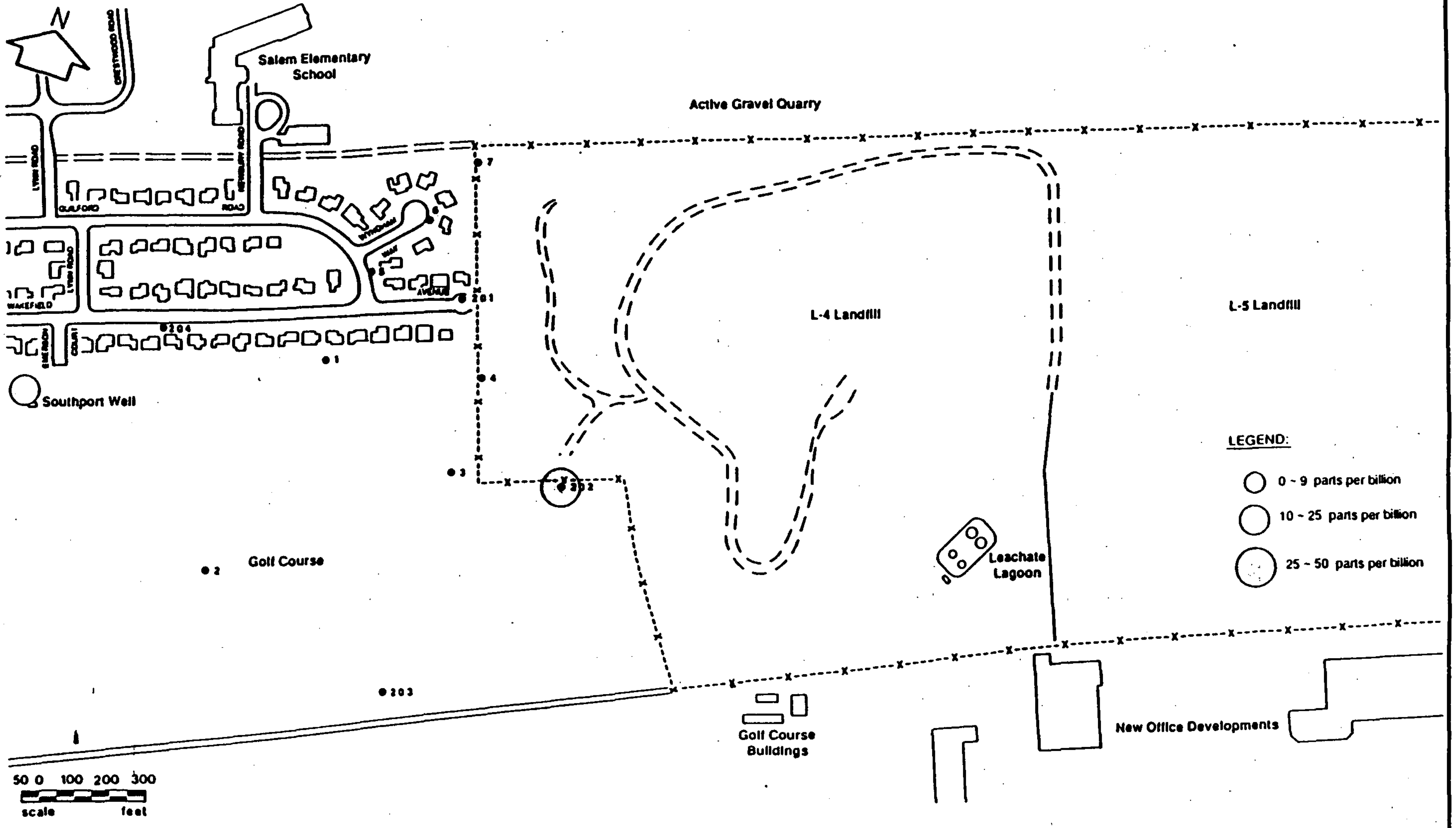


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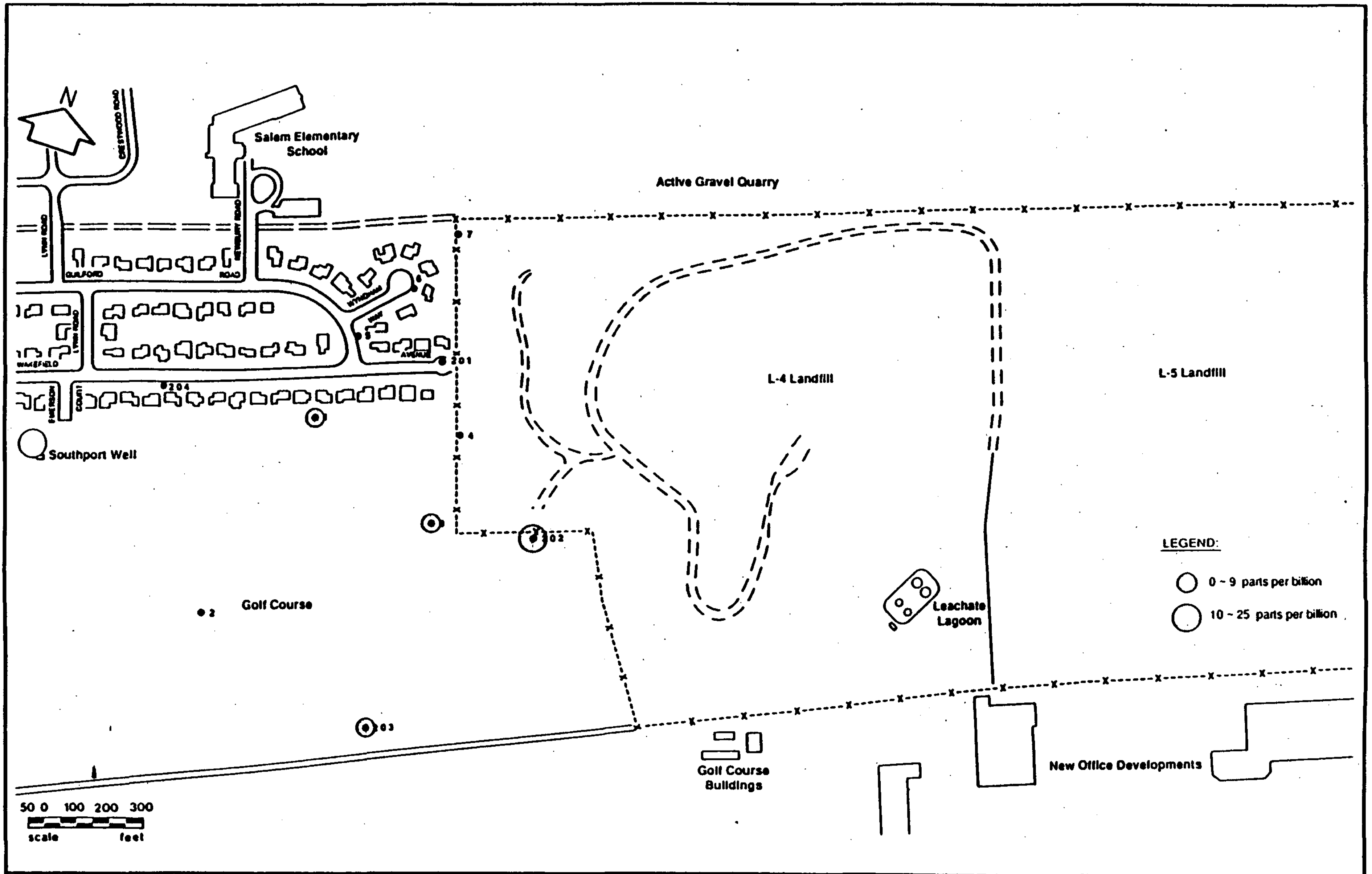
Figure 0-0

Trichloroethene
Round 2 (Shallow)

Port Washington Landfill, Port Washington, New York



CDM

environmental engineers, scientists, ...ants

Figure 0-0

Trichloroethene
Round 2 (Medium)

Port Washington Landfill, Port Washington, New York

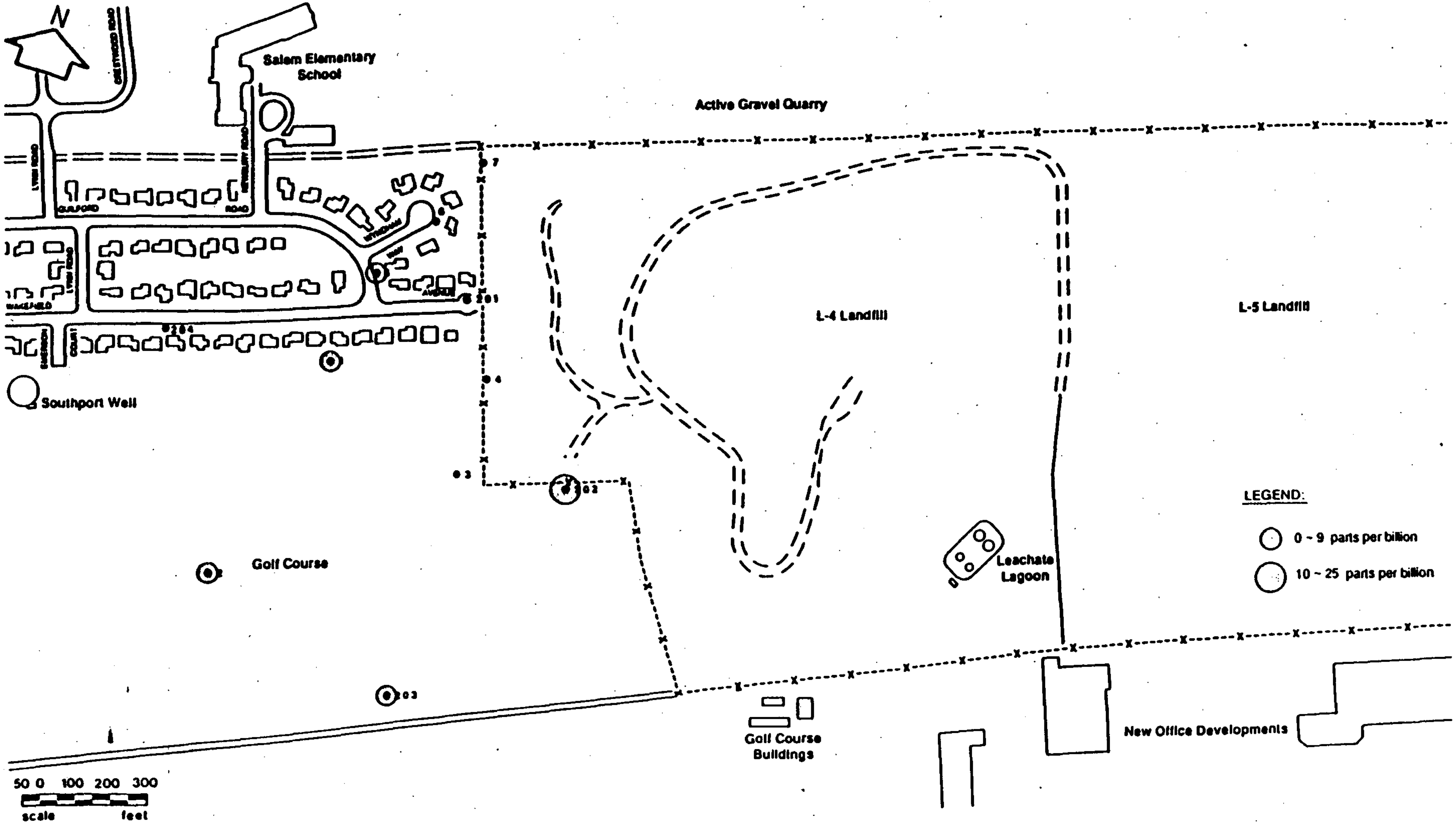


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Figure 0-0

Trichloroethene
Round 2 (Deep)

Port Washington Landfill, Port Washington, New York

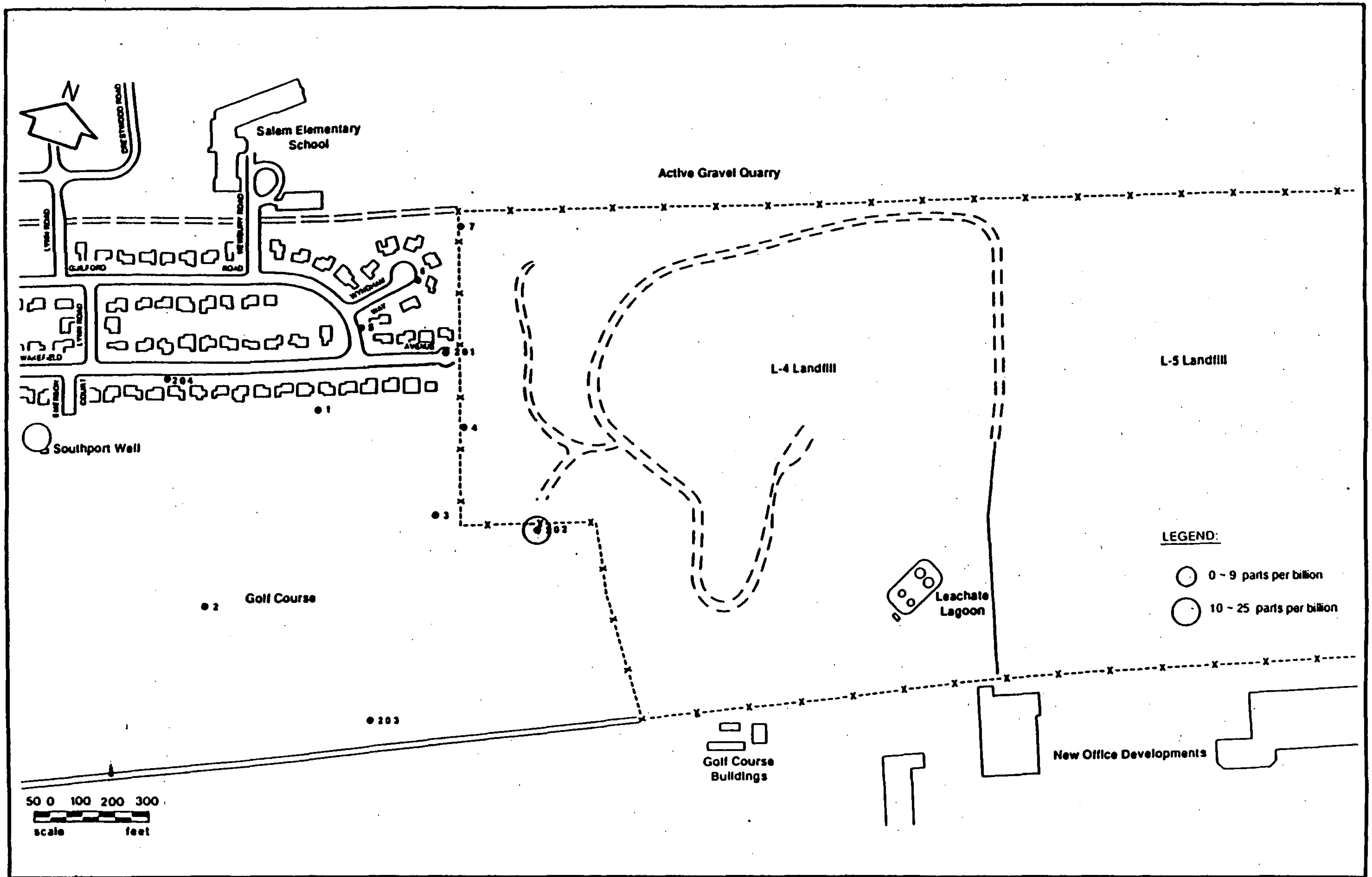

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Figure 0-0
Trichloroethene
Round 3 (Shallow)

Port Washington Landfill, Port Washington, New York

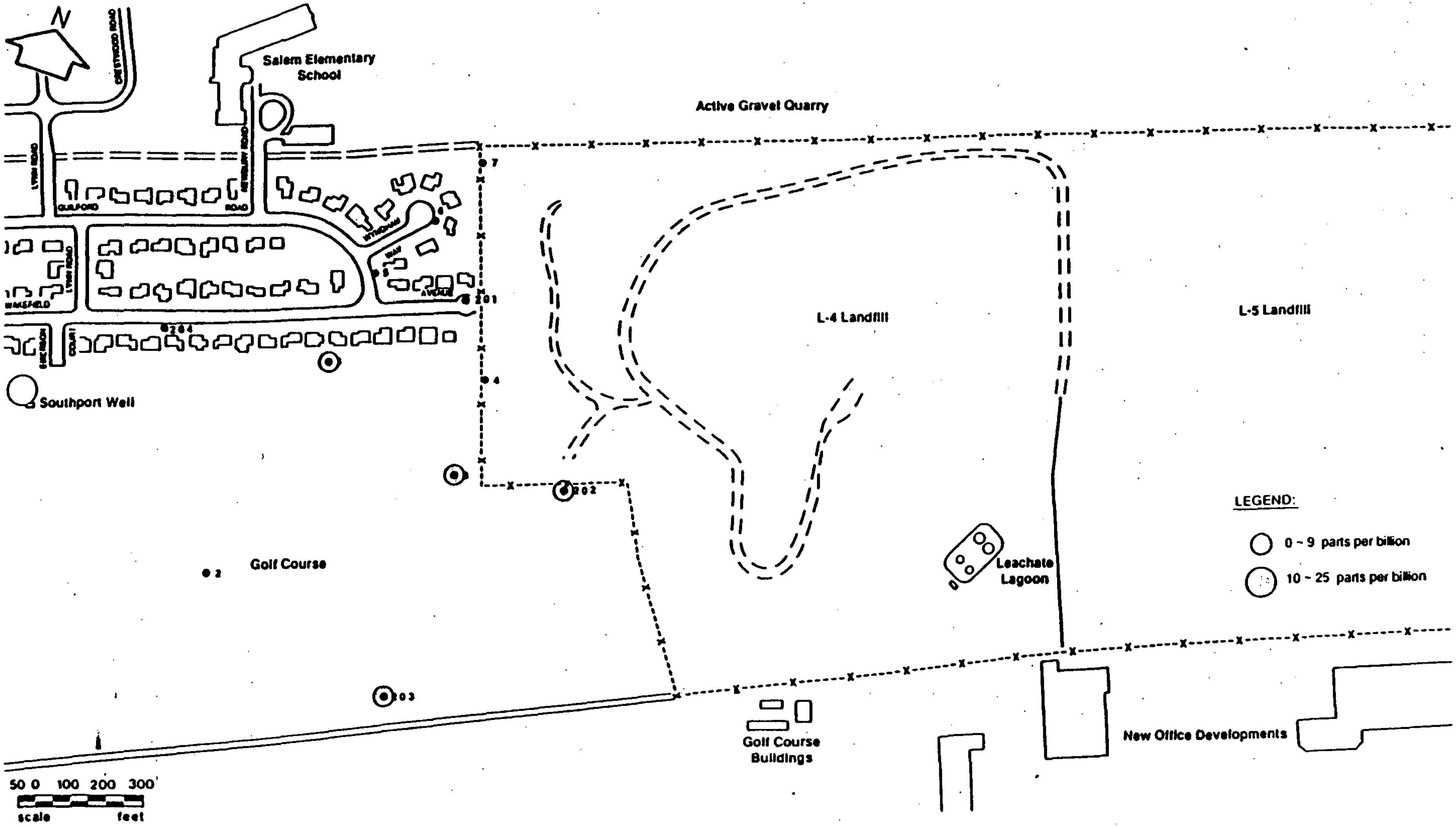

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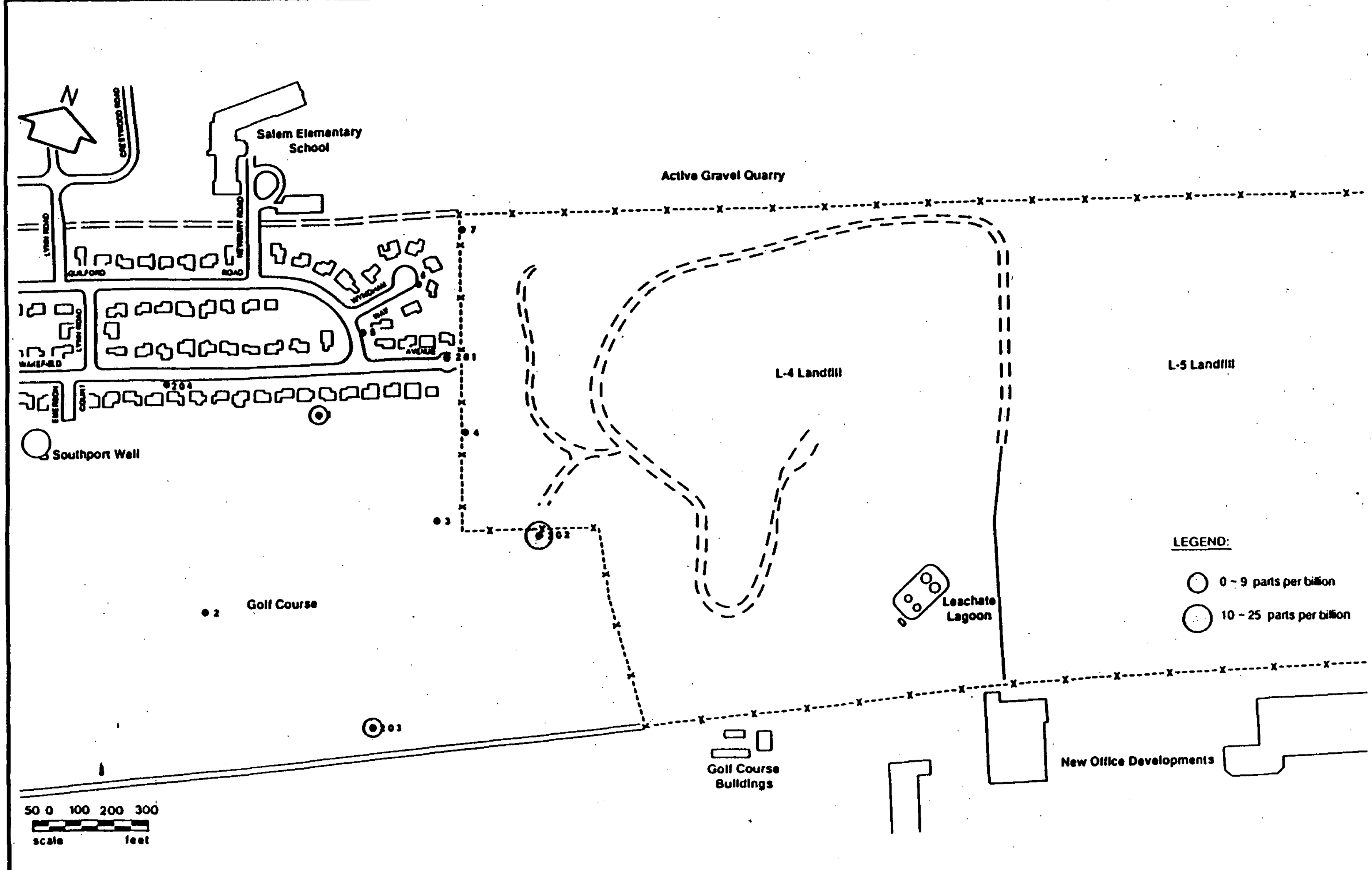
Figure 0-0

Trichloroethene
Round 3 (Medium)

Port Washington Landfill, Port Washington, New York



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Trichloroethene
Round 3 (Deep)

Port Washington Landfill, Port Washington, New York

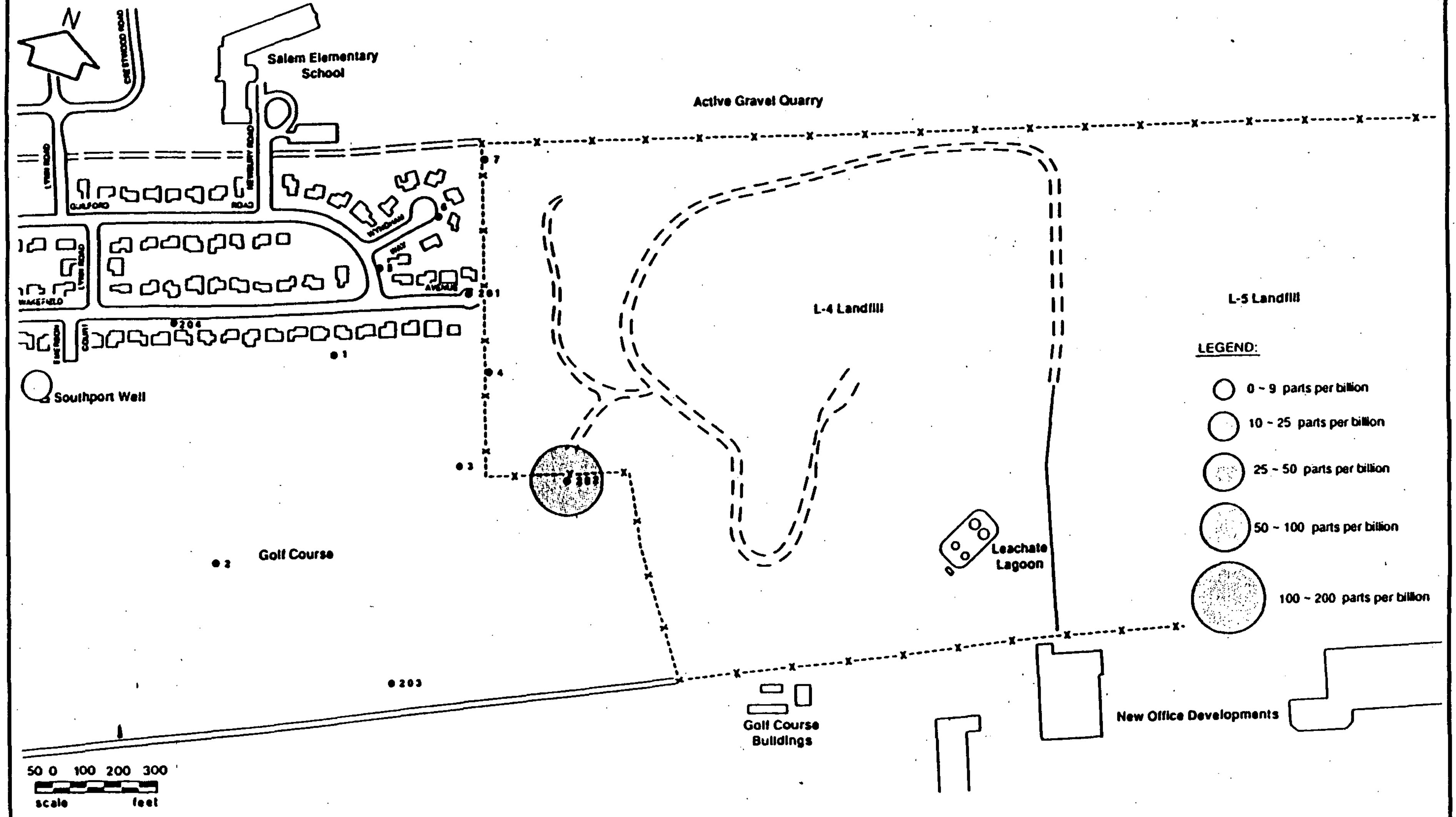

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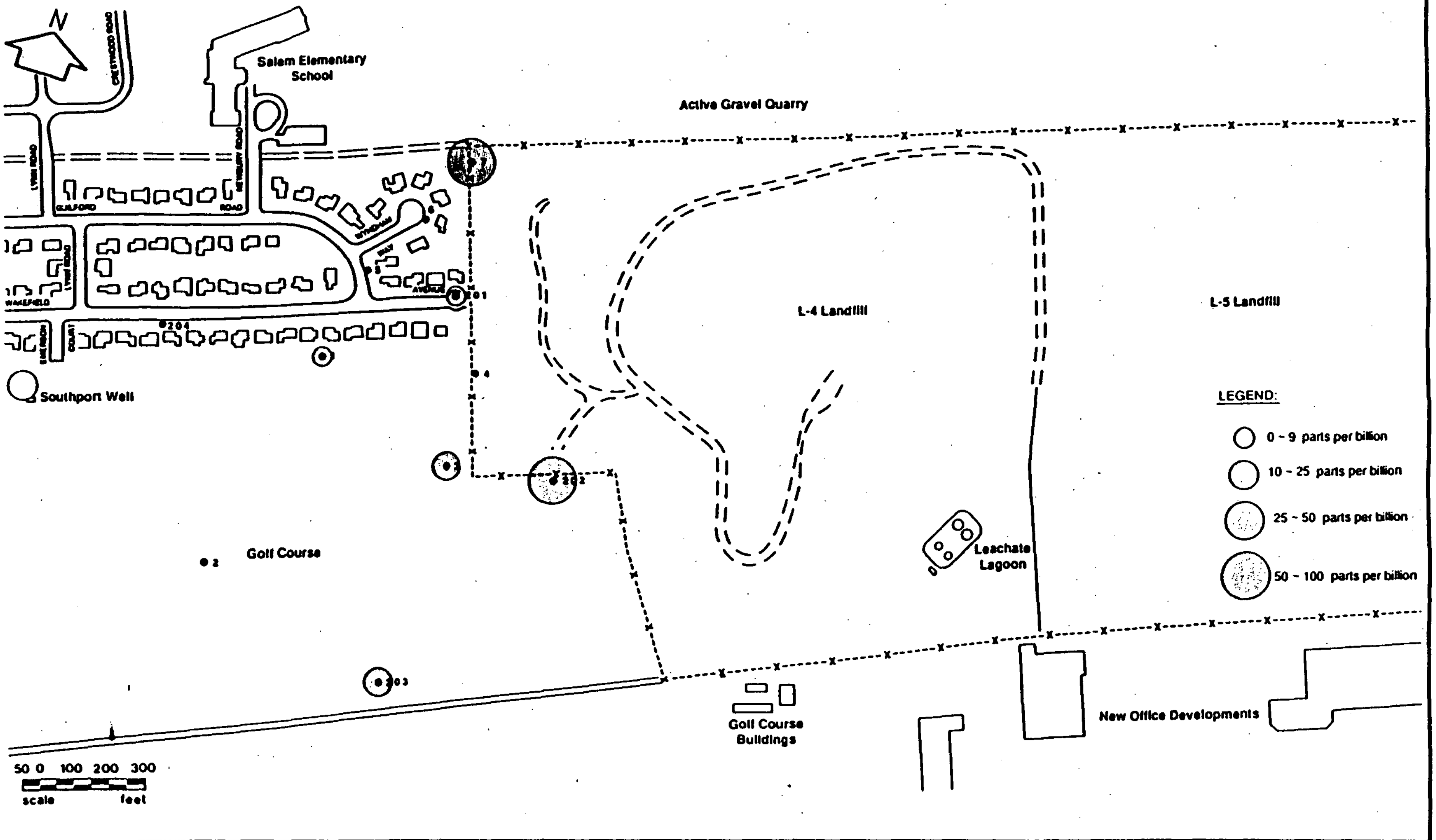
Figure 0-0

1,1 Dichloroethane
Round 2 (Shallow)

Port Washington Landfill, Port Washington, New York



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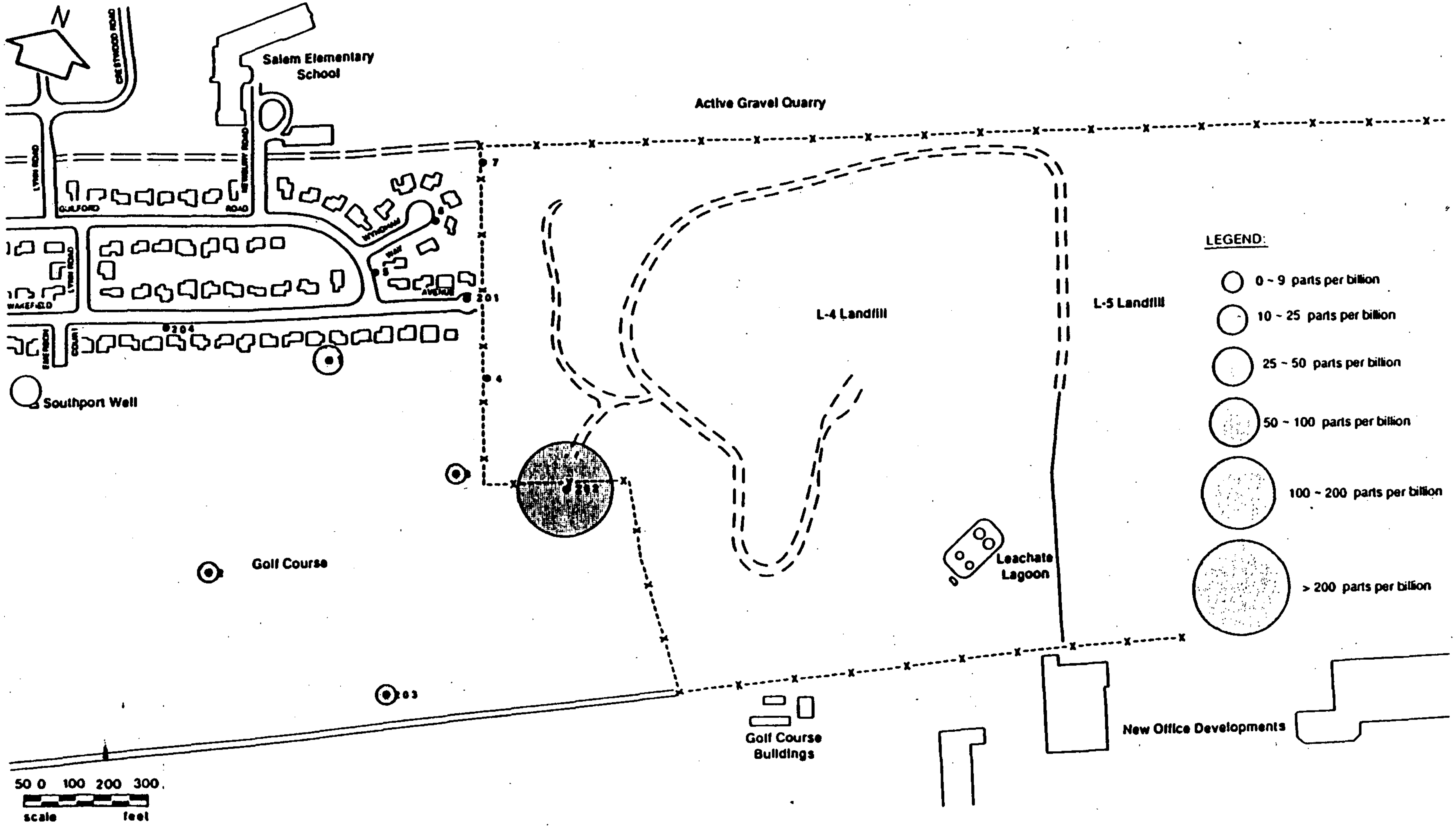
1,1 Dichloroethane
Round 2 (Medium)

Port Washington Landfill, Port Washington, New York



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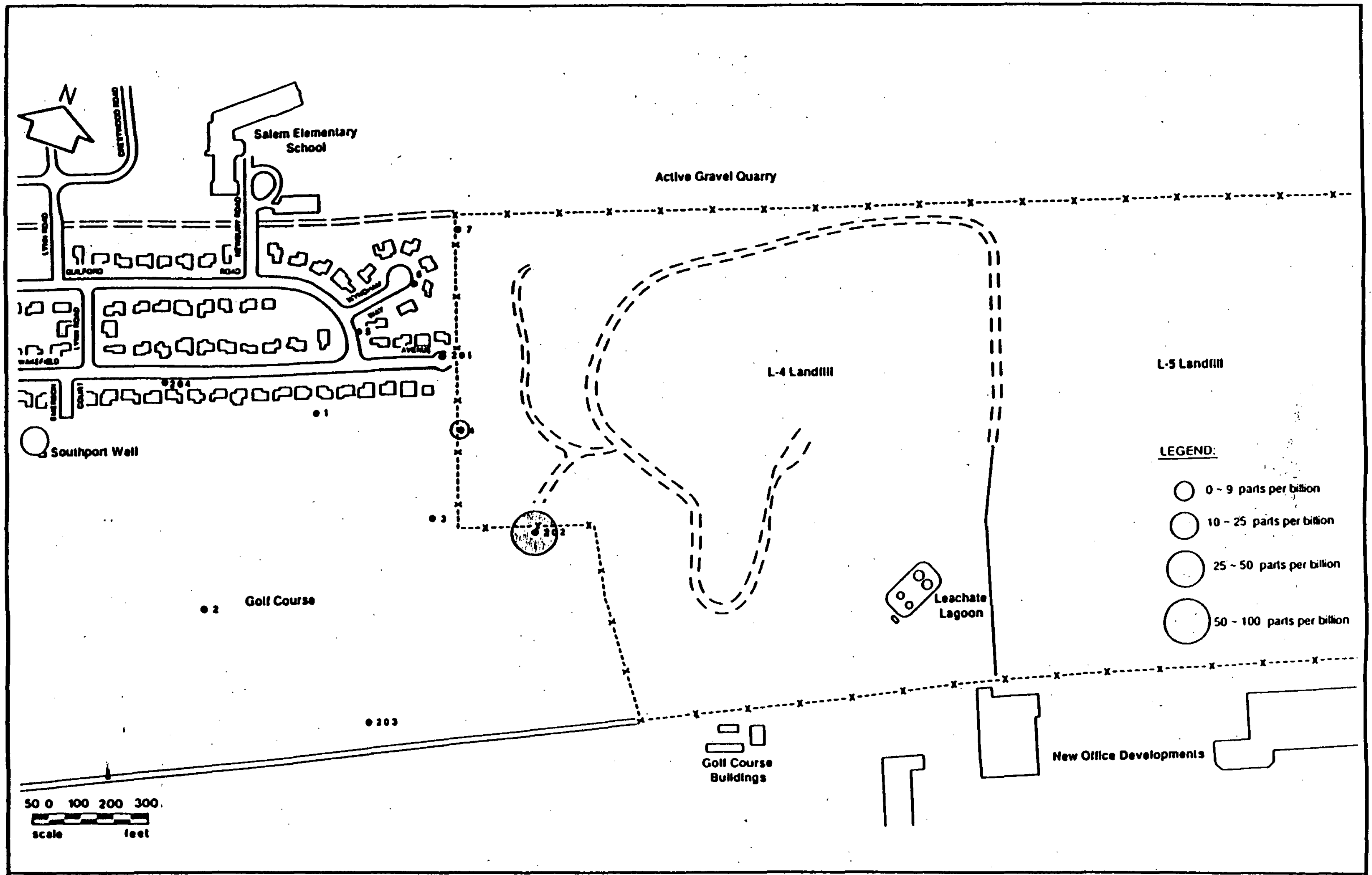
1,1 Dichloroethane

Round 2 (Deep)

Port Washington Landfill, Port Washington, New York



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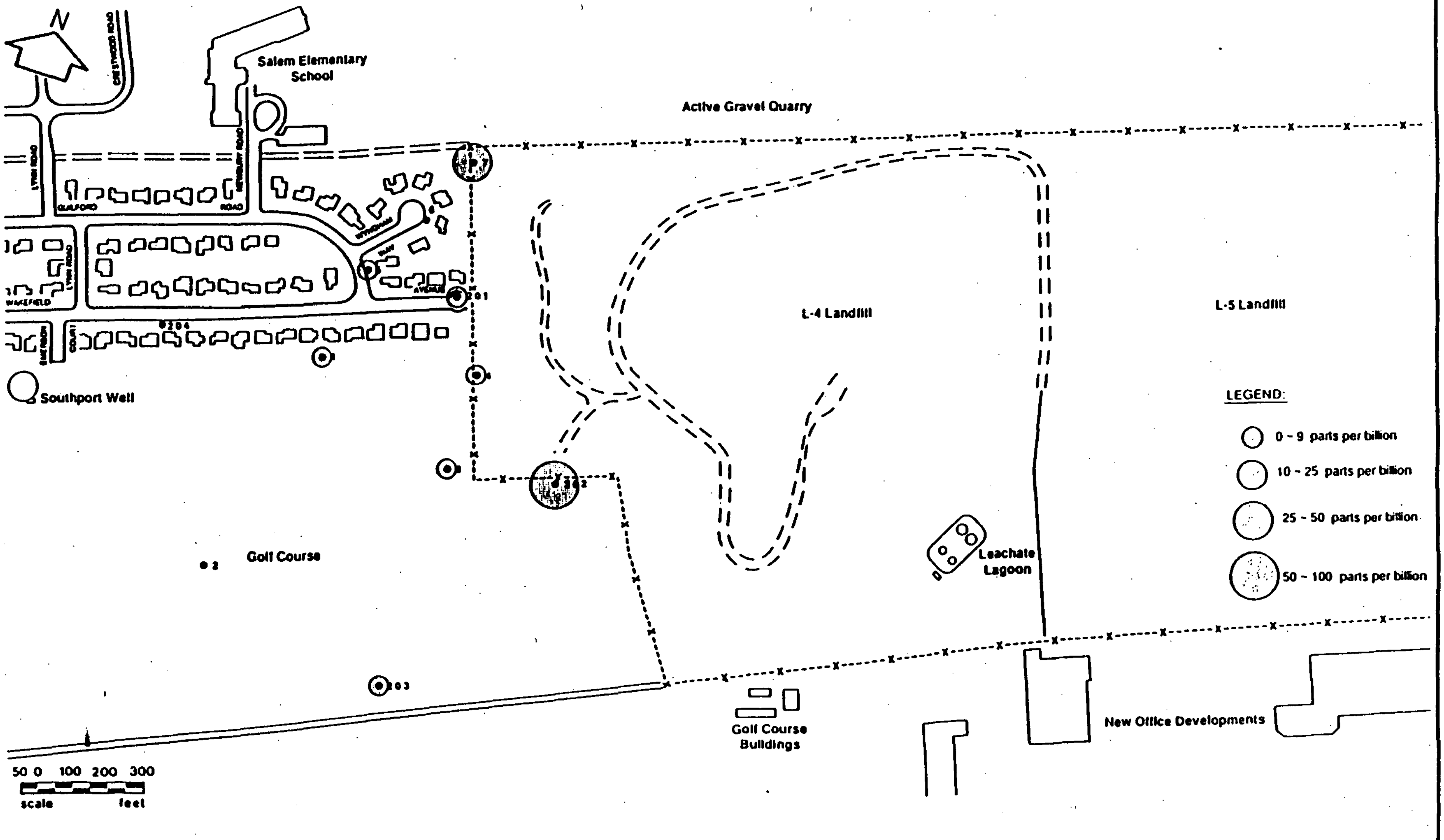
1,1 Dichloroethane
Round 3 (Shallow)

Port Washington Landfill, Port Washington, New York



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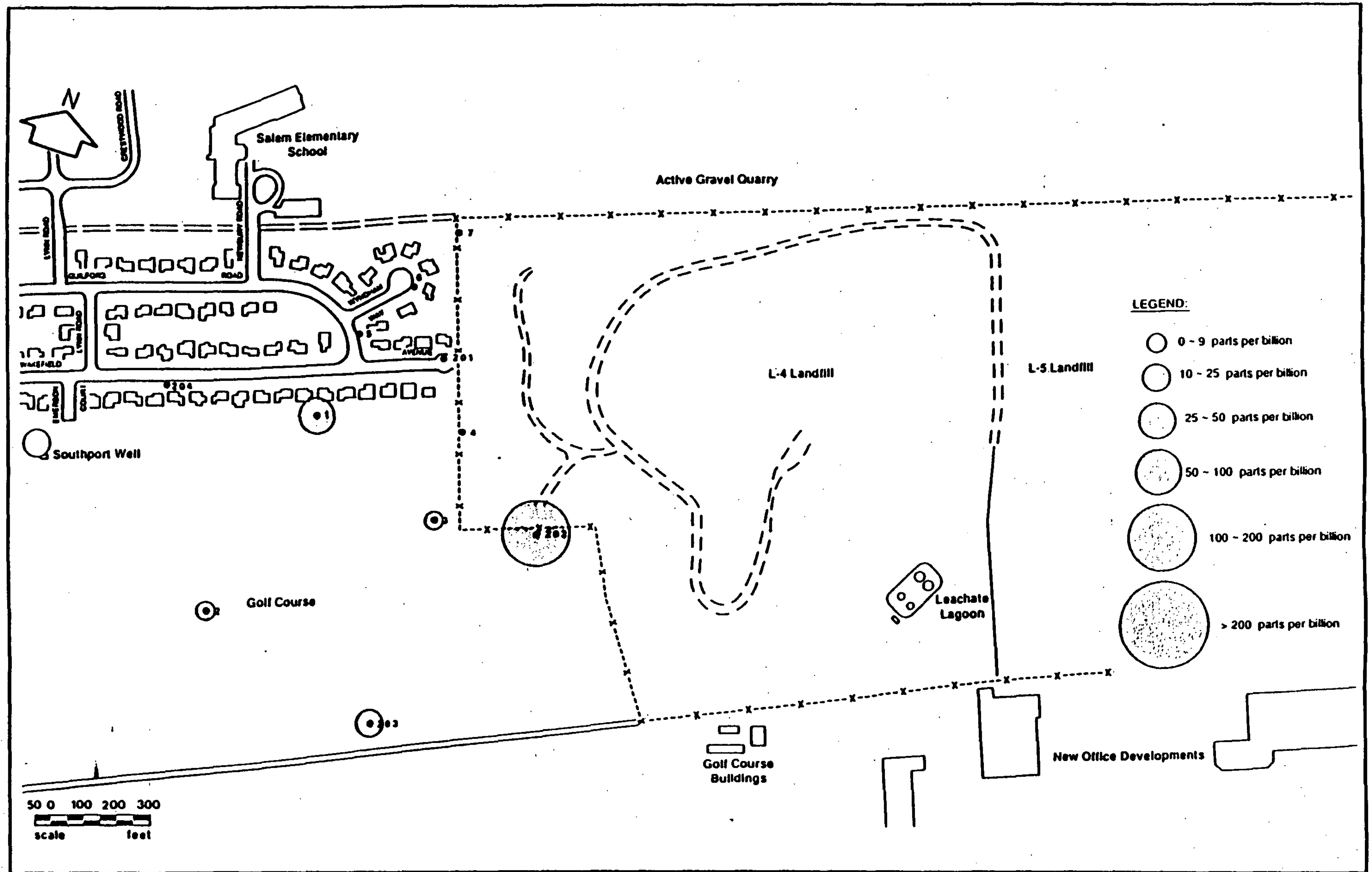
1,1 Dichloroethane
Round 3 (Medium)

Port Washington Landfill, Port Washington, New York



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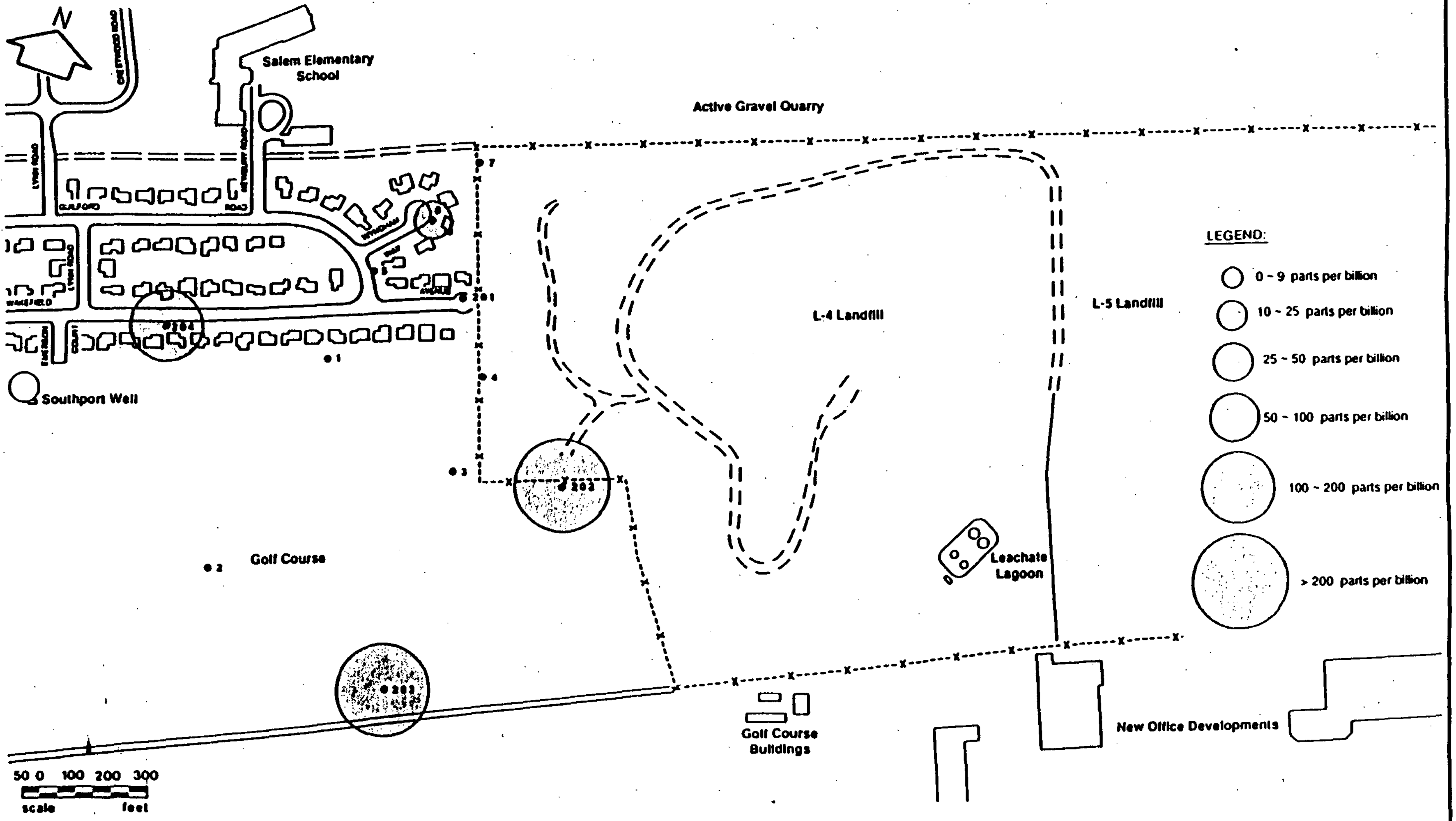
1,1 Dichloroethane
Round 3 (Deep)

Port Washington Landfill, Port Washington, New York



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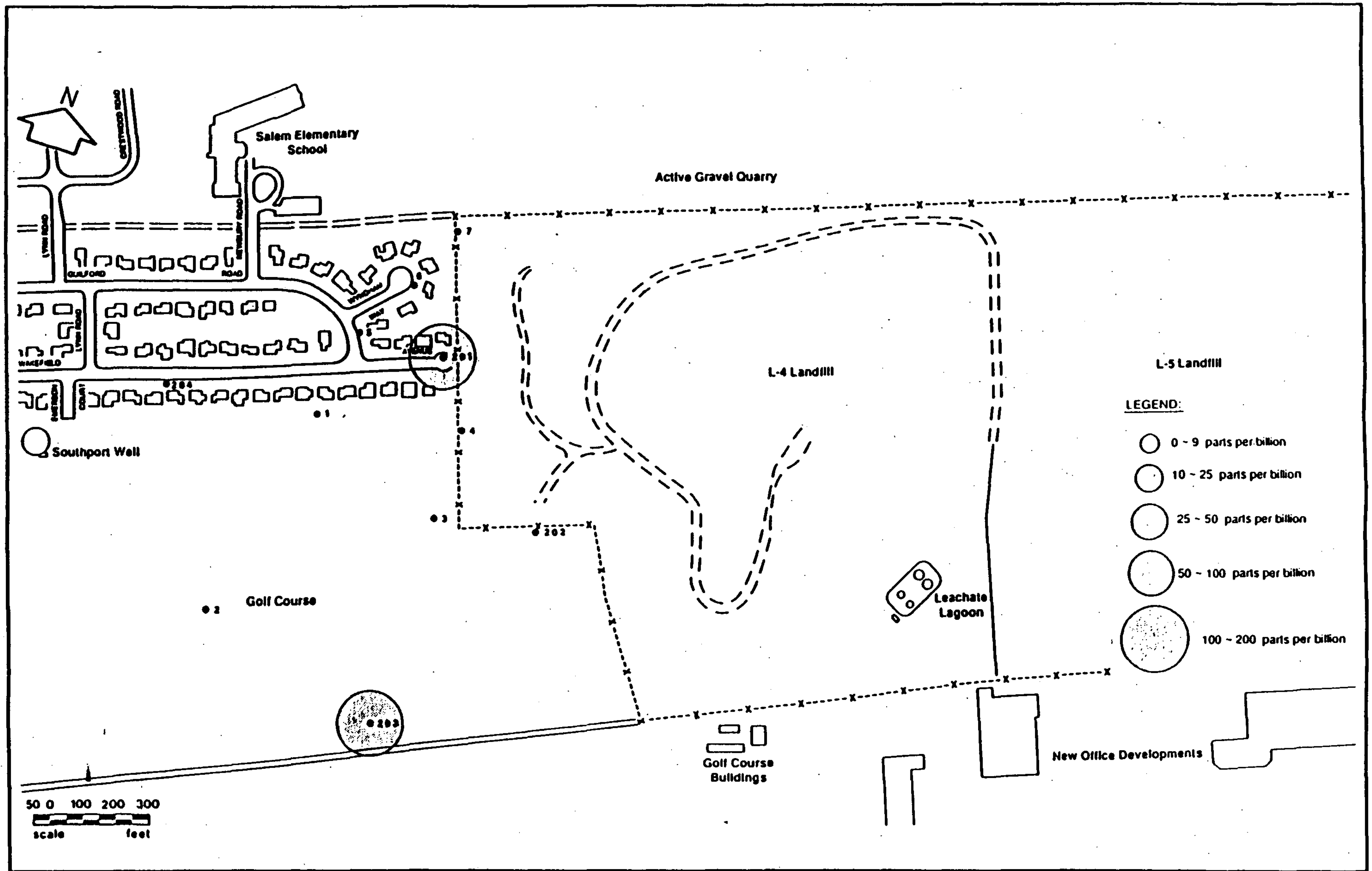
Tetrachloroethene
Round 1 (Shallow)

Port Washington Landfill, Port Washington, New York



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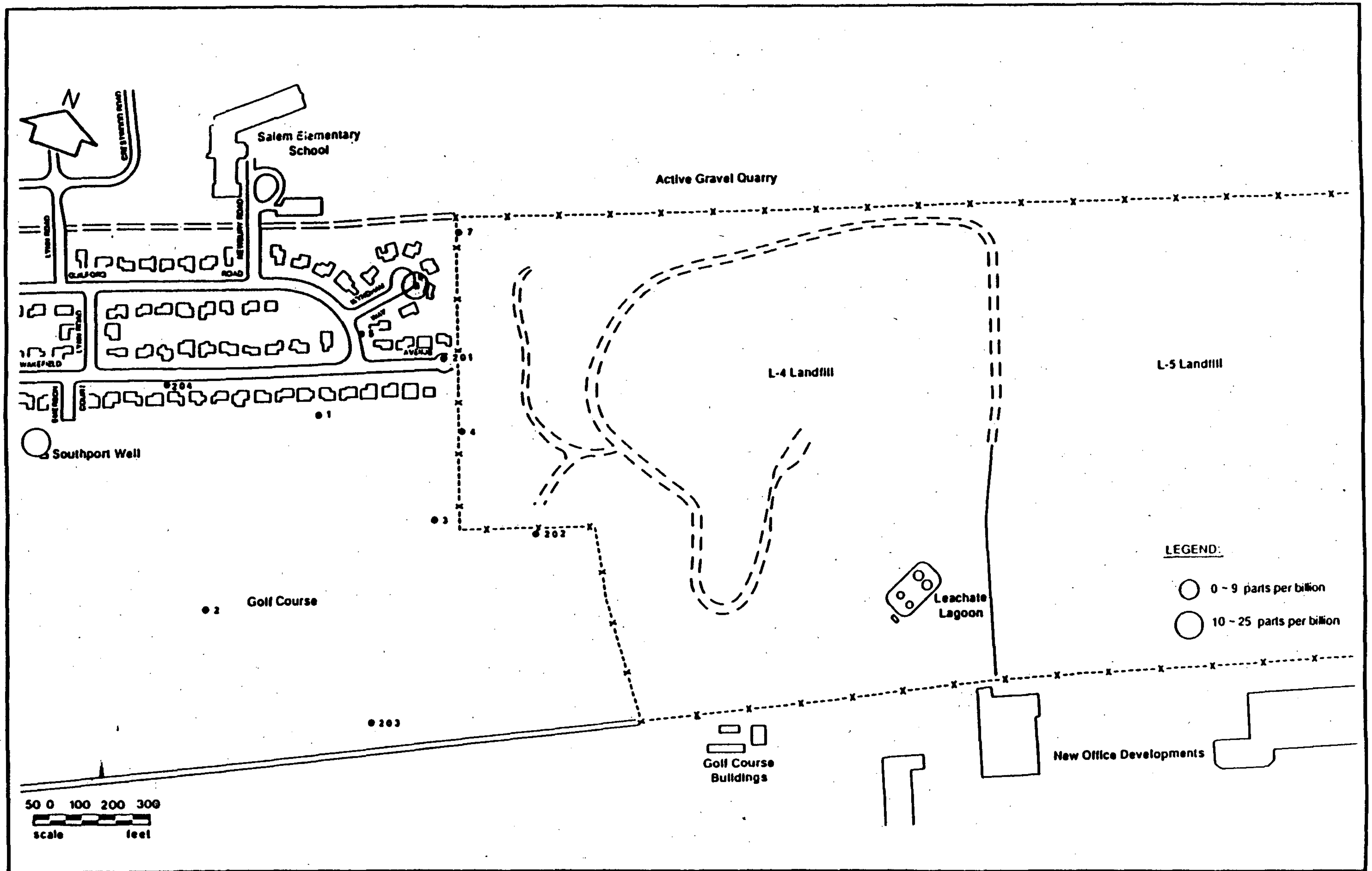
Tetrachloroethene
Round 1 (Medium)

Port Washington Landfill, Port Washington, New York



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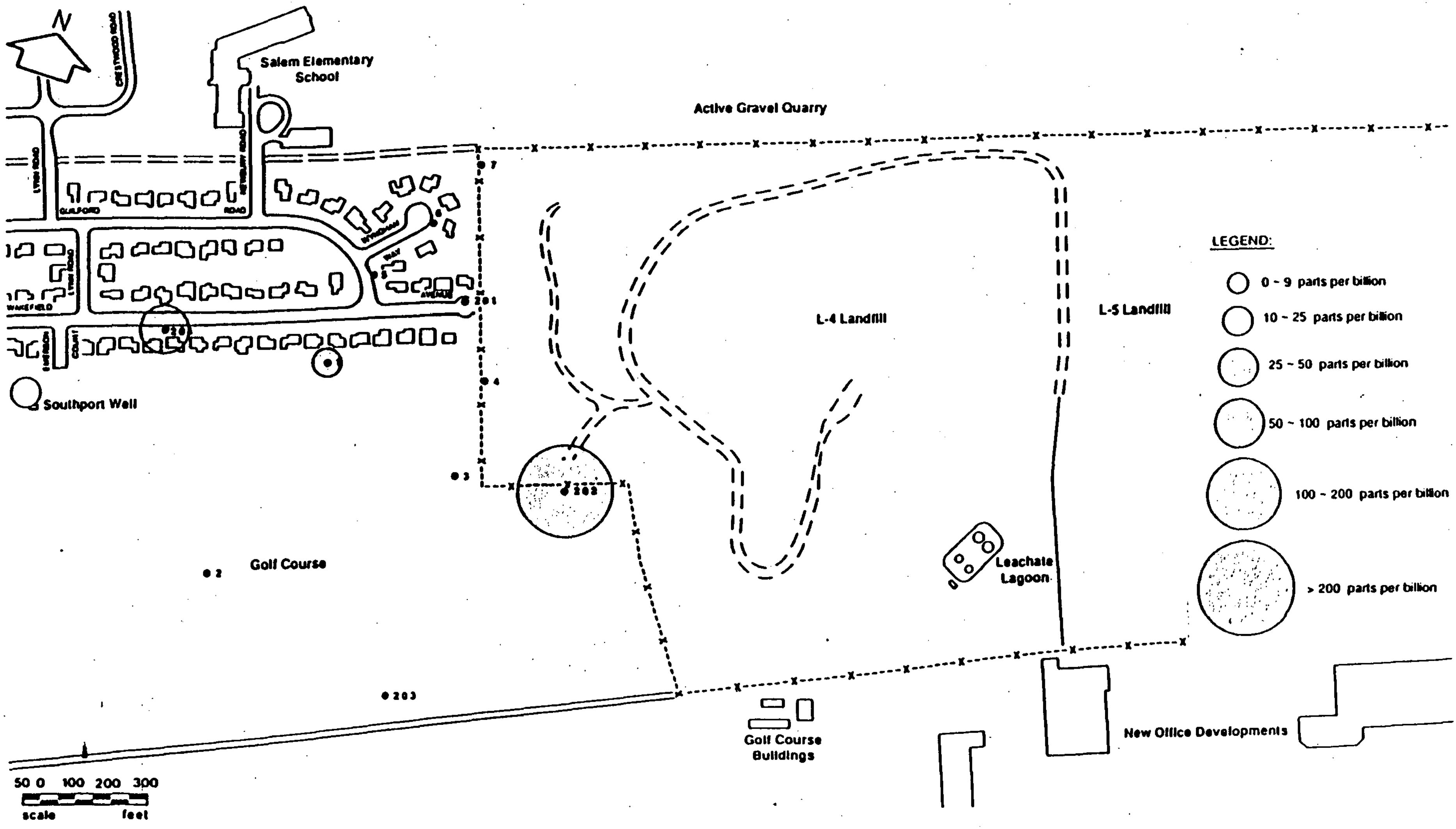
Tetrachloroethene
Round 1 (Deep)

Port Washington Landfill, Port Washington, New York



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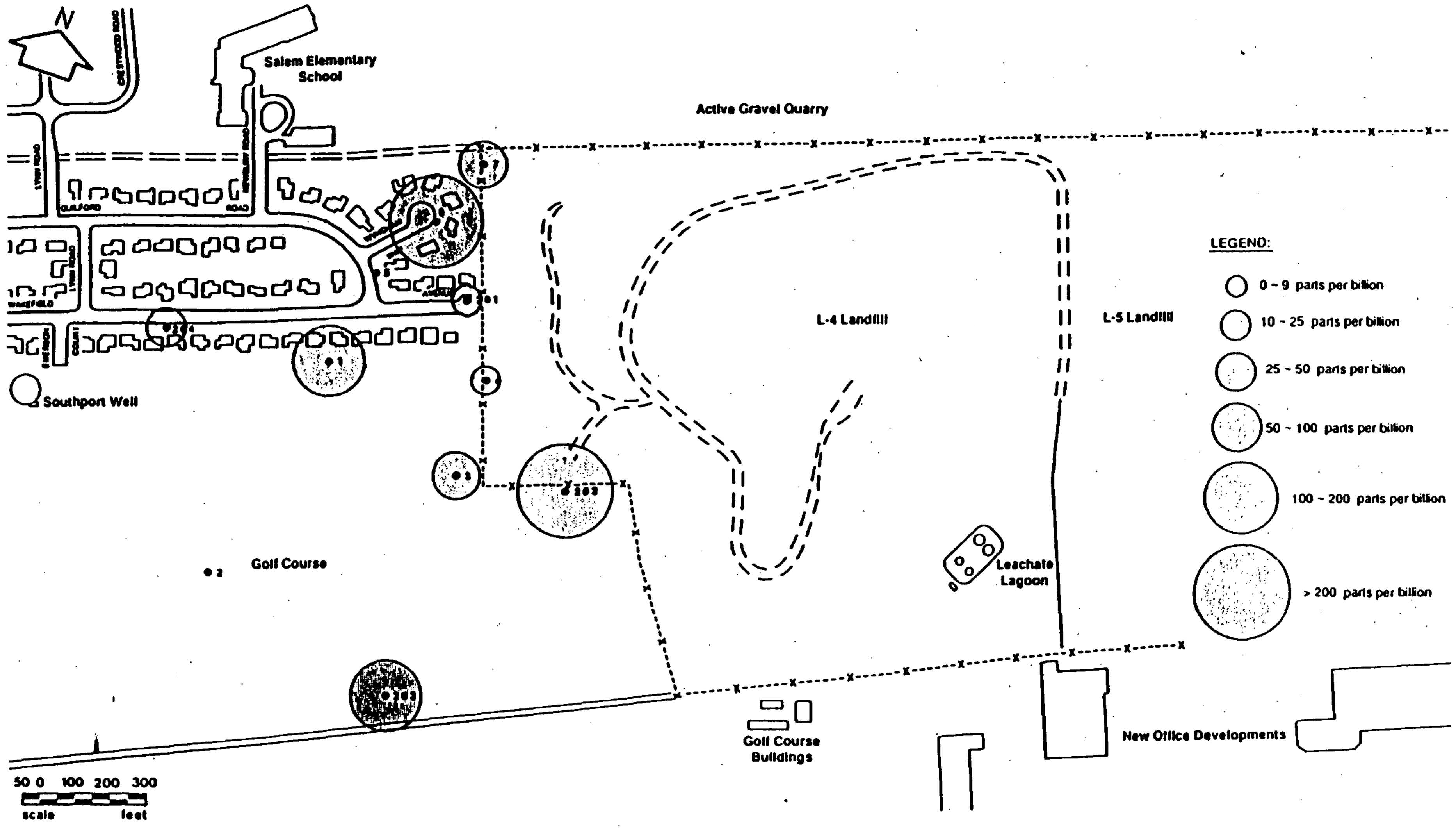
Tetrachloroethene
Round 2 (Shallow)

Port Washington Landfill, Port Washington, New York



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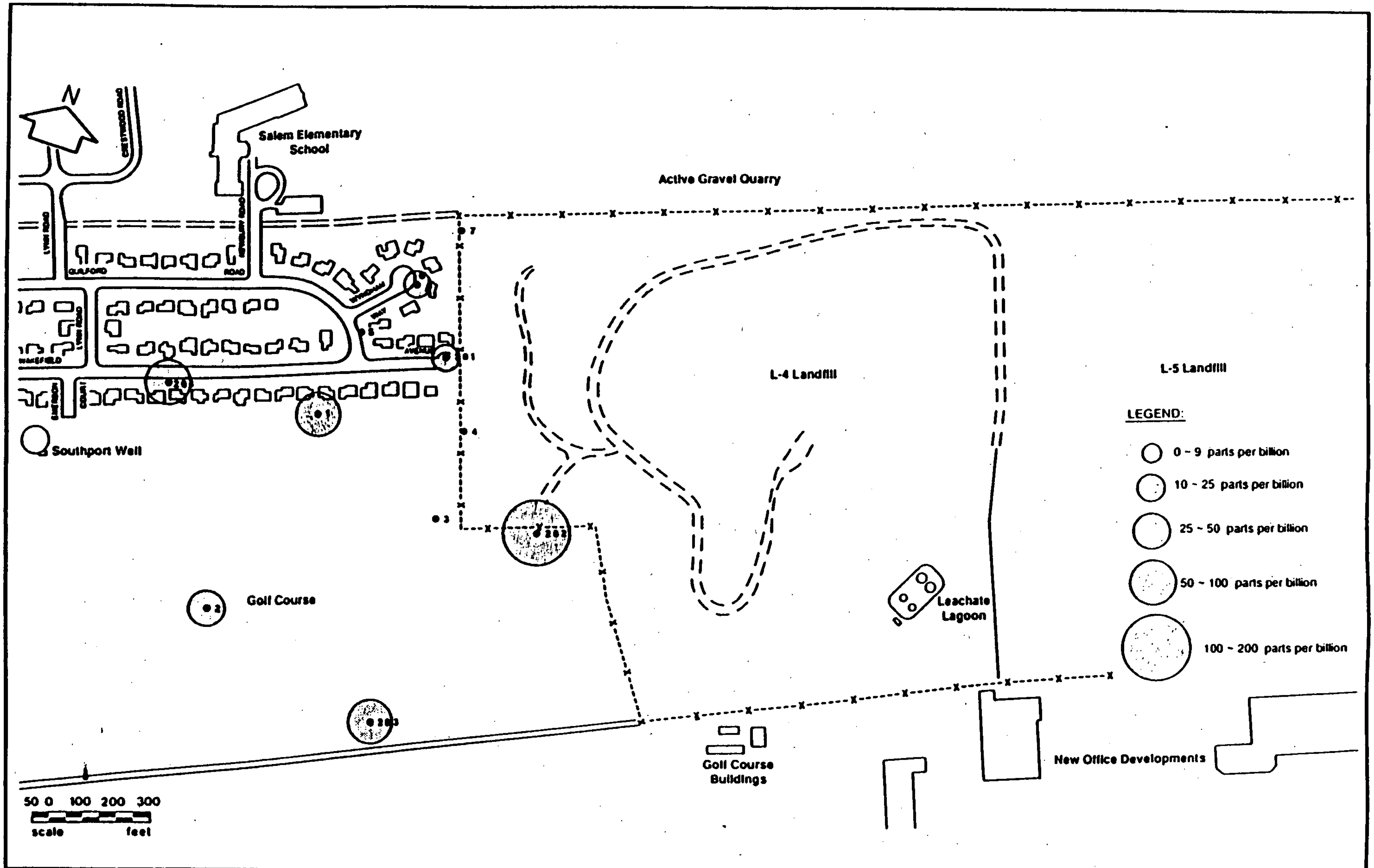
Tetrachloroethene
Round 2 (Medium)

Port Washington Landfill, Port Washington, New York



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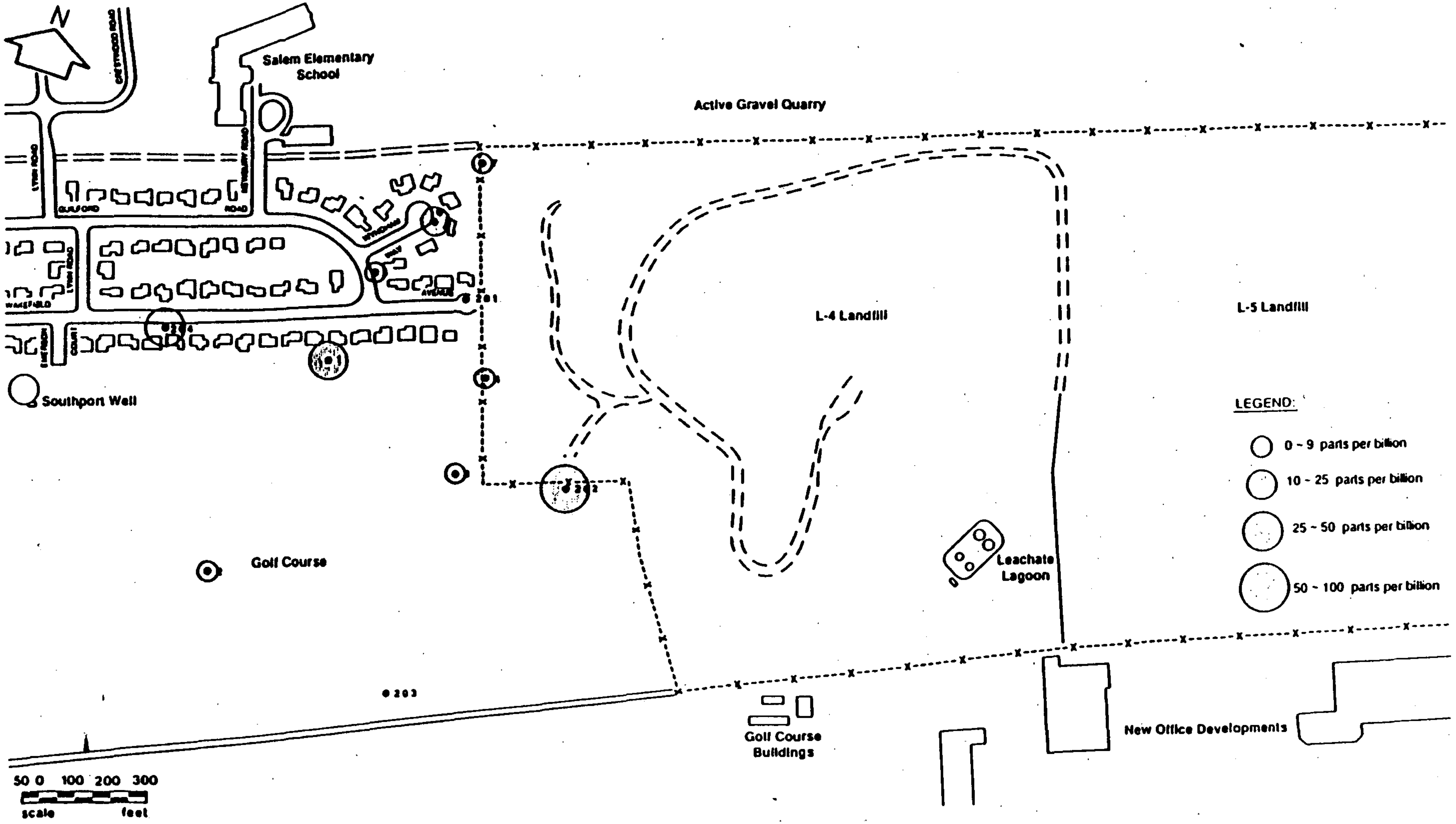
Tetrachloroethene
Round 2 (Deep)

Port Washington Landfill, Port Washington, New York



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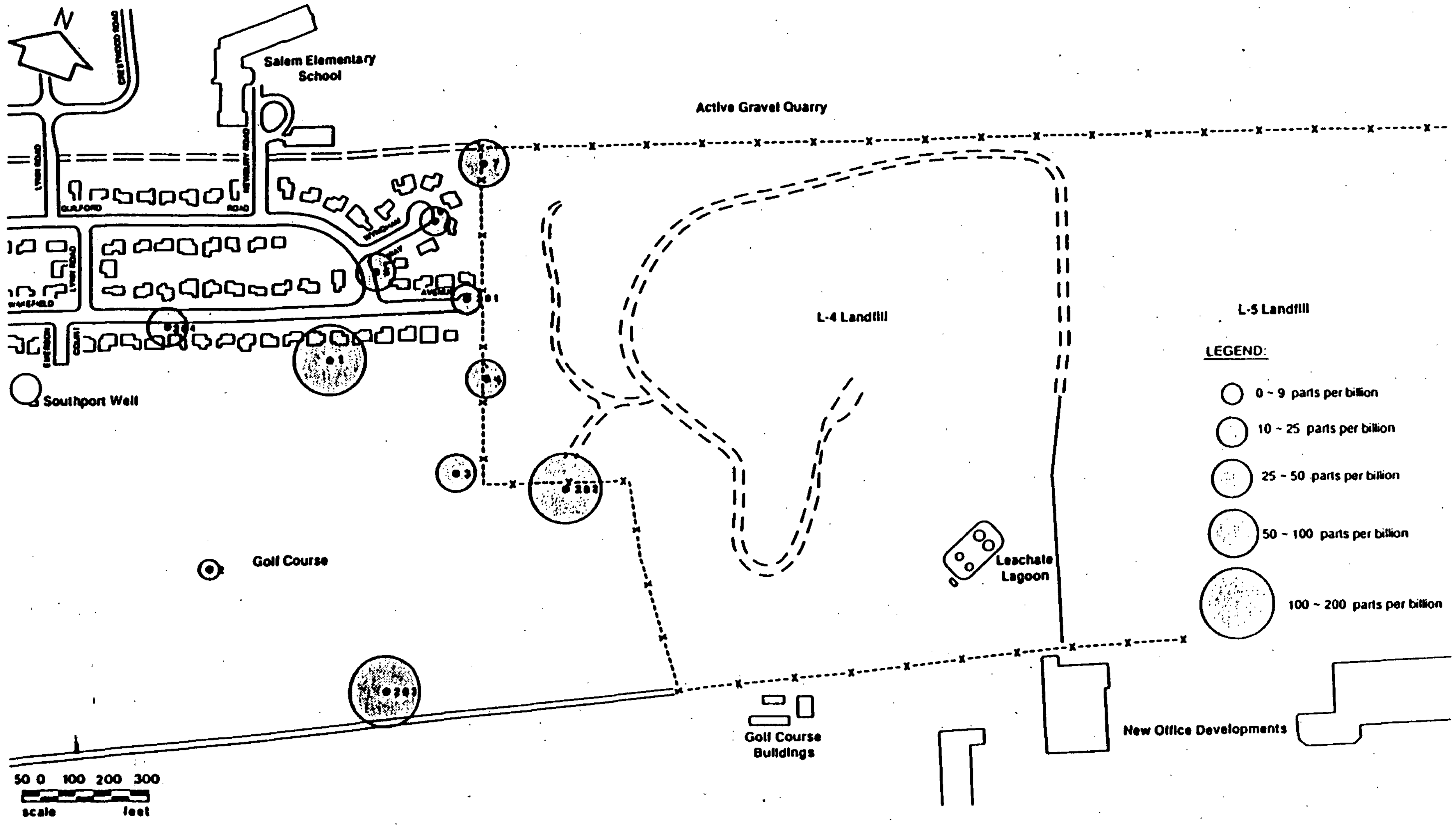
Tetrachloroethene
Round 3 (Shallow)

Port Washington Landfill, Port Washington, New York



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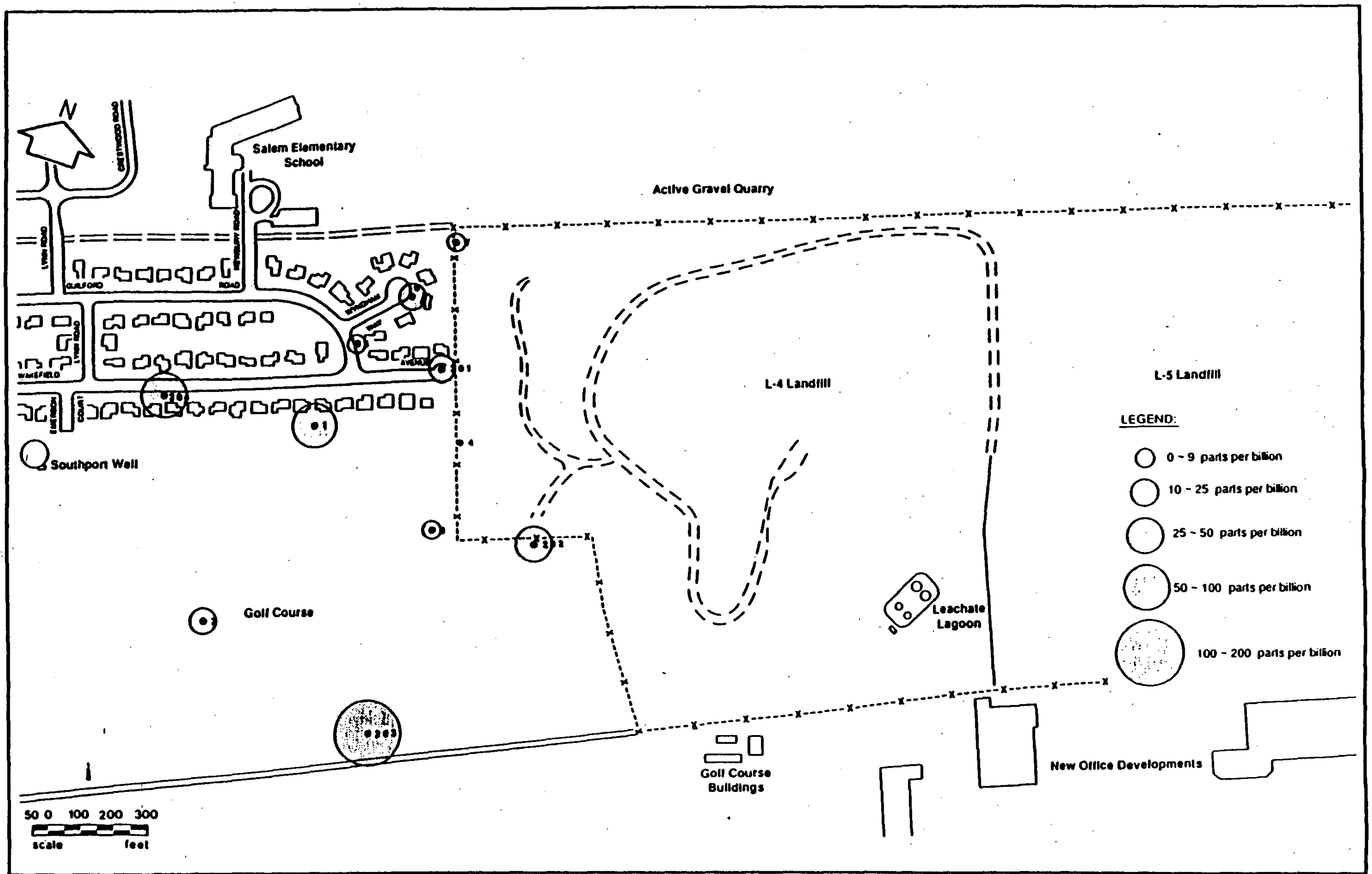
Tetrachloroethene
Round 3 (Medium)

Port Washington Landfill, Port Washington, New York



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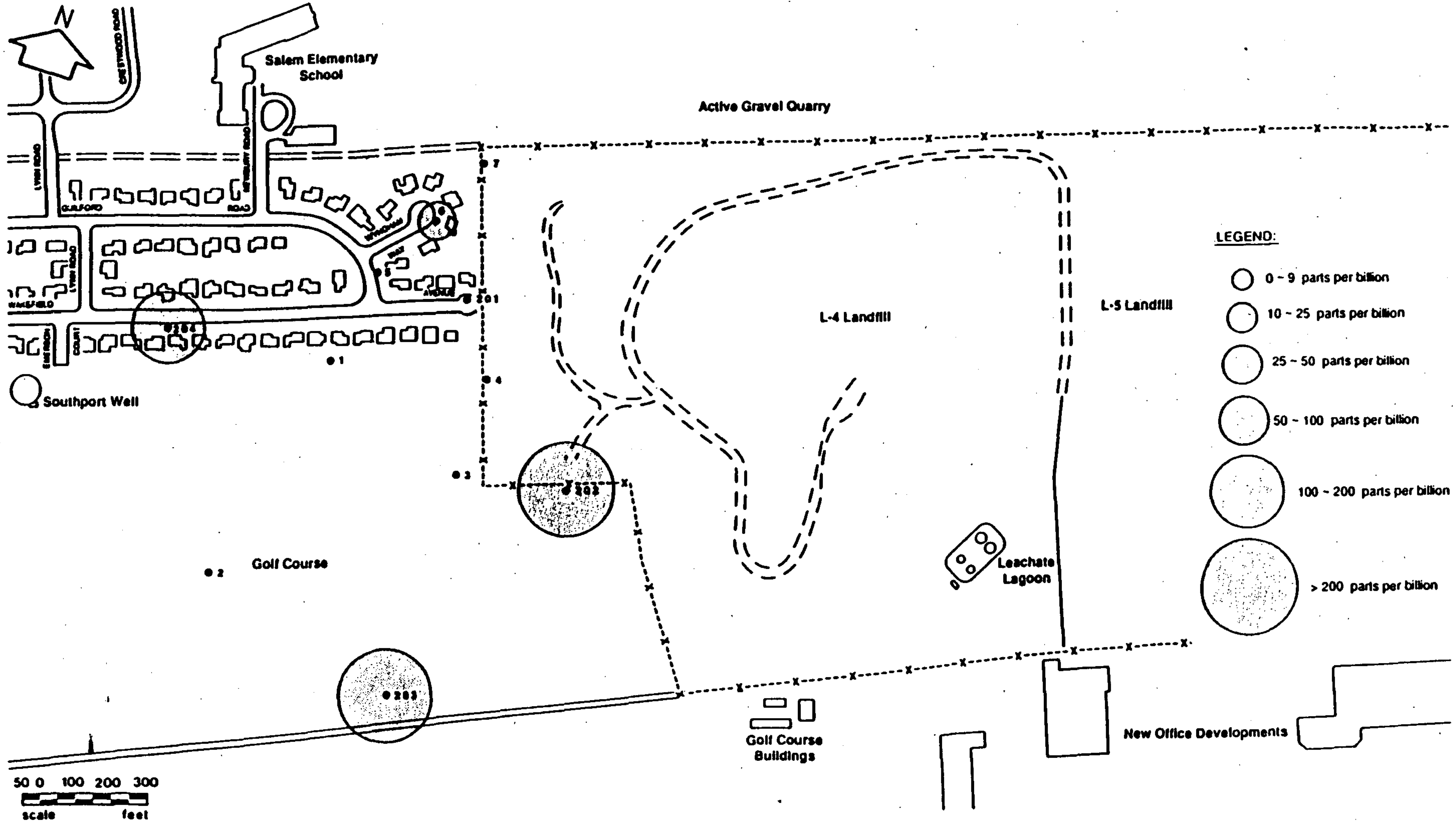
Tetrachloroethene
Round 3 (Deep)

Port Washington Landfill, Port Washington, New York



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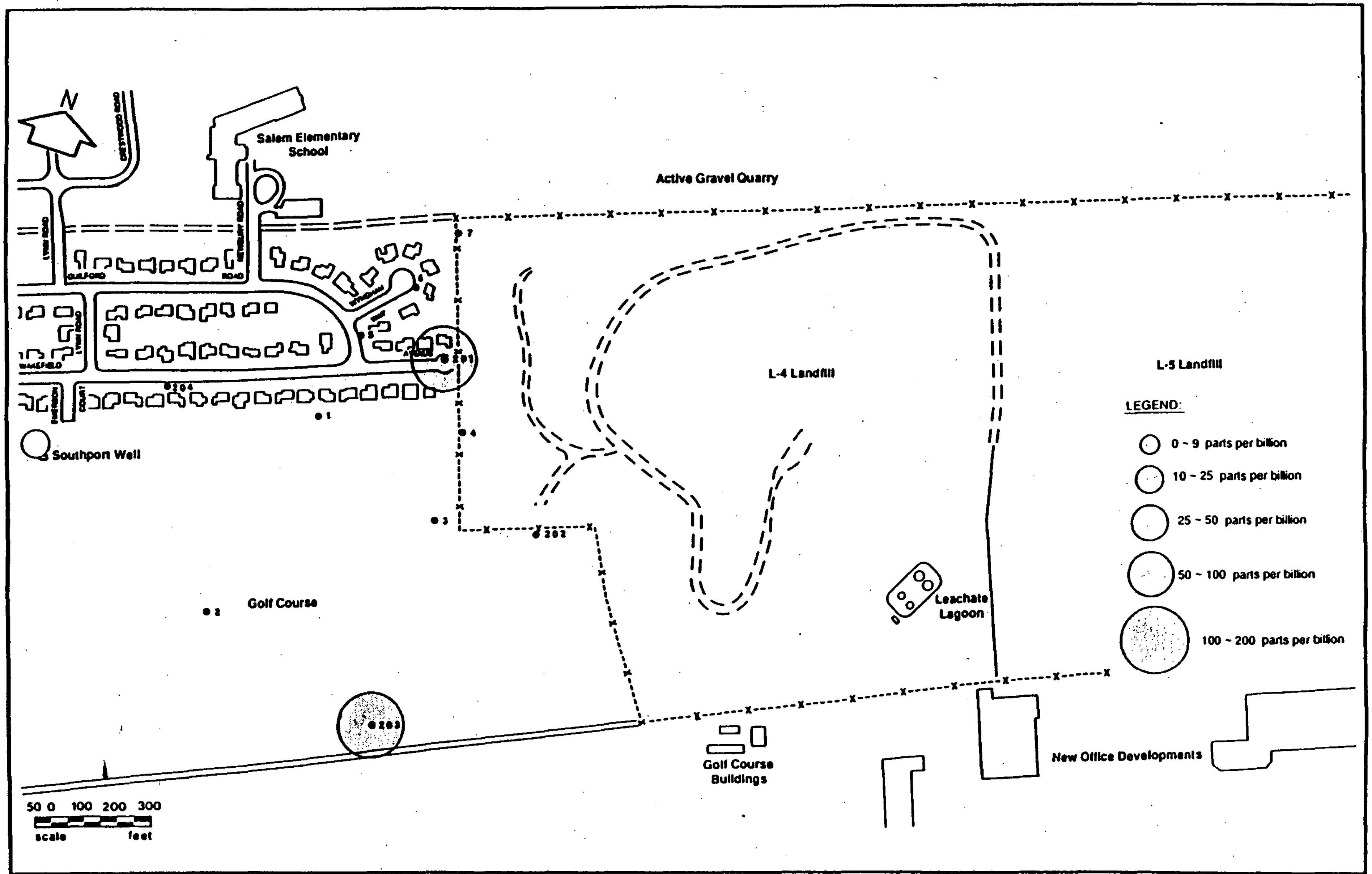
Tetrachloroethene
Round 1 (Shallow)

Port Washington Landfill, Port Washington, New York



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Tetrachloroethene
Round 1 (Medium)

Port Washington Landfill, Port Washington, New York

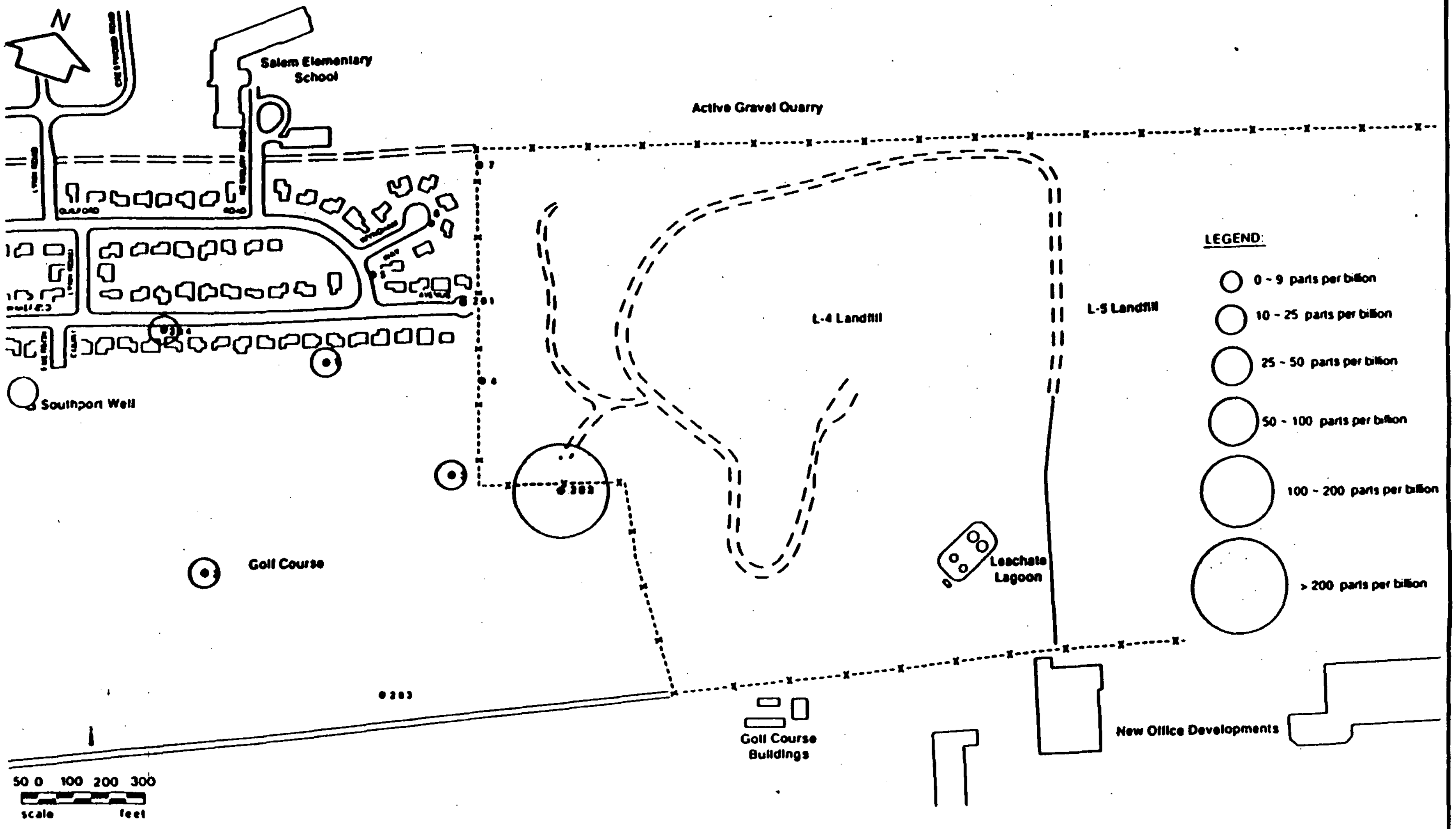

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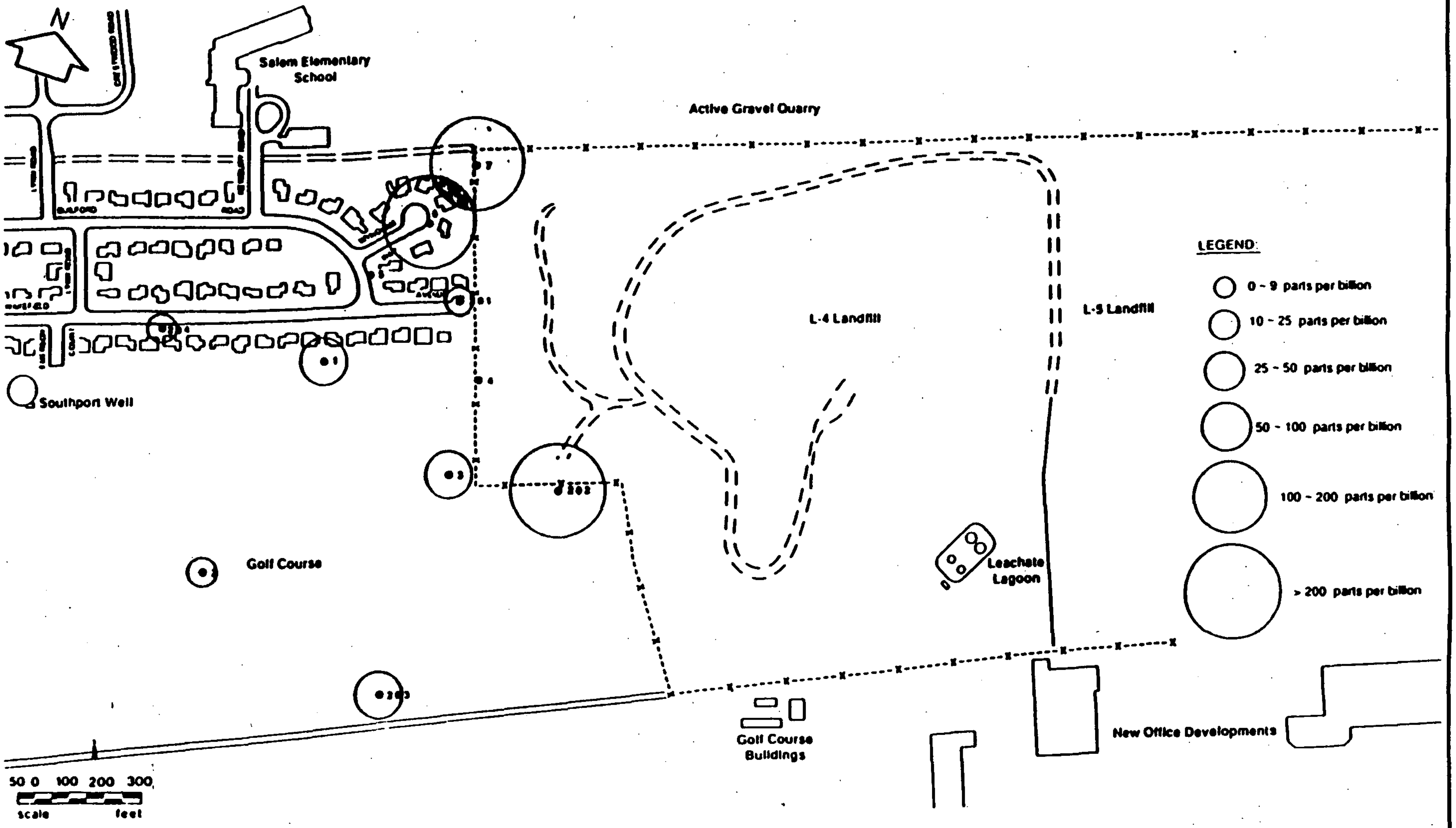
Figure 0-0

1,1,1 Trichloroethane

Round 2 (Shallow)

Port Washington Landfill, Port Washington, New York



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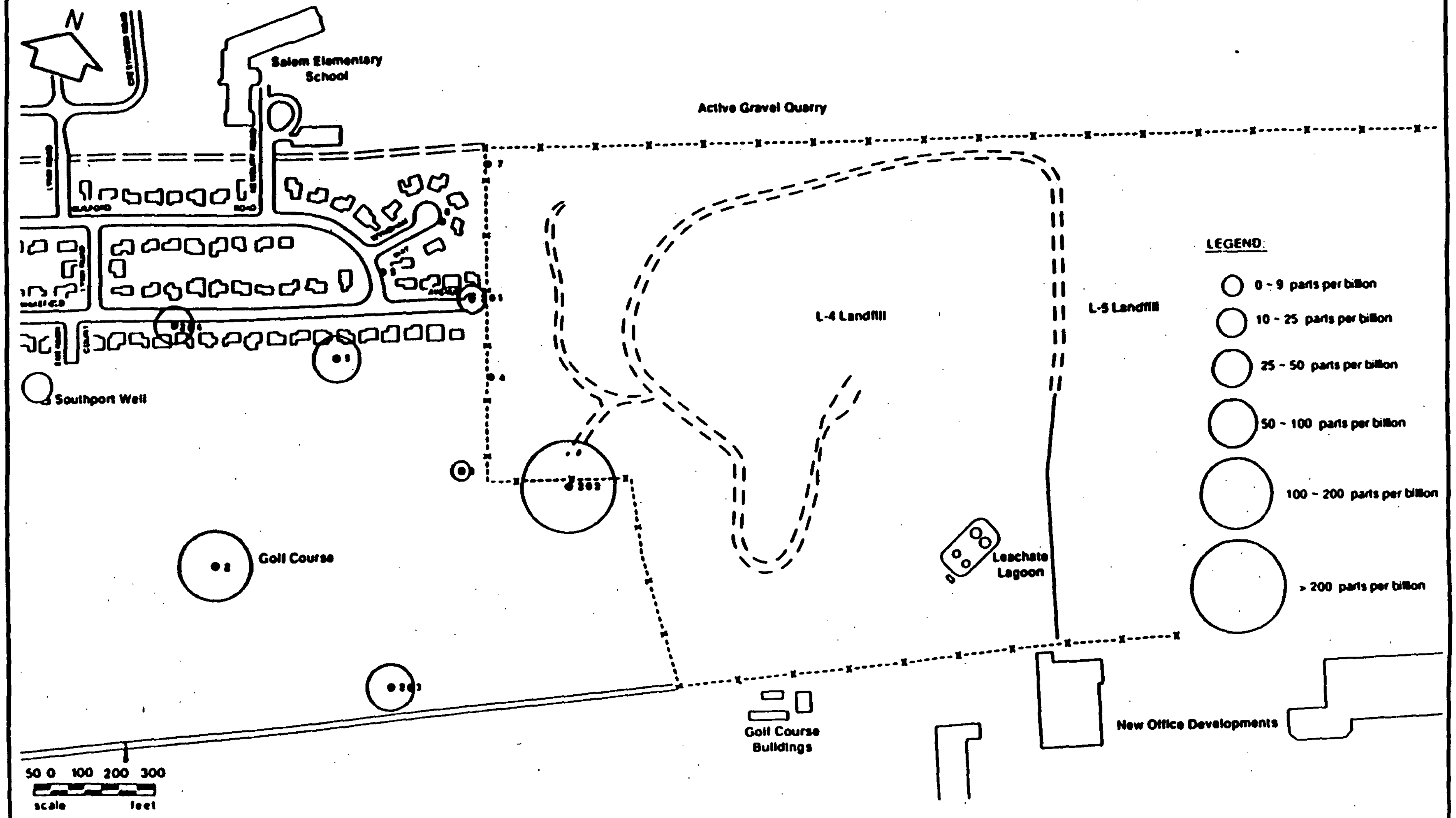
1,1,1 Trichloroethane

Round 2 (Medium)

Port Washington Landfill, Port Washington, New York



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1,1,1 Trichloroethane
Round 2 (Deep)

Port Washington Landfill, Port Washington, New York

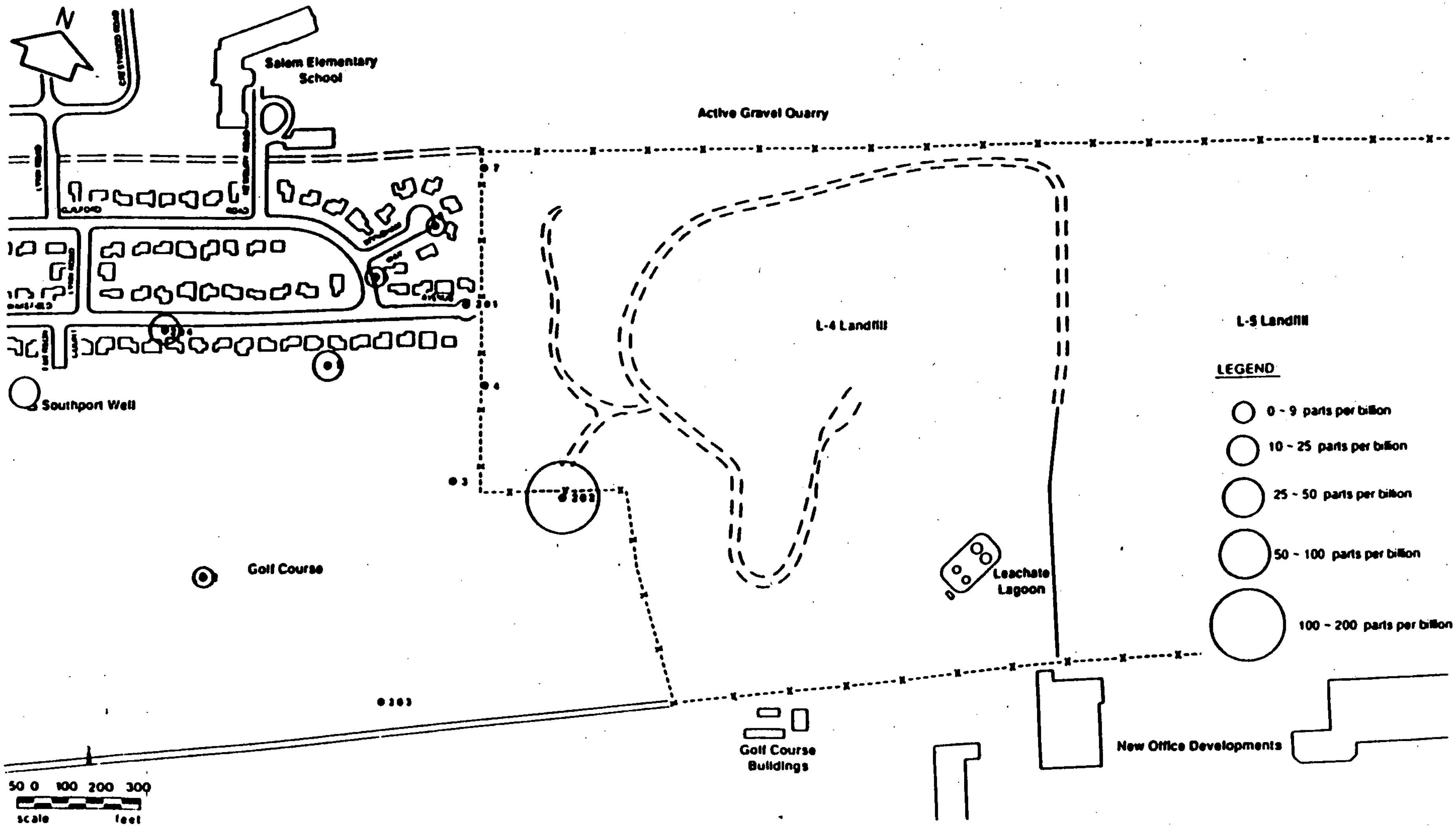

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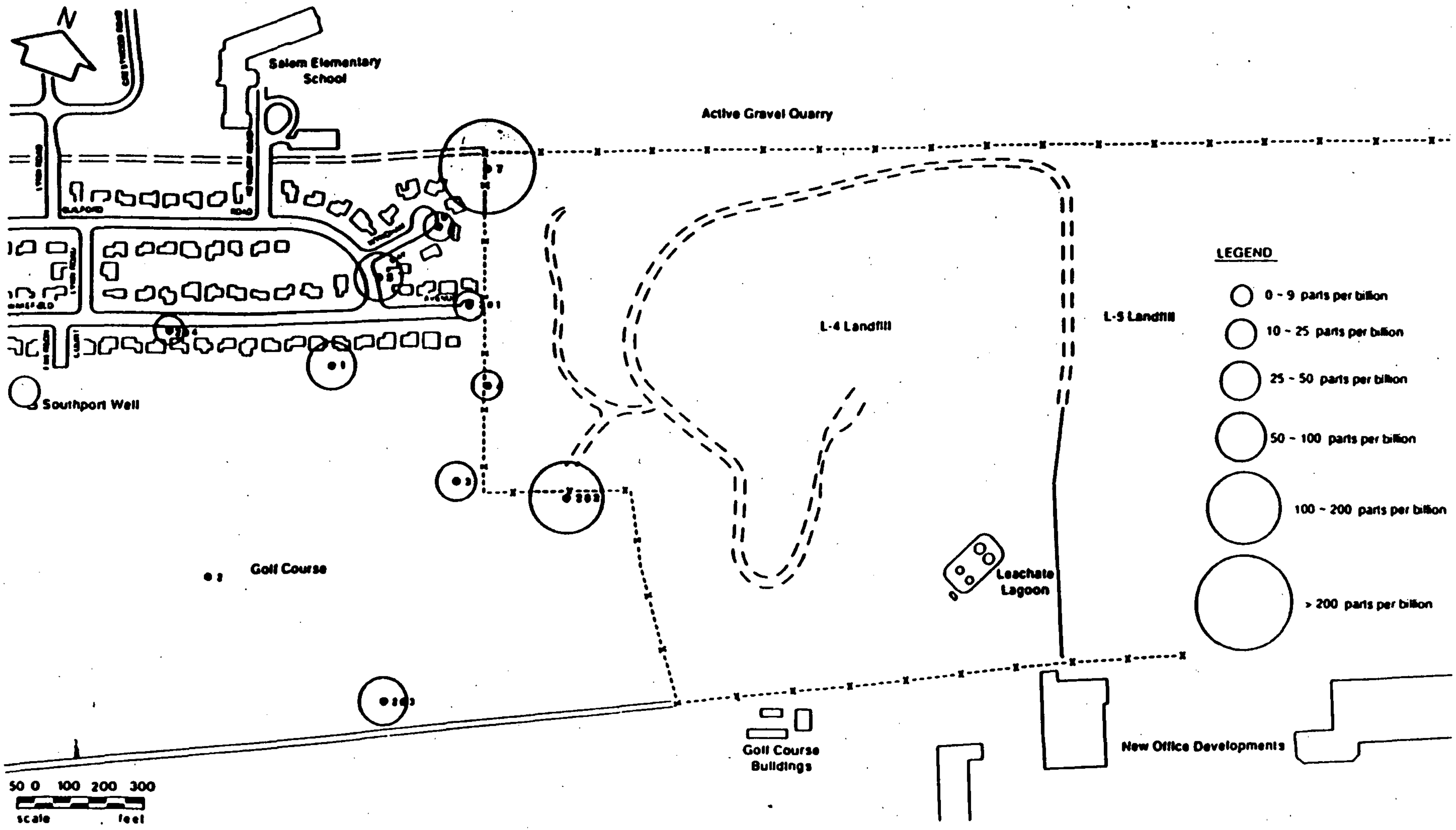
Figure 0-0
1,1,1 Trichloroethane
Round 3 (Shallow)

Port Washington Landfill, Port Washington, New York



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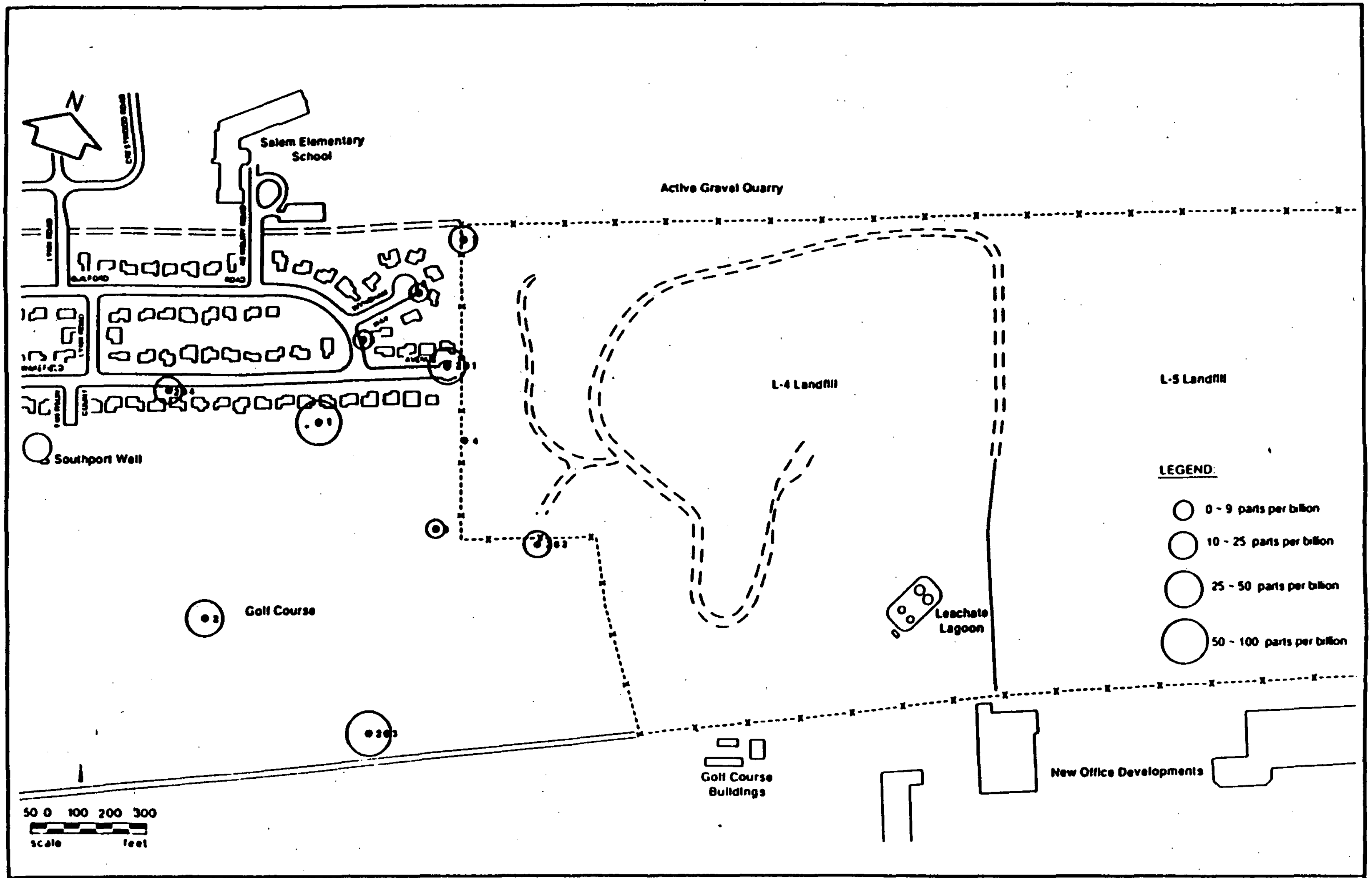
1,1,1 Trichloroethane
Round 3 (Medium)
Port Washington Landfill, Port Washington, New York



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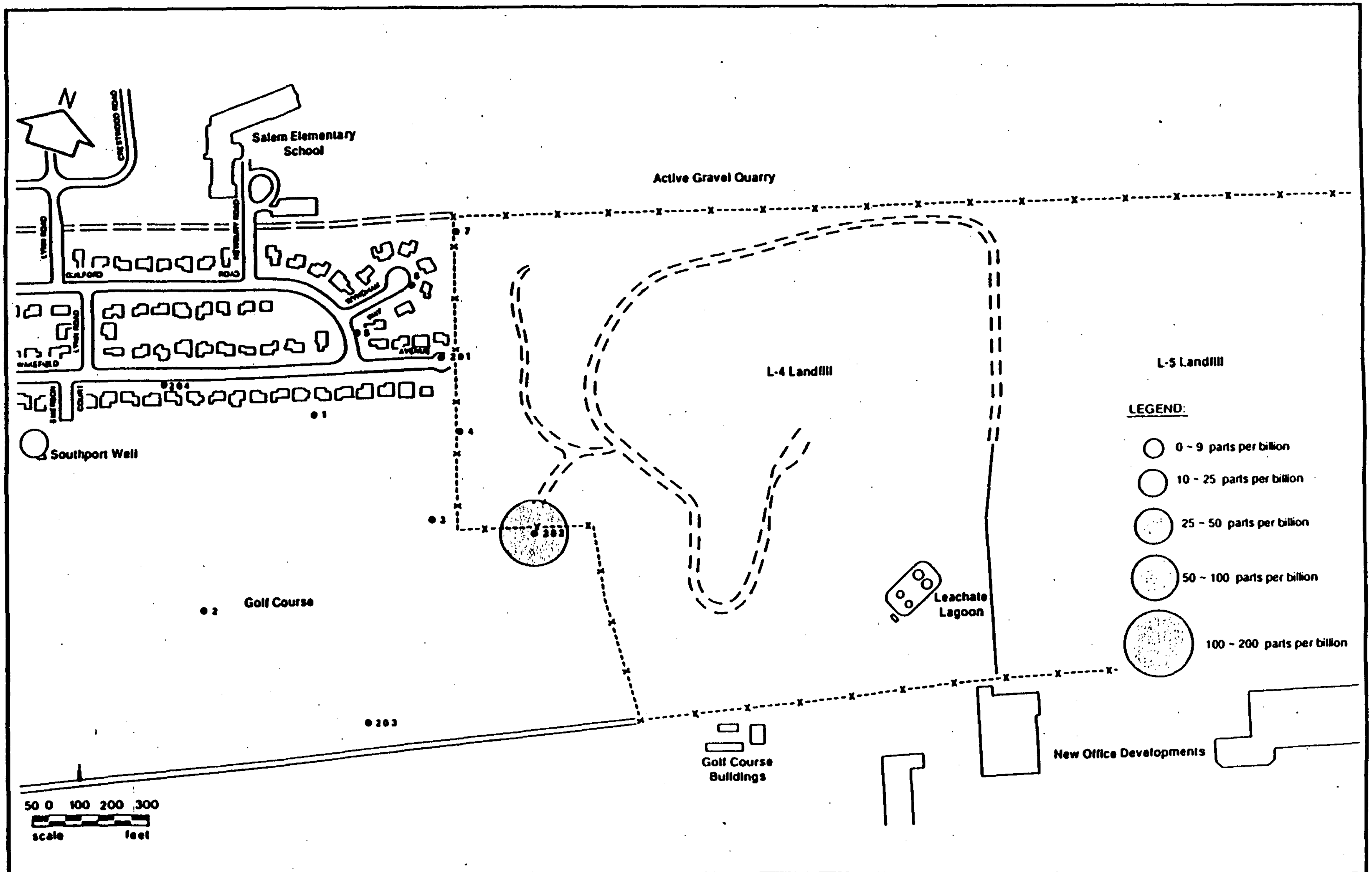
1,1,1 Trichloroethane

Round 3 (Deep)

Port Washington Landfill, Port Washington, New York



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1,1 Dichloroethane
Round 2 (Shallow)

Port Washington Landfill, Port Washington, New York

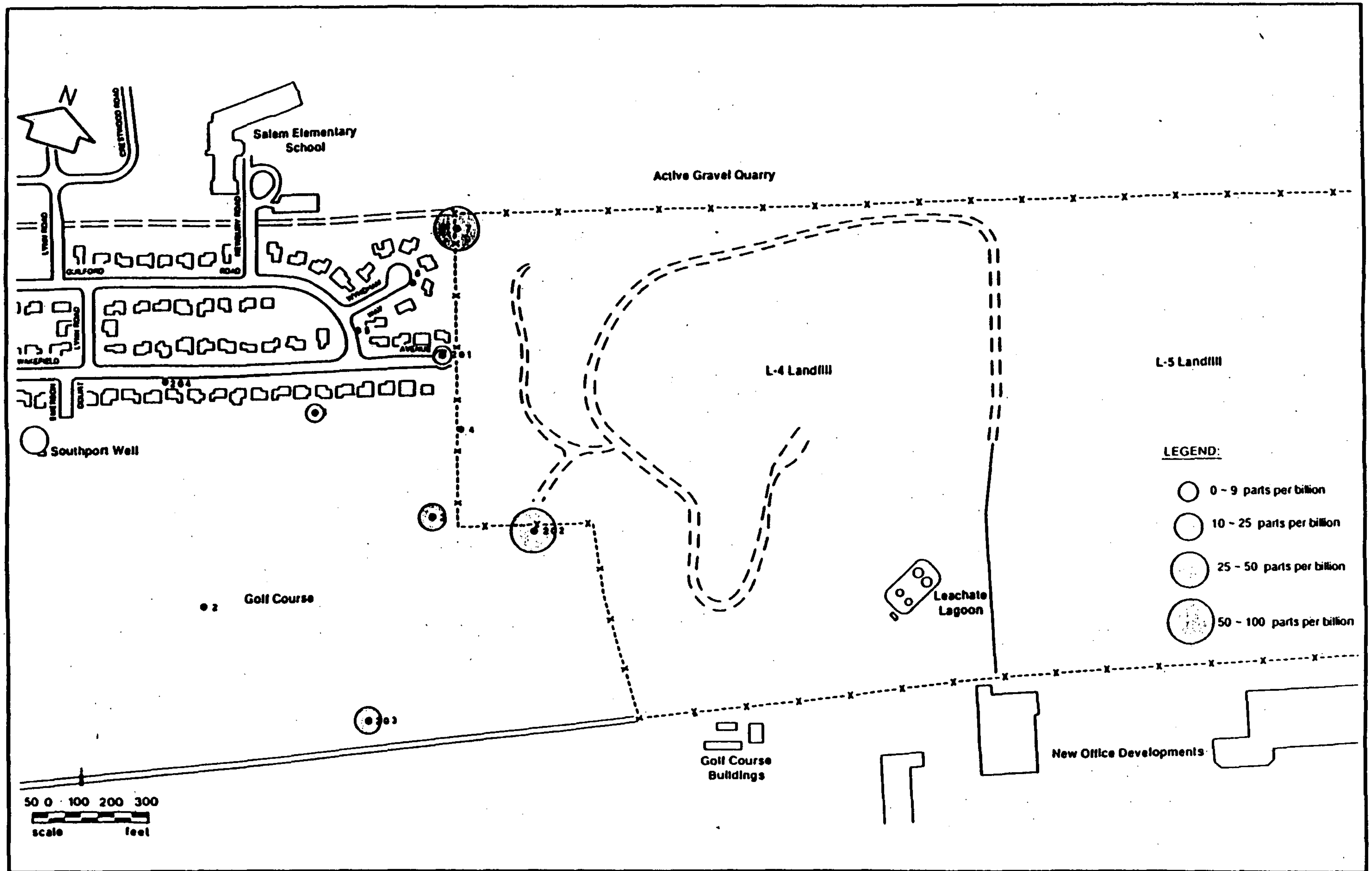

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Figure 0-0
1,1 Dichloroethane
Round 2 (Medium)

Port Washington Landfill, Port Washington, New York

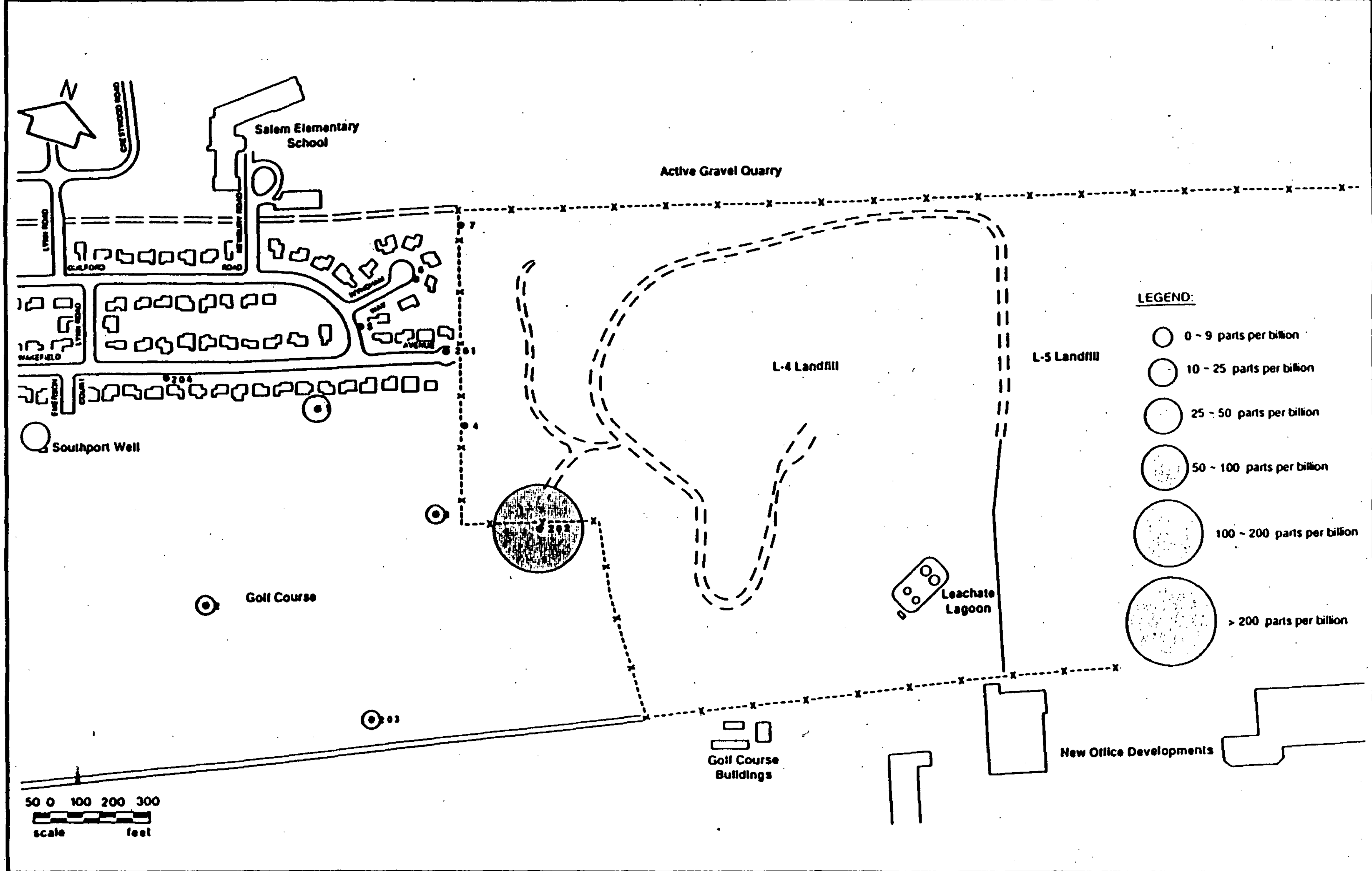

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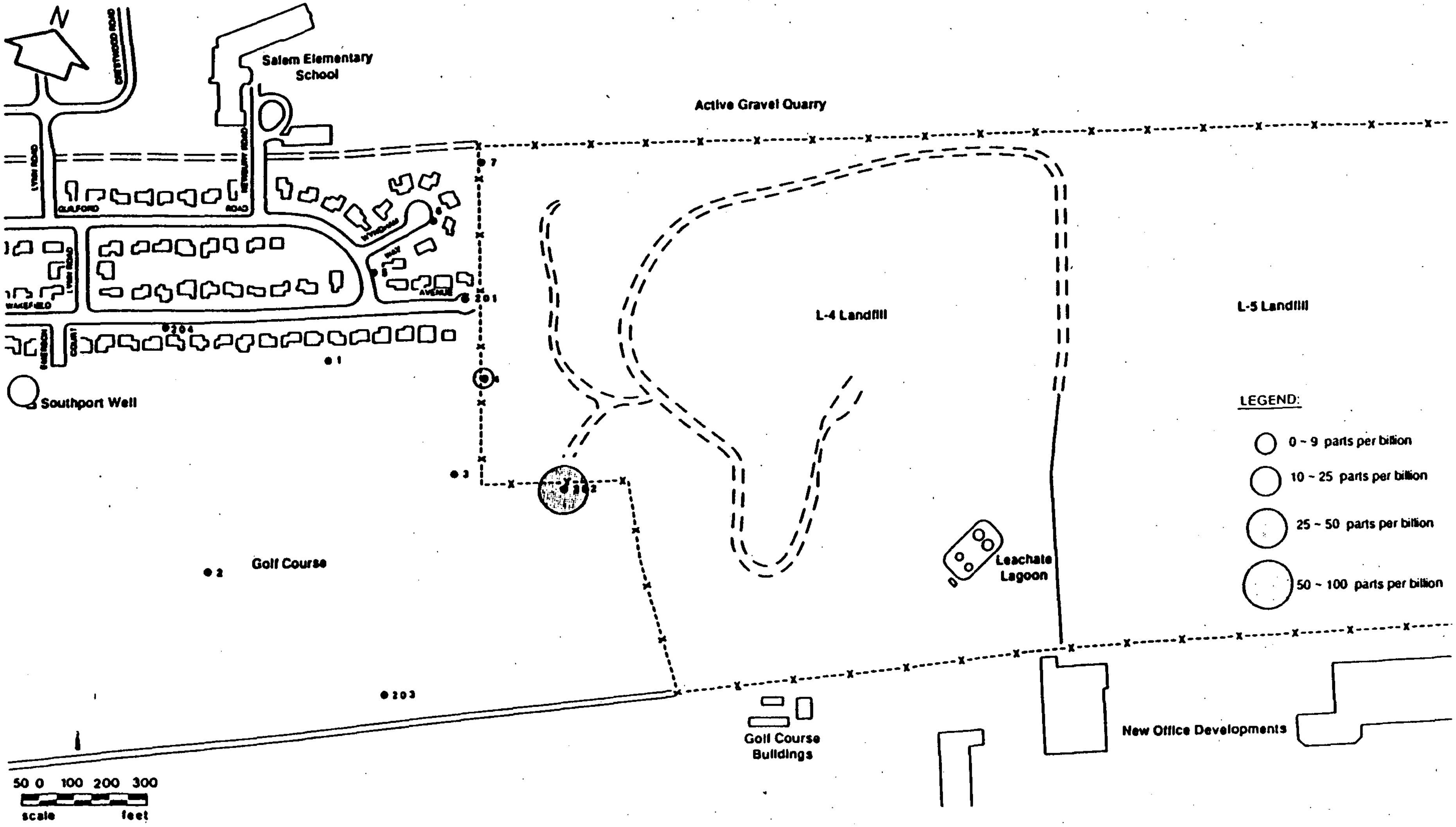
Figure 0-0

1,1 Dichloroethane
Round 2 (Deep)

Port Washington Landfill, Port Washington, New York



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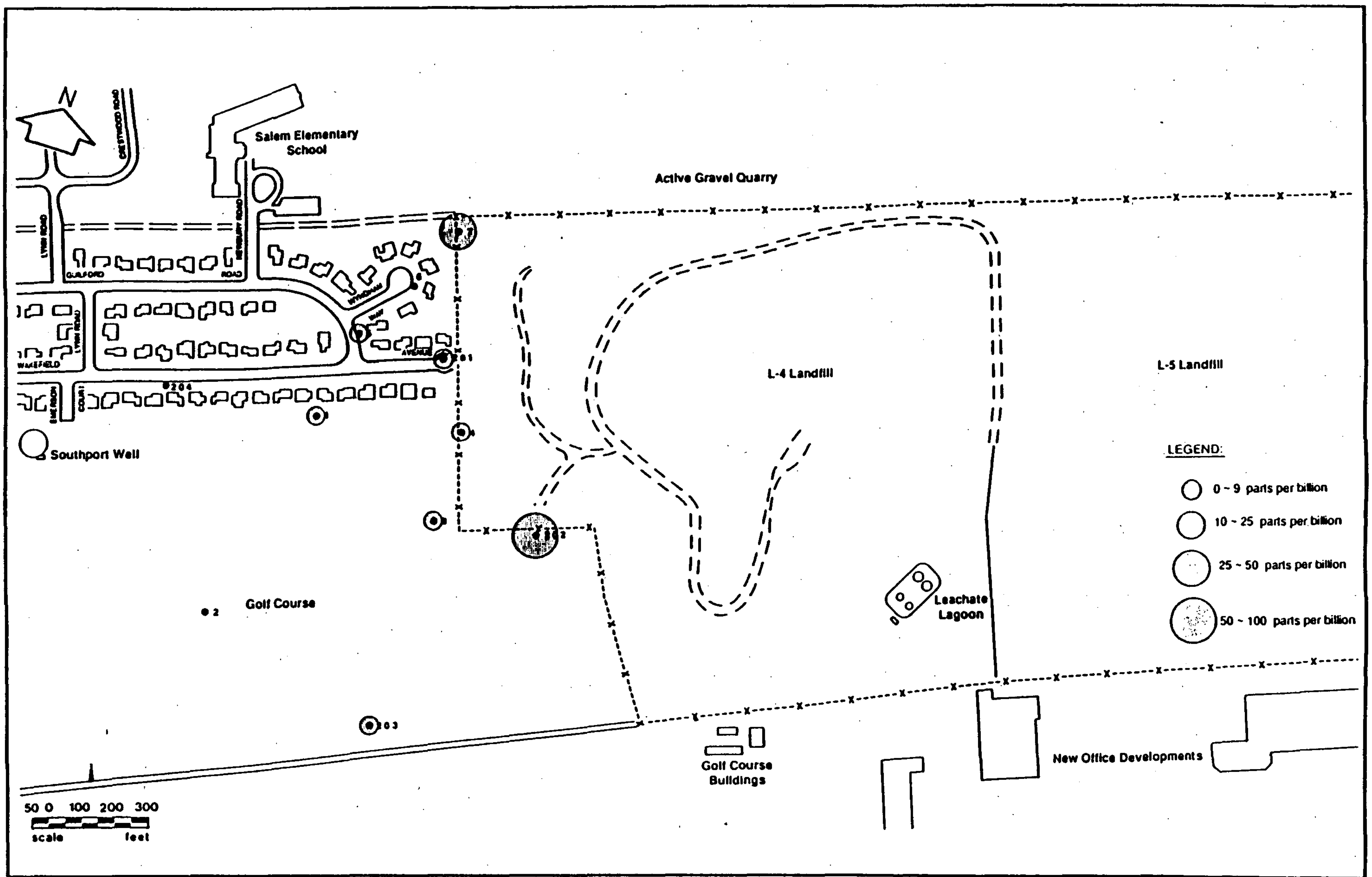
1,1 Dichloroethane

Round 3 (Shallow)

Port Washington Landfill, Port Washington, New York



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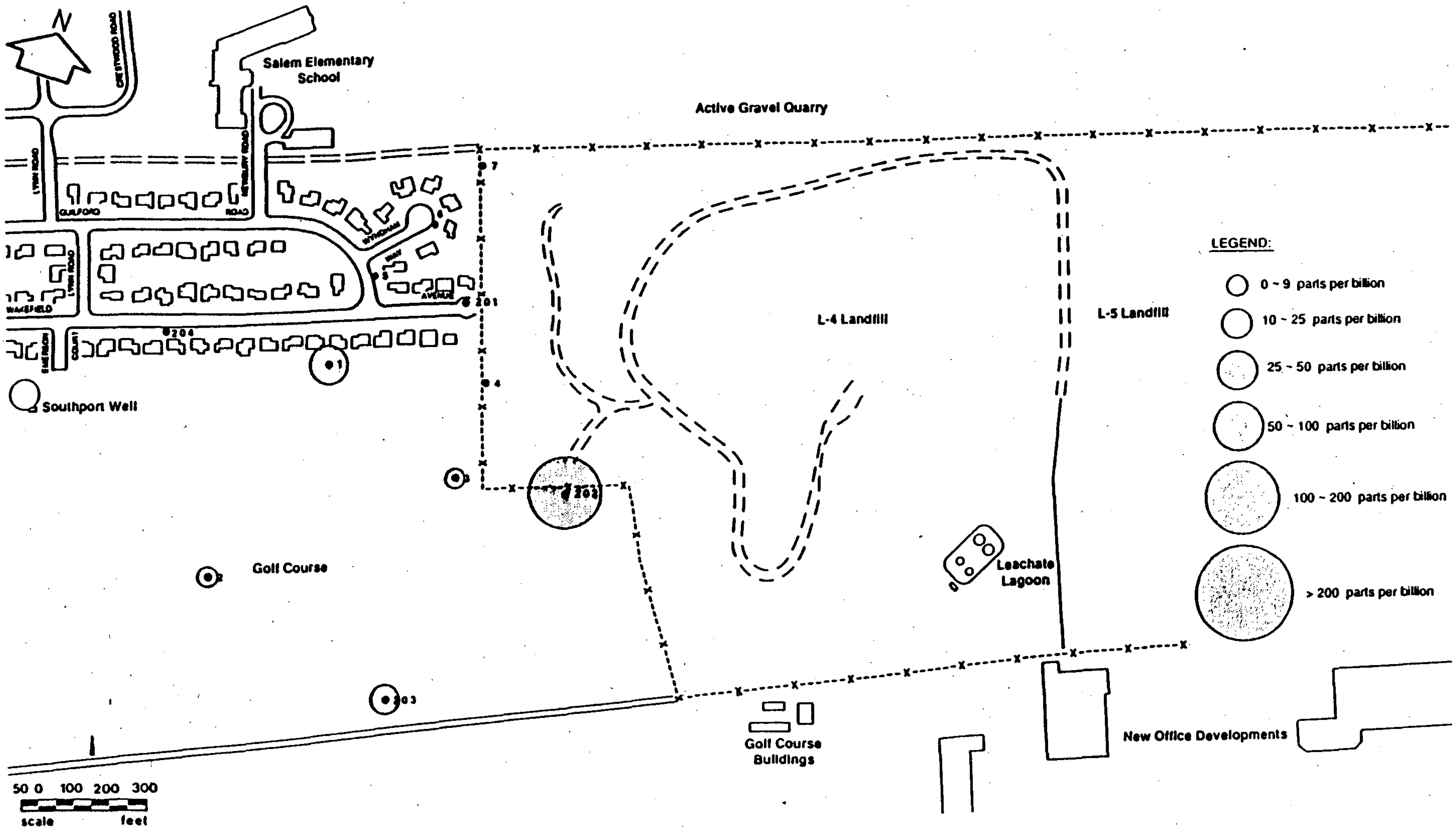
1,1 Dichloroethane
Round 3 (Medium)

Port Washington Landfill, Port Washington, New York



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1,1 Dichloroethane
Round 3 (Deep)

Port Washington Landfill, Port Washington, New York

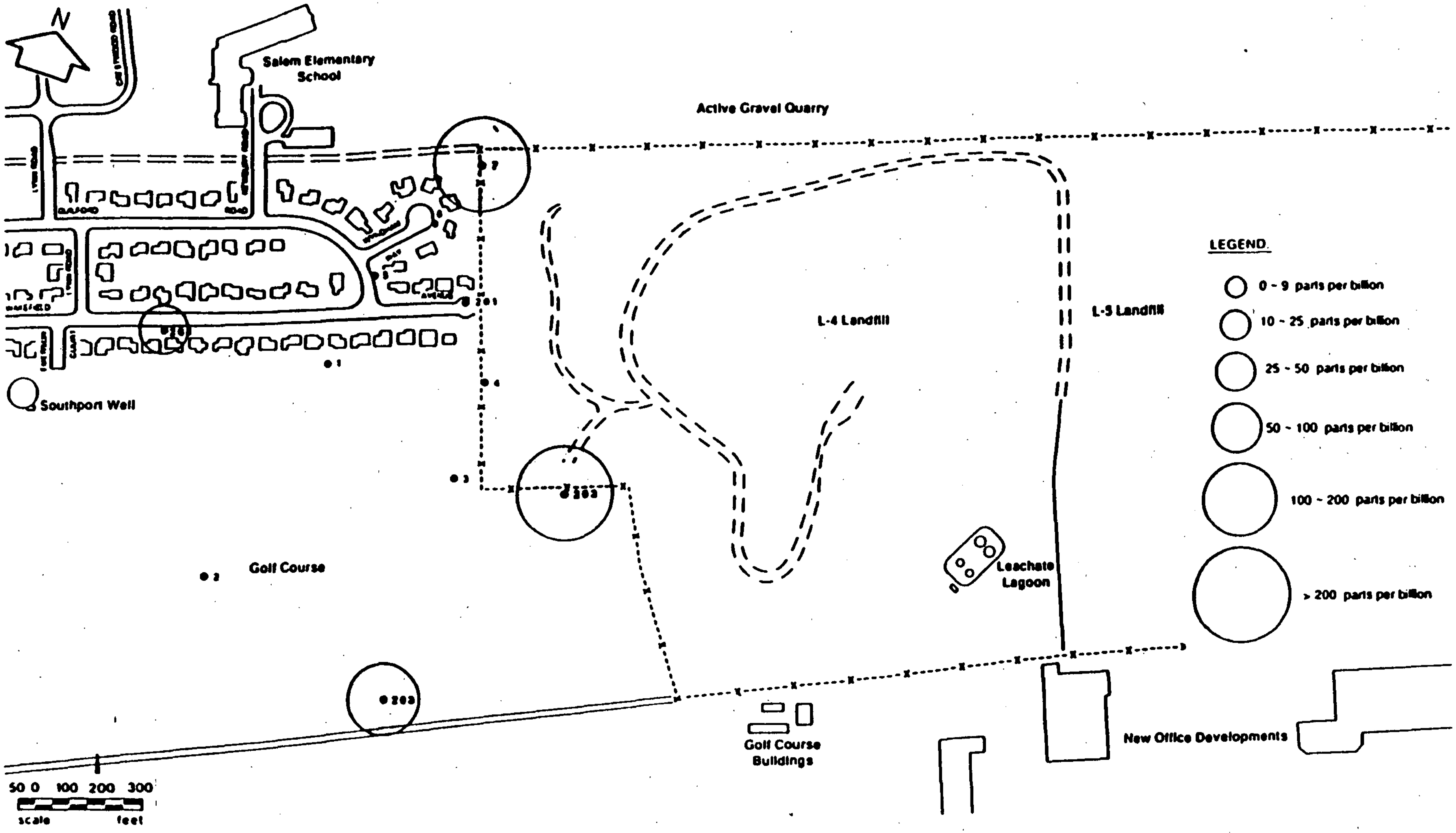

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Figure 0-0
1,1,1 Trichloroethane
Round 1 (Shallow)

Port Washington Landfill, Port Washington, New York

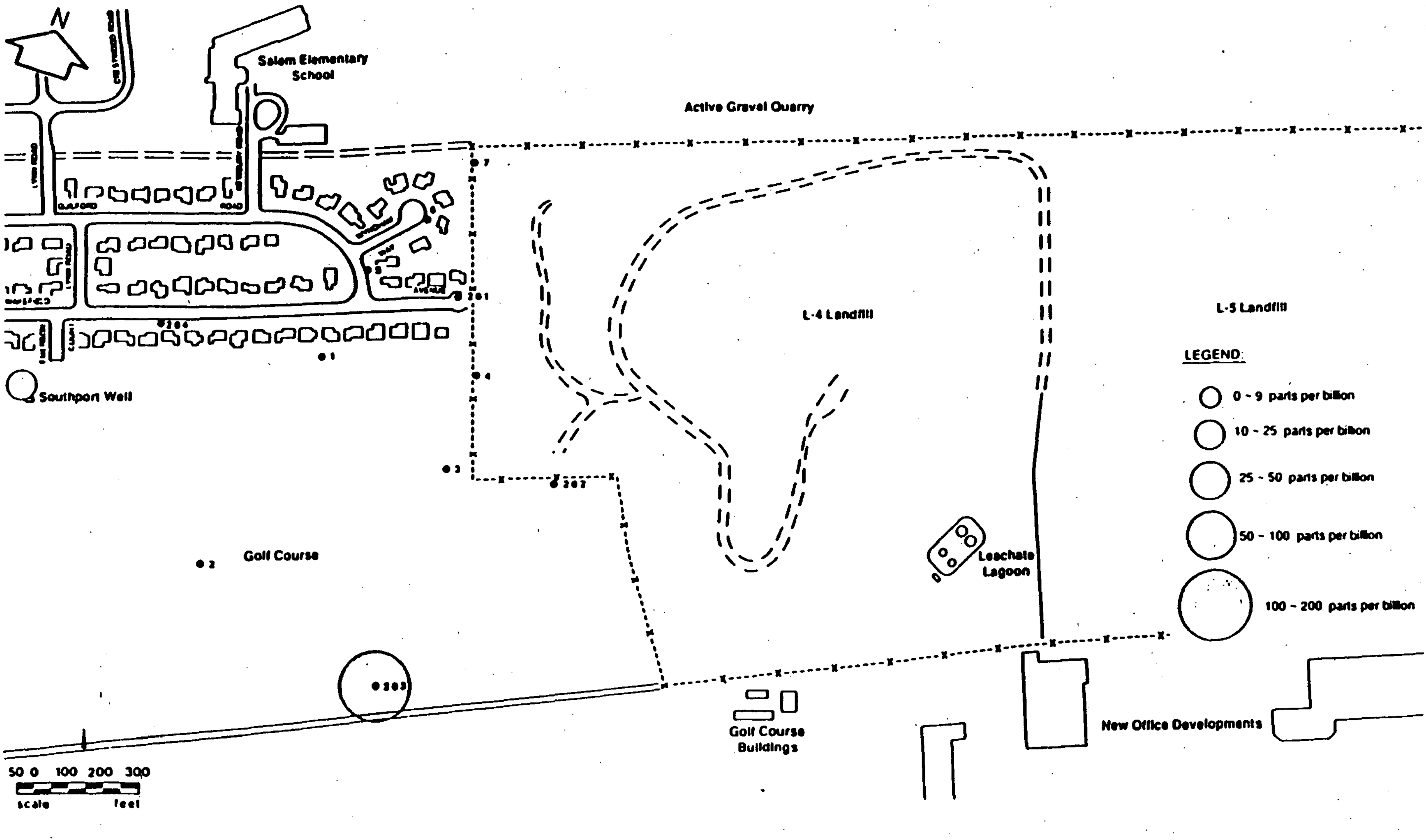

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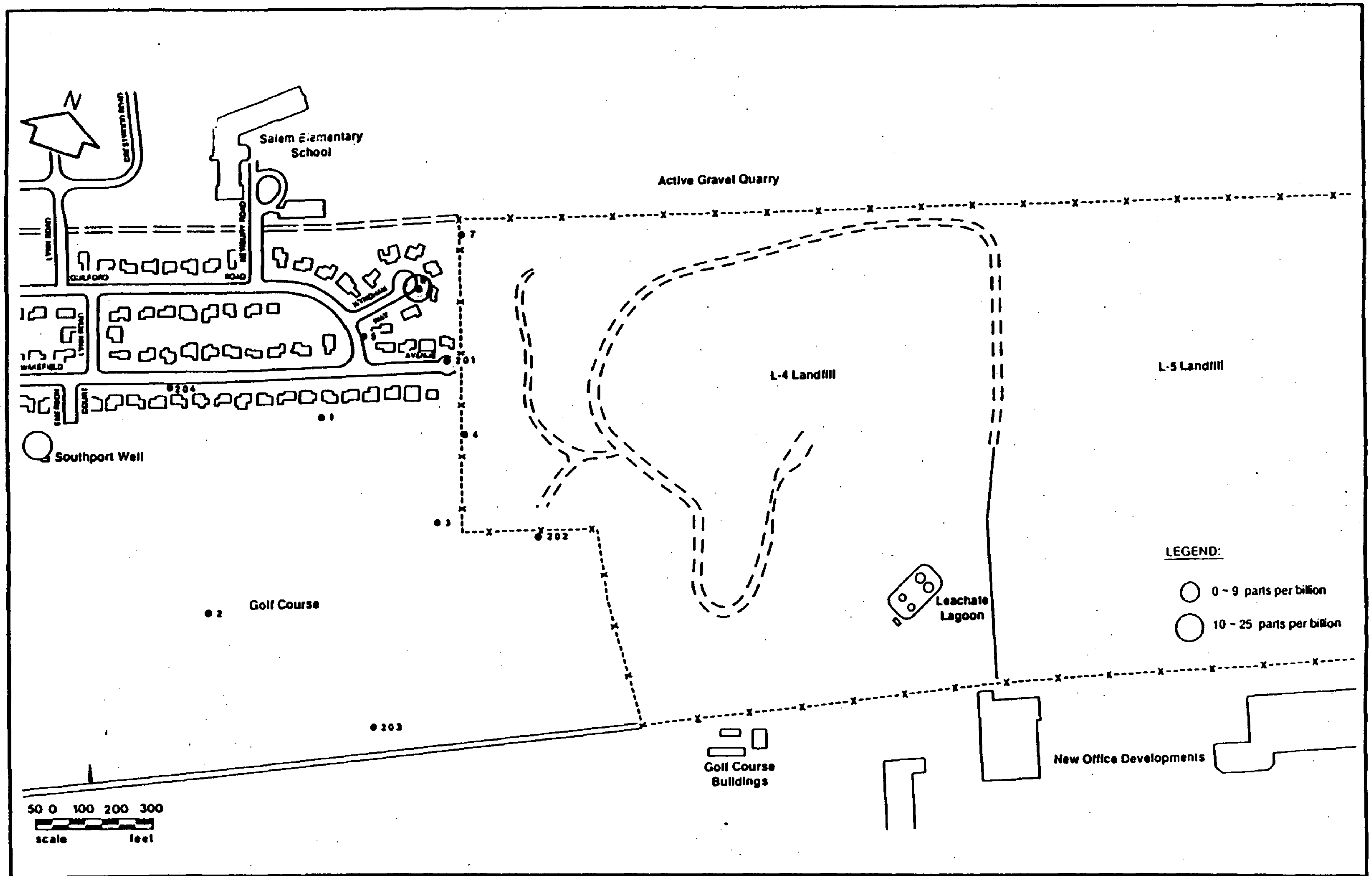
Figure 0-0
1,1,1 Trichloroethane
Round 1 (Medium)
Port Washington Landfill, Port Washington, New York



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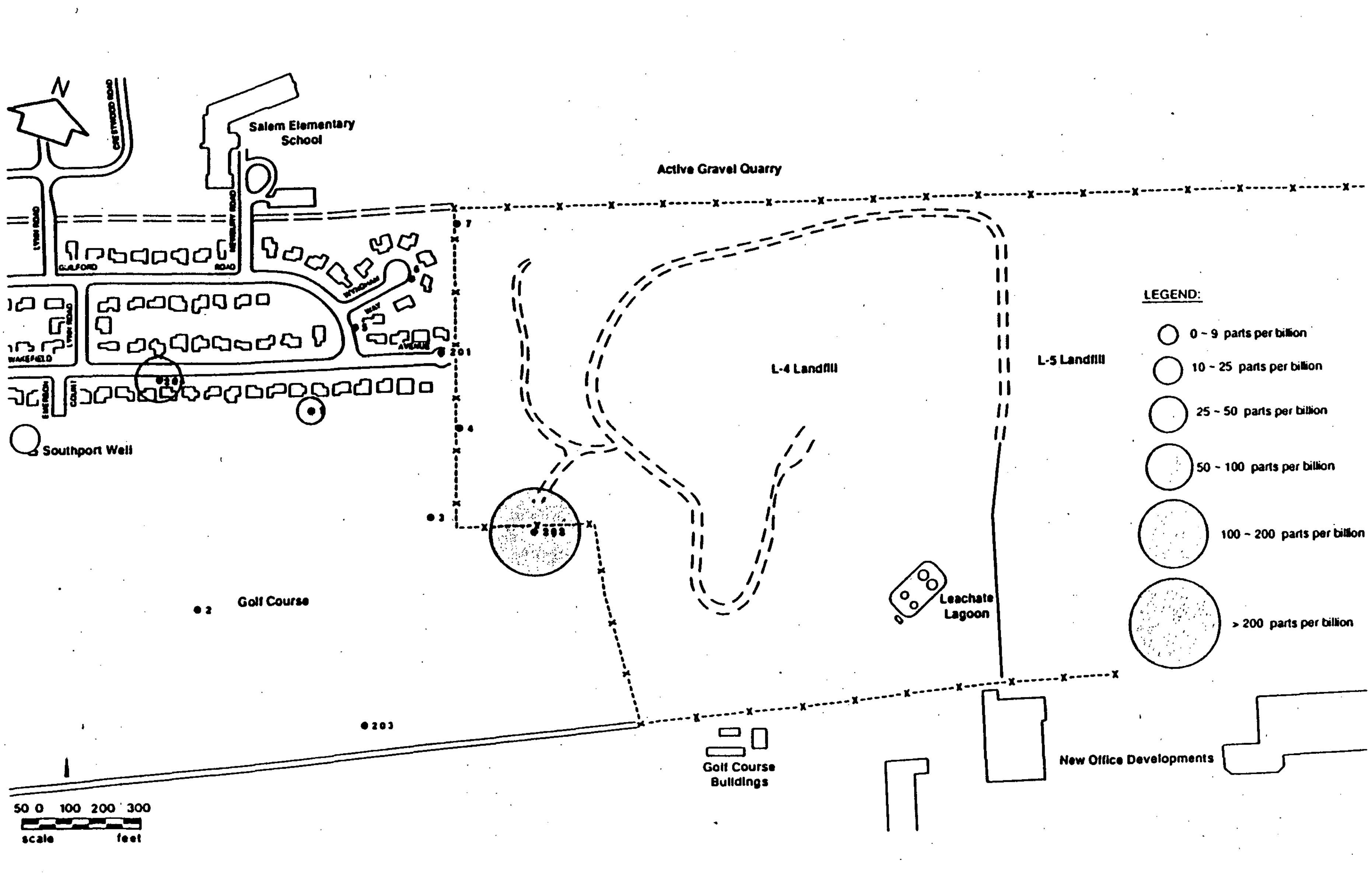
Tetrachloroethene
Round 1 (Deep)

Port Washington Landfill, Port Washington, New York



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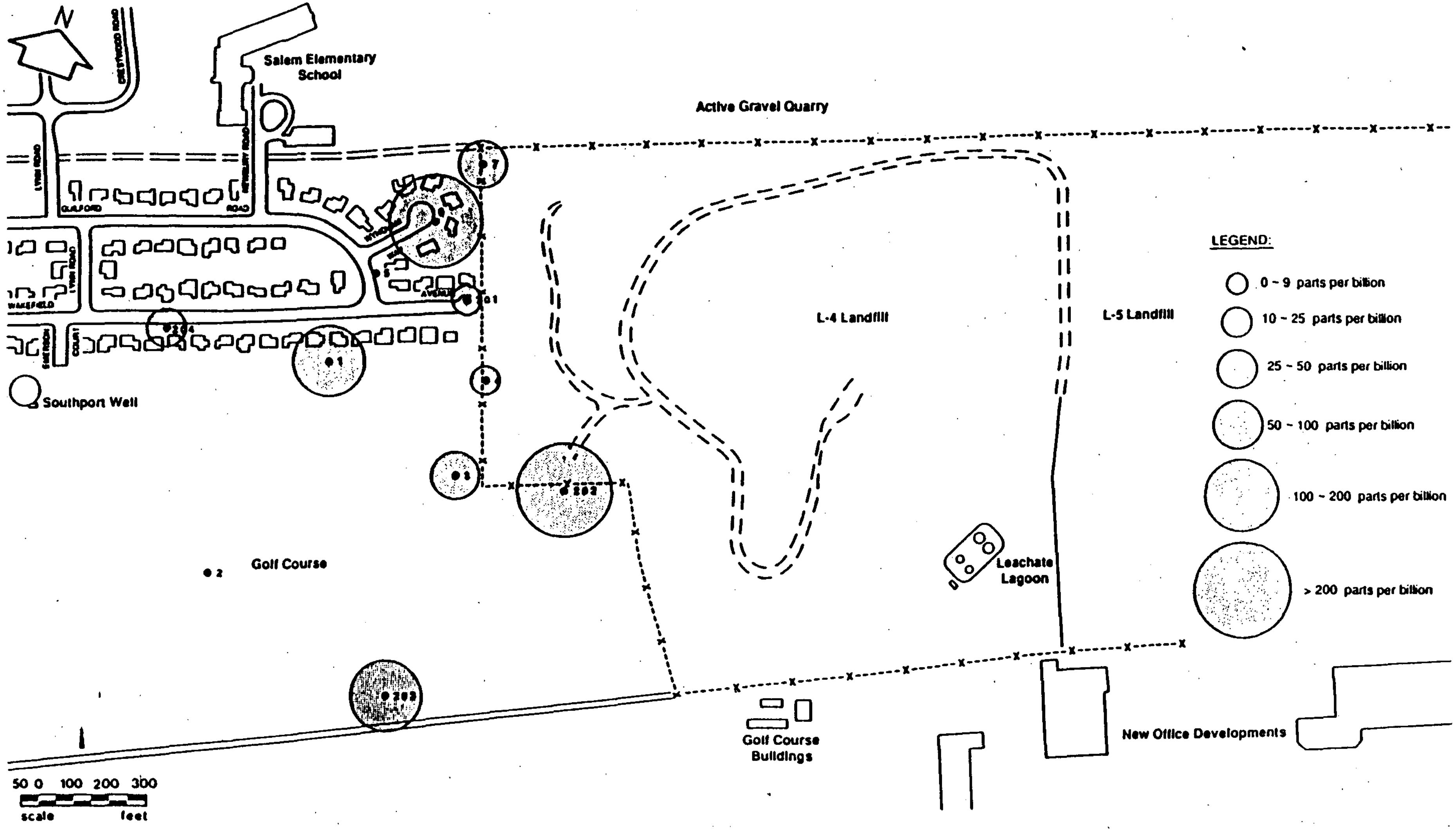
Tetrachloroethene
Round 2 (Shallow)

Port Washington Landfill, Port Washington, New York



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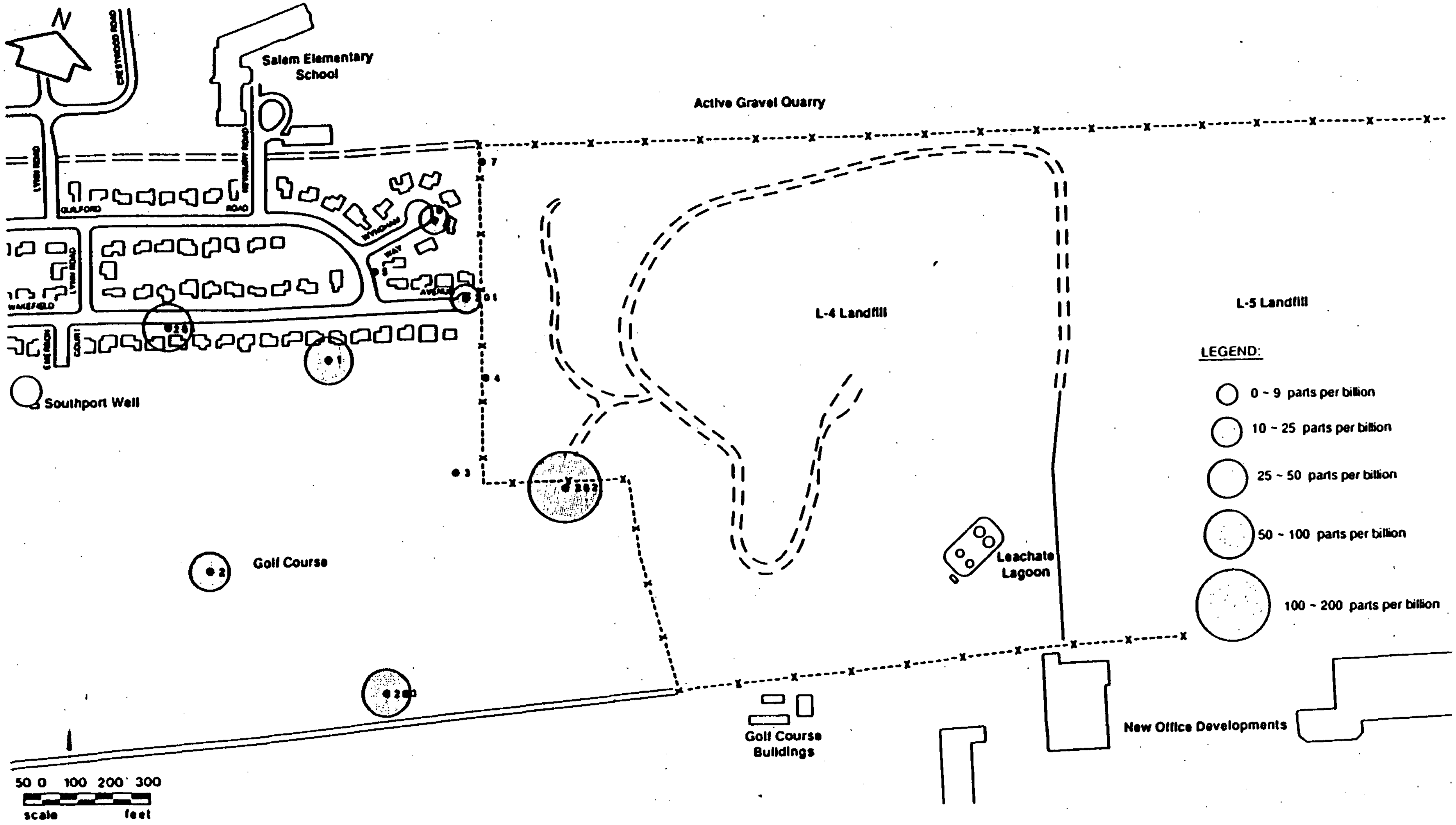
Tetrachloroethene
Round 2 (Medium)

Port Washington Landfill, Port Washington, New York



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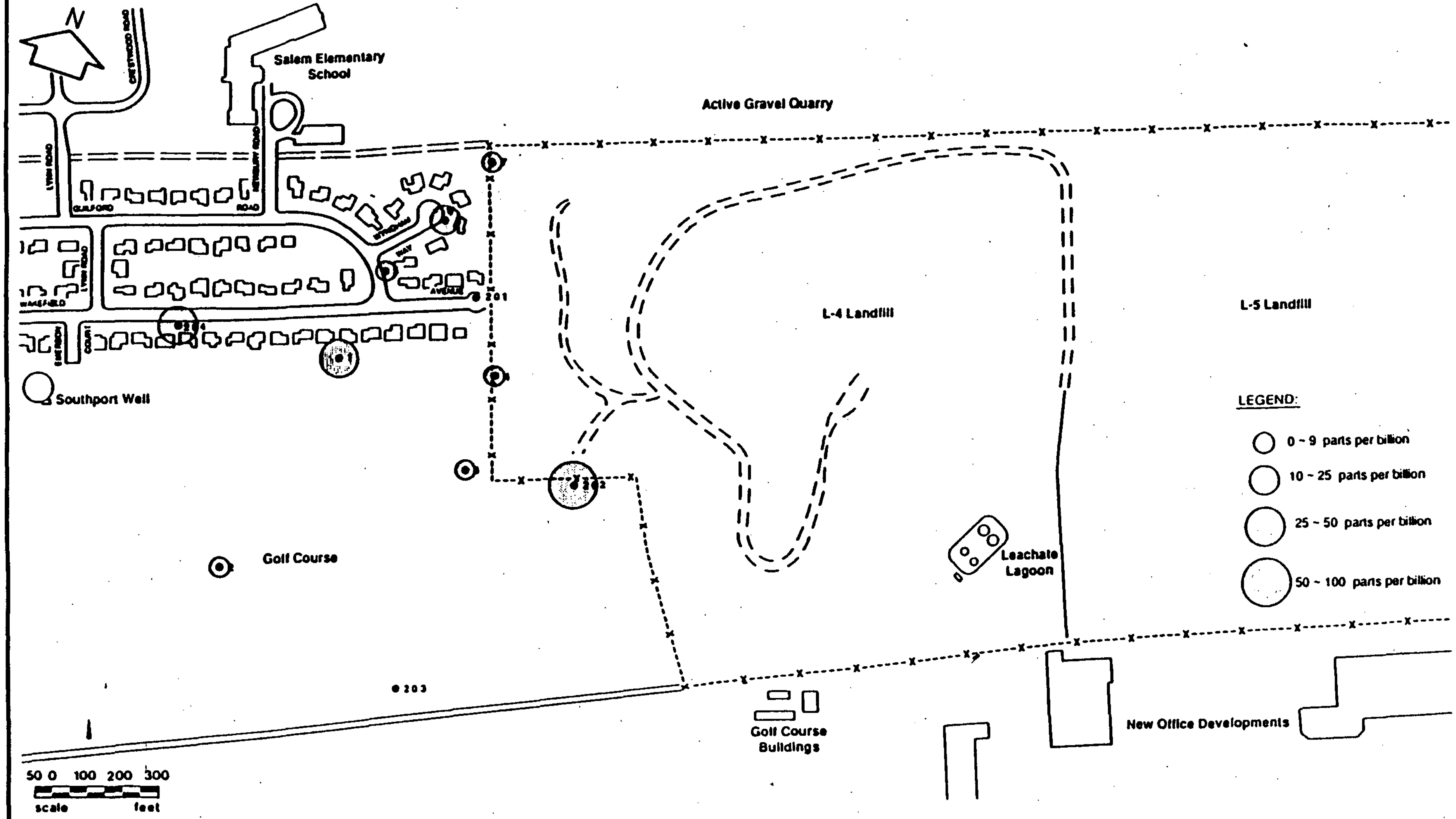
Tetrachloroethene
Round 2 (Deep)

Port Washington Landfill, Port Washington, New York



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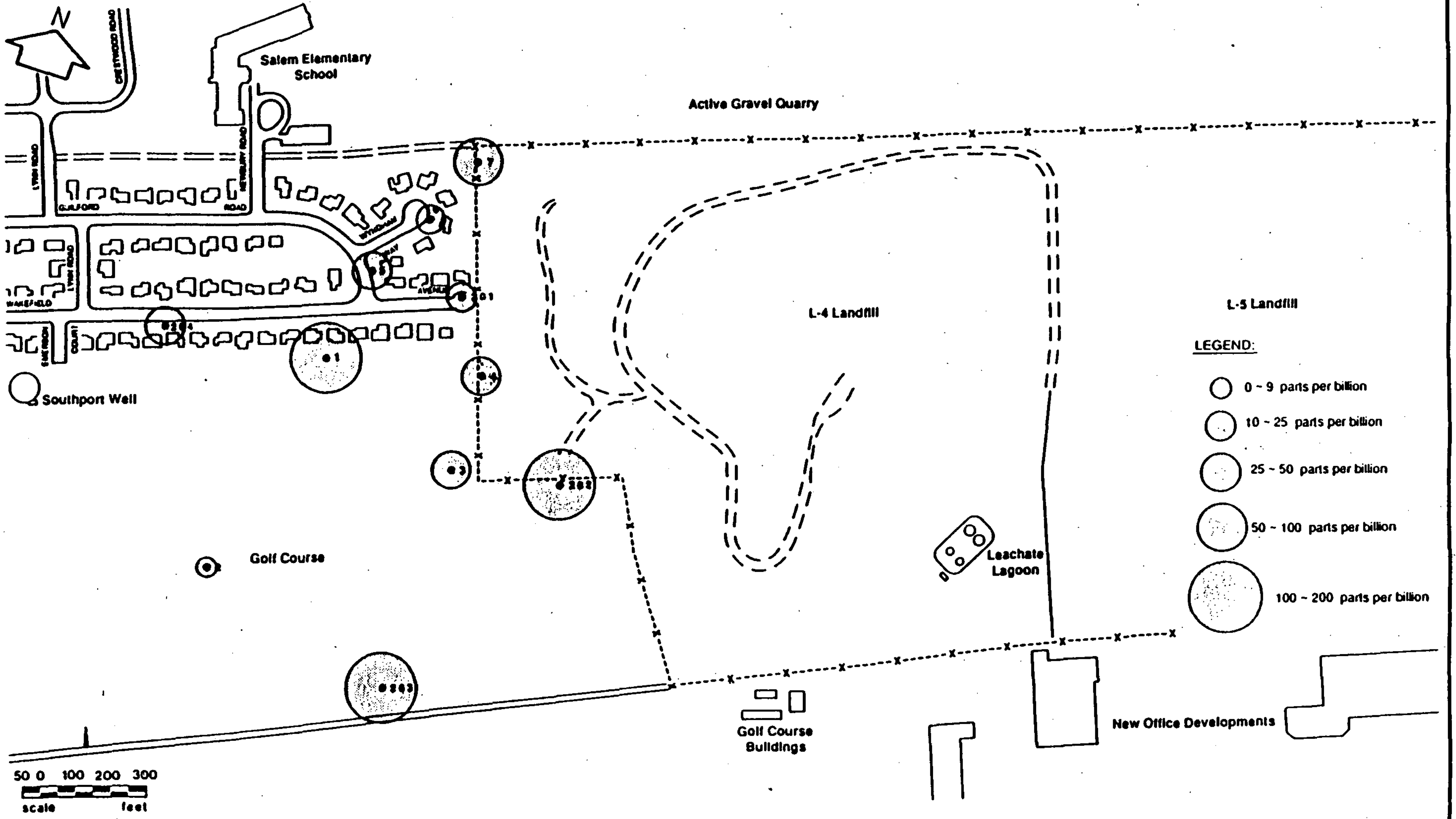
Tetrachloroethene
Round 3 (Shallow)

Port Washington Landfill, Port Washington, New York



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Tetrachloroethene
Round 3 (Medium)

Port Washington Landfill, Port Washington, New York

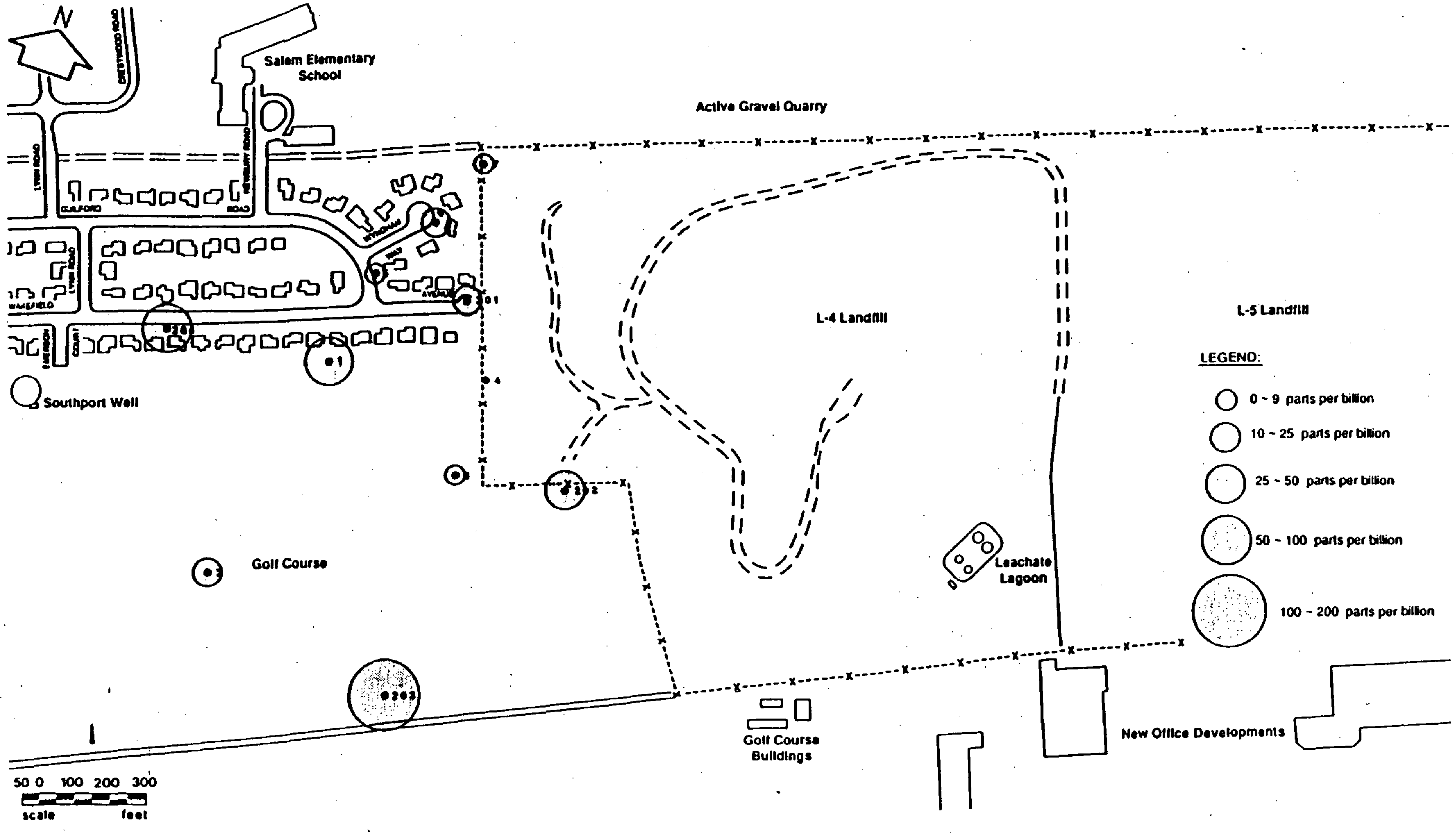

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Figure 0-0

Tetrachloroethene Round 3 (Deep)

Port Washington Landfill, Port Washington, New York

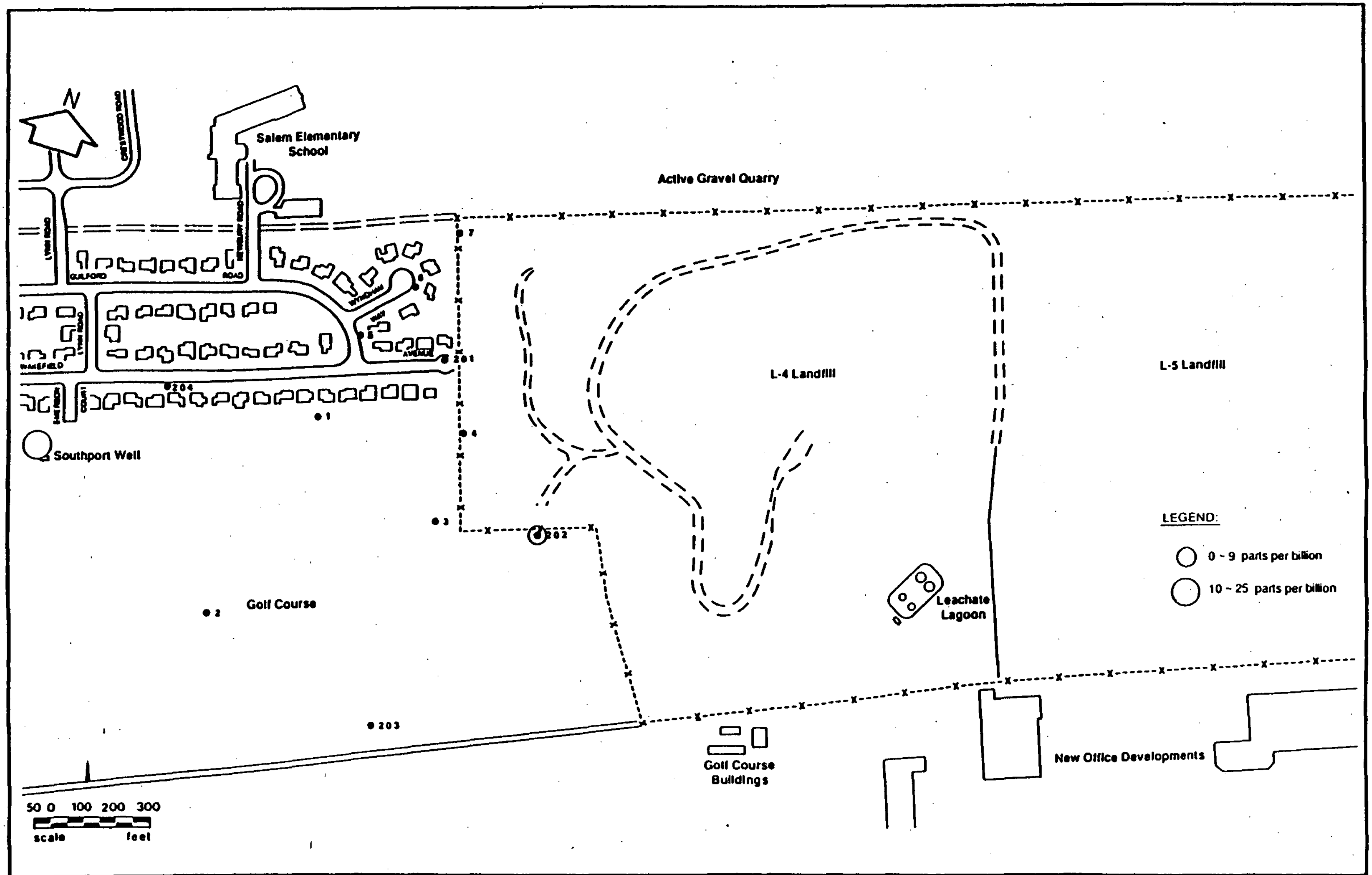

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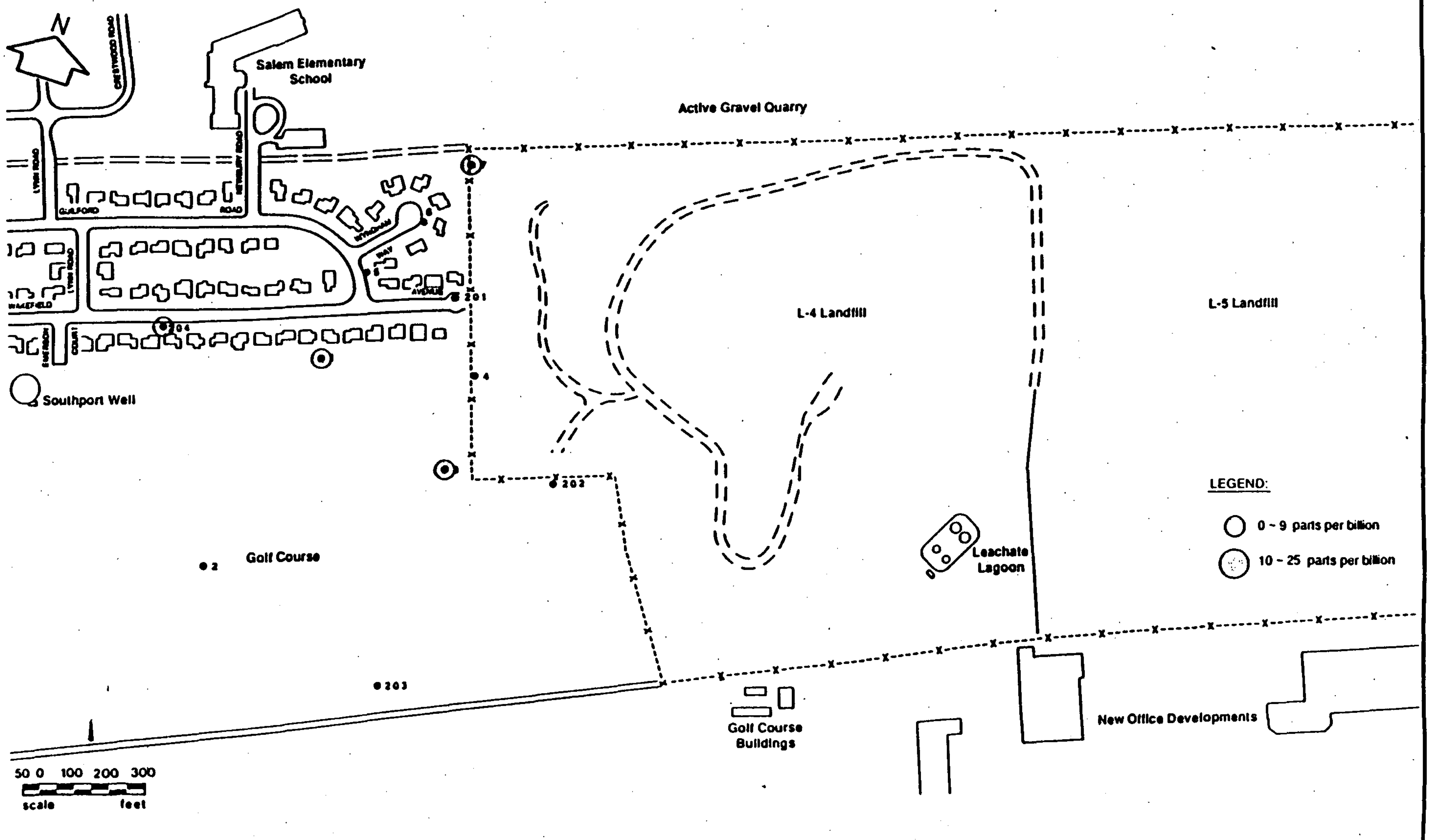
Figure 0-0

Chloroform

Round 2 (Shallow)

Port Washington Landfill, Port Washington, New York



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Chloroform
Round 2 (Medium)

Port Washington Landfill, Port Washington, New York

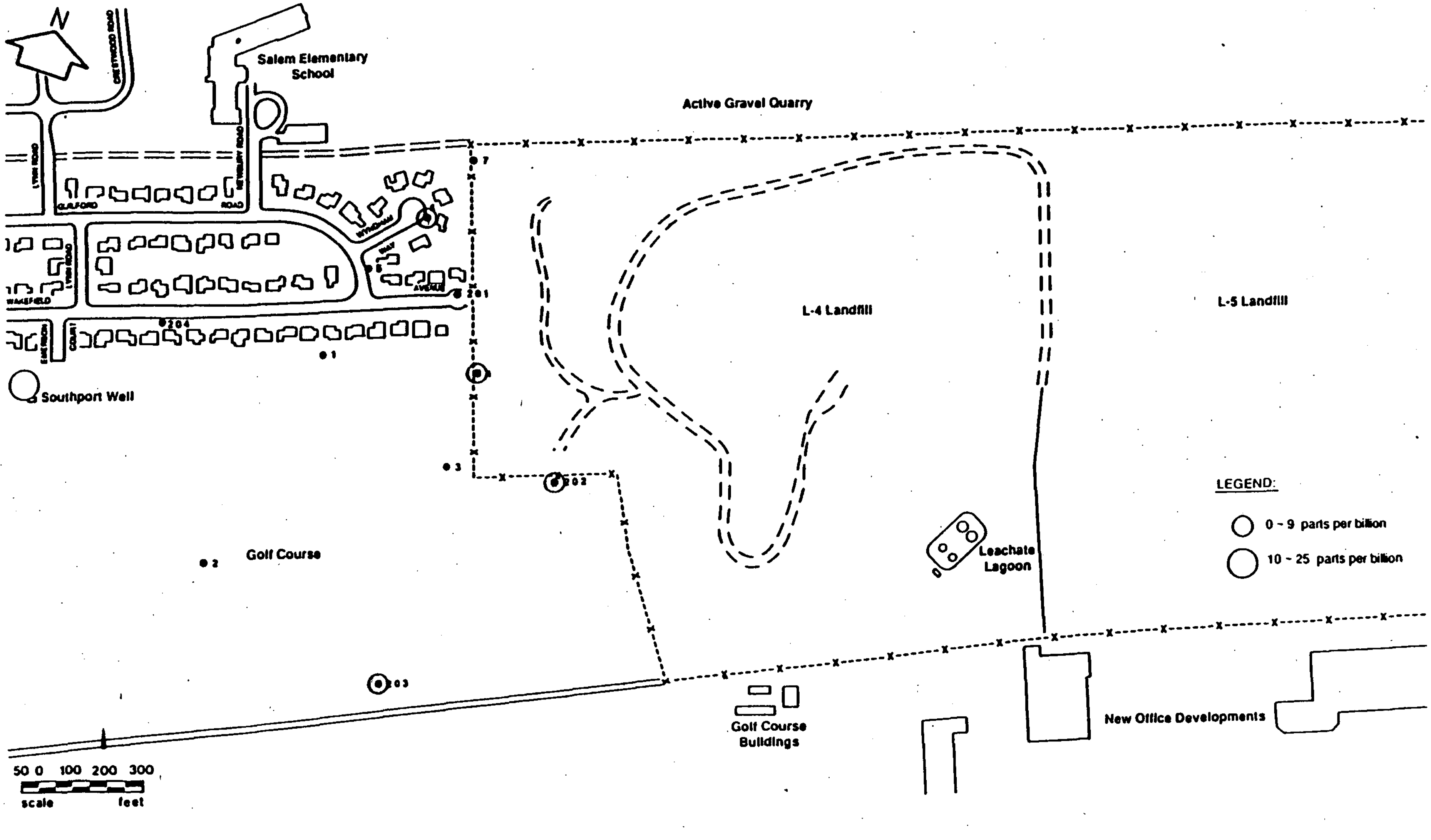

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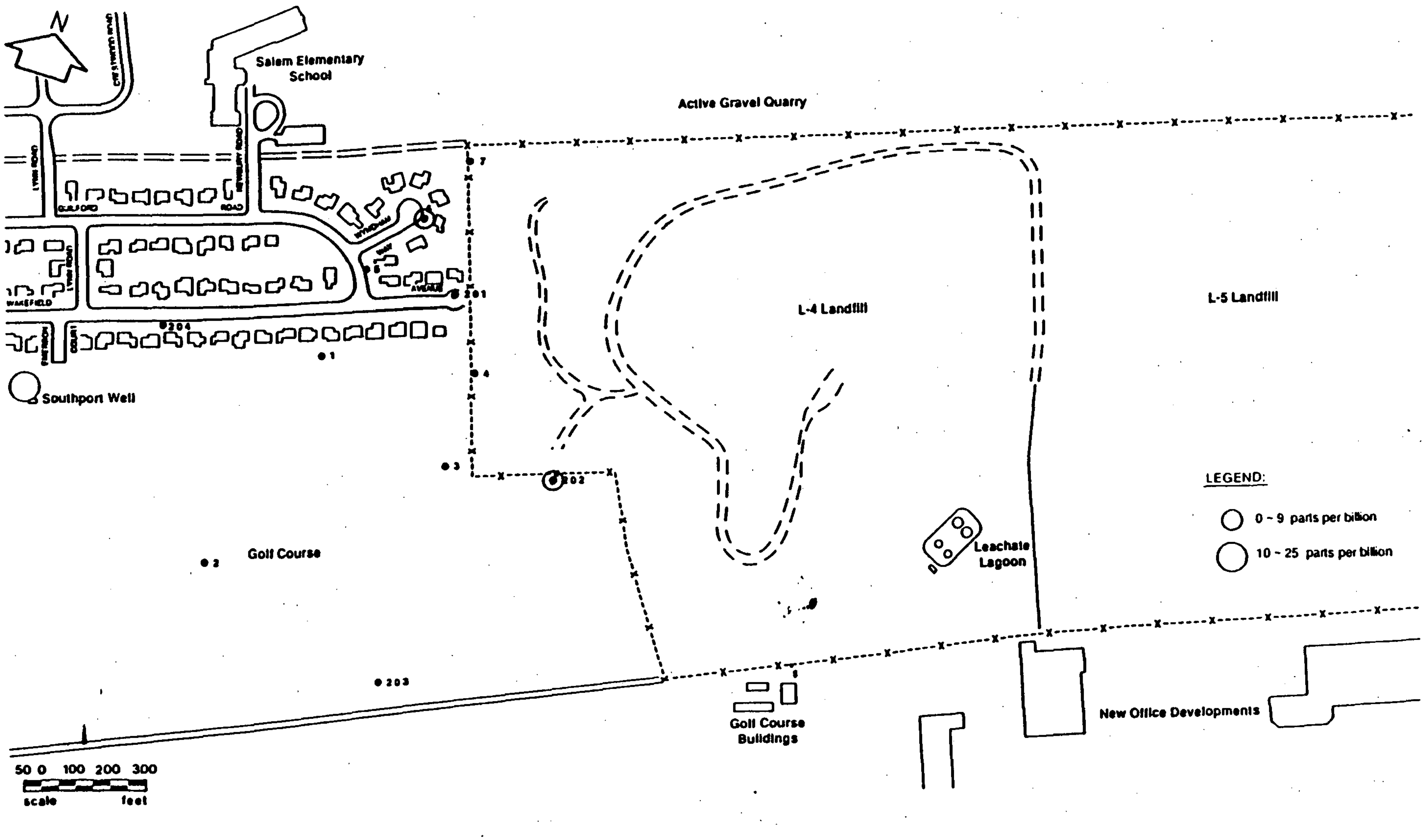
Figure 0-0

Chloroform
Round 2 (Deep)

Port Washington Landfill, Port Washington, New York



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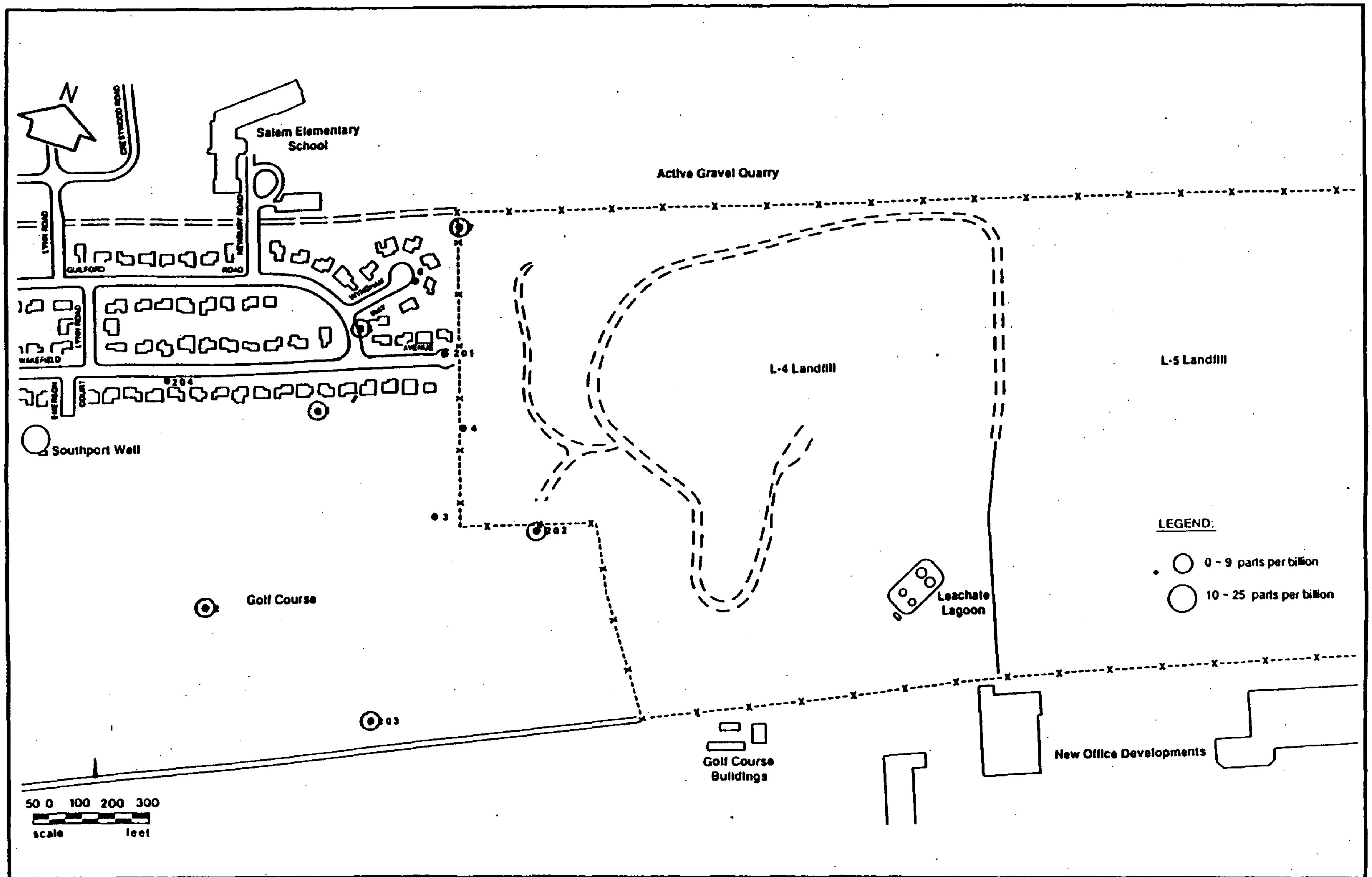
Chloroform

Round 3 (Shallow)

Port Washington Landfill, Port Washington, New York



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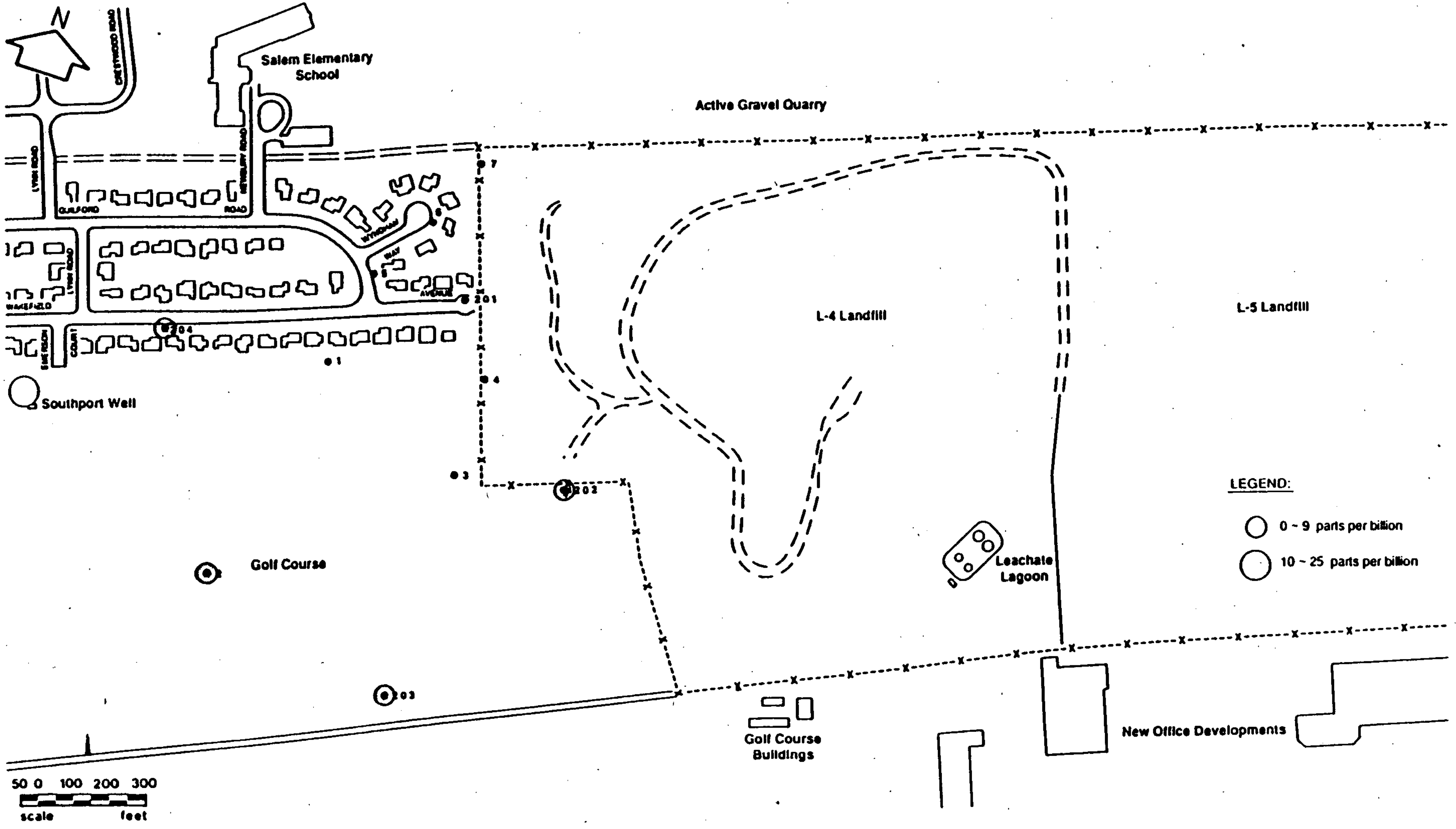
Round 3 (Medium)

Port Washington Landfill, Port Washington, New York



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Chloroform

Round 3 (Deep)

Port Washington Landfill, Port Washington, New York

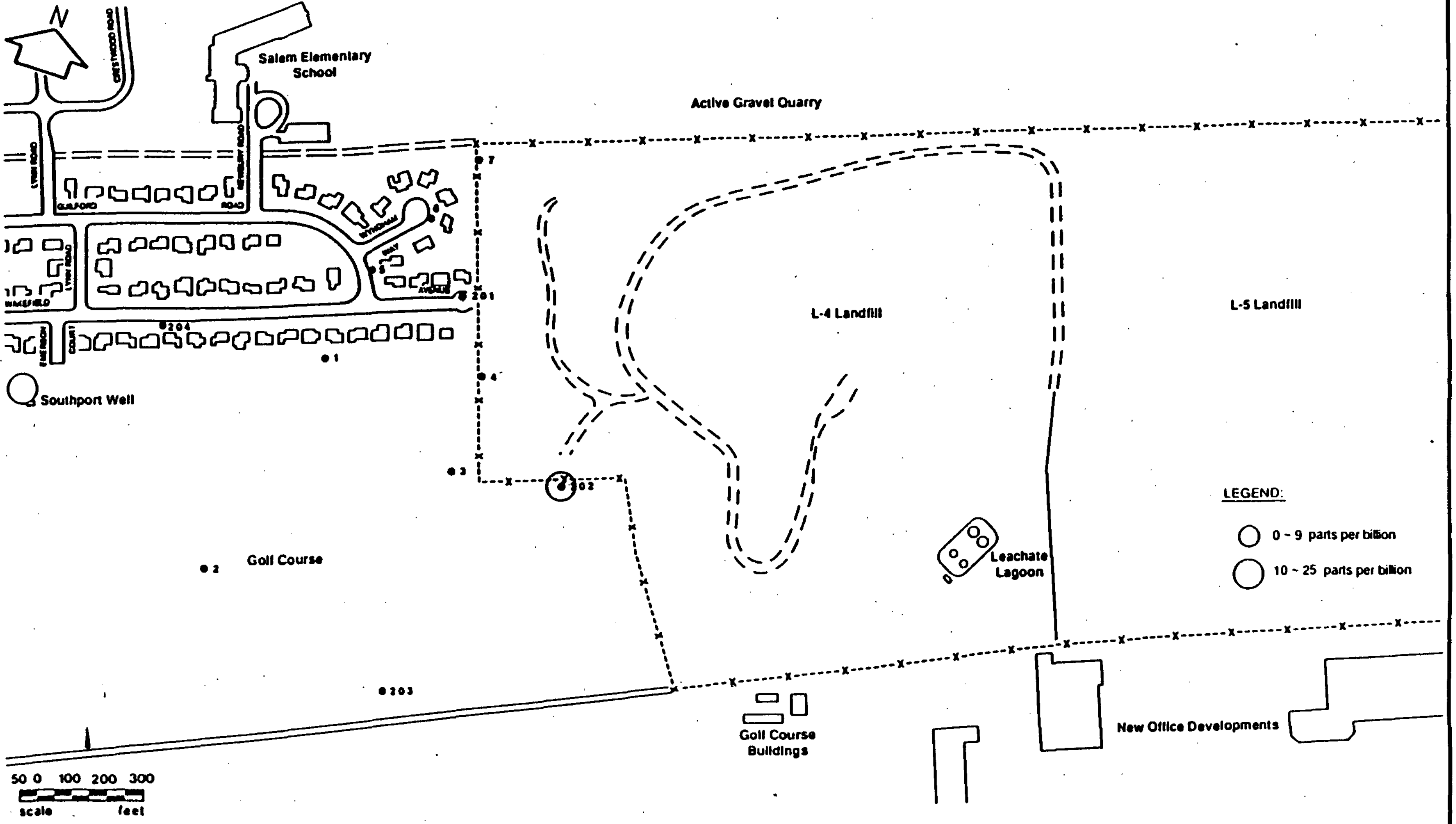

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Figure 0-0

1,1 Dichloroethene
Round 2 (Shallow)

Port Washington Landfill, Port Washington, New York

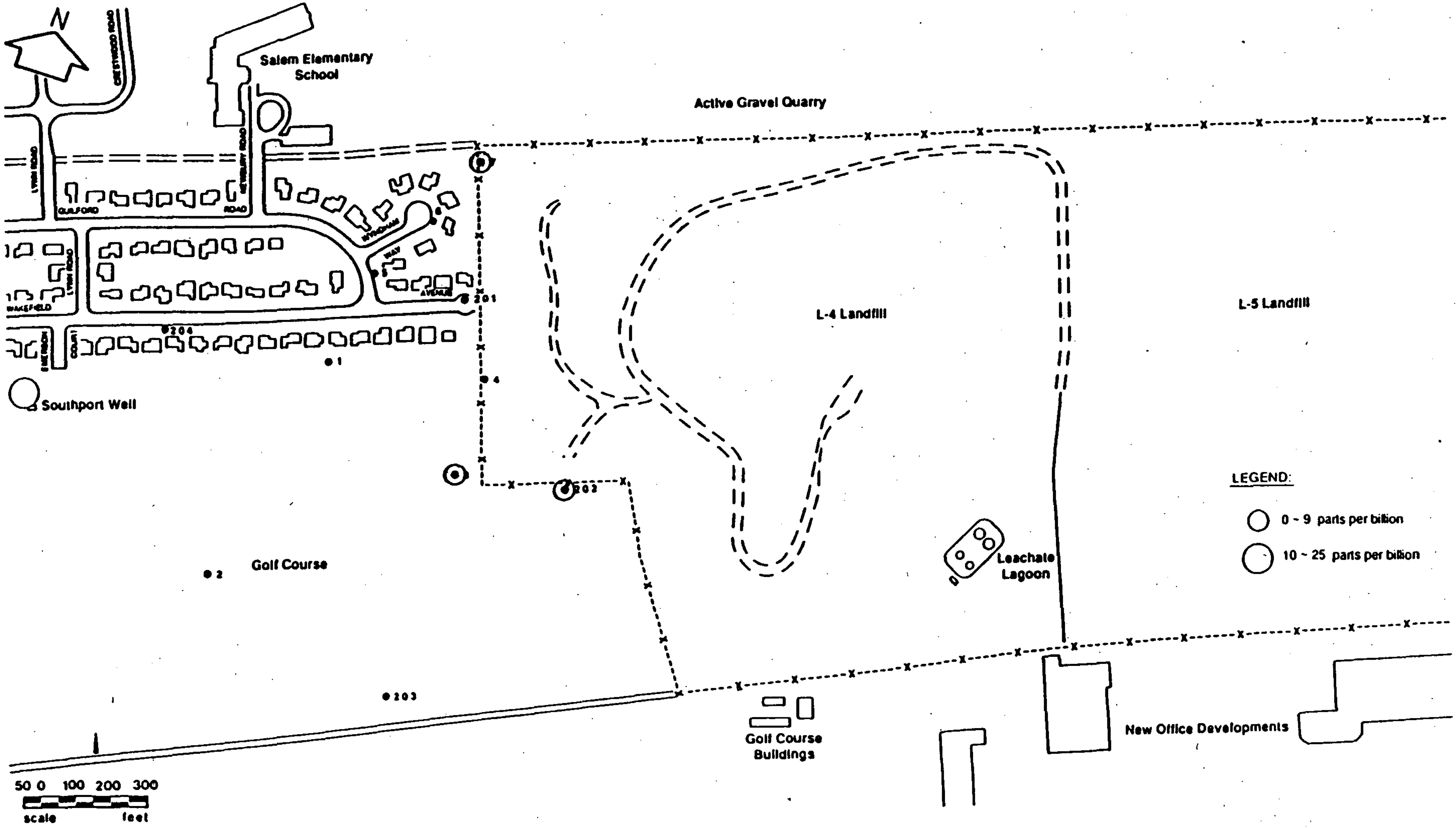

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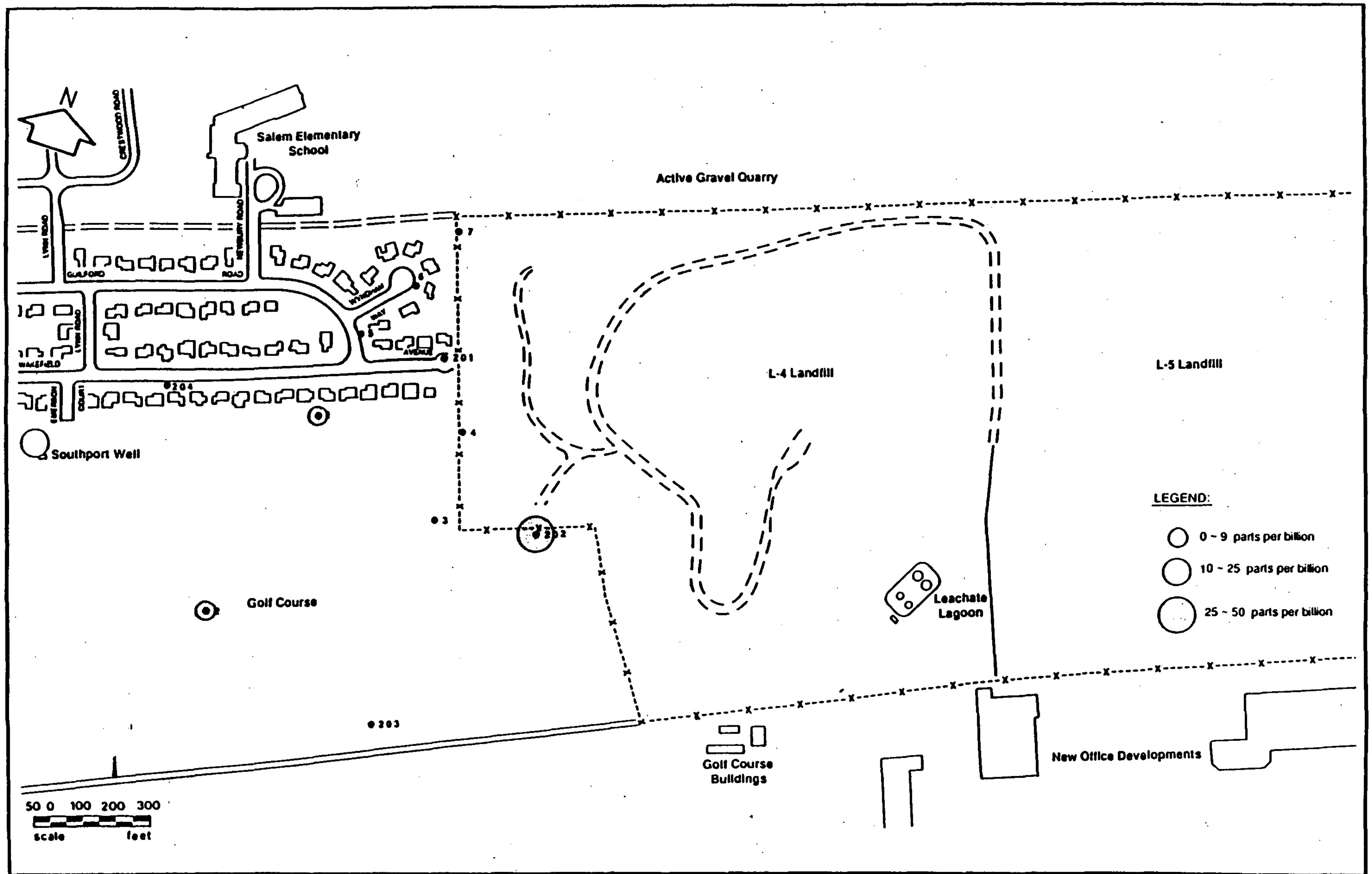
Figure 0-0

1,1 Dichloroethene
Round 2 (Medium)

Port Washington Landfill, Port Washington, New York



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1,1 Dichloroethene
Round 2 (Deep)

Port Washington Landfill, Port Washington, New York

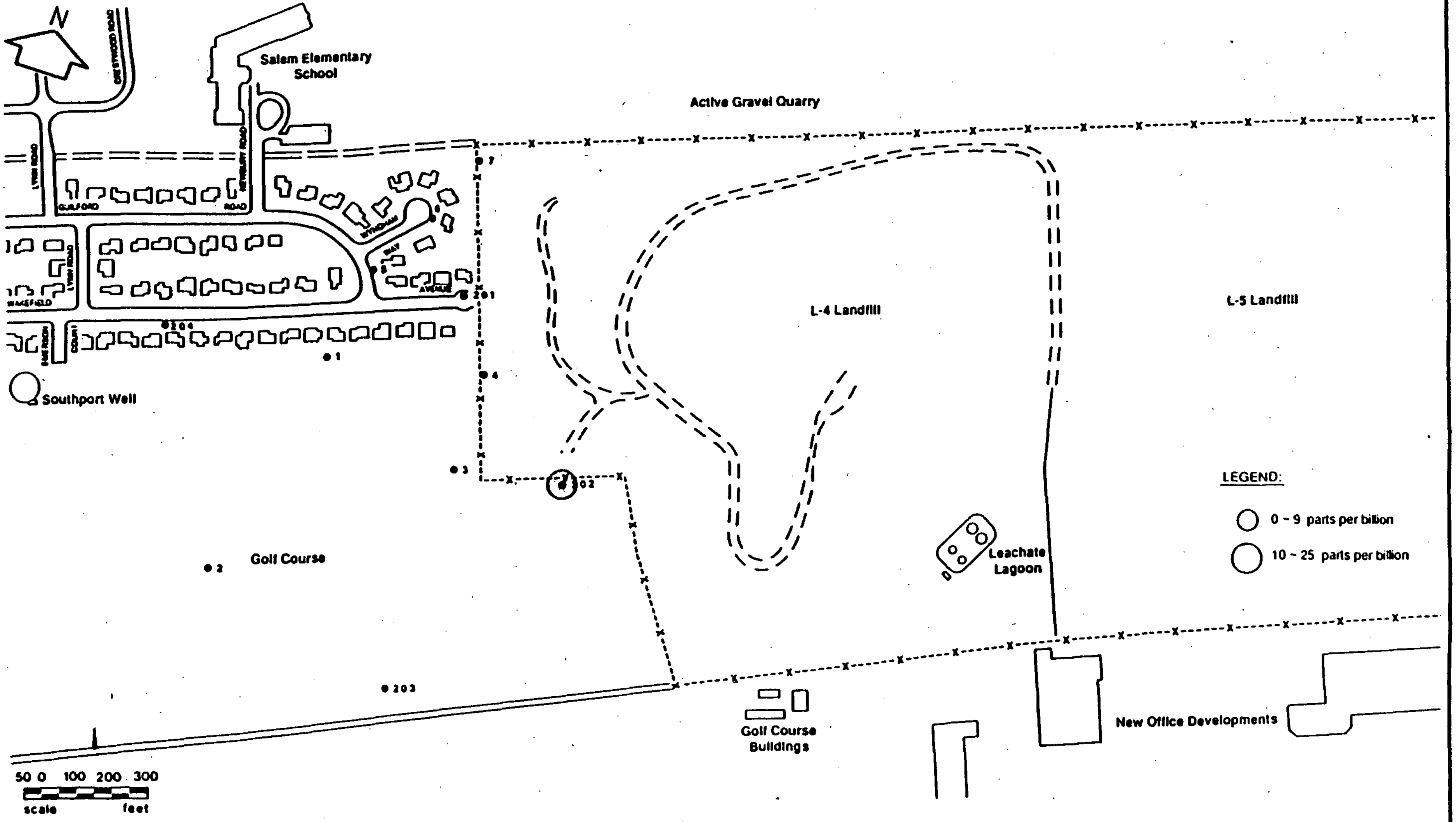

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Figure 0-0

1,1 Dichloroethene
Round 3 (Shallow)

Port Washington Landfill, Port Washington, New York

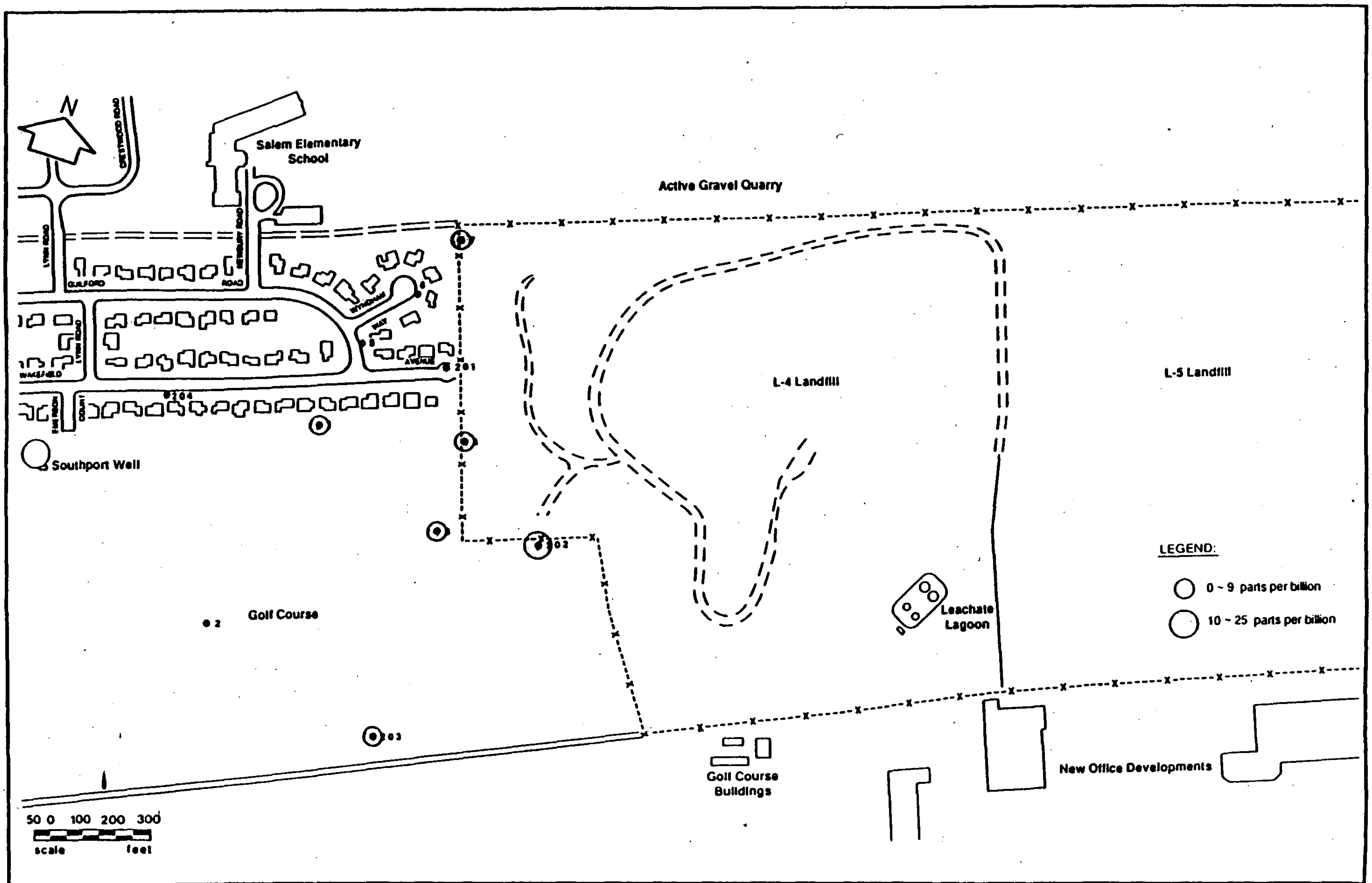

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Figure 0-0

1,1 Dichloroethene
Round 3 (Medium)

Port Washington Landfill, Port Washington, New York

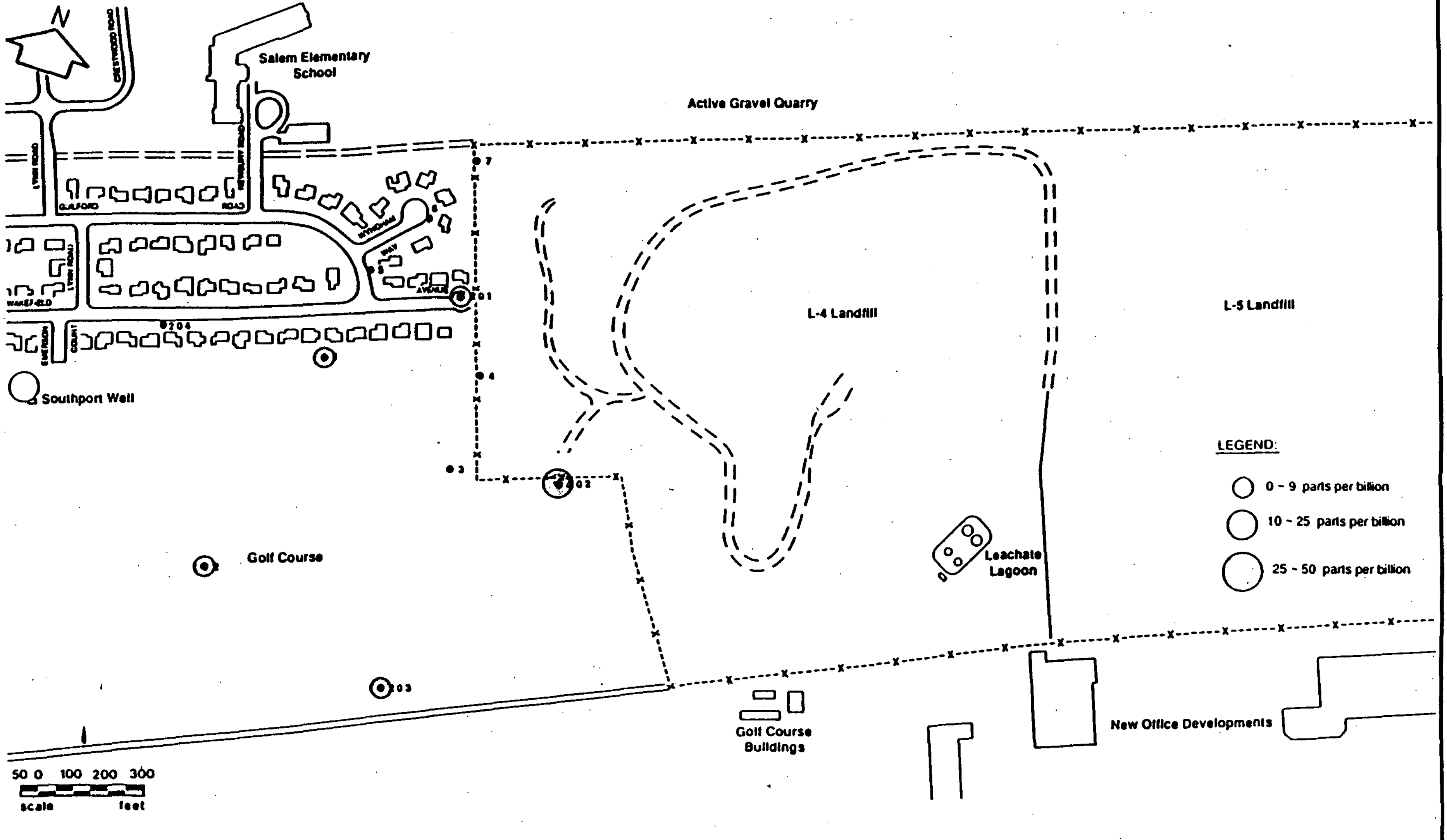

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Figure 0-0

1,1 Dichloroethene
Round 3 (Deep)

Port Washington Landfill, Port Washington, New York

- 1,1-dichloroethane
- tetrachloroethene
- chloroform
- 1,1-dichloroethene

These compounds were selected because they clearly indicate several trends in gas concentration and migration, as discussed below. These were not the only compounds detected during the three rounds of landfill gas sampling. Other compounds included trans-1,2-dichloroethene; vinyl chloride; 1,2-dichloroethane; 1,1,2,2-tetrachloroethane; 1,2-dichloropropane; benzene and carbon tetrachloride.

Figure 3-7 also plots the gas data as it was observed at varying depths in the subsurface. Table 3-18 previously outlined the depths at which sample probes were situated. For ease of presentation, each figure is denoted as representing either shallow, medium or deep conditions. Generally, shallow probes were installed 35 to 65 feet below grade, medium probes 90 to 100 feet below grade and deep probes 120 to 130 feet below grade. The following discussion has been organized first on a chemical by chemical basis and then on a sampling round by sampling round basis:

Trichloroethene(TCE): TCE has been demonstrated to be an animal carcinogen (International Agency for Research on Cancer [IARC], 1976). TCE is a colorless, nonflammable, non-corrosive liquid having a "sweet" odor characteristic of some chlorinated hydrocarbons. It is primarily used as a solvent in vapor degreasing. It is also used for extracting caffeine from coffee, as a dry-cleaning agent, and as a chemical intermediate in the production of pesticides, tars, paints and varnishes. In the ambient air the National Institute of Occupational Safety and Health (NIOSH) recommends limits of 100 parts per million (ppm) as an 8-hour time weighted average (TWA).

At the Port Washington landfill, the maximum concentration of TCE detected in the subsurface unsaturated zone was 119 parts per billion (ppb) which is equivalent to 0.119 ppm. This occurred at landfill gas (LFG) well EPA 202 during round 1. TCE was detected at LFG 202 and LFG 203 during each of the three rounds. These are the only wells where this occurred. In viewing figure 3-7 it appears that TCE is more prevalent at the medium and deep depths than in the shallow probes. It is also apparent that TCE is migrating off-site to the west of the L-4 boundary. Excursions of TCE have been detected as far from L-4 as EPA 203. The highest concentrations typically appear at EPA LFG 202. This appears to be the case in each of the three rounds of data collected to date.

1,1,1-Trichloroethane: This non-carcinogenic EPA priority pollutant is a colorless, nonflammable liquid with an odor similar to chloroform. In recent years, 1,1,1-trichloroethane has found wide use as a substitute for carbon tetrachloride. In liquid form it is used as a degreaser. Other industrial applications of this solvent include its use as a dry-cleaning agent, a vapor degreasing agent, and a propellant. In the ambient air the NIOSH criteria is 200 ppm.

At Port Washington, the maximum concentration of 1,1,1-trichloroethane detected in the subsurface was 692 ppb or 0.692 ppm. This occurred at TNH-7 (at the medium probe) during round 2. Looking at figure 3-7 it is clear that this chemical has been detected in all directions west of L-4 and at shallow, medium and deep probe locations. This chemical has been detected at all three of the furthest monitoring locations established during this study namely TNH-2, EPA LFG 203 and EPA LFG 204. Additionally, it has been detected on at least one occasion at all of the monitoring points. No trend is apparent concerning this compounds affinity for traveling off-site at either shallow, medium or deep depths as it has been found to be pervasive at all three elevations.

1,1-dichloroethane: This EPA priority pollutant is non-carcinogenic. It is a colorless liquid with a chloroform-like odor. It is a flammable liquid which is used as a solvent and cleaning and degreasing agent. In the ambient air the Federal limit for 1,1-dichloroethane is 100 ppm and the American Conference of Governmental Industrial Hygienists (ACGIH) time-weighted average is 200 ppm.

At Port Washington, the maximum concentration of 1,1-dichloroethane detected in subsurface gases was 385 ppb or 0.385 ppm. This was evidenced during round 1 in the shallow probe at location EPA LFG 202. Figure 3-7 indicates that the highest concentrations of 1,1-dichloroethane were found at EPA LFG 202 during all three rounds. Interestingly, no 1,1-dichloroethane was detected during round 1 in either the medium or deep probe at LFG 202; however, during rounds 2 and 3 levels of 1,1-dichloroethane were detected at this location at both of these depths. In fact, the round 1 results show 1,1-dichloroethane at only shallow and medium depths at only two locations (LFG 202 and LFG 203) but rounds 2 and 3 show this chemical to be much more widespread (appearing at all locations except TNH-6 and LFG 204) and with only limited travel in the shallow elevation, preferring instead to travel much more extensively at the medium and deep elevations.

Tetrachloroethene (PCE): PCE is both a carcinogen (National Cancer Institute, 1977) and EPA priority pollutant. It is a clear, colorless, non-flammable liquid. PCE is a widely used solvent with particular use as a dry cleaning agent, a degreaser, a chemical intermediate and a fumigant. The Federal limit in ambient air is 100 ppm as an 8-hour TWA. NIOSH has recommended a TWA limit of 50 ppm as has the ACGIH.

At Port Washington, the maximum concentration of PCE detected in the subsurface was 614 ppb (0.614 ppm) during round 1 at the shallow probe of EPA LFG 202. Figure 3-7 indicates that PCE was prevalent off-site in all directions west of L-4 and at all three monitoring depths. PCE was detected at least once during the three rounds at all monitoring locations. Of the six chemical compounds depicted in figure 3-7, PCE was the compound most frequently detected and was the most widespread in off-site locations.

Chloroform: Chloroform is a suspected animal carcinogen (IARC, 1979) and is an EPA priority pollutant. It is a clear, colorless, non-flammable liquid with a characteristic odor. Chloroform was one of the earliest general anesthetics; but its use for this purpose has been abandoned because of toxic effects. Chloroform is widely used as a solvent (especially in the lacquer industry); in the extraction and purification of penicillin and other pharmaceuticals and in the manufacture of plastics and floor polishes.

Chloroform is widely distributed in the atmosphere and water (including municipal drinking water primarily as a consequence of chlorination). A survey of 80 American cities by EPA found chloroform in every water system in levels ranging from <0.3 to 311 ppb.

In air the Federal standard is 50 ppm and the ACGIH recommends a TWA of 10 ppm. At Port Washington, the maximum concentration of chloroform detected in the subsurface was 8 ppb (0.008 ppm) during round 2 at a shallow probe at EPA LFG 202. Chloroform was not detected in the subsurface during round 1 sampling activities. In both rounds 2 and 3, however, it was found at shallow, medium and deep elevations. It was most extensive during round 3 at medium and deep elevations and has been found at all three monitoring locations most distant from the western boundary of L-4 namely TNH-2 and EPA LFG 203 and EPA LFG 204. Chloroform has been detected on at least one occasion at all monitoring locations except TNH-4 and EPA LFG-201.

<u>1,1-dichloroethene</u>: This compound is a colorless liquid having a "sweet" odor similar to chloroform. It is used in adhesives and is a component of synthetic fibers. At Port Washington the highest concentration in the subsurface was 31 ppb at the deep probe of EPA LFG 202 during round 2. Figure 3-9 indicates that 1,1-dichloroethane has been found at monitoring locations west of the perimeter of L-4. All locations have detected 1,1-dichloroethene during one of the three rounds with the exception of TNH-5, TNH-6 and EPA LFG-204.

Looking at the gas sampling data on a round by round basis it is clear that round 1 data, because a majority failed quality assurance/quality control protocols; detected the least amount of off-site subsurface landfill gas. In general, subsurface gas was mainly detected during this round at the EPA LFG wells (201, 202, 203 and 204). On only one occasion was landfill gas detected at the deep probes (at TNH-6). The bulk of the gas was detected at the shallow elevation.

Rounds 2 and 3 evidenced much more extensive gas migration patterns into the off-site areas. In these rounds landfill gas was detected at all of the off-site monitoring locations west of L-4 and, in general, it appeared that the gas preferentially migrated at medium and deep elevations. There is no explanation of this difference between the gas patterns evidenced in round 1 as opposed to rounds 2 and 3 other than the sampling episodes represent merely a "snapshot in time" under but one range of climactic conditions and barometric pressures (as opposed to continuous sampling) and probably are not representative of off-site gas migration patterns at all times. The difference in migration patterns cannot be attributable to variable operating conditions of the active vent system since during all three rounds of sampling three blowers were operating.

To conclude this discussion, it is relevant to return for a moment to the historical conditions which led to the need for landfill gas monitoring at the Port Washington site. Recall that February 26, 1981 results of ground water sampling at the Southport well by the NCDOH detected levels of 1,1,1-trichloroethane and tetrachloroethylene (synonym: tetrachloroethene). Recall also that resampling of the Southport well in May and June 1981 detected concentrations of vinyl chloride. Furthermore, sampling of the passive vents at L-4 between July and October 1982 by the EPA-FIT detected the presence of vinyl chloride; tetrachloroethylene; 1,1-dichloroethane and 1,1,1-trichloroethane among others.

These chemicals are the same found by the REM II team during three rounds of sampling at the off-site subsurface gas monitoring locations. In other words, chemicals found six years ago in the passive vents at L-4 (such as tetrachloroethylene (PCE) and 1,1,1-trichloroethane) are being found today in the subsurface gas at off-site locations. These chemicals in the subsurface gas are the same as those found in the ground water pumped at the Southport well in 1981. [redacted] depicts which chemical compounds have been found at which of these locations and intimates a connection between the contaminants found in the passive vents, active vents, flux boxes, off-site LFG wells and the Southport well. This issue is discussed in more detail in section 6.0.

TABLE 3-24

CHEMICAL CONSTITUENTS AND LOCATIONS DETECTED

	Location Detected				
	Off-site Locations		On-site Locations		
Chemical	Southport Well	Off-site LFG Wells	On-site Passive Vents	On-site Passive and Active Vents	Landfill Surface Emissions (Flux Bo
Tetrachloroethylene (PCE)	X	X	X	X	X
1,1,1-Trichloroethane	X	X	X	X	X
1,2-dichloropropane	X	X			
Vinyl chloride	X	X	X	X	X
Toluene			X		X
trans 1,2-dichloroethylene		X	X	X	X
1,1-dichloroethane		X	X	X	X
Ethylbenzene			X		
Trichloroethene (TCE)		X		X	X
Chloroform		X			X
1,1-dichloroethene		X		X	X
Benzene		X		X	X
1,2-dichloroethane		X		X	
1,1,2,2-tetrachloroethane		X		X	
Chlorobenzene				X	X
Xylene					X

Notes:

Southport well sampled in 1981 by NCDOH
*Passive vents sampled in 1982 by EPA-FIT
All other samples collected in 1987 and 1988 by the REM II team

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3.4.4 SUPPLEMENTAL SOIL GAS SURVEY

As discussed in section 2.4.1, EPA's Environmental Response Team (ERT) conducted a supplemental soil gas survey on September 21, 1988 in the commercial tract area along the fenceline comprising the southern boundary of the L-4 and L-5 landfill. Thirteen sampling stations were established along this boundary in addition to sixteen stations perpendicular to this transect. Subsurface gases extracted during this survey were analyzed for benzene, toluene, xylene, trichloroethylene, tetrachloroethylene, ethylbenzene, vinyl chloride, total organics and methane. EPA-ERT's results, conclusions, and recommendations are as follows.

The significant portion of contamination in this study was reported by EPA-ERT to be methane. For the most part, the largest concentrations of methane were detected along the fenceline adjacent to L-4. The methane concentration was found to decrease as measurements moved to the south away from L-4 toward the industrial park road. The total volatile organics measured were found by EPA-ERT to be too low or near the detection limit to provide enough information to form a conclusion with respect to these constituents. However, ERT did conclude that the predominant contaminant in their study area was methane. ERT further concluded that the source of the methane was apparently the L-4 landfill and that significant concentrations of methane have migrated south as least as far as the industrial park road.

EPA-ERT recommended in the interest of public health, the recognition of the possibility of an explosion hazard in one of the new commercial buildings along the industrial park road. ERT further recommended that a monitoring system be installed in these buildings adjacent to L-4. The monitors proposed would run 24 hours per day and be equipped with an evacuation alarm set for 5 percent of the lower explosive limit (LEL) or approximately 2500 ppm methane. ERT noted that a more expensive option would be to extend or upgrade the existing landfill gas vent curtain along the industrial park fenceline. The complete text of the ERT report is included as Appendix D.

3.5 AMBIENT AIR QUALITY

The indoor ambient air has been monitored at various times in the past at the residential area of Wakefield Avenue and Guilford Road. In March 1981, 240 parts per billion on a volume by volume basis (ppb v/v) of vinyl chloride was detected by the Nassau County Department of Health (NCDOH) at 48 Wakefield Avenue. This was attributed to indoor contamination not related to the landfill operations.

Follow-up testing by the NCDOH indicated that vinyl chloride was not detected in quantifiable levels in the air of four homes tested which were previously impacted in 1981 by the infiltration of methane gas from the landfill. Findings of trace quantities of vinyl chloride under 1 ppb in homes in both the impacted and control areas, used for comparison purposes, indicated that vinyl chloride may be common in the interior air environment and might be expected to be found almost anywhere with the use of high sensitivity analytical instrumentation.

An ambient air survey carried out at the residential area of Wakefield Avenue and Guilford Road by the Nassau County Department of Health in August 1983, suggested that the vinyl chloride detected in the homes was not infiltration from the landfill nor from the outside ambient air, but was generated within the homes. Vinyl chloride monomer has been historically used as a propellant in hair sprays, deodorants and other aerosol cans. Since only an intermittent presence of vinyl chloride was found, and then with a maximum level of 0.5 ppb v/v in a control home, a condition of public health concern caused by the landfill was not demonstrated.

As indicated in section 2.5.2, in response to concerns raised by the residential community, the outdoor ambient air in the vicinity of Wakefield Avenue was monitored by EPA-ERT during the period from September 27 through September 29, 1988 for seven target volatile organic compounds. Twenty-four separate sampling events were reported by ERT. According to ERT "The results are mainly negative, i.e., most of the time the seven compounds are not present exceeding the detection limits measured. Most of the exceptions, benzene and toluene, are thought to derive from motor vehicle emissions. Very low levels of vinyl chloride, at or just above the detection limit, are thought to derive from interference" (EPA-ERT, 1988).

The complete text of EPA-ERT's report entitled "TAGA Analysis of Ambient Air in the Vicinity of the Landfill at Port Washington, New York" dated December 1988 is attached herein as Appendix E.

3.6 METEOROLOGICAL STATION DATA

Data obtained from the meteorological station has been compiled and can be found in Appendix F. This data includes solar radiation, air temperature, relative humidity, soil temperatures recorded at different depths (three, nine, eighteen and twenty four inches) below ground surface at the landfill, barometric pressure, wind speed and direction and precipitation.

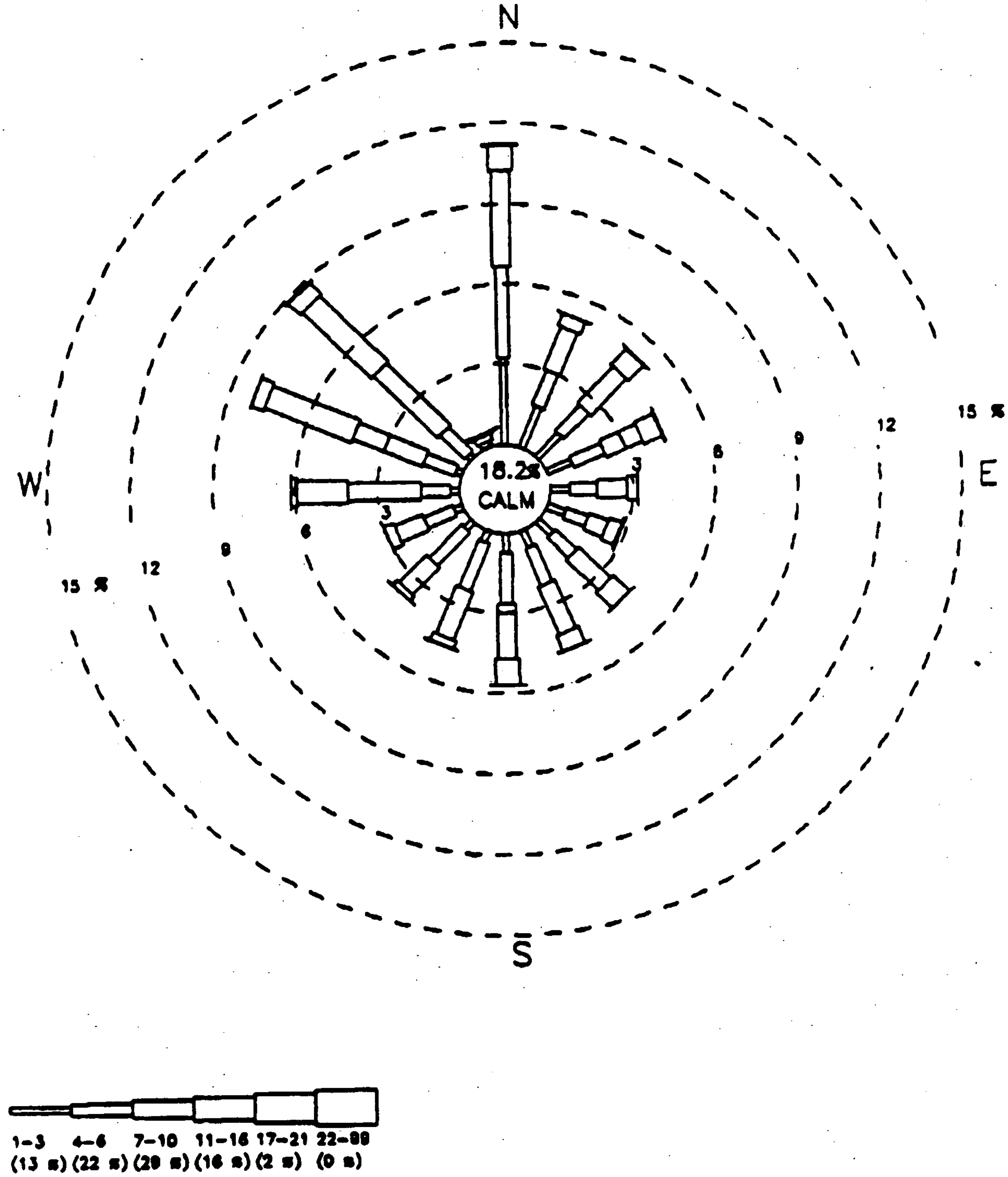
This section of the report serves to briefly highlight the major points of importance of the meteorological data. This includes barometric pressures, wind speed and wind direction.

3.6.1 BAROMETRIC PRESSURE AND GAS WELLS PRESSURE

While barometric pressures were recorded, typically a diurnal fluctuation was observed with a low pressure in the early hours of the day, rising very slowly towards late afternoon. Changes in barometric pressure were compared with well head pressures measured with a pressure gage at the landfill gas monitoring wells. It was observed that when barometric pressures were falling, this caused the well head pressures to rise and become positive. Accordingly, sampling of the landfill gas monitoring wells was only done when positive pressures were obtained in the landfill gas monitoring wells.

3.6.3 WIND SPEED AND WIND DIRECTIONS

A wind rose for the period of October 1987 to September 1988 is shown in [redacted]nd indicates that the predominant wind direction was to the north and west. This wind rose is utilized in the Public Health Evaluation



WIND SPEED SCALE (KNOTS)

NOTE – WIND DIRECTION IS THE DIRECTION WIND IS BLOWING FROM

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Figure

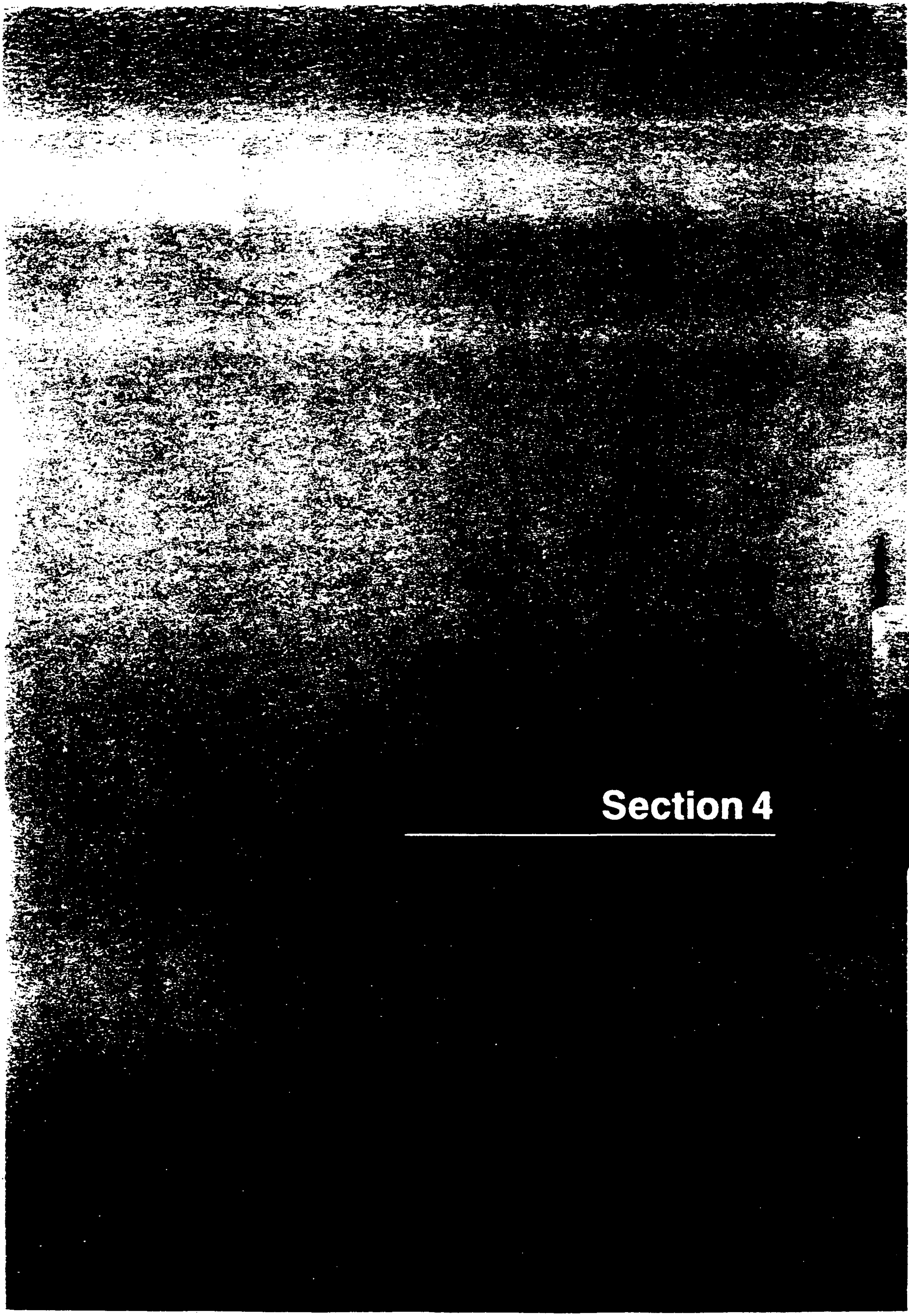
Wind R

December 1987 to September 1988

Port Washington Landfill, Port Washington, New York

as an indicator as to how often volatile organics and other contaminants might be carried from the landfill to adjacent residential properties west of the site.

(545)



Section 4

4.0 REMEDIAL INVESTIGATION ACTIVITIES - HYDROGEOLOGY

The methodologies used in the field to secure the necessary data to portray the hydrogeology at the site are described in this section. Section 5.0, alternatively, presents the methods used to characterize the site hydrogeology and explains how the field-secured data were utilized.

The field activities covered in this section include:

- Borehole soil logging;
- Borehole geophysical logging;
- Ground water monitoring well drilling and installation;
- Laboratory permeability tests of the Raritan Clay;
- Monitoring well insitu permeability tests ("slug" tests);
- Pump testing of the Stonytown well;
- Topographic survey;
- Measurement of the piezometric surface in various water-bearing zones; and
- Ground water and landfill leachate sampling

Supplementary field activities also described herein relate to the oversight performed at the drum excavation undertaken by the Town of North Hempstead in an area to the southeast of L-4 during August 31 to September 25, 1987.

Overall, the goals of the hydrogeologic study were to:

1. determine if ground water contamination exists off-site (where on-site is defined by the Town of Hempstead Port Washington Landfill cell L-4);
2. if found offsite, delineate the extent of the contamination and determine if contamination continues to migrate off-site; and,

3. evaluate the landfill as a potential source of ground water contamination.

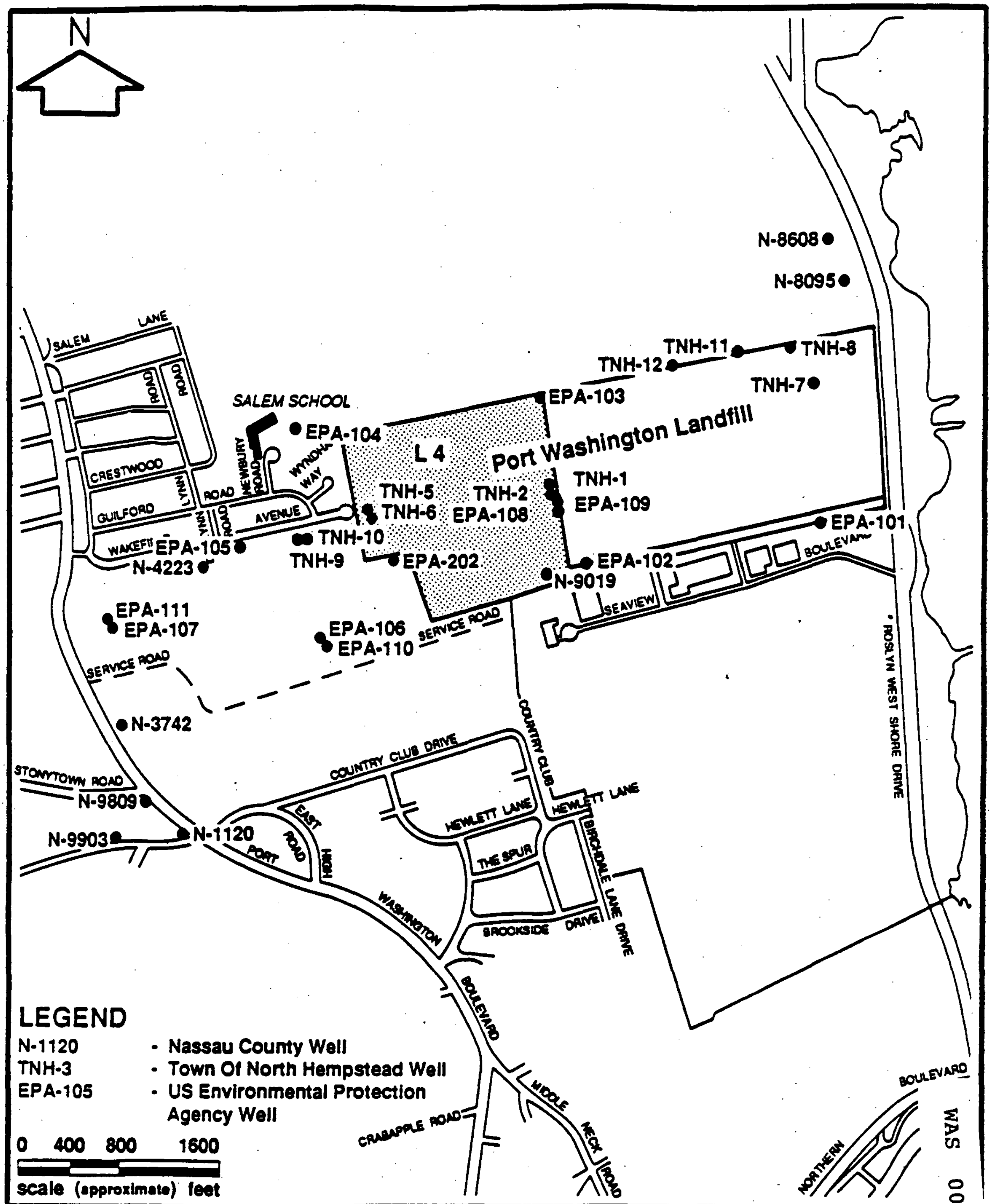
4.1 GEOLOGIC INVESTIGATION

The geologic investigation activities included soil borings and geophysical logging. The investigation centered on defining the stratigraphy in the immediate vicinity of the landfill and identifying the hydraulic connections between the known aquifers on a local basis. Additionally, chemical analyses were performed on retained soil samples to determine the distribution of volatile organic contamination in the unsaturated zone.

4.1.1 SOIL BORINGS

Eleven ground water wells and four landfill gas wells were drilled and installed at Port Washington at locations shown in Figures 4-1 and 2-4, respectively. During drilling of these wells, split spoon soil samples were collected between the addition of each drill rod or at a noticeable change in strata (typically at 10 to 20 foot intervals) for the purposes of collecting soils samples for classification of the stratigraphy and analyzing the relative organic vapor content of the soil column. Additionally, undisturbed soils samples were collected using 4-inch sleeves inside of a split spoon sampler for the purpose of determining insitu volatile organic constituent concentrations at various depths and locations.

The REM II field geologist placed the soil samples collected from the split-spoons into plastic bags and classified each using the Unified Soil Classification System. The descriptions were entered into a dedicated field notebook and a soil boring log sheet. Boring logs are presented in Appendix G for the Landfill Gas Wells and in Appendix H for the Ground Water Wells. A portion of each disturbed soil sample was placed in a "Ziplock bag" and allowed to equilibrate for no more than 15 minutes. A reading of the organic vapor in the head space of the bag was then checked using an HNu and/or OVA meter. The results which were recorded on the soil boring log sheet and in the dedicated field notebook are presented in table [illegible] for the ground water monitoring wells and landfill gas wells. This



LEGEND

N-1120 - Nassau County Well
TNH-3 - Town Of North Hempstead Well
EPA-105 - US Environmental Protection Agency Well

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environmental engineers, scientists
planners & management consultants

Figur

Location Of Ground Water Monitoring W

Port Washington Landfill, Port Washington, New

Port Washington Landfill Site

TABLE 4-1

OVA & HNU DATA ON SPLIT SPOON SAMPLES TAKEN FROM GROUND WATER WELL BORINGS 101-106

101				102				103				104				105				106			
Ft. B.G.	ELEV.	OVA	HNu	Ft. B.G.	ELEV.	OVA	HNu	Ft. B.G.	ELEV.	OVA	HNu	Ft. B.G.	ELEV.	OVA	HNu	Ft. B.G.	ELEV.	OVA	HNu	Ft. B.G.	ELEV.	OVA	HNu
0.0	38.8	--	--	0.0	54.8	--	--	0.0	58.3	--	--	0.0	191.7	--	--	0.0	194.0	--	--	0.0	150.1	--	--
16.0	22.8	0.5	NA	18.0	36.8	NA	ND	13.0	45.3	NA	NA	14.0	177.7	3.5	ND	10.0	184.0	NA	0.2	10.0	140.1	NA	0.0
30.0	8.8	0.2	NA	33.0	21.8	NA	0.2	28.0	30.3	NA	NA	20.0	171.7	NA	NA	20.0	174.0	NA	1.5	20.0	130.1	NA	0.0
40.0	-1.2	ND	NA	48.0	6.8	NA	0.1	33.0	25.3	NA	NA	29.0	162.7	1.0	ND	30.0	164.0	NA	0.0	30.0	120.1	NA	0.0
----	----	--	--	----	----	--	--	48.0	10.3	5.0	NA	49.0	142.7	NA	NA	40.0	154.0	NA	0.2	40.0	110.1	NA	0.0
----	----	--	--	----	----	--	--	----	----	--	--	51.0	140.7	NA	NA	50.0	144.0	NA	0.0	50.0	100.1	NA	0.0
----	----	--	--	----	----	--	--	----	----	--	--	59.0	132.7	1.2	ND	58.0	136.0	NA	1.0	60.0	90.1	NA	0.0
----	----	--	--	----	----	--	--	----	----	--	--	74.0	117.7	1.5	0.0	68.0	126.0	NA	0.0	70.0	80.1	0.0	NA
----	----	--	--	----	----	--	--	----	----	--	--	89.0	102.7	0.3	0.0	73.0	121.0	NA	0.0	80.0	70.1	0.0	NA
----	----	--	--	----	----	--	--	----	----	--	--	99.0	92.7	NA	NA	88.0	106.0	NA	0.0	90.0	60.1	6.0	2.0
----	----	--	--	----	----	--	--	----	----	--	--	104.0	87.7	1.5	1.0	98.0	96.0	NA	0.0	100.0	50.1	3.0	6.0
----	----	--	--	----	----	--	--	----	----	--	--	119.0	72.7	2.0	1.0	108.0	86.0	NA	NA	108.0	42.1	NA	0.4
----	----	--	--	----	----	--	--	----	----	--	--	134.0	57.7	3.5	0.0	118.0	76.0	NA	NA	118.0	32.1	1.0	0.3
----	----	--	--	----	----	--	--	----	----	--	--	149.0	42.7	2.0	0.0	128.0	66.0	5.1	0.0	133.0	17.1	7.0	0.0
----	----	--	--	----	----	--	--	----	----	--	--	166.0	25.7	6.5	0.0	138.0	56.0	2.0	0.8	143.0	7.1	30.0	0.5
----	----	--	--	----	----	--	--	----	----	--	--	179.0	12.7	4.0	0.0	148.0	46.0	0.5	0.0	153.0	-2.9	20.0	2.0
----	----	--	--	----	----	--	--	----	----	--	--	184.0	7.7	9.5	0.0	163.0	31.0	1.2	0.0	163.0	-12.9	10.0	1.0
----	----	--	--	----	----	--	--	----	----	--	--	189.0	2.7	26.5	0.0	178.0	16.0	1.2	0.0	178.0	-27.9	15.0	1.0
----	----	--	--	----	----	--	--	----	----	--	--	----	----	--	--	183.0	11.0	0.0	0.0	----	----	--	--

Footnotes:
1. OVA and HNU data are reported in ppm above ambient.
2. Ft. B.G. denotes feet below grade level.
3. NA denotes not analyzed.
4. All samples were collected over a 24-in. interval beginning at the depth indicated.

ABLE (cont.)

OVA & HNU DATA ON SPLIT SPOON SAMPLES TAKEN FROM GROUND WATER WELL BORINGS 107-111

107				108				109				110.0				111.0			
Ft. B.G.	ELEV.	OVA	HNu	Ft. B.G.	ELEV.	OVA	HNu	Ft. B.G.	ELEV.	OVA	HNu	Ft. B.G.	ELEV.	OVA	HNu	Ft. B.G.	ELEV.	OVA	HNu
0.0	153.6	--	--	0.0	50.8	--	--	0.0	50.9		--	0.0	150.3	--	--	0.0	153.9	--	--
28.0	125.6	0.0	0.0	14.0	36.8	NA	0.0	28.0	22.9	NA	1.5	180.0	-29.7	25.0	1.0	14.0	139.9	0.2	0.0
48.0	105.6	0.0	0.0	18.0	32.8	NA	0.0	43.0	7.9	NA	0.0	195.0	-44.7	30.0	2.5	29.0	124.9	0.2	0.0
88.0	65.6	0.0	0.0	103.5	-52.7	0.0	0.0	58.0	-7.1	>1000	0.0	210.0	-59.7	0.5	0.0	44.0	109.9	5.0	0.0
114.0	39.6	0.0	0.0	118.5	-67.7	3.0	NA	73.0	-22.1	>1000	NA	225.0	-74.7	2.0	0.0	59.0	94.9	1.0	0.0
----	----	--	--	----	----	--	--	88.0	-37.1	8.0	NA	240.0	-89.7	0.5	0.5	74.0	79.9	1.0	0.0
----	----	--	--	----	----	--	--	103.0	-52.1	6.0	NA	255.0	-104.7	3.0	0.5	89.0	64.9	1.0	0.0
----	----	--	--	----	----	--	--	118.0	-67.1	3.0	NA	270.0	-119.7	15.0	1.0	104.0	49.9	10.0	0.0
----	----	--	--	----	----	--	--	133.0	-82.1	6.0	NA	285.0	-134.7	35.0	0.2	119.0	34.9	5.0	0.0
----	----	--	--	----	----	--	--	148.0	-97.1	1.0	NA	300.0	-149.7	10.5	2.0	134.0	19.9	15.0	0.0
----	----	--	--	----	----	--	--	163.0	-112.1	0.0	NA	315.0	-164.7	40.0	1.0	149.0	4.9	10.0	0.0
----	----	--	--	----	----	--	--	178.0	-127.1	25.0	NA	330.0	-179.7	2.8	1.0	164.0	-10.1	14.0	0.0
----	----	--	--	----	----	--	--	193.0	-142.1	8.0	3.0	345.0	-194.7	0.0	0.0	179.0	-25.1	NA	0.0
----	----	--	--	----	----	--	--	208.0	-157.1	5.0	NA	348.0	-197.7	NA	NA	194.0	-40.1	NA	0.5
----	----	--	--	----	----	--	--	223.0	-172.1	8.0	0.0	360.0	-209.7	NA	NA	209.0	-55.1	10.0	0.0
----	----	--	--	----	----	--	--	238.0	-187.1	NA	NA	375.0	-224.7	OFF BIT		224.0	-70.1	10.0	0.0
----	----	--	--	----	----	--	--	253.0	-202.1	1.0	NA	----	----	--	--	234.0	-80.1	NA	0.0
----	----	--	--	----	----	--	--	268.0	-217.1	NA	NA	----	----	--	--	254.0	-100.1	NA	5.0
----	----	--	--	----	----	--	--	285.0	-234.1	0.0	0.0	----	----	--	--	269.0	-115.1	NA	NA
----	----	--	--	----	----	--	--	289.0	-238.1	2.0	0.0	----	----	--	--	284.0	-130.1	4.0	0.0
----	----	--	--	----	----	--	--	293.0	-242.1	NA	NA	----	----	--	--	299.0	-145.1	0.0	0.0
----	----	--	--	----	----	--	--	----	----	--	--	----	----	--	--	314.0	-160.1	0.0	0.0
----	----	--	--	----	----	--	--	----	----	--	--	----	----	--	--	329.0	-175.1	5.0	5.0
----	----	--	--	----	----	--	--	----	----	--	--	----	----	--	--	344.0	-190.1	NA	NA
----	----	--	--	----	----	--	--	----	----	--	--	----	----	--	--	364.0	-210.1	NA	NA
				--	----	--	--	----	----	--	--	----	----	--	--	379.0	-225.1	NA	0.5

a are reported in ppm above ambient.
s feet below grade level.
3. NA denotes not analyzed.

TABLE 4-1 (cont.)

OVA & HNU DATA ON SPLIT SPOONS TAKEN FROM LFG WELL BORINGS

201				202				203				204			
Ft. B.G.	ELEV.	OVA	HNu	Ft. B.G.	ELEV.	OVA	HNu	Ft. B.G.	ELEV.	OVA	HNu	Ft. B.G.	ELEV.	OVA	HNu
0.0	155.9	--	--	0.0	152.9	--	--	0.0	153.6	--	--	0.0	199.7	--	--
10.0	145.9	0.0	0.0	10.0	142.9	2.0	NA	19.0	134.6	NA	NA	20.0	179.7	NA	NA
20.0	135.9	0.0	0.0	20.0	132.9	0.5	NA	49.0	104.6	0.0	NA	50.0	149.7	0.0	NA
30.0	125.9	300.0	0.0	30.0	122.9	0.4	0.0	84.0	69.6	2.0	NA	95.0	104.7	0.0	NA
40.0	115.9	800.0	0.0	40.0	112.9	75.0	0.6	114.0	39.6	0.0	NA	125.0	74.7	0.0	0.0
50.0	105.9	90.0	0.0	50.0	102.9	0.0	NA	----	----	--	--	----	----	--	--
60.0	95.9	10.0	0.0	60.0	92.9	0.4	0.6	----	----	--	--	----	----	--	--
70.0	85.9	15.0	0.8	70.0	82.9	0.4	0.6	----	----	--	--	----	----	--	--
80.0	75.9	2.0	1.2	80.0	72.9	0.3	0.2	----	----	--	--	----	----	--	--
90.0	65.9	3.0	0.4	90.0	62.9	1.0	0.0	----	----	--	--	----	----	--	--
104.0	51.9	0.0	NA	100.0	52.9	1.5	0.1	----	----	--	--	----	----	--	--
120.0	35.9	6.0	0.8	110.0	42.9	1.0	0.2	----	----	--	--	----	----	--	--
127.0	20.9	NA	NA	120.0	32.9	1.5	0.6	----	----	--	--	----	----	--	--
----	----	--	--	130.0	22.9	4.5	0.5	----	----	--	--	----	----	--	--
----	----	--	--	140.0	12.9	20.0	0.0	----	----	--	--	----	----	--	--
----	----	--	--	150.0	2.9	150.0	0.0	----	----	--	--	----	----	--	--

Footnotes:
1. OVA and HNU data are reported in ppm above ambient.
2. Ft. B.G. denotes feet below grade level.
3. NA denotes not analyzed.
4. All samples were collected over a 24-in. interval beginning at the depth indicated.

information was collected not only for screening purposes in identifying which boreholes contained volatile organic contamination, but also to aid in health and safety monitoring.

During the installation of EPA 103 and EPA 108, which are adjacent to the L-4 cell, high levels of methane (>100% LEL) were encountered in "pockets" in the subsurface. These high levels of methane were not detected during the headspace analyses perhaps because the methane emanated from very thin permeable seams in the subsurface. The presence of methane at these two locations may indicate that landfill gases are migrating off-site in the subsurface to the north and east of L-4.

Soil samples which were collected from both the ground water and landfill gas wells (at locations identified in table 4-2), were sent to the laboratory for volatile organic analyses. These analyses were performed to determine if the constituents present in the gases being emitted by the landfill were also present on the unsaturated soils and thus could represent a potential "passive" source of ground water contamination.

4.1.2 GEOPHYSICAL LOGS

For each of the three deep well locations (i.e. EPA ground water wells Nos. 109, 110, 111), the REM II field geologist performed a geophysical log in accordance with the procedures outlined in the Project Operations Plan dated November 14, 1986. The logs were used to make an accurate correlation of the contacts between the geologic formations as well as to assist in the placement of the well screens. The boreholes were logged (before casing was installed) with a downhole logger using gamma, resistivity, and spontaneous potential. The geophysical logs are included in the Appendices as plates.

4.2 HYDROLOGIC INVESTIGATION

The goals of the hydrologic investigation included: defining the static water level pressure heads in the aquifers beneath the L-4 site (Upper Glacial, Magothy and Lloyd) and the resulting ground water piezometric

Table 4-2
Location of Undisturbed Soil Samples Collected for Volatile Organic Analysis

		Sample Interval (ft. below grade)			
	WELL ID	SAMPLE # 1	SAMPLE # 2	SAMPLE # 3	SAMPLE # 4
Landfill Gas Monitoring Wells	201	20-24	50-55	110-112	127-130
	202	20-24	50-55	100-104	130-134
	203	19-20.5	49-50.5	84-90.5	114-115.5
	204	20-24	50-54	95-99	125-129
Ground Water Monitoring Wells	102	48-50	NS	NS	NS
	103	28-30	NS	NS	NS
	104	20-22	49-51	104-106	149-151
	107	28-36	48-50	88-96	114-116
	108	18-20	NS	NS	NS

Footnote: NS - Not Sampled.

surfaces; determining the hydraulic conductivity of various portions of the aquifers; determining the vertical permeability of the Raritan Clay; and, evaluating the hydraulic connections between the aquifers in the vicinity of the landfill.

4.2.1 GROUND WATER MONITORING WELL DRILLING AND INSTALLATION

On December 12, 1986 the REM II team's drilling subcontractor began a monitoring well drilling and installation program at the site. A total of 11 ground water monitoring wells were installed between December 1986 and September 1987. All of the wells were installed using either mud rotary or hollow stem auger methods. A Gus Peck Model 22R combination rotary wash/auger drill rig was used for all of the drilling and well installation work. The drilling mud was composed of Port Washington Water District (PWWD) tap water and pure Wyoming grade bentonite without the addition of polymers. All of the drilling fluid and drill cuttings produced during the drilling program were placed in 55 gallon ring topped drums and stored at the landfill for subsequent testing and management.

The monitoring wells were constructed by lowering type 304 stainless steel wire wound well screens with 0.020-inch slots (20 slot) attached to type 304 stainless steel casing down into the borehole and then placing a filter of Morie # 1 sand around the screens. For the installation of the monitoring wells west of the landfill, that is, EPA Well Nos. 104, 105, 106, 107, 110 and 111, 4-inch stainless steel well casing was used from the well screen upward until the casing was at a depth that was at least 10 feet above the water table. From this point upward, 4-inch schedule 40 PVC casing was used to complete the installation. A bentonite seal followed by cement and bentonite grout was installed above the sand pack. Each well was then given a permanent notch for use as a survey bench mark and was protected with a locking steel protective casing. All other monitoring wells, with the exception of EPA 202 which is constructed of 2-inch stainless steel, were constructed entirely of 4-inch stainless steel. To protect well Nos. 102, 103, 108 and 109 from vehicular traffic on the service roads at the landfill, an eight foot high chain link fence was placed around each well.

Before the wells could be used for sampling and hydraulic testing, they had to be developed to remove any drilling fluid that may have entered the aquifer and to remove the naturally occurring clays and silts surrounding the sand pack. Development was performed by air lifting, air surging, hydraulic jetting, bailing and pumping methods. Once the wells started producing clear, sediment free water, the wells were pumped for an extended period to assure that representative aquifer water was entering the well. All development water was pumped into a water truck and disposed of at the landfill leachate lagoon. A detailed description of the construction of each well is presented in Appendix J.

4.2.2 LABORATORY PERMEABILITY TESTS OF THE RARITAN CLAY

At the bottom of each of the three monitoring wells installed to the base of the Magothy Sands, an undisturbed sample of the Raritan Clay was collected using a Denison-type core barrel equipped with a Shelby-type inner tube. Sampling depths were as follows:

Well Number	Sample Collection Depth (feet below grade)
109	293 to 295
110	348 to 350
111	381 to 383

All three samples were sent to Woodward-Clyde Consultants' (WCC), Clifton, NJ, soils laboratory for liquid and plastic limits analyses and falling-head permeability testing.

Testing Procedures

All tests were performed in accordance with the appropriate WCC standard testing procedures. These typically follow those prescribed by either ASTM or the U.S. Army Corps of Engineers. The permeability tests were conducted using a flexible wall permeameter (triaxial cell) and demineralized water as a permeant. A constant-volume falling-head hydraulic system was used. Each specimen was saturated by applying a backpressure and consolidated prior to the permeability determination. The effective consolidation stress was approximately equal in the insitu effective overburden stress, except for the test specimen obtained from Well No. 109. In this case, the effective stress was significantly less than the insitu effective overburden stress since the sample appeared moderately disturbed and applying such a high confining stress would most likely have caused an excessive change in void ratio and unit weight.

The orientation of each specimen and the direction of flow were such that the vertical permeability of the material being tested was measured. Each specimen had a diameter of about 2.9 inches, and a height of about 4 inches.

4.2.3 GROUND WATER MONITORING WELL INSITU PERMEABILITY TESTS

During the period of February 8 through 12, 1987, thirteen of the monitoring wells at the site were tested using the "slug" method to determine insitu permeability of the various water bearing zones. The wells included in this task are EPA Well Nos. 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, and Town of North Hempstead Wells 1 and 2 (only TNH monitoring wells without permanently installed pumps were tested using this method (see table 4-5)).

The testing was performed using an Insitu brand Hermit data logger model SE1008 with a 10 psi transducer. A five-foot long by three-inch diameter galvanized steel slug was used to perform the tests.

Testing was performed by lowering the transducer 10 to 15 feet below the water surface in the well and then zeroing the data logger. After this was completed, the slug was positioned using a braided monofilament polypropylene rope to a depth of 5 to 10 feet above the water surface. The test was started by turning on the logger and "instantaneously" lowering the slug below the water surface. Once submerged, the time required for the water level to return to static was logged. Once the water level returned to static, the data logger was restarted and the slug removed causing the water surface in the well to drop. Again the time required for the water level to return to static was logged on the data logger. A file of the water level at each time setting programmed into the logger was transferred from the data logger into a portable computer on-site for analysis. A paper copy was printed as a back-up record. All data collected during the slugg tests are presented in Appendix K.

Before beginning the first test and between each test, the slug and transducer were decontaminated by washing in a mixture of liquinox and tap water followed by a tap water rinse.

4.2.4 PUMP TEST OF THE STONYTOWN WELL

A six day constant rate pumping test of the Port Washington Water District's (PWWD) Stonytown Well (N9809) was initiated on February 18, 1988. Between four to six days prior to beginning the test, the area water supply wells operated by PWWD were taken off-line. Then, in the hours before the pump test began, a full round of static water levels were collected (see section 4.2.6). All of the well pump controls and valves were operated by an employee of the PWWD. Pumping was maintained at an average rate of 1250 gpm (± 10%).

Water levels were monitored in a total of 31 wells during the test. Slope Indicator Co. (Sinco) electronic water level indicators were used to measure the water levels in all of the wells with the exceptions of Well N3742 and EPA Well Nos. 107, 110 and 111. A steel tape had to be used on well N3742 due to the presence of a layer of lubrication oil at the water surface of this well. EPA Well Nos. 107, 110 and 111 were monitored with Insitu brand Hermit data loggers, model SE1008 equipped with 10 psi transducers.

During the test, the following thirty-one wells were monitored:

EPA 101
EPA 102
EPA 103
EPA 104
EPA 105
EPA 106
EPA 107
EPA 108
EPA 109
EPA 110
EPA 111

TNH 1
TNH 2
TNH 5
TNH 6
TNH 7
TNH 8
TNH 9
TNH 10
TNH 11
TNH 12

N1102
N9903
N9809 (Stonytown)
N4223
N9019
N8790
N3742
N1716
N8095
N5210

A record of the pump discharge rate, the barometric pressure and the local rainfall were also kept throughout the test.

On February 24, 1988, the constant rate test was ended and a three day recovery test was initiated. Using the same methods as for the pump test, the recovery of water levels in the wells most influenced by the pump test were recorded. Again, the barometric pressure and rainfall were recorded. All data collected during the pump test and the subsequent recovery, is presented in Appendix K.

4.2.5 TOPOGRAPHIC SURVEY

During the spring of 1988, a topographic survey was performed at the Port Washington Landfill site. The survey was performed by Lippincott Engineering Associates, Delanco, New Jersey.

In total, 38 existing ground water wells, landfill gas (LFG) wells, and pressure probe wells were located by elevation (based on National Geodetic Vertical datum) and coordinate (based on New York State Coordinate System). All EPA ground water wells (EPA 101-EPA 111), LFG wells and pressure probe wells were located. All TNH ground water wells were located by elevations only. In addition, two benchmarks were located by elevation and coordinates: one adjacent to ground water well EPA 103 on the L-4 landfill; and, one at the impoundment on the property of the Cow Bay Sand Company located north of L-4. The base of the weather station on the L-4

Landfill was located by elevation and coordinates. Also, approximately 3500 feet of above ground pipeline on the L-4 landfill comprising the main header line of the gas vent system was mapped in plan and profile (see plate in the Appendix). A base map (also included in the Appendix) at 1 inch = 100 feet was developed which includes portions of Port Washington Boulevard, Wakefield Avenue, Guilford Road, Lynn Road, Wyndam Way, Newbury Road, and West Shore Road.

For each ground water well, the elevation of both the top of the inner and outer casing were determined. For the LFG and pressure probe wells, the elevation of the top of the valve box was determined. On each well, a permanent file cut was made at the point at which the elevation was determined. Table 4-[illegible] contains all the pertinent survey data collected describing the ground water monitoring wells. Tables 2-2 and 2-4 present the pertinent survey data for the landfill gas wells installed for EPA and the Town of North Hempstead, respectively.

4.2.6 MEASUREMENT OF WATER TABLE ELEVATION

Static water level measurements were collected on numerous occasions at both monitoring wells and water supply wells. On two separate occasions, once on February 16 and 17, 1988, and again on August 31, 1988 a complete round of synoptic water levels were obtained. In addition, the water level in the wells included in ground water well sampling activities were measured on December 3 through 16, 1987, and on April 25 through May 6, 1988.

Each well measured had a designated measuring point that was tied into the U.S.G.S. elevation datum. The depth to water in each of these wells was measured using either a Sinco electronic water level indicator or a steel tape. The depth to water was subtracted from the measuring point to obtain the elevation of the water level surface. Appendix L contains all the depth to water and water level elevations measured during the REM II team's remedial investigations. Data from the two events when synoptic water levels were obtained are presented in [redacted]

Table 4-3: Ground Water Monitoring Well Survey Data

WELL	FORMATION	COORDINATES LON(E)	COORDINATES LAT(N)	ELEVATION GROUND	ELEVATION TIC	ELEVATION TOC
N1120	UG	89201	213002	116.47	116.17	116.52
N1716	LLOYD	86958	216435			
N3742	UG	88903	213969	137.96	137.59	138.53
N4223	MAG	89693	215165		197.98	
N5210	UG	89869	219667			
N8608	UG					
N8790	LLOYD					
N9019	LLOYD	92406	214820	50.41	41.65	
N9809	MAG/LLOYD	89138	213224		113.56	
N9903	UG	88788	212874	139.65	139.38	139.65
EPA101	UG	94635	215206	38.37	38.3	38.69
EPA102	UG	92718	214924	54.83	56.46	56.93
EPA103	UG	92357	216240	58.26	58.81	59.5
EPA104	UG	90354	216018	191.72	192.87	193.21
EPA105	UG	89915	215243	194.01	195.12	195.34
EPA106	UG	90556	214343	150.05	151.43	151.82
EPA107	UG	88820	214495	153.6	154.38	155.26
EPA108	UG	92473	215442	50.76	52.2	52.66
EPA109	MAG	92473	215485	50.89	52.27	52.89
EPA110	MAG	90563	214329	150.29	151.76	152.04
EPA111	MAG	88817	214507	153.88	155.22	155.44
EPA202	UG	91139	215049	152.84	152.56	152.97
TNH1	UG	92466	215500	52.86	53.42	
TNH2	UG	92468	215491	52.74	53.09	
TNH5	UG	90899	215482	154.6	157.38	156.99
TNH6	UG	90901	215472	154.59	157.57	157.19
TNH7	UG	94615	216279	45.76	48.91	49.15
TNH8	UG	94552	216478	53.34	56.35	56.86
TNH9	UG	90585	215294	173.15	175.44	
TNH10	UG	90739	215387	173.15	175.42	
TNH11	UG	94066	216508	54.63	58.43	
TNH12	UG	93523	216416	55.5	58.56	58.81

NOTES:
UG=Upper Glacial
MAG=Magothy
TIC=top of inner casing
TOC=top of outer casing
Elevations are reported in feet above mean sea level (MSL)
LON (E) = New York State Coordinate - Longitude (east)
LAT (N) = New York State Coordinate - Latitude (north)
TNH5 and TNH6 have no inner casing. The TIC value is the elevation of the measuring port.

Table 4-4: Synoptic Ground Water Level Data

WELL	FORMATION	2/16/88		8\31\88	
		DTW	WAT.ELV.	DTW	WAT.ELV.
N1120	UG	73.09	43.08	73.33	42.84
N1716	LLOYD	101.12		112.36	
N3742	UG	104.29	33.30	NA	
N4223	MAG	173.6	24.38	174.74	23.24
N5210	UG	200.98		181.91	
N8608	UG	22.99		26.73	
N8790	LLOYD	66.05		82.29	
N9019	LLOYD	24.82	25.59	NA	
N9809	MAG/LLOYD	85.72	27.84	90.96	22.60
N9903	UG	97.05	42.33	96.84	42.54
EPA101	UG	14.01	24.29	15.27	23.03
EPA102	UG	31.64	24.82	31.28	25.18
EPA103	UG	35.51	23.30	28.01	30.80
EPA104	UG	169.76	23.11	170.3	22.57
EPA105	UG	167.14	27.98	167.6	27.52
EPA106	UG	122.21	29.22	124.00	27.43
EPA107	UG	121.33	33.05	124.86	29.52
EPA108	UG	28.87	23.33	27.76	24.44
EPA109	MAG	29.35	22.92	29.67	22.60
EPA110	MAG	127.26	24.50	128.00	23.76
EPA111	MAG	122.8	32.42	126.2	29.02
EPA202	UG	128.77	23.79	129.11	23.45
TNH1	UG	30.04	23.38	30.25	23.17
TNH2	UG	29.82	23.27	29.92	23.17
TNH5	UG	134.06	23.32	134.49	22.89
TNH6	UG	134.37	23.20	134.68	22.89
TNH7	UG	28.14	20.77	28.48	20.43
TNH8	UG	35.87	20.48	36.21	20.14
TNH9	UG	152.00	23.44	152.3	23.14
TNH10	UG	151.99	23.43	152.2	23.22
TNH11	UG	36.95	21.48	38.04	20.39
TNH12	UG	37.95	20.61	36.78	21.78

NOTES:
UG=Upper Glacial
MAG=Magothy
DTW=depth to water
All elevations are reported in feet above mean sea level (I
NA=Not Available

4.3 GROUND WATER AND LANDFILL LEACHATE SAMPLING

Three rounds of ground water and leachate sampling were performed at the site to evaluate the ground water quality upgradient and downgradient of the landfill and evaluate landfill leachate as a potential source of ground water contamination.

Two sampling rounds were conducted by the REM II team as follows: a fall round from December 3 through 16, 1987; and, a spring round from April 25 through May 6, 1988. Ground water and leachate samples collected in the first two rounds were analyzed for target compound list (TCL) constituents. The analytical methods used for the analysis of the organic portion of the TCL were EPA methods 624 (volatiles), 625 (extractables), and 608 (pesticides). The samples were also analyzed for total dissolved solids, alkalinity, MBA's, BOD, nitrate, carbonate, free CO_2, sulfate, hardness, hexavalent chromium, TOC, Kjeldahl nitrogen, nitrate, COD, ammonia, and chloride content. All the data associated with these two rounds of sampling are presented in Appendix M.

A third round of ground water quality samples were collected by ERT in Fall 1989 from September 25 to September 28. The data collected by ERT is in Appendix N. The organic fractions of these samples were analyzed using EPA methods 524 (volatiles), 625 (extractables) and 608 (pesticides).

The wells sampled in the first two rounds consisted of EPA monitoring wells without permanently installed pumps, TNH wells both with and without permanently installed pumps, and PWWD wells with permanently installed pumps as well as an L-4 leachate collection manhole. [illegible] lists the wells sampled and the method of sample collection.

Monitoring wells that were 4-inches in diameter or larger, did not have permanently installed pumps, and could sustain a yield of more than 1 gallon per minute (gpm) were first purged by lowering a pump into the well. A 3-3/4 inch diameter submersible pump secured by braided polypropylene rope and a flexible polypropylene discharge hose was placed down the well. After a minimum of three casing volumes of water were evacuated, the pump

TABLE 4-5

GROUND WATER WELL SAMPLING DATA

	Permanent Pump Installed	Sample Collected from discharge or with bailer	Slug Testing	Diameter
TNH 1	No	bailer	Yes	6 inches
TNH 2	No	bailer	Yes	6 inches
TNH 5	Yes	discharge	No	6 inches
TNH 6	Yes	discharge	No	6 inches
TNH 7	Yes	discharge	No	6 inches
TNH 8	Yes	discharge	No	6 inches
TNH 9	Yes	discharge	No	6 inches
TNH 10	Yes	discharge	No	6 inches
TNH 11	Yes	discharge	No	6 inches
TNH 12	No	bailer	Yes	6 inches
Leachate manhole	No	bailer	No	-
EPA 101	No	bailer	Yes	4 inches
EPA 102	No	bailer	Yes	4 inches
EPA 103	No	bailer	Yes	4 inches
EPA 104	No	bailer	Yes	4 inches
EPA 105	No	bailer	Yes	4 inches
EPA 106	No	bailer	Yes	4 inches
EPA 107	No	bailer	Yes	4 inches
EPA 108	No	bailer	Yes	4 inches
EPA 109	No	bailer	Yes	4 inches
EPA 110	No	bailer	Yes	4 inches
EPA 111	No	bailer	Yes	4 inches
EPA 202	No	bailer	No	2 inches
PWWD 4223	Yes	discharge	No	-
PWWD 9809	Yes	discharge	No	-
NHCC 8761	Yes	discharge	No	-
TNH 9019	Yes	discharge	No	-

(565)

was slowly raised while pumping until the pump broke suction. This was done to ensure that all the stagnant water in the well casing was removed prior to sampling. A sample was then collected by lowering a stainless steel or Teflon bailer into the well, raising the bailer, and then slowly pouring the sample water into the sample bottles such that the water was not aerated.

For wells that had permanently installed pumps, samples were collected directly from the pump discharge. The wells were first purged by pumping at least three casing volumes of water. The discharge valve was then adjusted such that a slow and steady stream of water was achieved. The sample bottles were then filled taking care not to aerate the water during collection.

Wells which could not sustain a yield of 1 gpm or that were less than 4-inches in diameter were purged by bailing at least 3 casing volumes of water from the well using a stainless steel or Teflon bailer. The well was then sampled using the bailer.

4.4 BURIED DRUM EXCAVATION

On August 31, 1987, the Town of North Hempstead's Consultants (LKB and Marine Pollution Control) directed excavation of approximately 60 buried drums from a small area adjacent to the southern access road between L-4 and L-5. During the excavation, at the request of EPA, a REM II field geologist was on-site to observe the clean-up and take sample splits with the Town's consultant. The samples were taken to compare with the results of the ground water and landfill gas investigation.

4.4.1 PROCEDURES FOR SAMPLING FROM DRUM EXCAVATION AREA

During the excavation process, the REM II geologist took photographs of the drums and potentially contaminated areas. A map was drawn in a field notebook and the location of the excavation pit was approximately located. The sample collection areas were also located on the map. The results of this mapping are presented in Figure 4-2.

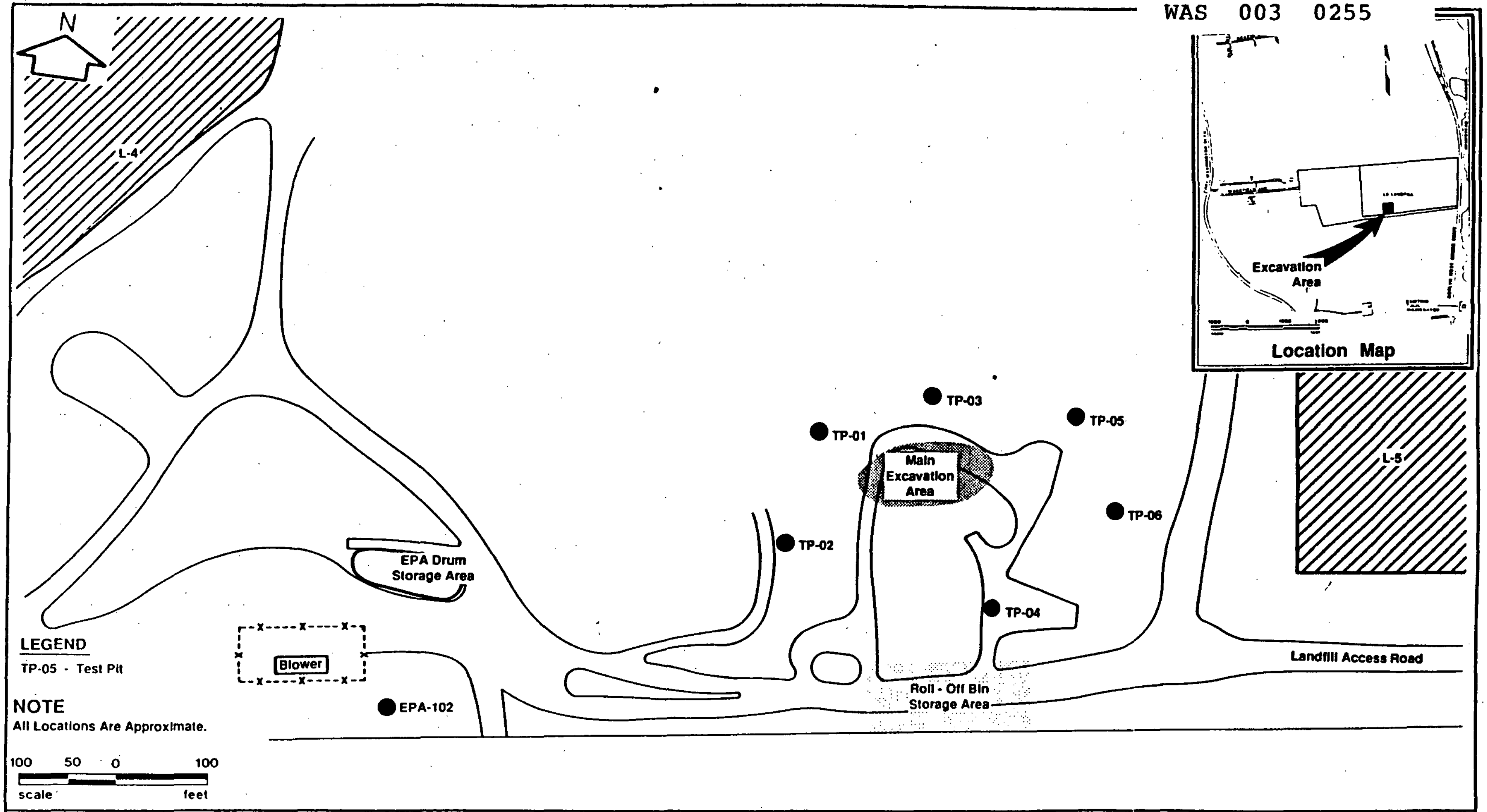

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Figure 4-2

Drum Excavation Map

Port Washington Landfill, Port Washington, New York

Samples were taken of the solid contents of two of the drums as well as the leachate from these drums. Most of the drums were highly corroded and the remaining contents were insufficient for sampling. Fifteen additional samples were taken: four soil samples from the main excavation pit; five samples from the excavated soil stored in roll-off bins; and, six samples from test pits surrounding the main excavation area.

The samples were collected by the Town's personnel in EPA sample jars. The REM II geologist observed the sample collection and took responsibility for the custody of the samples. The samples were analyzed for all TCL (Target Compound List) substances.

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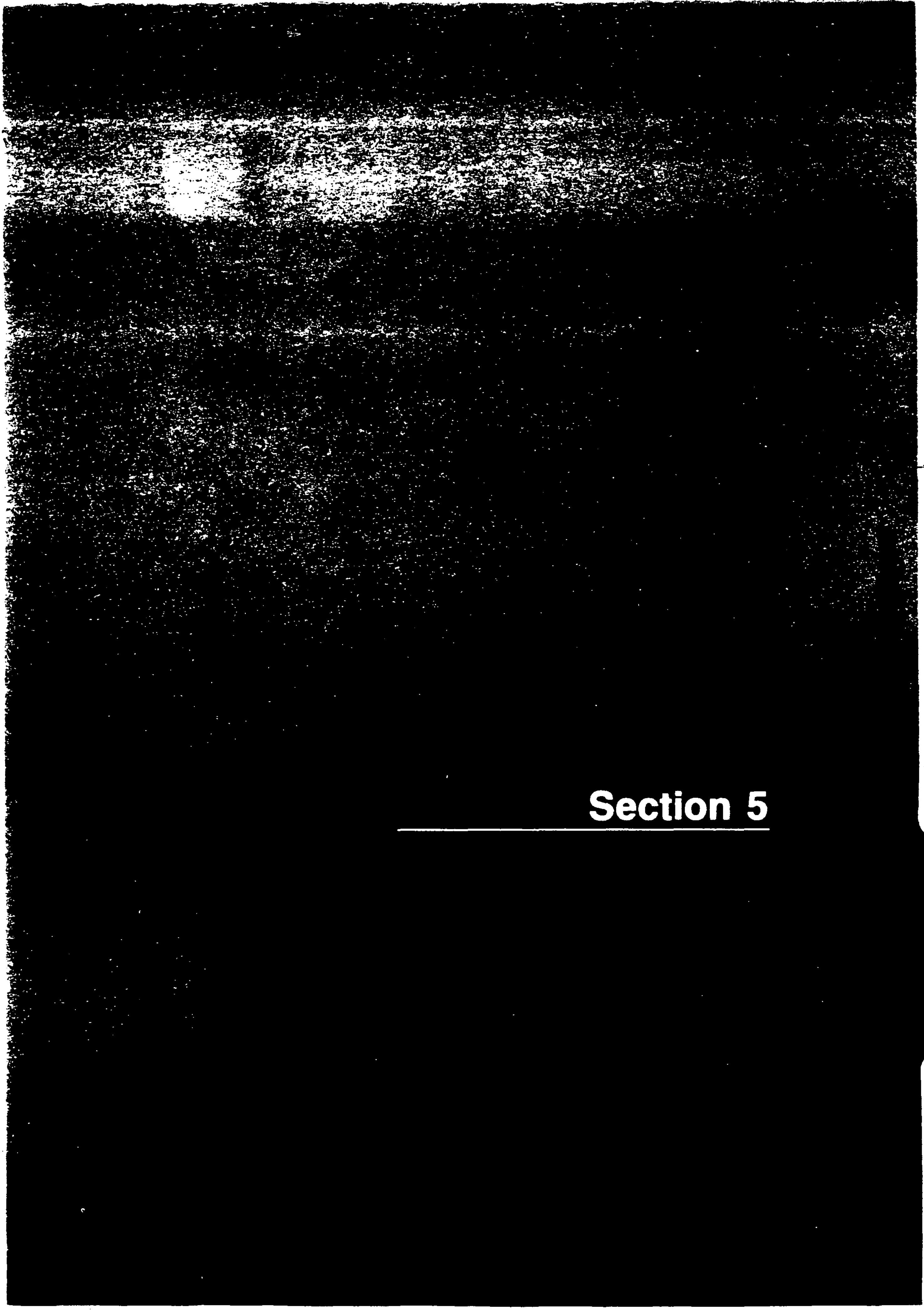

Section 5

5.0 DATA RESULTS AND ANALYSIS - HYDROGEOLOGIC INVESTIGATION

Section 5.0 presents the results of the field activities overviewed in Section 4.0. The purpose of this section is not only to present the hydrogeologic data collected, but also to characterize the ground water flow system, and the unsaturated and saturated zone water soluble contamination unique to the Port Washington Landfill area. The information collected will be presented in the following order:

- geologic investigation and mapping;
- unsaturated zone soil contaminant characterization;
- hydrogeologic, data acquisition and parameter definition; and
- ground water contaminant mapping and analysis.

A subsection presenting the results of sampling in the drum disposal area, as discussed in section 4.4, is provided at the end of this section.

5.1 GEOLOGIC INVESTIGATIONS

Deeply buried bedrock, unconsolidated late Cretaceous coastal plain deposits, and unconsolidated Pleistocene glacial deposits comprise the geologic strata of the Port Washington Landfill area. Glaciation eroded and re-worked the Cretaceous deposits, and deposited the Pleistocene sediments upon the resulting erosional surface, leaving a complex interface between the various unconsolidated sediments. In the vicinity of the landfill, these sediments have been differentiated into three Cretaceous and three Pleistocene formations. The following paragraphs describe the site specific characterization and configuration of each formation beneath and in the vicinity of the landfill. [redacted]esent generalized stratigraphic cross-sections discussed in the following narrative.

Also contained within this sub-chapter is a presentation of the soil quality analyses in the unsaturated zone. These analyses involved measuring the distribution of organic and inorganic contaminants in the residual soil waters within the unsaturated soil column.

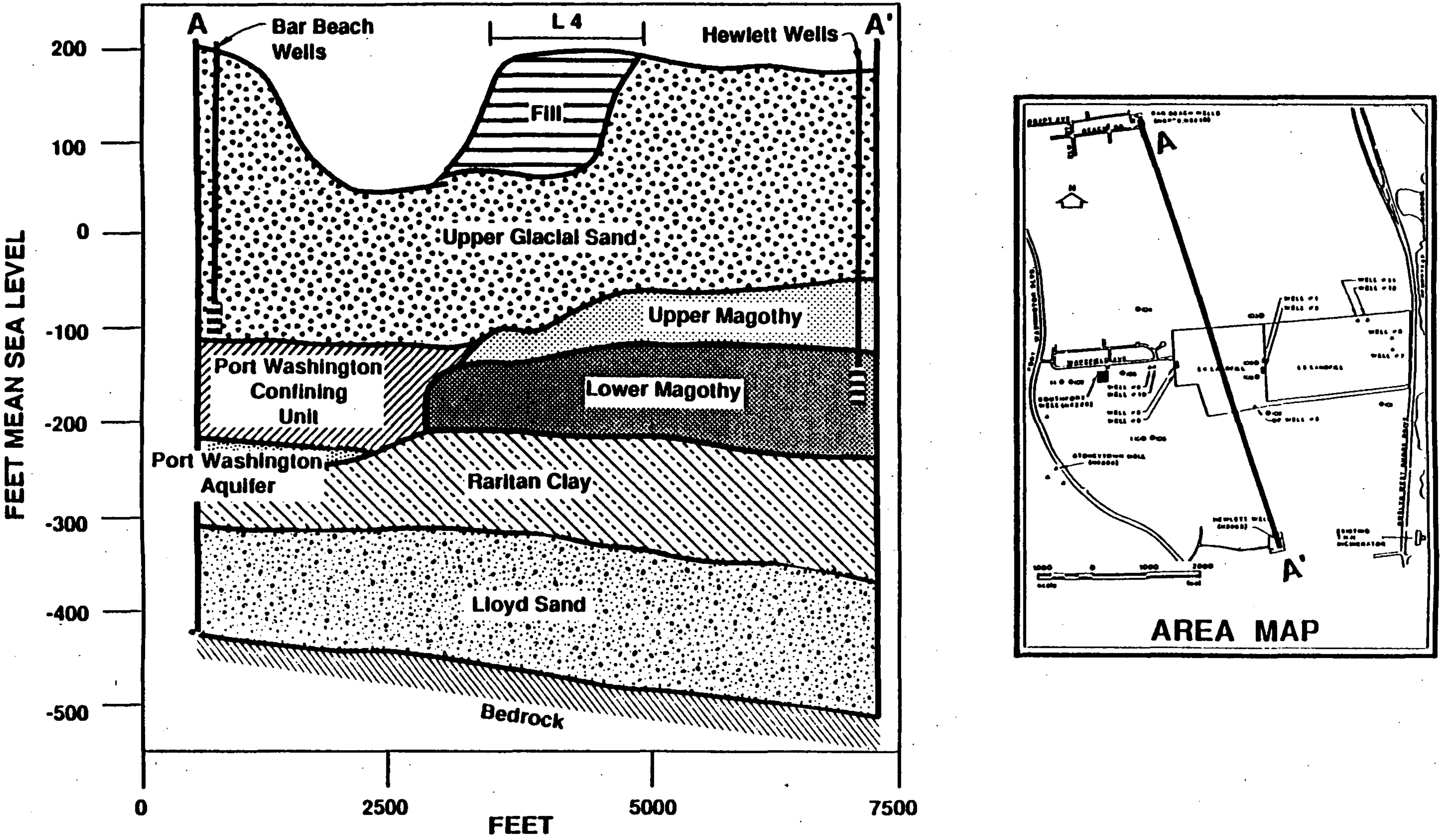

Figure 5-1

Generalized Stratigraphic Cross Section A-A'

Port Washington Landfill, Port Washington, New York

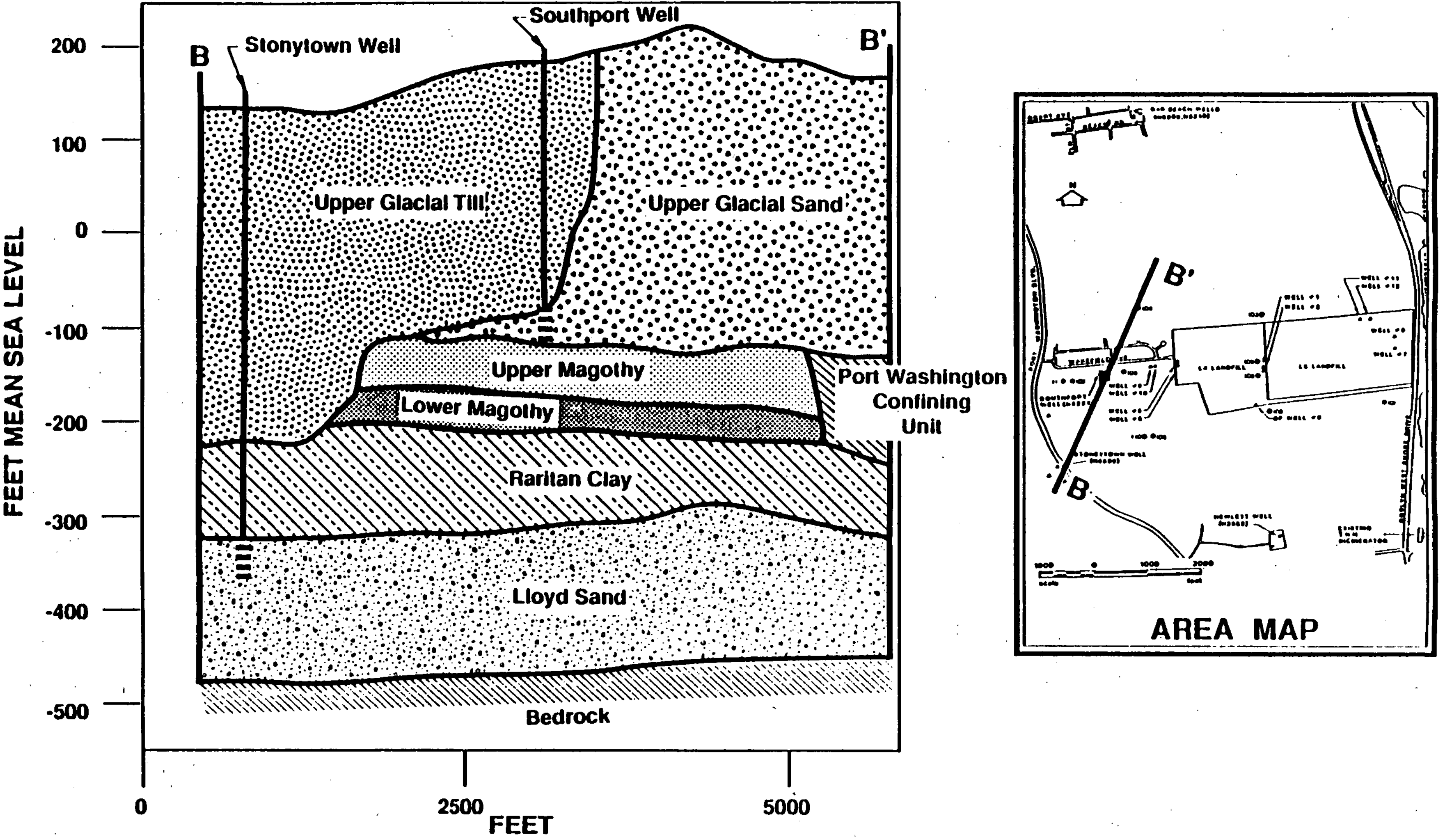

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Figure 5-2

Generalized Stratigraphic Cross Section B-B'

Port Washington Landfill, Port Washington, New York

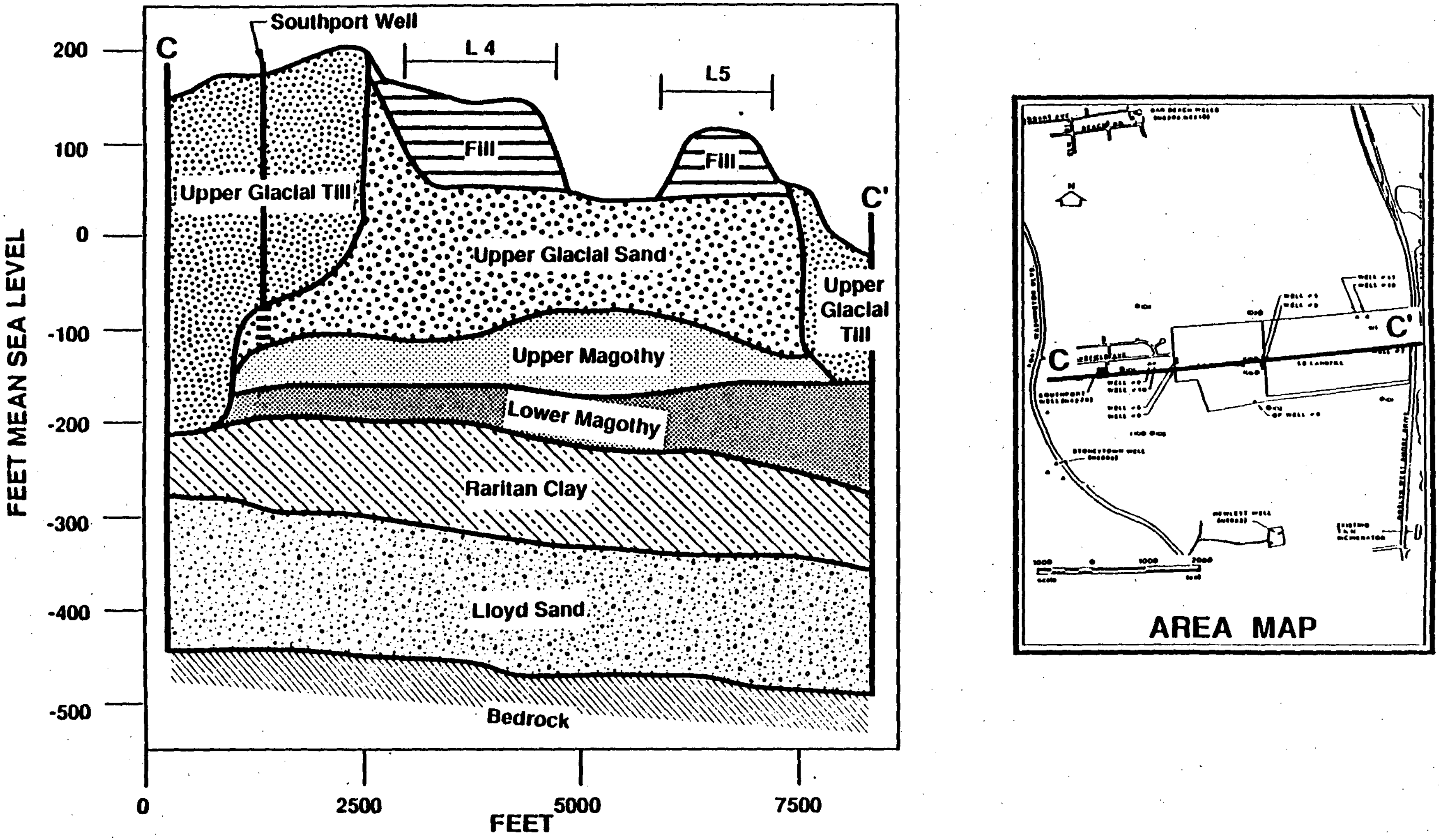

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Figure 5-3

Generalized Stratigraphic Cross Section C-C'

Port Washington Landfill, Port Washington, New York

5.1.1 BEDROCK

Bedrock of Lower Paleozoic and/or Precambrian age underlies the Port Washington Landfill and all of western Long Island. It consists of schist and gneiss punctuated with igneous intrusions. Its uppermost zone is highly weathered in places. The weathered zone varies from zero to more than 67 feet thickness in the Town of North Hempstead (Kilburn, 1979).

No borings at the Landfill penetrate bedrock. The only nearby wells that reach bedrock are the Stonytown Well (N-9809) and two Neulist Avenue wells (N-1715 and N-1716). These wells encounter bedrock at -493 feet (as determined from Port Washington Water District records and driller's log), -397 feet, and -408 feet MSL, respectively. Extrapolating from this data, the general trend of the bedrock surface in the area indicates a slope dipping approximately 60 feet per mile to the southeast with the bedrock surface elevation ranging from -450 to -500 feet MSL at the Landfill. This interpretation of the bedrock surface is consistent with the bedrock surface map generated by Kilburn (1979), which included data from 34 wells drilled in the Town of North Hempstead.

Although fractures or the weathered zone might yield useful quantities of water, the bedrock is generally dense and has a low permeability. Therefore the bedrock is considered the base of the ground water flow system in the area.

5.1.2 CRETACEOUS DEPOSITS

The Cretaceous units occurring in the Landfill area are (from deepest to shallowest) the Lloyd Sand Member and Raritan Clay Member of the Late Cretaceous Raritan Formation, and the Magothy Formation, also of Late Cretaceous age.

The Lloyd Sand Member of the Raritan Formation (referred to elsewhere in this report by its hydrogeologic name, the Lloyd Aquifer) directly overlies bedrock at the landfill and across much of Long Island. It extends northwards as far as the northern limits of the sand and gravel pits. It is composed of discontinuous layers of gravel, sand, sandy clay, silt, and clay. It is typically described as a white coarse sand and gravel with some interbedded fine to medium sand and clay. The only well penetrating the Lloyd at the site is well N-9019 which encounters the Lloyd at -326 feet MSL. Regional data indicate that the top of the Lloyd Sand slopes downwards to the southeast approximately 60 feet per mile with elevations ranging from -300 feet MSL at the northwestern corner of the Landfill to -350 feet MSL at the southeastern corner (Kilburn, 1979). The Lloyd is about 130 feet thick within the Town of North Hempstead boundaries based upon data for all Lloyd wells in the area. The Lloyd Sand is a significant water supply aquifer in the Port Washington area and throughout Long Island.

The Raritan Clay Member of the Raritan Formation overlies the Lloyd Sand at the Landfill and throughout much of Long Island, extending north to the northern limits of the gravel pits along the eastern side of Manhasset Neck, and as far as Leeds Pond on the western side of Manhasset Neck. It is primarily clay with varying amounts of silt and sand. The elevation of the top of the Raritan Clay varies from -200 feet MSL to -250 feet MSL at the Port Washington Landfill, so that its thickness is between 100 and 150 feet at the site area. The Raritan surface shows no distinctive slope at the site.

The Raritan Clay is a major aquitard on Long Island, confining the Lloyd below, although some vertical leakage of water does occur. When encountered during the REM II team's drilling operations, the Raritan was described as a gray to light gray or olive clay with interbedded seams of fine sand and silt. The vertical permeability of this unit was characterized and is discussed in section 5.2.4.

The Magothy Formation is the uppermost of the Cretaceous deposits in the Port Washington area. The formation is present throughout most of Long Island and extends northwards as far as the Landfill on Manhasset Neck. As determined by drilling operations on and around the Landfill, the Magothy is comprised of lenticular and discontinuous beds of very fine to medium sand with some clay, and is interbedded with clay and sandy clay, silt, and some sand and gravel. Coarse sand and gravel beds are present near the base of the formation, while locally thick silt and clay beds are found near the formation's top. These characteristics agree with the common classification of the formation into two units: the Basal Magothy; and, the Upper Magothy. At EPA Ground Water Well No. 110, the less permeable Upper Magothy is approximately 60 feet thick. At EPA Ground Water Well No. 109, it is apparently only 20-25 feet thick.

The top of the Magothy varies considerably. Boring logs for EPA Ground Water Well No. 109 at the Landfill and EPA Ground Water Well No. 110 a few hundred feet to the west of the Landfill show the upper surface of the Magothy to be about -70 feet MSL while Kilburn (1979) placed the upper surface of the Magothy as deep as -200 feet MSL in the same area.

The Magothy Formation is the primary public water supply aquifer for most of Long Island and a significant aquifer in the Port Washington area. Water in the aquifer becomes more confined as the formation dips to the south, however, in the vicinity of the site the Magothy is in direct communication with the water table.

5.1.3 QUATERNARY DEPOSITS

Pleistocene glaciation advanced from the north to just south of the present-day Long Island Expressway, leaving thick; heterogeneous morainal deposits on Manhasset Neck, burying and locally removing existing Cretaceous strata so that many of the Pleistocene deposits are composed of reworked or re-located Cretaceous sediments.

The lowermost of these units in the stratigraphic sequence is the Port Washington Aquifer, consisting of sand or sand and gravel interbedded with varying amounts of clay, silt, and sandy clay. While this unit is more than 100 feet thick in the northern part of Manhasset Neck, it is only zero to 50 feet thick in the vicinity of the landfill, which corresponds roughly to the formation's southernmost extent. Except along Hempstead Harbor, where Port Washington Aquifer deposits extend as far south as Northern Boulevard, wells on Manhasset Neck south of the landfill are beyond the limit of this unit. The uppermost elevation of the Port Washington Aquifer is about -150 feet MSL in the vicinity of the landfill with a surface sloping downwards to the north at about 60 feet per mile. Boring logs for the EPA wells drilled during this study suggest that the Port Washington Aquifer may not be present at the Landfill. The Port Washington Aquifer, as its name implies, is a significant source of water, especially in the northern part of the Neck, where the Magothy Formation is absent.

The Port Washington Confining Unit overlies the Port Washington Aquifer wherever the latter is present except in parts of Sands Point and Manorhaven which are in the northwestern section of Manhasset Neck north of the area of interest. The Confining Unit contains clay and silt, with lenses of sand, or sand and gravel. The Port Washington Confining Unit is flat-lying, with a nearly uniform upper surface elevation of about -100 feet MSL over most of its extent on Manhasset Neck. Its thickness in the vicinity of the landfill is about 50 feet although it may be much thinner near its limits. The Port Washington Confining Unit is an aquitard confining water in the Port Washington Aquifer, but permitting limited vertical movement of ground water. The exception to this flow regime may exist in areas where the Port Washington Aquifer is in direct communication with the Magothy Formation allowing exposure of the lower sands to near water table (or unconfined aquifer) pressure conditions. Such an exposure of the Port Washington Aquifer to the Magothy could only occur at its southernmost boundary with the Port Washington Formation. Past investigators have suggested that this particular configuration of water bearing zones exists in the vicinity of the Landfill and neighboring public water supply wells. No evidence was found during the REM II team's field activities to substantiate this hypothesis.

From 100 feet to over 300 feet of late Pleistocene sediments known as the Upper Glacial Aquifer overlie the older deposits throughout the study area. This unit is the most important formation controlling ground water flow and contaminant transport at the Landfill because it contains the uppermost water bearing zone, which is the first part of the saturated zone to come into contact with subsurface contaminants, and it is regionally extensive.

It is also the formation characterized by the greatest amount of subsurface investigations.

The Upper Glacial Aquifer extends downward from the ground surface, except in areas where it is overlain by thin, unsaturated Holocene deposits, to cover either the Magothy Formation or Port Washington Confining Unit. Its varied sediments consist of beds of fine to coarse stratified sand and gravel, glacial till, and locally, lacustrine silts and clays as determined by the subsurface exploration performed in the vicinity of the Landfill. Widely ranging thicknesses of these deposits are attributable to the irregularity of the present ground surface. At the Landfill, the Upper Glacial varies from 250 feet thick along the western boundary to about 150 feet thick on the east.

The Upper Glacial sediments at the Landfill are coarse to fine grained stratified sands. It is this type of soil which was (and continues to be) mined for concrete aggregate and bedding material. The glacial till, also part of the Upper Glacial Aquifer, is not present immediately at the Landfill. It has, however, been found both east and west of the Landfill, and its presence generally controls the ground water flow beneath the buried refuse.

The coarse to fine sands of the Upper Glacial Aquifer sediments are productive units and are used for cooling water and private water supply throughout Manhasset Neck, whereas the till, which does not produce significant quantities of water, is not.

Noteworthy are three significant features of the Upper Glacial sediments in the vicinity of the Landfill, each affecting local and regional ground water flow. The first feature is associated with the configuration of the Upper Glacial Aquifer adjacent to Hempstead Harbor. There is evidence that the erosional face of the glaciation was significantly deep along the harbor in a north-south orientation such that the Raritan Formation may be directly exposed to the overlying Quaternary Deposits. This means that the Upper Glacial Aquifer may extend vertically downward from the Harbor to the Raritan clay, contacting the entire depth of the Magothy water bearing zones. More importantly, however, is the fact that the clayey and silty faces of the Magothy Formation have been removed. This feature is significant due to the fact that the ground water flow above the Raritan Formation discharges upward into the Harbor. No appreciable volume of ground water flows under the Harbor in the upper water bearing zones above the Raritan Clay - either east to west or west to east - excepting waters which ultimately discharge into the water body. Therefore, the Upper Glacial sediment deposited above the Raritan will carry the ground water from the Magothy or Port Washington Aquifer into Hempstead Harbor to be discharged.

The second feature is the existence of the aforementioned bands of till - a greatly variable, non-stratified, glacial deposit - within the Upper Glacial Aquifer. Such till features were located directly, with the REM II team's drilling operations at wells EPA No. 107 and EPA No. 111, and indirectly, with historic water level readings at numerous monitoring and pumping wells across the peninsula (e.g., N-1120, N-3742, TNH-11, TNH-12). Two specific bands of till were found to significantly impact the ground water flow system beneath the Landfill - one, along the center of the peninsula (roughly aligned with Port Washington Boulevard) and one, along the bluff bordering Hempstead Harbor (roughly aligned with West Shore Drive). Both of these bands were characterized as much tighter, less permeable unstratified sands and gravels in the Upper Glacial Aquifer (as compared to the soils existing beneath the Landfill or North Hempstead Country Club) with vertical extent down to the Raritan Formation (see figure 5-3).

The third feature of the Upper Glacial Aquifer is a narrow band of till located in a fairly localized area oriented north-south between the Landfill and the Southport Well. This till is differentiated from that described in the previous paragraph by its vertical extent - the narrow band of till extends only down to the top of the Magothy Formation. Most of the evidence supporting the existence of this feature is hydraulic in nature, and is therefore presented in later sections. It is noteworthy to mention, however, that the existence of this feature is further proof of the heterogeneities within the Upper Glacial Aquifer sediments.

Other local anomalies within the sediments of the Upper Glacial Aquifer are small clay and silt lenses which support perched water tables. These perched water tables are indicative of horizontal stratification within the quaternary deposits and exist due to the presence of either locally extensive fine to very fine grained soils or till. Perched water was repeatedly found while installing landfill gas wells west of the Landfill in the residential area and beneath the golf course.

The impact of the perched water locally is that the downward percolation of recharge into the ground water system is impeded west of the Landfill. However, the seams of fine to very fine grained soils or till do not appear to be extensive enough to significantly impact the shallow ground water flow system, nor significantly retard the downward migration of rainfall percolate.

5.1.4 SOIL SAMPLING ANALYTICAL RESULTS

Soil samples collected from the unsaturated zone, as described in section 4.1.1, were analyzed for the complete scan of priority pollutants including acid and base/neutral extractables, volatiles, metals, and conventionals. The results of the analyses for both the samples collected during ground water monitoring well and landfill gas well installations are presented in Appendix O.

The samples were obtained mainly to characterize any partitioning of the landfill gas into the soil grains and interstitial waters between the soil grains. If partitioning was a significant phenomenon, the soil samples would be expected to contain detectable levels of volatile contamination with constituents similar to the landfill gas quality detected west of the landfill. However, the analytical results indicated that very little organic contamination partitions onto the soil column while migrating through the unsaturated zone (see table 5.1).

This observation may be explained in the following way. The absorption of vapor phase volatile organics to the soil column is dependent on partitioning driven by organic carbon factions resident in the interstitial

TABLE 5-1

VOLATILE ORGANICS DETECTED IN SOIL SAMPLES

COMPOUND	WELL #	LOCATION # DEPTH			
		#1	#2	#3	#4
TETRACHLOROETHENE	202				2J
TOLUENE	202	2J	5J		2J
CHLOROFORM	102	2J			
2-BUTANONE	107	6J	31	31	
	204				10J
BENZENE	104		3J		

NOTES:

J - Reported value is estimated because it is below method detection limit.

See Table 4-2 for depth of sample intervals.

soil spaces. Since landfill gas would preferentially travel through the most porous zones of the subsurface, as characterized by medium to coarse-grained sand (which does not contain fines and little organic carbon), there is little or no attenuation of the vapor phase by the soils at these locations. Therefore, landfill gas volatile constituents may not partition in significant volumes as they migrate through the soil media in the vicinity of the Landfill. Conversely, the less porous zones which would contain fine sediments and organic materials would be less likely to transmit landfill gas. Therefore, samples taken from medium to coarse-grained soils would not contain fine grain and organic material onto which volatiles would partition, and samples taken from fine to very fine soils may not have been exposed to migrating landfill gas.

5.2 HYDROGEOLOGY

The hydrogeology of the Port Washington area is complex due to its glacial origins. The farthest advance of the last glacier to just a few miles south of the Landfill resulted in several of Long Island's geological formations having their northern or southern limits in Port Washington. Knowledge of the hydraulic properties of these sediments is required in order to understand the mechanisms affecting contaminant transport phenomena within the ground water flow system.

This section of the report presents a brief overview of historic efforts focused on estimating the hydraulic properties of the Manhasset Neck strata, and the data and analyses developed by the REM II team to characterize the sediments beneath and in the vicinity of the Port Washington Landfill. The REM II database includes piezometric data, laboratory permeability test results, single well slug test results, and aquifer pump test analyses. In addition, a three-dimension finite element computer simulation of the ground water flow system was developed to further define the configuration and the hydraulic properties of the strata beneath the site.

5.2.1 HISTORICAL DATA

Ground water is the sole source of drinking water supplies in Manhasset Neck. For this reason, historical analyses characterizing the water bearing zones are plentiful and noteworthy. Therefore, the purpose of this subsection is to present the historical data. This will help to facilitate cross-references with the REM II team data, presented immediately following, and allow comparisons for consistency.

Ground water pumpage for water supply and cooling water dates back to the early 1900's on Manhasset Neck. Generally, the earliest wells were drilled down to the water table, the Upper Glacial Aquifer, where siting involved very little analysis. By the 1940's, however, population increased, as did water demand, mandating well yield analyses. Jacob (1946) performed the first pump test in the area to determine the hydraulic properties of the Magothy Formation.

Specific capacity tests were regularly performed upon the installation of pumping wells after the 1940's to further characterize well yield. The Port Washington Water District has re-tested many wells since 1976 as a means of maintaining records of area well yields. A summary of the historical specific capacity data collected to determine well yields are presented in table 5.2.

Historical data maintained in New York Department of Environmental Conservation (NYSDEC) files in Stony Brook, NY, indicate that drinking water supplies in Manhasset Neck are limited. New York State has recently denied the installation of 900 and 1,000 gallon per minute (gpm) wells by the Port Washington Water District (PWWD) as the water district had reached capacity. The yield from the aquifers in Manhasset Neck is limited to 400,000 to 500,000 gallons per day per square mile, and the PWWD to 2.4 to 3.48 million gallons per day.

Recent hydrogeologic investigations have been conducted in the vicinity of the Port Washington Landfill to evaluate the hydraulic, and therefore, transport characteristics of the Upper Glacial Aquifer and Magothy Forma-

TABLE 5-2

SUMMARY OF HISTORIC SPECIFIC CAPACITY DATA ANALYSES

Well	Transmissivity (sq. ft./day)	Estimated Hydraulic Conductivity (ft/day)	Estimated Storage Coefficient	Screen length (feet)	Well diameter (inches)	Number of observations
Upper Glacial Aquifer	13,800	92	0.01			23
N-4223 (Southport)	17,700	118		53	12	14
N-4860	15,000	100		29	12	2
N-5209	15,400	103		40	20	3
N-5876	6,600	44		70	12	2
N-6087	14,400	96		29	10	2
Magothy Aquifer	8,100	81	0.001			34
N-2030	2,500	25		25	16	28
N-2052	13,800	138		50	18	6
Port Washington Aquifer	17,100	43	0.01			8
N-4859	17,100	43		30	20	8
N-9809 (Stonytown)	3,900	26	0.0001	150	26	22
Lloyd Aquifer	10,700	72	0.0002			19
N-1715	11,400	76		50	18	4
N-1716	10,100	67		50	18	15

Notes:

1. See Appendix K for all specific capacity data.

uifer data presented represents average values based upon the data from the reened in that aquifer.

tion. Specifically, four separate pump tests have been performed on the neighboring water supply wells, N-4223 (Southport) and N-9809 (Stonytown); two at each location. The Southport pump tests were conducted in March 1981 and March 1983. The Stonytown pump tests were conducted in April and November 1984. A summary of the historical pump test analyses are presented in table 5-3.

Analyses of aquifer responses to the pump tests indicate, not surprisingly, that the Upper Glacial Aquifer and Magothy Formation are hydraulically contiguous in the vicinity of the Landfill. Pumping at either the Southport or the Stonytown cause drawdowns not only beneath the North Hempstead Country Club, but beneath the Landfill as well. What is surprising, however, is that pumping the Stonytown affects water levels in the Lloyd Sands as well as water levels in the Upper Glacial Aquifer and Magothy Formation even though the well is supposedly screened only in the Lloyd Aquifer. This indicates that some hydraulic connection exists along the well casing between the formations. The analyses conducted here and subsequently during the ground water modeling procedure, indicated that the hydraulic connection is a very localized phenomenon, and is probably associated with the well construction at the Stonytown Well rather than a stratigraphic anomaly in its vicinity. The hydraulic connection was rigorously investigated during the RI using water level observations, the ground water model, and available drillers logs and geophysical logs for the Stonytown well. The only conclusion consistent with the available data is that the Raritan Clay does exist (perhaps not to its full extent) at the Stonytown well from approximately 298 feet below grade to perhaps 427 feet below grade. Therefore, some other phenomenon probably associated with well construction and completion is the only mechanism by which the observances can be explained.

Another important observation associated with the Stonytown pump test is that wells in the upper most water bearing zones achieved significant drawdowns northeast of the extraction point. This observed phenomena may indicate that the hydraulic properties of the Upper Glacial Aquifer and Magothy Formation are much tighter south and west of the Stonytown well. This indication is based on the presumption that a symmetrical cone of

TABLE 5-3

SUMMARY OF HISTORICAL PUMP TESTING ANALYSES

Observation well	Transmissivity (sq. ft/day)	Storage Coefficient	Hydraulic Conductivity** (ft/day)	Number of pump tests observed
N-1715	17,000	0.0003	110	2
N-3742	14,000	0.006	60	4
N-4223 (Southport)	6,000	0.0005	20	4
N-9480 (TNH-5)	54,000	0.0006	220	3
N-9481 (TNH-6)	52,000	0.007	210	1
N-9809 (Stonytown)*	31,000	0.001	124	1
N-9977 (TNH-10)	34,000	0.002	140	3
N-9978 (TNH-9)	26,000	0.001	100	3

* Hydraulic properties estimated from observation data collected at the Stonytown well characterize the Upper Glacial/Magothy aquifers.

**Hydraulic conductivity estimates reflect an assumed saturated thickness of 250 feet in the Upper Glacial/Magothy aquifers and 50 feet in the Lloyd aquifer.

(605)

depression around the Stonytown Well would not impact ground water levels beneath the Landfill. Since the pumping did impact ground water levels beneath the Landfill, a boundary, or change in the water bearing zone permeability must exist south and/or west of the pumping center. This finding is consistent with the mapping of till ridges (described earlier) in the Upper Glacial Aquifer sediments.

Due to the hydraulic connection between the Lloyd Aquifer and the Magothy/Upper Glacial water-bearing zones, which has been observed to exist at the Stonytown well, it becomes important to determine the ratio of water removed from the Lloyd Aquifer versus water removed from the Upper Glacial and Magothy water-bearing zones when pumping at the Stonytown well. The results of the pump tests will be used to determine aquifer characteristics and to evaluate the potential for contamination to migrate from the Landfill to the public water supply wells under various pumping scenarios.

The method used to determine the ratio of water extracted from the various stratigraphic units during pumping at the Stonytown well involved comparing the results of Southport pump tests with the expected results of the Stonytown pump tests (assuming all water extracted by the Southport well is removed from the Upper Glacial Aquifer and Magothy Formation). Key to this evaluation was a comparison of storage coefficients for pump tests at the two wells. Based on this comparison (presented in Appendix K) it is estimated that the Lloyd Aquifer contributes approximately 75 percent of the waters produced by the Stonytown well under the pumping scenarios analyzed.

5.2.2 PIEZOMETRIC SURFACE

Depth-to-water data is among the simplest and most accurate measurement which can be obtained in the field to characterize any ground water flow system. At the Landfill, depth-to-water data, which is synonymous with piezometric data, was collected over many different dates by the REM II team during the field investigation. However, synoptic data is required to effectively evaluate the rate and direction of ground water flow.

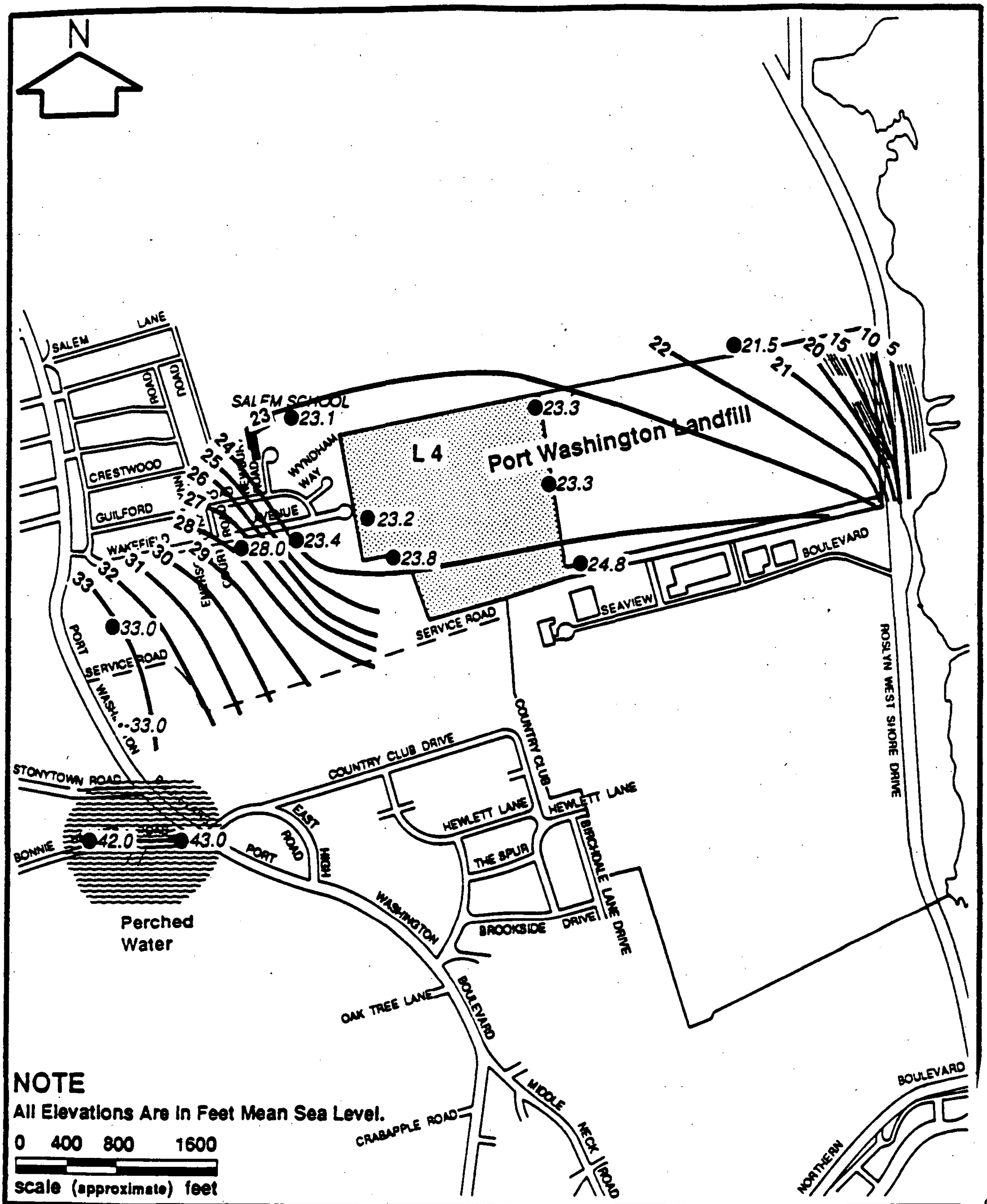
A complete round of synoptic data was collected twice by the EPA from the wells in the vicinity of the Landfill; once on February 16, 1988 and again on August 31, 1988. The first was collected as part of the REM II team's Stonytown pump test and the second was collected as a result of the second full round of ground water quality sampling. Other water level data collected by the REM II team in conjunction with well installation and sampling activities is presented in Appendix L.

The results of these two sampling dates are presented as piezometric surfaces in figures 5-4 and 5-5. Each date is depicted in two related figures accounting for the change of piezometric head with depth in the stratigraphic formations; Upper Glacial and Magothy water bearing zones.

It is important to note that the piezometric surface depictions for the shallow depth on both dates illustrate that the prevailing gradient beneath the golf course is generally southwest to northeast. Beneath the Landfill, however, the gradient flattens considerably and changes to a mainly northern orientation. This northern orientation is especially obvious in the February 1988 observation (figure 5-4).

The late August 1988 observation (figure 5-5) includes a significant feature observed at well EPA 103-a ground water mound. This mound, while dominating the flow system beneath the Landfill, is merely a transient condition not representative of long term average conditions (based on historical depth-to-water data presented in Appendix L). The mound is probably indicative of dewatering operations performed by the Town of North Hempstead where pooled water collecting in low spots between L-4 and L-5 is pumped north into the abandoned gravel pits. If the dewatering activity continues for a significant length of time, then the average flow field could be seriously impacted, but again, the historic database does not support it as a continuously occurring phenomenon.

The piezometric surface in the shallow sediments supports the presence of the narrow band of till between the Southport well and the Landfill in that a steep gradient is observed in the Upper Glacial Aquifer at this location but not in the Magothy Formation. Also, the steep gradients measured both



NOTE

All Elevations Are In Feet Mean Sea Level.

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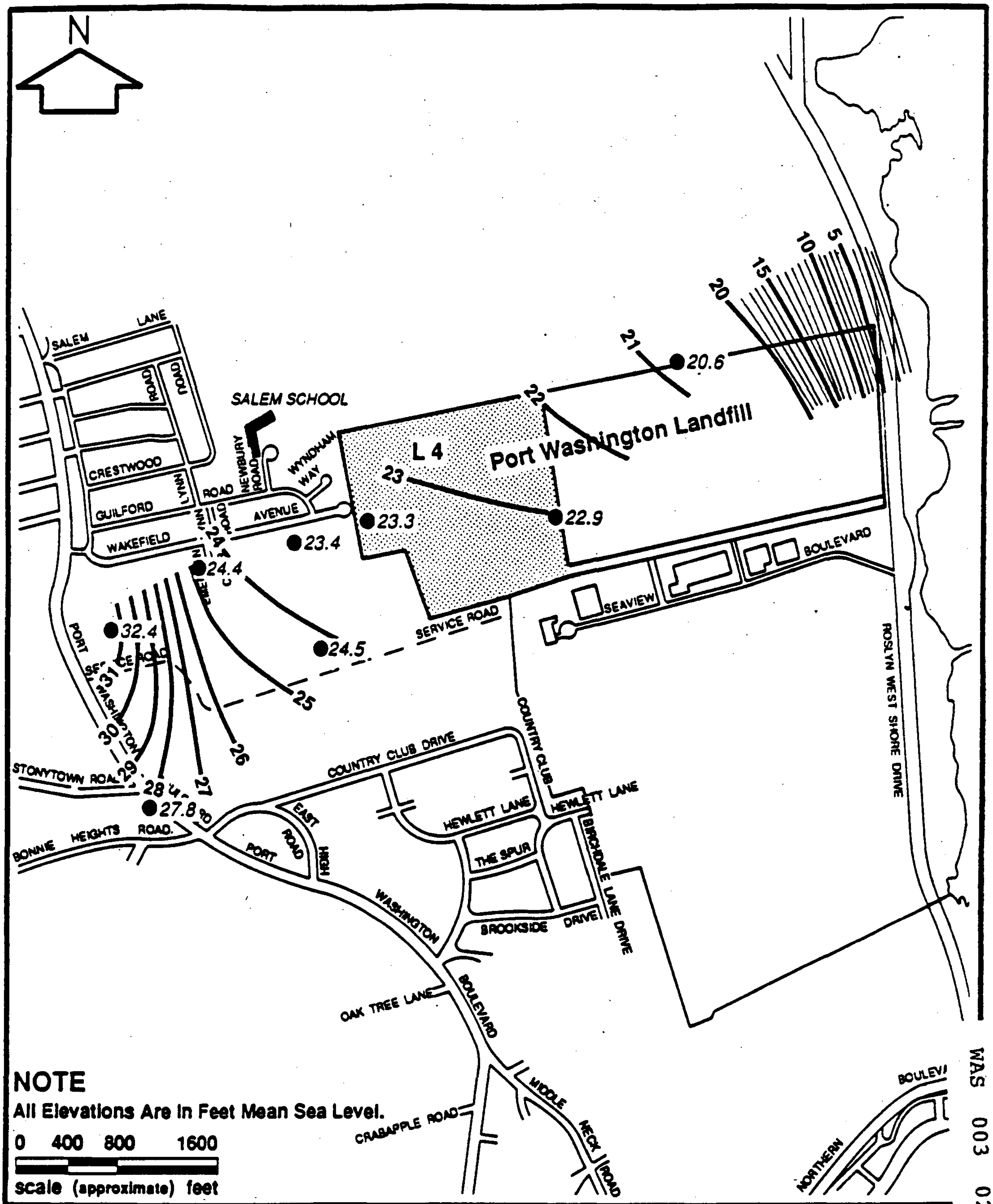
Figure 5-4

Piezometric Surface Of Upper Glacial Aquife

February 16, 198

Port Washington Landfill, Port Washington, New York



NOTE

All Elevations Are In Feet Mean Sea Level.

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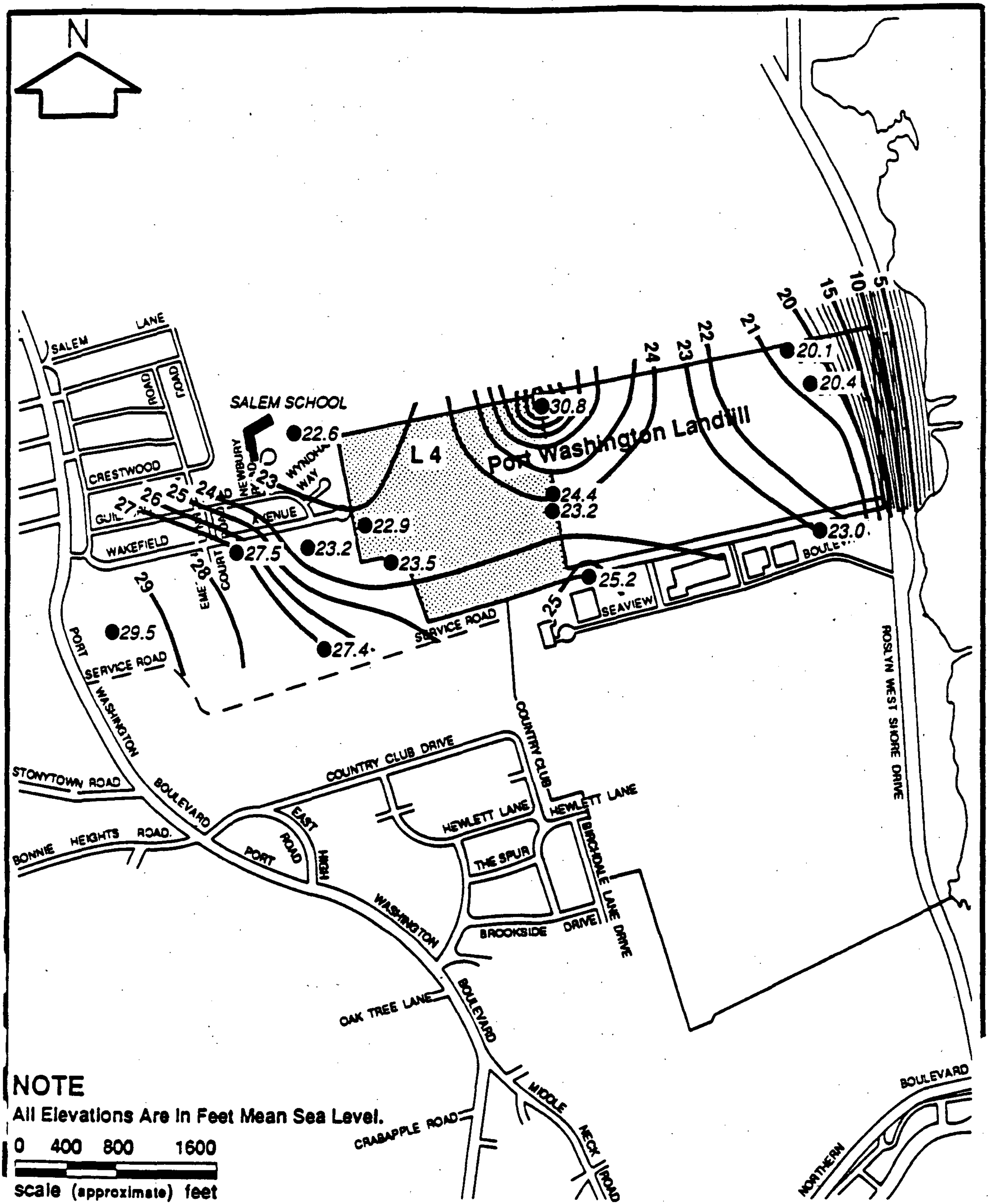
Figure 5-

Piezometric Surface Of Magothy Aquife

February 16, 198

Port Washington Landfill, Port Washington, New York



NOTE
All Elevations Are In Feet Mean Sea Level.

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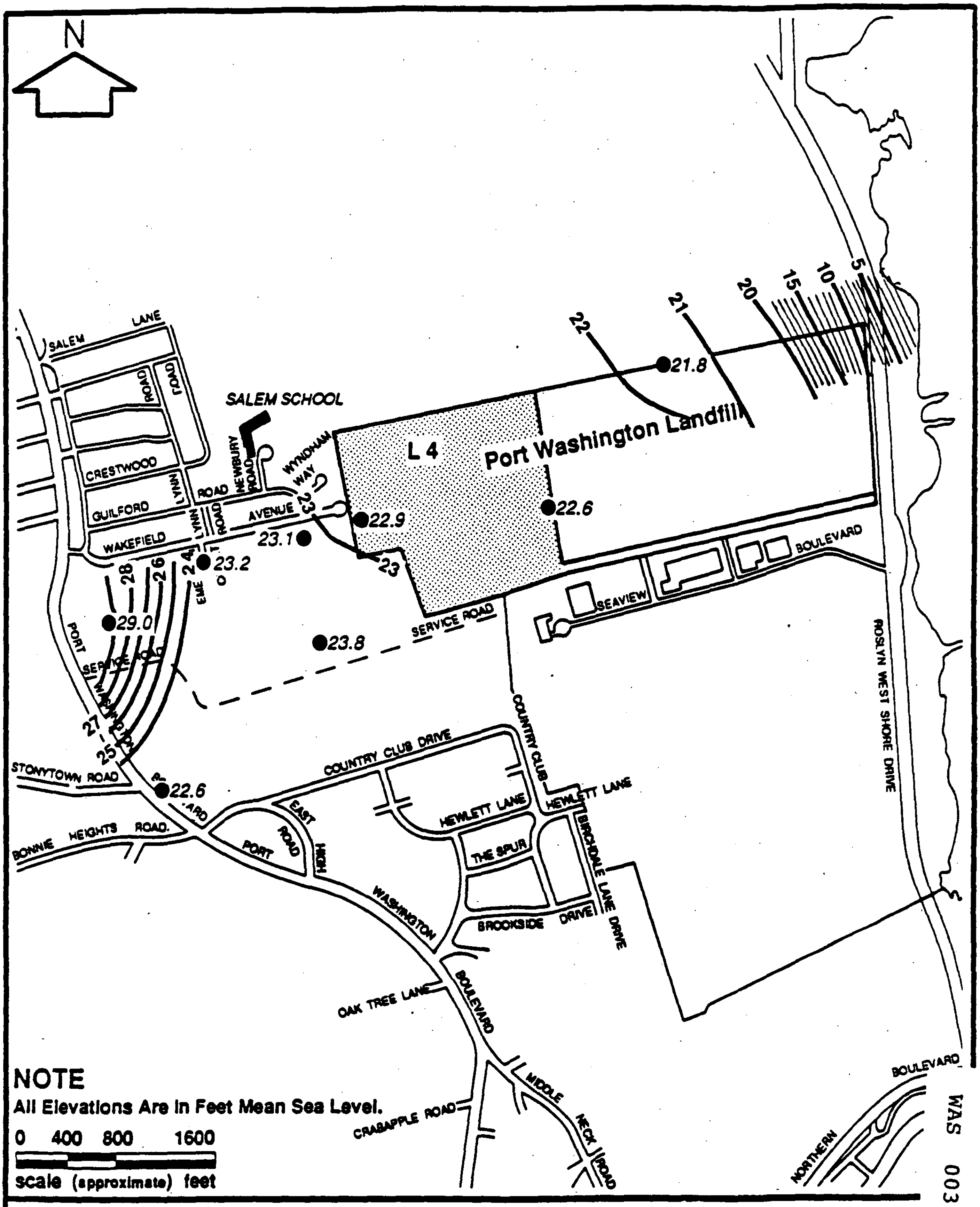
Figure 5-5a
Piezometric Surface Of Upper Glacial Aquifer
August 31, 1988
Port Washington Landfill, Port Washington, New York



NOTE

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Figure

Piezometric Surface Of Magothy Aqu

August 31, 1

Port Washington Landfill, Port Washington, New

east of the Landfill between L-5 and Hempstead Harbor, and west of the Landfill between EPA 107 and TNH-10 are indicators of sediments less permeable than those directly beneath the Landfill in these isolated locations, given that no other physical evidence such as local pumping supports the observation. The piezometric surfaces on both dates are consistent with these observations.

It should be noted that since the deeper formation piezometric surface does not indicate the presence of this till between the Southport well and the Landfill, it must not penetrate to a depth of more than about -50 feet MSL at this location. However, the existence of steep observed gradients both east of the band and west of the Southport well indicate that till in these areas extends vertically downward to at least -170 feet MSL, and probably deeper.

It should also be noted that the existence of a north-south till ridge located south and west of the Stonytown well (as discussed in section 5.2.1) is supported by the observed water levels in wells N-9903 and N-1120. These wells appear to represent perched water or water within a very tight formation, given that the heads measured at these two locations are approximately 10 feet above any other observed ground water level in the site vicinity.

Another indication of the heterogeneous saturated sediments which exist beneath the Landfill is the observed vertical gradient, which can be evaluated by comparing the mapping of the shallow and deep piezometric surfaces. Beneath the Landfill, very slight vertical gradients have been observed (ignoring the ground water mound observed at EPA 103 which is probably a short-term transient condition influencing the observed vertical gradient at EPA 109 and EPA 108 in August 1988). Around the landfill, the Upper Glacial sediments are characterized by hydraulic gradients of less the 0.006 (see [redacted] However, in the vicinity of the till ridge between the Southport Well and the Landfill, a sizable gradient is found which is at least twice as large as that observed in the rest of the monitored Upper Glacial. This most probably occurs because the till ridge only penetrates the upper portion of the saturated sediments. Further to the

TABLE 5-4

OBSERVED VERTICAL GRADIENTS AT WELL PAIRS

		February 16, 1988				August 31, 1988			
WELL PAIRS	DISTANCE BETWEEN WELL SCREENS (FT)	HEAD (FT MSL)	DIFFERENCE (FT)	DIRECTION	GRADIENT	HEAD (FT MSL)	DIFFERENCE (FT)	DIRECTION	GRADIENT
EPA 111	174'	32.42				29.02			
EPA 107		33.05	0.63	DOWN	0.004	29.52	0.5	DOWN	0.003
EPA 110	141'	24.50				23.76			
EPA 106		29.22	4.72	DOWN	0.033	27.43	3.67	DOWN	0.026
N - 4223	95'	24.38				23.24			
EPA 105		27.98	3.60	DOWN	0.038	27.52	4.28	DOWN	0.045
TNH 9	26'	23.44	0.01	UP	0.0004	23.14			
TNH 10		23.43				23.22	0.08	DOWN	0.003
TNH 5	92'	23.32	0.12	UP	0.001	22.89	0.0	———	-------
TNH 6		23.20				22.89			
EPA 109	65'	22.92				22.60			
EPA 108		23.33	0.41	DOWN	0.006	24.44	1.84	DOWN	0.028*
TNH 1	35'	23.38	0.11	UP	0.003	23.17	0.0	---------	------
TNH 2		23.27				23.17			

*Influenced by transient mound at EPA 103.

west, near EPA 111 and EPA 107 where the till perhaps exists to the top of the Raritan, the observed vertical gradient is on the order of 0.004 even though the horizontal gradient is still significant.

It is important to note that the till ridge does not appear to exist at the Stonytown well. In fact the till may very well exist immediately north, south, and west of the Stonytown well, but not at it.

5.2.3 PERMEABILITY TESTING

The relative rate of ground water flow is dependent not only on the prevailing gradient, but on the hydraulic conductivity, or permeability of the formation as well. During the REM II team field investigations, three specific activities were performed to characterize the hydraulic properties of the Upper Glacial Aquifer, Magothy Formation, Raritan Clay, and Lloyd Aquifer. These activities included the collection of cores from the Raritan Clay for laboratory testing, the in situ recovery testing of the EPA monitoring wells, and the performance of a five-day pump test on the Stonytown well. This section reviews the results of these activities.

Laboratory Permeability Tests of the Raritan Clay

The core samples retained from the Raritan Clay were tested to determine the potential for vertical flow between the Lloyd Aquifer and Magothy Formation.

Therefore, core samples from well EPA 109, EPA 110, and EPA 111 were collected and analyzed to determine the vertical permeability of the Raritan's silt and clay. Selected parameters from each of the tests performed, along with a description of each permeability test specimens are presented in Appendix P. Review of the resultant test data indicate the following:

- All the samples tested classify as silt, with the soil from EPA 109 having the lowest plasticity index and the material from EPA 110 having the highest plasticity index;

- The permeability (hydraulic conductivity) values (corrected to 20 degrees Celsius) of the material tested from EPA 109, EPA 110 and 111 were 0.0009 feet/day (3.1 x 10^{-7} cm/sec), 0.000015 feet/day (5.4 x 10^{-9} cm/sec) and 0.0003 feet/day (9.3 x 10^{-8} cm/sec) respectively; and
- The trend in permeability and plasticity index between samples tested is relatively consistent (i.e. permeability decreases with increasing plasticity index).

Based on the low permeabilities and high plasticity index, it can be interpreted that the Raritan Clay acts as an effective aquitard where it exists, restricting flow from the Lloyd Aquifer upward to the Magothy Formation, and vice versa.

In situ Permeability Test of the Upper Glacial and Magothy Formations

All EPA ground water monitoring wells installed at the Landfill and two Town of North Hempstead monitoring wells were tested using in situ techniques to determine the hydraulic conductivity of the water-bearing formations at the respective well screens. In this way, data was collected from eleven specific locations in the Upper Glacial Aquifer and from two specific locations in the Magothy Formation.

It should be noted that all the monitoring wells tested by the REM II team were installed using drilling mud and as such, could be influenced by mud "caking" in the boreholes thus reducing the communication of the well with the formation. For this reason it is expected that the results of in-situ permeability tests produced lower hydraulic conductivities than actually exist. However, comparisons between results at different sampling points provide insight into relative changes in the hydraulic properties given that all measurements are influenced similarly by the expected interferences.

Results of the in situ permeability tests are presented in [redacted] Recovery curve plots appear in Appendix K. All analyses were performed using the Hvorslev time-lag analysis (Freeze and Cherry, 1979) for rising head data (water level recovery after a slug of water is removed from the well).

TABLE 5-5

RESULTS OF IN-SITU PERMEABILITY TESTS

Well	Hydraulic Conductivity (feet/day)
EPA 101	0.28
EPA 102	16.0
EPA 103	1.7*
EPA 104	6.4
EPA 105	15.0*
EPA 106	0.68
EPA 107	4.7
EPA 108	15.0
EPA 109	8.2
EPA 110	4.7
EPA 111	0.41
TNH-1	50.0
TNH-2	5.4

***Data of limited value due to partial dewatering of well screen during testing.**

(564)

It should be noted that results obtained from EPA 103 and 105 are of limited value because partial dewatering of the well screens occurred during the tests. Noteworthy is the observation that the formation screened by EPA 109 and EPA 110 is slightly confined based on the observed vertical gradients; however, the analysis technique can still be used reliably for these data.

Piezometer slug tests indicate hydraulic properties only in the vicinity of the well tested and cannot individually characterize regional aquifer parameters. However, these tests indicate fairly consistent results. Hydraulic conductivities near the wells tested varied from 0.28 to 50 feet per day, with a median of 5.4 and a mean of 10 feet per day, indicating that the aquifers in the landfill area are silty to clean sands (Freeze and Cherry, 1979).

Table 5-[illegible] shows a qualitative grouping of the hydraulic conductivities of the wells tested. The qualitative grouping illustrates two important points. One is that the Upper Glacial Aquifer, where till does not exist, is fairly transmissive as evidenced by EPA 102, EPA 104, EPA 108 and TNH-1 and TNH-2. Conversely, the Upper Glacial wells located in the till areas, EPA 101, EPA 106, EPA 107, EPA 110, and EPA 111, have measurably lower permeabilities.

The slug test results yielded hydraulic conductivities that were generally one tenth of the values obtained from pump tests and pumping well specific capacity data. This is not unusual for thick sand units such as the Upper Glacial Aquifer and may be due to the anisotropy between vertical and horizontal conductivity in the local strata. It may also be caused, in part, by the small size of the monitoring wells and the small drawdowns produced by the slug tests. These results are best used to compare relative hydraulic properties among the monitoring wells, and to estimate vertical hydraulic conductivity for the formations of interest.

TABLE 5-6

RELATIVE HYDRAULIC CONDUCTIVITIES OF TESTED WELLS

Cleaner Sands <<==>> Siltier Sands

$50 \geq K > 5$	$5 > K > 0.5$	$0.5 > K > 0.05$
TNH-1	EPA 106	EPA 101
TNH-2	EPA 107	EPA 111
EPA 102	EPA 110	
EPA 104		
EPA 108		
EPA 109		

K = hydraulic conductivity (ft/day)

(564)

Stonytown Pump Test

A pump test was performed at the Stonytown well, similar to the previous efforts outlined in the discussion of historic data, with the following important exceptions:

- o the area water supply wells were removed from service for at least 48 hours prior to the test to reduce interference and inaccuracy associated with determining the zone of influence of the Stonytown well; and
- o the EPA monitoring wells were available to determine the extent and degree of impact on the shallow flow system caused by pumping the Stonytown well, especially in the vicinity of the Landfill.

Drawdowns from the pump test were measured in four Lloyd wells and eleven wells above the Raritan Clay. In addition, recovery data were collected in two Lloyd Aquifer wells and all eleven wells above the Raritan Formation. This data was collected to determine the configuration of the stratigraphy at the Stonytown well, define the extent of the drawdown caused by pumping the Stonytown well, and characterize the hydraulic properties of the water-bearing formations in the vicinity of the Landfill. Further, the configuration of the varying stratigraphy in the area of interest was characterized.

From the drawdown data, it was determined that all the area water-bearing zones were significantly impacted by pumping the Stonytown well. The Lloyd wells experienced drawdowns of between 1.6 to 3.4 feet. These observations were made at distances of up to 8,000 feet away from the Stonytown well, and indicate that the Lloyd Aquifer is a fully confined sand unit.

To reiterate, it is doubtful, based on the observed system response and historical water levels, that a significant stratigraphic anomaly exists at the Stonytown well as hypothesized by other investigations. It is more likely that the casing has been damaged allowing for hydraulic communication between the Magothy Formation and Lloyd Aquifer at the Stonytown well. Given that the pump is set above the Raritan Formation any break in the continuity of the casing would allow water to be drawn from overlying aquifers and would explain the observed phenomenon. However, the exact mechanism of the observed hydraulic connection cannot be pinpointed at this time.

The Magothy response to the Stonytown pump test was not as dramatic or widespread as the Lloyd response, indicating that the Magothy is not a confined sand unit. The drawdowns varied from 0.4 to 3.6 feet at wells located between 800 to 4,000 feet away from the Stonytown. It should be noted that the wells in the vicinity of the till ridges (wells N-3742, N-4223 (Southport well), and EPA 111) had the largest observed drawdowns. This type of response is indicative of semi-confining conditions in the Magothy further denoting the existence of the shallow till located west of the Landfill. The response of the Magothy beneath the Landfill is fairly consistent with the observed response of the Upper Glacial Aquifer in the same location, illustrating that the heterogeneity of the till does not exist immediately beneath the site.

The Upper Glacial response was much less wide spread and less severe than the observed Magothy response. The Upper Glacial realized maximum drawdowns of no more than 0.9 feet, and the zone of influence caused by pumping the Stonytown well extended to just over 3,000 feet. This response is characteristic of an unconfined aquifer system.

This analyses of drawdown data were possible only for those wells experiencing significant drawdowns and where sufficient data were gathered during the first day of the pump test. Shortly after the 24 hour mark in the test, the pump rate surged from an average of 1140 gallons per minute (gpm) to 1340 gpm. Several hours later (from the 30 to the 33 hour mark) over 0.6 inches of rain fell, causing water levels to rise up to 0.5 feet at some of the monitoring wells. Therefore, the only wells for which drawdown analyses were performed are N-3742, N-4223 (Southport well) and EPA 111.

The analyses and related log-log plots are presented in Appendix K. On the other hand, the recovery data collected was not impacted by rainfall, and was only slightly impacted by the change in pumping rate. Table 5-7 presents the results of the pump test drawdown and recovery analyses.

TABLE 5-7

RESULTS OF THE REM II TEAM STONYTOWN PUMP TEST

Observation Well	Transmissivity (sq. ft/day)	Storage Coefficient	Formation
N-3742*	4,000	0.004	Till
N-4223 (Southport)*	6,000	0.0004	Magothy
N-8790	22,000	0.002	Lloyd
N-9019*	11,000	0.002	Lloyd
N-9480(TNH-5)	25,000	0.001	Magothy
N-9481(TNH-6)	36,000	0.001	Upper Glacial
N-9977(TNH-10)	17,000	0.002	Upper Glacial
N-9978(TNH-9)	22,000	0.001	Magothy
EPA 106	30,000	0.001	Till
EPA 107	7,000	0.01	Till
EPA 110	19,000	0.001	Magothy
EPA 111*	2,000	0.003	Till

See Appendix K for detailed analyses and data.
- All values are reported to the nearest thousand/thousandth
- Reported values are adjusted for relative discharge (75%-25%)

* Transmissivity value is average of value calculated from drawndown data and value calculated from recovery data. Storage coefficient determined from reported transmissivity value.

(564)

It has been determined that the Stonytown draws approximately 75% of its water from the Lloyd and this value was used to evaluate the pump test drawdown and recovery data. From these analyses, the Lloyd Aquifer was found to have a transmissivity ranging from 11,000 to 23,000 square feet per day, with storage coefficients between 0.001 and 0.002. Wells above the Raritan Clay yielded a broad range of values, with transmissivities between 2,000 and 36,000 square feet per day, and storage coefficients between 0.01 and 0.005. It should be noted that the wells closest to the till which proportedly extends down to the Raritan Clay, (ie. N-3742, N-4223 (Southport well), EPA No. 107, and EPA No. 111) have transmissivities ranging between 2,000 and 7,000 square feet per day and the other wells above the Raritan have transmissivities ranging between 11,000 and 36,000 square feet per day or about 5 times larger than those near the till.

5.2.4 OVERVIEW OF GROUND WATER FLOW SYSTEM

A computerized numerical model of the ground water flow system was developed to facilitate analysis of aquifer hydraulics, and to provide a tool for studying contaminant transport in the vicinity of the Landfill. This tool will also be used in the Feasibility Study to evaluate remedial alternatives. The following section presents an overview of the model and highlights the findings pertinent to the ground water hydraulics which were made during the modeling process. A detailed discussion of the development and configuration of the model is included in Appendix A.

The ground water flow system in the vicinity of the Port Washington Landfill and nearby public supply wells was modeled using DYNFLOW, a computer program developed at Camp Dresser & McKee Inc. that simulates three-dimensional ground water flow using a finite element grid representation of aquifer geometry. The model was configured to simulate ground water flow in sections of Port Washington, Plandome, and Manhasset, as well as in parts of Manhasset Bay and Hempstead Harbor, [redacted].

Six vertical levels were developed to define five stratigraphic layers within the model, as shown in the generalized cross-sections of model

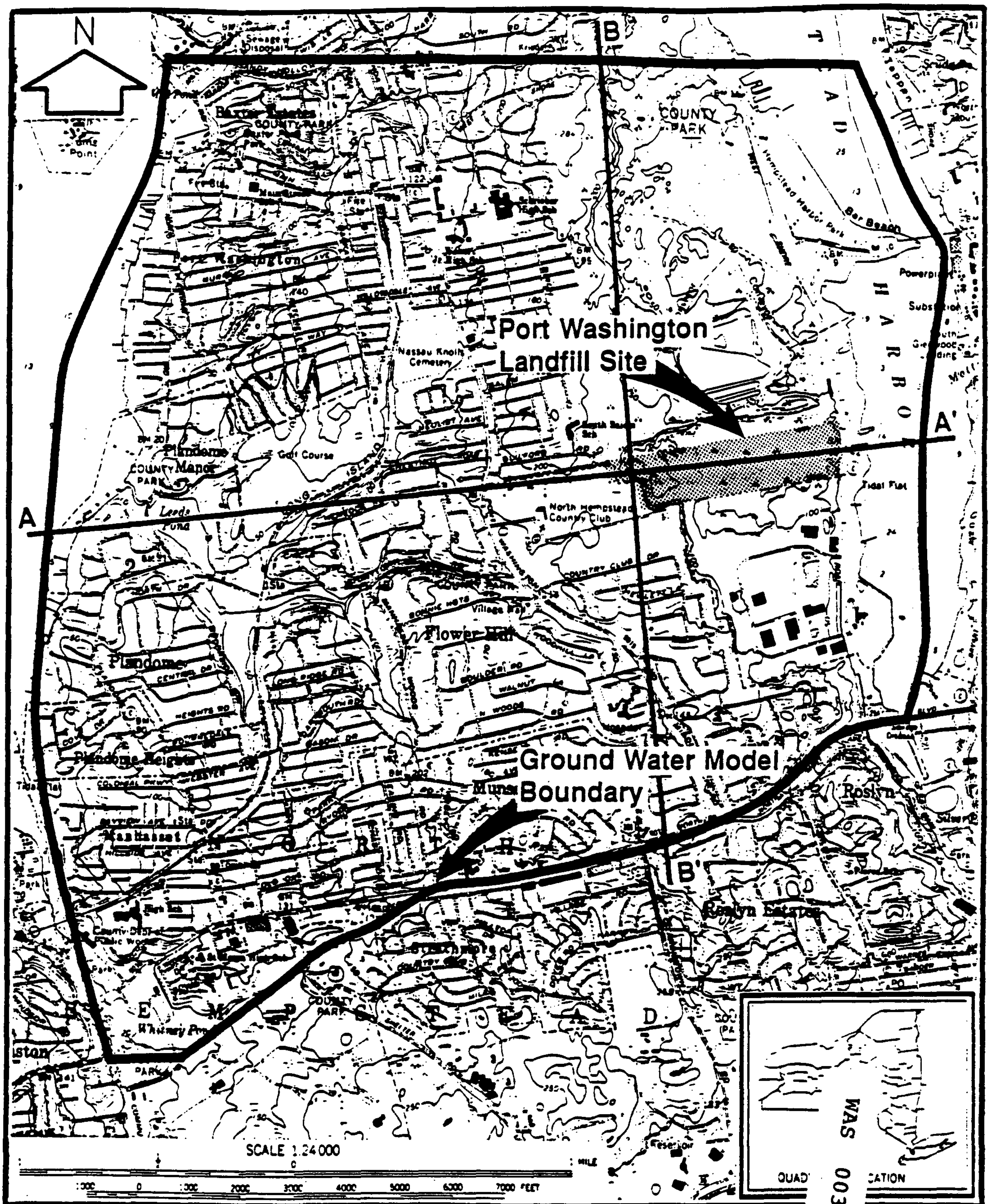

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Figure 5-6

Study Area W ocation Of
Ground Water Mo oundaries
Port Washington Landfill, Port W ton, New York

stratigraphy depicted in figures 5-7 and 5-8. Lateral boundaries between formations and changes in hydraulic character within individual units are described by property assignments within layers. The southern section of the model area presents stratigraphy comparable with much of Long Island - the Lloyd Aquifer overlies an impermeable bedrock base, and is overlain, in turn, by the Raritan Clay, Magothy Formation and Upper Glacial Aquifer. In the northern part of the model domain, the Raritan Clay and Magothy Formation are replaced by the Port Washington Aquifer and Port Washington Confining Unit, respectively. All major geologic units and identified heterogeneities described in earlier sections are incorporated into the ground water flow model configuration.

The ground water flow field was calibrated to replicate steady-state and transient flow conditions based upon field observations during the February 1988 static water level survey and subsequent Stonytown pump test. Calibration required modifying stratigraphy and hydraulic parameters to best simulate observed conditions. This process helped clarify numerous outstanding issues concerning the hydraulics of the ground water system, including the:

- configuration of the till within the Upper Glacial and Magothy aquifers;
- well hydraulics and stratigraphy at the Stonytown well;
- relative location of the southern boundaries of the two Port Washington units; and
- whether or not perched water is a significant factor in the ground water system.

These clarifications constitute the major findings associated with the ground water flow modeling effort and are explained in the paragraphs that follow.

The most important finding of the modeling effort was perhaps the configuration of the Upper Glacial and Magothy sediments in the vicinity of the Landfill, and especially near public water supply wells N-4223 (Southport) and N-9809 (Stonytown). The heterogeneities which were identified during

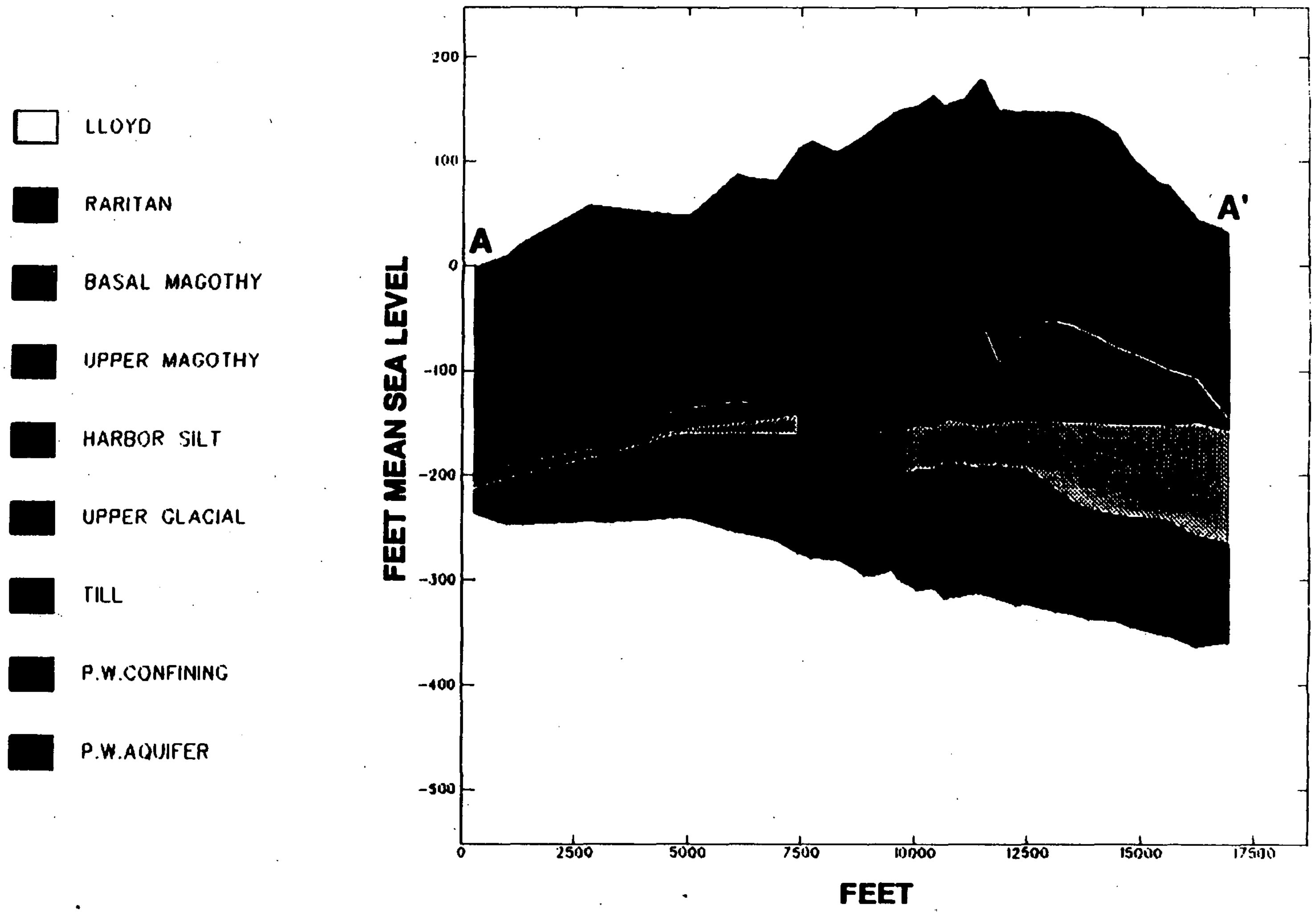

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Figure 5-7
'Stratigraphic Cross Section Of Ground Water Model - West To East

Port Washington Landfill, Port Washington, New York

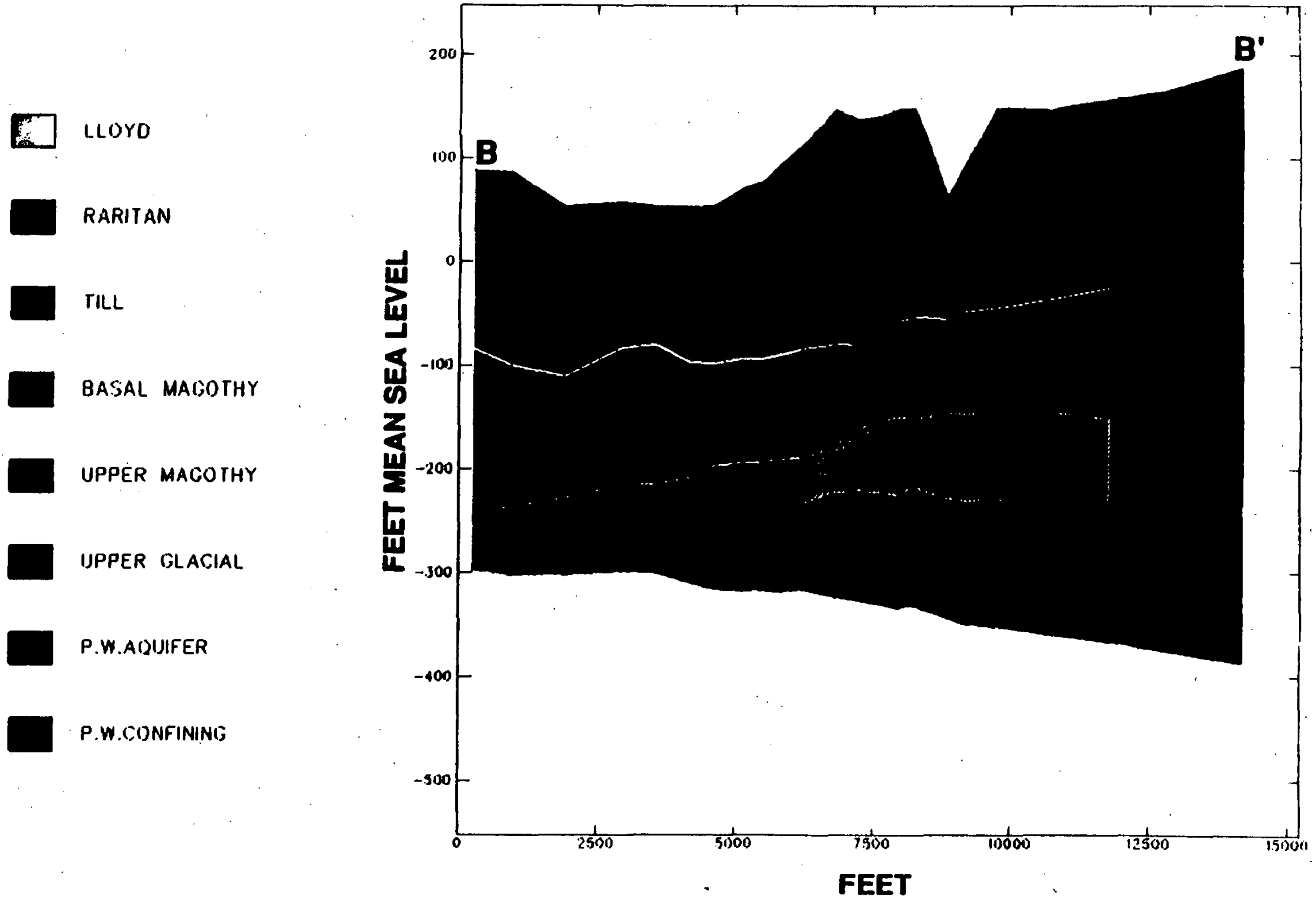

Figure 5-8
Stratigraphic Cross Section Of Ground Water Model
- North To South

Port Washington Landfill, Port Washington, New York

the field activities and further defined with the data analyses presented earlier in this section control the shallow flow system, and therefore significantly impact contaminant transport. Since these heterogeneities, generally defined by zones of till, vary in extent both horizontally and vertically, their impact on the flow system between the public water supply wells and the Landfill could only be evaluated with the advanced computer model simulation techniques described herein. The stratigraphic configuration in the Upper Glacial Aquifer defined from the simulations is presented in figure 5-9. This configuration accounts for all the till areas described in section 5.1.3.

The till bordering the east side of L-5, aligned north-south along Hempstead Harbor, and the till located west of the Landfill and golf course, aligned north-south roughly along with Port Washington Boulevard, both penetrate the Magothy Aquifer whereas the till east of Port Washington Boulevard beneath the golf course only penetrates the Upper Glacial Aquifer sediments.

The fundamental difference between the two tills west of the Landfill directly impacts the way in which water is supplied to the major pumping centers - the Stonytown and Southport wells. At the Stonytown well, most of the water is pulled from the Lloyd due to the tight nature of the till and its proximity around the borehole. At the Southport Well, the configuration of the till above the well screen forces it to pull water from the Magothy Formation and from the Upper Glacial Aquifer north of and beneath the Landfill.

The Stonytown well stratigraphy has often been in question during subsurface investigation in this vicinity due to its oft-measured static water level and pumping characteristics. The static water level in the Stonytown appears to reflect strict communication between the Lloyd and the Upper Glacial water bearing units, however, during periods of pumping, the Lloyd Aquifer appears to react as a confined sand unit (although some drawdown has been observed above the Raritan Clay). Various configurations of stratigraphic anomalies were investigated and simulated with the model, and the only feasible explanation for the observed phenomenon is that some

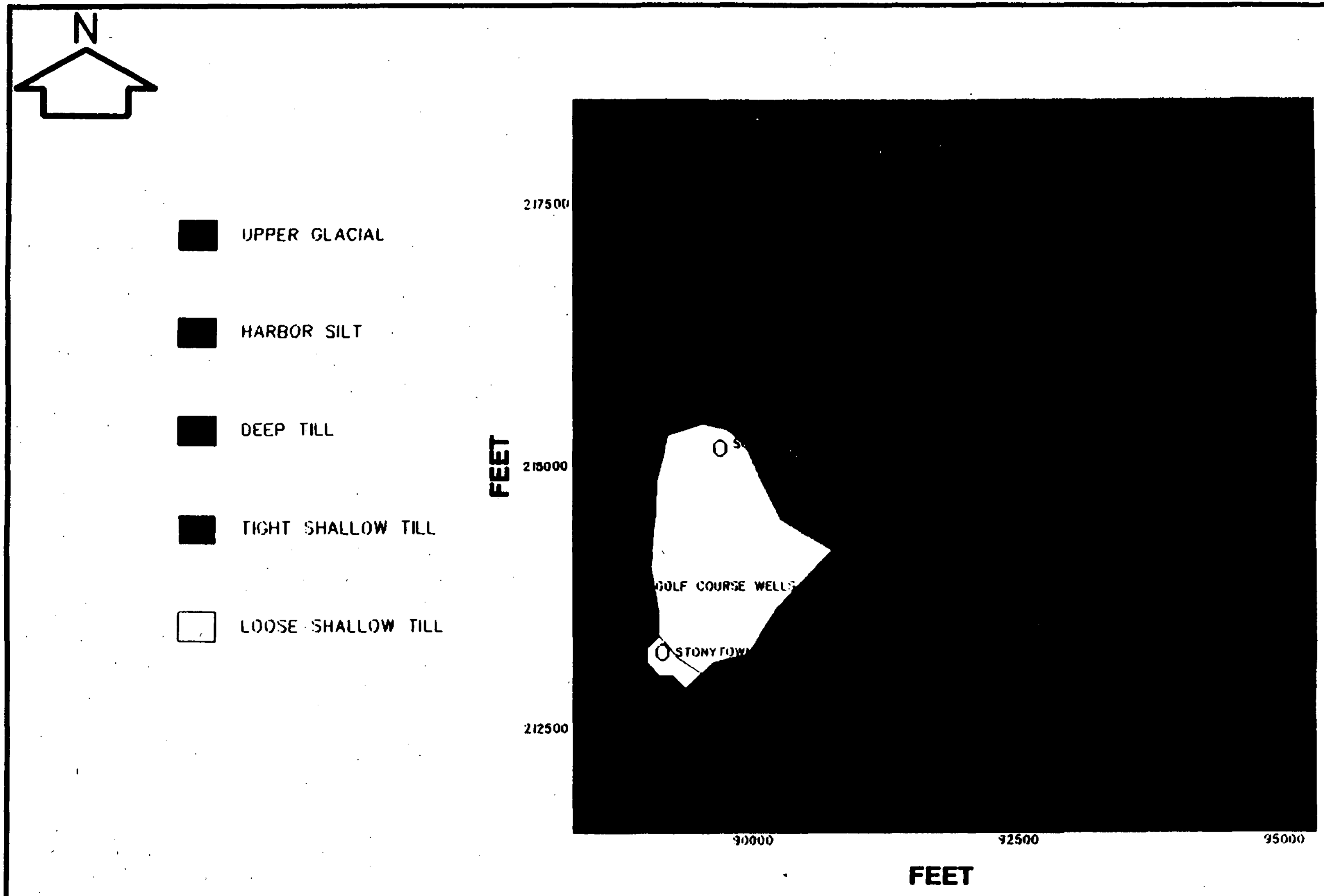

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Figure 5-9

Stratigraphic Configuration Of Upper Glacial In The Landfill Vicinity

Port Washington Landfill, Port Washington, New York

anomaly exists at the well (e.g., gravel pack installed during construction of the well along the casing through the Raritan Clay or a damaged well casing above the Raritan Clay allowing hydraulic communication between the Lloyd and overlying aquifers). It is the opinion of the REM II team that the Raritan Clay exists at the Stonytown well. There is no other explanation for the data in that if a "hole" existed in the Raritan Clay at the Stonytown well, heads in the Magothy and Upper Glacial Formation would be lowered in its vicinity (as would heads in the Llyod rise) and these phenomenon have not been observed.

The ground water model was also used to determine the approximate locations of the Port Washington Aquifer and Confining Unit in the immediate vicinity of the Landfill. Based upon the model, these units appear to be located a few thousand feet to the north of L-4. The presence of the Port Washington Aquifer at this location influences the waters flowing through the Magothy and Upper Glacial as evidenced by the northward component observed in the piezometric surfaces in these units (see Figure 5-10) This observation is substantiated by water level readings obtained in EPA 104, the northernmost monitoring point in the Upper Glacial associated with the field investigations, which were always lower than those obtained from monitoring points to the south and east (eg. TNH-1, TNH-2, TNH-5, TNH-6, EPA 103, EPA 202, etc.). It appears that the Port Washington Aquifer (which replaces the Raritan Clay) acts as a local ground water sink for the water-bearing zones which overlie it, especially since there is a till ridge insulating the Magothy and Upper Glacial Formations located beneath landfill from Hempstead Harbor, limiting the amount of west to east flow which can occur.

Lastly, perched water was evaluated as a component of the ground water flow field. Its existence is undisputable in the area beneath the golf course and adjacent residential area as perched water was encountered by the REM II team during installation of all the EPA Landfill Gas wells. It is important to note that these gas wells could have all been installed in areas where some form of till exists in the unsaturated zone. In that sense, the existence of perched water may be an indicator of the presence of till. At locations where the till is known to exist (southwest of the Stonytown well), wells N-9008 and N-1120 which are screened in the Upper

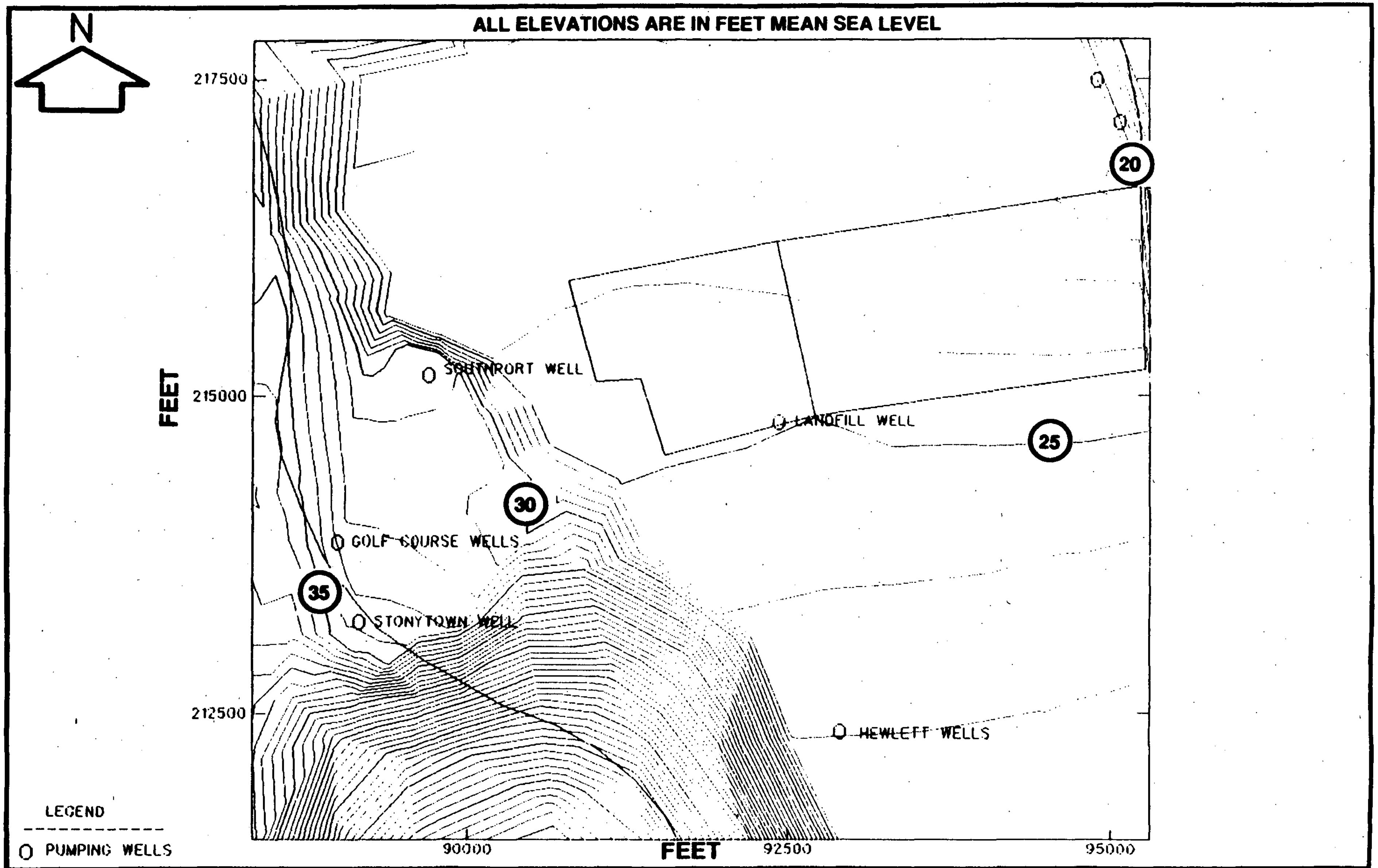

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Figure 5-10

Simulated Water Table Aquifer, Piezometric Surface, February, 1988

Port Washington Landfill, Port Washington, New York

Glacial Aquifer sediments did not respond to the pump test although these monitoring points are only a few hundred feet from the pumping center.

Since the perched water is not in direct contact with the ground water, it does not directly influence the shallow flow system. Additionally, the perched water appears to be discontinuous enough to allow rainfall recharge to percolate freely to the water table.

The piezometric surface of the water table aquifer resulting from the calibration process is presented in figure 5-10. The features of the calibrated model piezometric surface are consistent with those identified in historical water level data. The water table has a steep slope west and south of the Stonytown well and along a band between the Southport well and L-4. Beneath the Landfill, the water table has a gentle slope to the north and northeast. Between the Southport well and the Landfill, the water table slopes to the north and northwest. This northward component is again consistent with the observation that the Port Washington Aquifer is acting as a ground water sink to the water bearing formations above it. The Port Washington Aquifer has lower heads than the upper water bearing zones and, because they are hydraulically connected, there is discharge from the upper aquifers into the Port Washington Aquifer especially along its southernmost border where it has replaced the Raritan Clay.

Figure 5-11 presents a cross-section through the Landfill from just west of the Southport well to Hempstead Harbor. The significant features of this figure are the sharp gradients across the till and Raritan Clay and the flat gradient beneath the Landfill. Both the till east of the landfill and the Raritan Clay are significant units insulating the upper most water bearing zones from influences of Hempstead Harbor and the Lloyd Aquifer respectively.

Figure 5-12 presents a cross-section from near the Southport well north to a location where the Port Washington Aquifer and Confining Unit are thought to exist. From this cross-section, a significant downward vertical gradient can be observed illustrating the impact of the Port Washington Aquifer (or the lack of the Raritan Clay) north of the Landfill. This lack

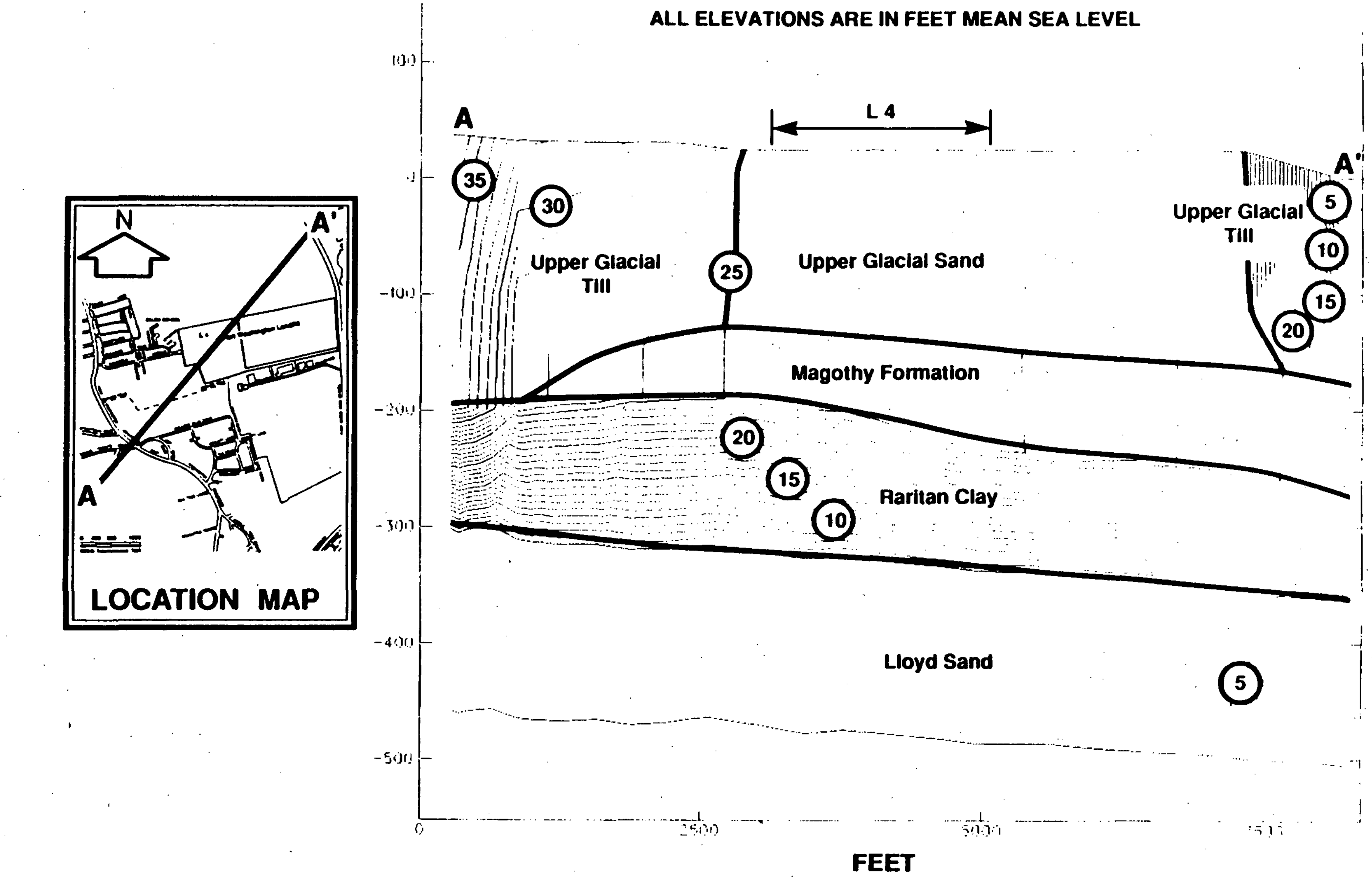

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Figure 5-11

Cross Section A-A' Of Piezometric Heads For Steady-State, February, 1988

Port Washington Landfill, Port Washington, New York

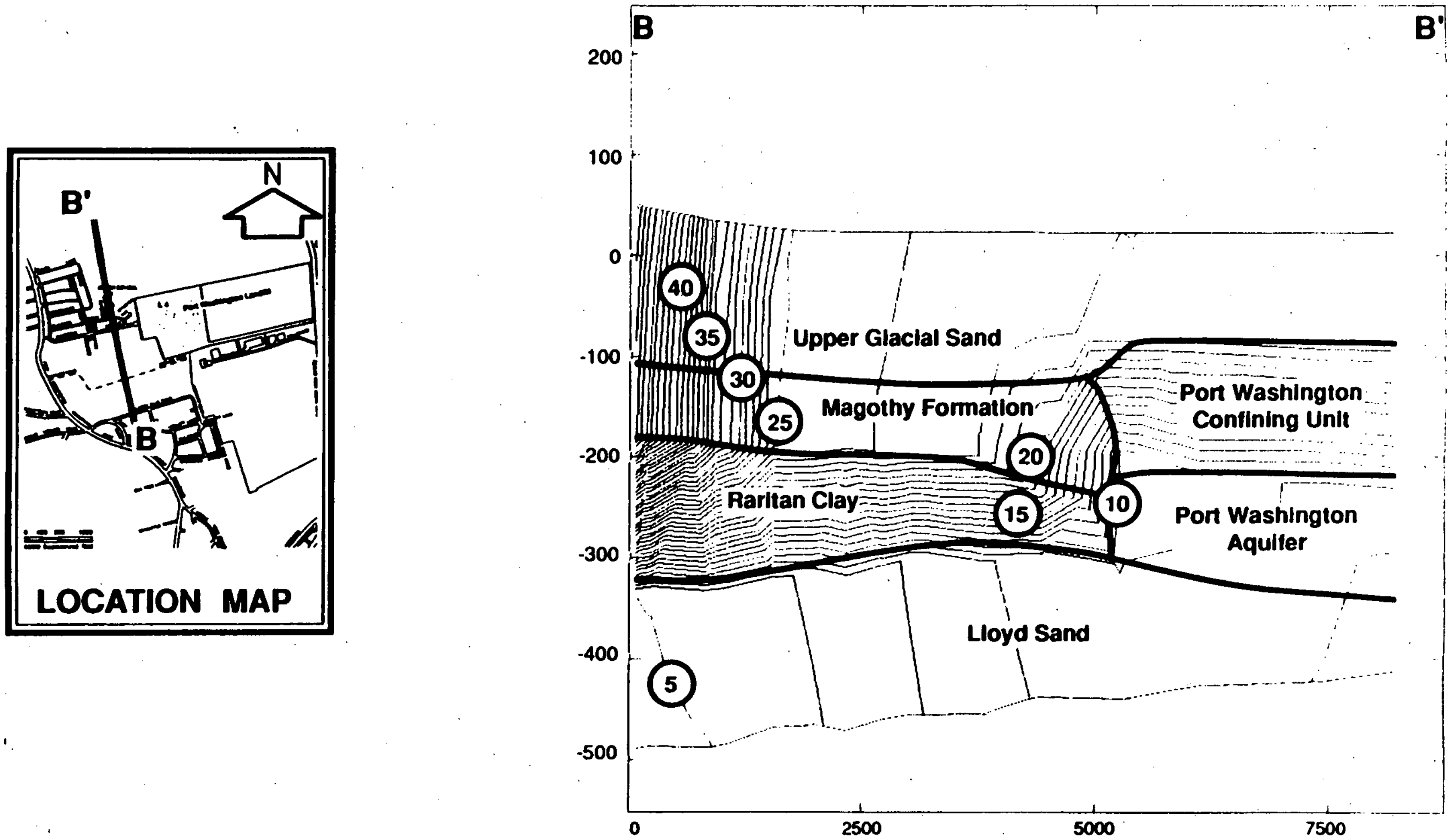

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Figure 5-12

Cross Section B-B' Of Piezometric Heads For Steady-State, February, 1988

Port Washington Landfill, Port Washington, New York

of a significant confining unit between the upper water bearing zones and the Lloyd and Port Washington Aquifers defines an important component of the ground water flow regime which impacts the migration of contaminants beneath and in the immediate vicinity of the Landfill.

5.3 GROUND WATER QUALITY

The ground water quality field activities were developed to characterize the nature and extent of subsurface water-borne contamination in the vicinity of the Landfill and attempt to determine potential sources for the detected contaminants. This purpose was addressed through installing monitoring wells and collecting ground water samples, as well as, collecting samples of the L-4 Landfill leachate and buried drum wastes located adjacent to L-4.

The following section reviews historical ground water quality data, presents mappings of data collected by the REM II team, and characterizes the observed subsurface, water-borne contamination. In addition, drum wastes sampling results are discussed.

5.3.1 HISTORICAL DATA

Ground water quality data has been available from wells in the study area ever since the Nassau County Department of Health (NCDOH) began sampling the public water supply in 1930. Historically, however, this data quantified only conventional parameters such as chloride and sulfate.

Once the Landfill began operations in 1974, ground water wells were installed by the Town of North Hempstead at the Landfill and in its vicinity for monitoring purposes. The 1974 sampling campaign, performed to characterize the background ground water quality, analyzed for conventional pollutants and inorganics. The result of the analyses was that a large mass of poor quality water underlies the Landfill site most probably associated with past soil washing practices. (Chloride was the key constituent in the analyses.)

Sampling records for these wells other than the 1974 data are generally unavailable or non-existent until 1982 at which point volatile organic constituent data began to be collected quarterly. Volatile organic data was collected for the leachate during a regular sampling regime begun in 1979. In addition, the NCDOH collected volatile organic data in the late 70's and early 80's from the Stonytown and Southport wells for selected constituents as a means to protect public health. (It should be noted that the repeated detection of volatile organic constituents in the Southport well during early 1981 by the NCDOH was instrumental in putting this site on the NPL).

The historical data suggests the following trends:

- organic contamination has existed in the ground water west of L-4 since 1981, and perhaps earlier;
- organic contamination appears to be most severe in the upper part of the Upper Glacial Aquifer west of the Landfill;
- elevated chloride concentrations in the shallow ground water system west of the Landfill have dissipated since the Southport well has stopped pumping; and
- most of the organic contaminants found in the leachate have been detected west of the Landfill in Town of North Hempstead monitoring wells.

Volatile organic constituents have been detected in the ground water in the vicinity of the Landfill since 1981. The fact that the most elevated levels of organic contamination occur west of the Landfill (see Table 5-8) is somewhat surprising given that the prevailing hydraulic gradient beneath the Landfill is fairly small and generally to the north. Table 5-8 illustrates the breakdown of detected total volatile priority pollutants in the ground water both east and west of the Landfill. It should be noted that shallow wells (TNH-1, TNH-6 and TNH-10) show the highest levels of detected contamination. It should also be noted that to the west of the Landfill numerous saturated and unsaturated chlorinated hydrocarbons were detected whereas east of the Landfill (specifically at TNH-1) trichloroethene constitutes the majority of the detected total volatile priority pollutants.

TABLE 5-8

SUMMARY OF HISTORIC VOLATILE ORGANIC CONTAMINATION IN GROUND WATER

			Total Volatile Priority Pollutant Concentrations Observed from December 1982 to January 1985	
Well No.	Screened elevation (ft msl)	Location with respect to L-4	Maximum Concentration (µg/l)	Average Concentration (µg/l)
TNH-5	-103 - -113	West	26	13
TNH-6	-1 - -11	West	859	479
TNH-9	-49 - -73	West	39	19
TNH-10	1 - -23	West	798	508
TNH-1	-27 - -32	East	95	54
TNH-2	13 - 8	East	3	3
TNH-7	2.5 - -1.5	East	ND	ND
TNH-8	12.5 - 2.5	East	6	6
TNH-11	-38 - -42	East	ND	ND
TNH-12	12.5 - 8	East	2	2

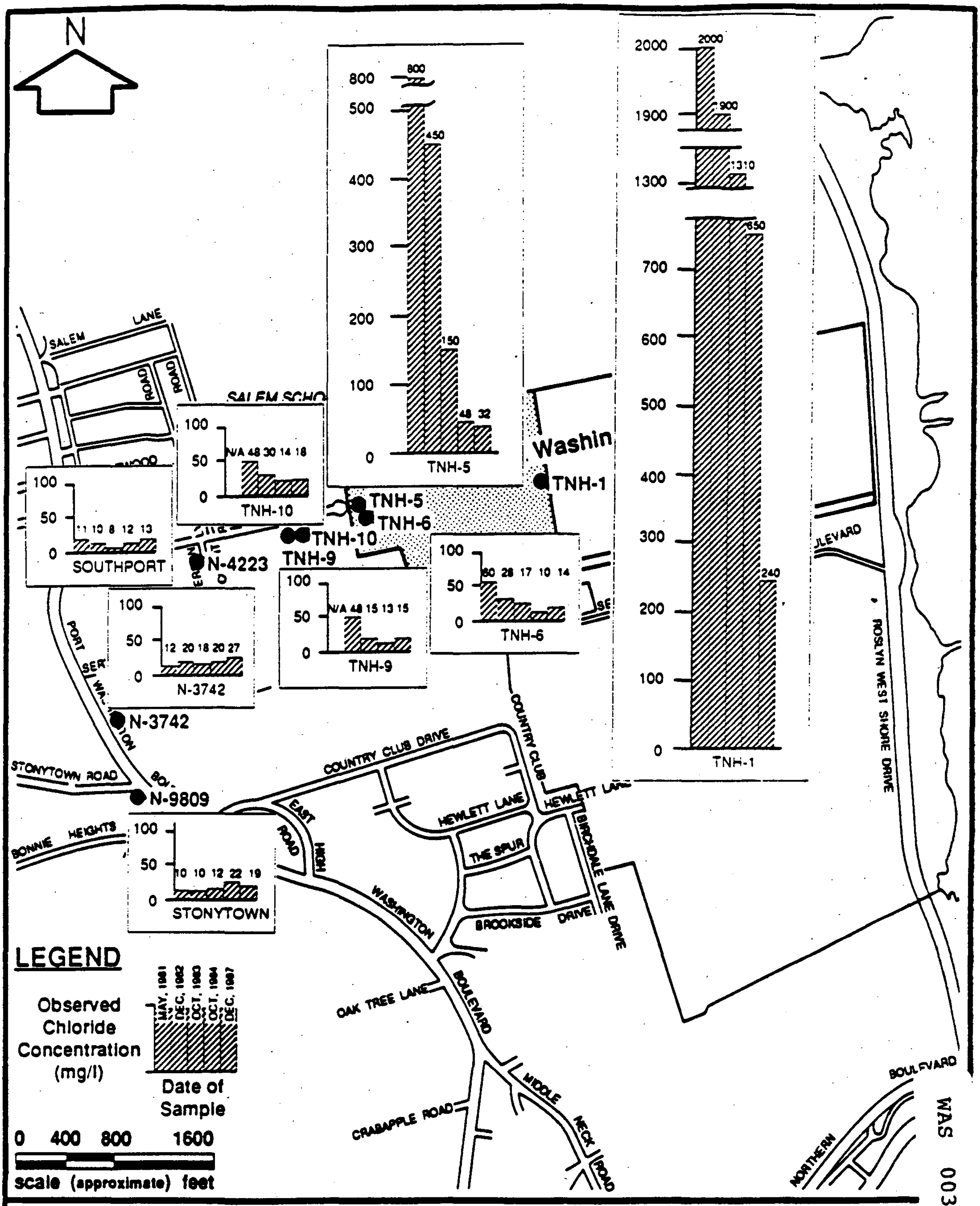
ND = Not detected.
MSL = Mean sea level.

(603)

This distribution perhaps suggests that the major source of volatile organic contamination exists only on the western boundary of L-4. Whatever the source, the contamination appears to reach the saturated zone in a diluted state (i.e., no pure product appears to have been released into the ground water system) since the constituents have only been detected near the top of the water bearing zone, and at levels well below the solubility limit. This could indicate that the leachate or some percolated rainfall has carried contamination downward to the water table, however, the localized nature of the detected organic constituents does not necessarily agree with either of these conceptual pathways.

Historical chloride data presented in figure 5-13 illustrates that an obvious trend of decreasing observed concentrations has been occurring at monitoring wells west of the Landfill. The origin of the chloride is speculated to be associated with past gravel washing operations. These operations, which included the land directly beneath where the Landfill now sits, involved pumping Hempstead Harbor water inland to erode the soil and wash it toward a sluice where it was sorted and removed.

This data is important for two reasons. First, where the chloride concentrations appear to be dissipating west of the Landfill, the organic constituents are not. In some aspects this is expected, given that the organic constituents adhere to the soil particles and are generally much slower moving than conventional constituents. However, as presented in the following subsection, the persistence of volatile organic constituents at elevated concentrations west of the Landfill indicates the presence of some source or sources continuing to impact water quality at TNH-6, TNH-9, and TNH-10. Second, although volatile organic constituents were detected at the Southport Well causing its closing, inorganic constituents such as chloride were never detected above background concentrations that far west of the Landfill. Since the organic constituents detected in the Southport move more slowly through the ground water than chloride, it can be concluded that the contamination observed at the Southport does not appear to have traveled from the Landfill to the well solely through the ground water.



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Select Historic Observed Chloride Concentratic

Port Washington Landfill, Port Washington, New Y

The origin of the organic and inorganic constituents detected historically in the ground water system could be from Landfill leachate. According to the Nassau County Department of Health, 10 to 20 million gallons of leachate could have discharged into the ground from 1974 to 1977 due to an incompleted liner and lack of a proper leachate collection system. However, the constituents found in the leachate do not all appear in the monitoring wells to the west; specifically the inorganic constituents naturally occurring in the leachate have not been detected in commensurate levels west of L-4. Nonetheless, the leachate has been shown to contain all the volatile organic constituents detected in the monitoring wells (see [redacted] with the exception of dichlorofluoromethane (found only once in forty-eight samples obtained), and chloroform (generally found below 20 ppb and a demonstrated biodegradation by-product of the oft-found volatile organic constituents at the site). It is once again important to note that the lack of detected inorganic constituents characteristic of Landfill leachate at the Southport well indicates that historically volatile organic contamination does not appear to have migrated to the well solely through the ground water flow system.

5.3.2 GROUND WATER ANALYTICAL RESULTS

The Port Washington Water District, Town of North Hempstead and EPA series ground water monitoring wells and area municipal supply wells were sampled by the REM II team in December 1987 and April 1988 to further characterize water-borne contamination. The wells were sampled concurrently with the Landfill leachate and the condensate associated with the Landfill gas venting system. Selected results from these sampling programs are presented on [redacted]. The complete results of these sampling programs are presented in Appendix M.

Generally, the results of the sample events supported the observed historical trends presented in the last section. Volatile organic contamination remains most severe west of the Landfill (see [redacted] Of interest, is the fact that the concentrations appear to be decreasing at well TNH-10 (screened just below the water table) and increasing at well TNH-9 (screened approximately 80 feet below the water table) suggesting perhaps

TABLE 5-9

COMPARISON OF ORGANIC CONSTITUENTS HISTORICALLY DETECTED IN GROUND WATER AND LEACHATE

Leachate	Vapor phase	Ground water	Leachate
Dichlorodifluoromethane		✓	
Chloroform	✓	✓	
Vinyl Chloride	✓		✓
1,1 Dichloroethene	✓	✓	✓
1,1 Dichloroethane	✓	✓	✓
Trichloroethene	✓	✓	✓
1,1,1 Trichloroethane	✓	✓	✓
Tetrachloroethane	✓	✓	✓
cis/trans 1,2 Dichloroethene	✓	✓	✓
Chloroethane		✓	✓
Benzene	✓	✓	✓
Toluene	✓	✓	✓
Xylene	✓	✓	✓
Chlorobenzene	✓	✓	✓
Ethylbenzene	✓	✓	✓
Methylene Chloride	✓	✓	✓
Trichlorofluoromethane		✓	✓

(786)

TABLE 5-10
SELECTED RESULTS OF GROUNDWATER ANALYTICAL ANALYSES FOR VOLATILE ORGANIC CONSTITUENTS

CONSTITUENT	WELL	RND 1	RND 2	RND+ 3
TETRACHLOROETHENE	TNH1			3.4
	TN5			2J
	TNH6	69	44*	60
	TNH9	43	33	30
	TNH10	34	8	22
	TNH11			0.1J
	EPA104	1J	5J	3.7
	EPA105	5	3J	6.4
	EPA106		6J	8.8
	EPA108	1		0.8
	EPA202	10	32	23
	N2052	NS	NS	0.8
	N9809			0.4J
TRICHLOROETHENE	TNH1			8.6
	TNH6	21	17.5*	20
	TNH7			0.3J
	TNH8			0.3J
	TNH9	18	14	13
	TNH10	6		4
	EPA104			0.6
	EPA105			0.1J
	EPA106			1.0
	EPA108	28	18	15
	EPA109			8.9
	EPA202			0.5
	N9019	1J		-
	N4223			0.6
	N9809	1J		1.6
1,1, DICHLOROETHENE	TNH1			0.6
	TNH6	10	12	11
	TNH9	10	9	8.7
	TNH10	3J		2.4
	EPA104			0.6
	EPA105			0.2J
	EPA106			0.8
	EPA202		1J	0.6
1,2 DICHLOROETHENE (TOTAL OF CIS AND TRANS)	TNH1			7.8
	TNH6	119	120	260
	TNH8			0.8
	TNH9	80	64	61.3
	TNH10	50	6	28
	TNH11			0.7
	EPA103			0.25

TABLE 5-10
SELECTED RESULTS OF GROUNDWATER ANALYTICAL ANALYSES FOR VOLATILE ORGANIC CONSTITUENTS

CONSTITUENT	WELL	RND 1	RND 2	RND+ 3
1,2 DICHLOROETHENE (TOTAL OF CIS AND TRANS) (CONT'D)	EPA104	1J	9J	5.6
	EPA108	2		0.8
	EPA202	2	2J	1.1
	N2052			1.1
	LEACHATE	14	8.5	NS
VINYL CHLORIDE	TNH6	19	41J*	25
	TNH9	16	7J	15
	TNH10	5		5.7
	EPA104			1
	EPA106			0.8
	LEACHATE	12	6J*	NS
1,1,2,2 TETRACHLOROETHANE	TNH1			0.4J
	TNH7			0.2J
	TNH8			1.1
1,1,1 TRICHLOROETHANE	TNH5		4J	
	TNH6	109	89*	81
	TNH8			0.3J
	TNH9	130	61	52
	TNH10	37	8	19
	EPA104	2J	5J	4.3
	EPA105	7	2J	4.3
	EPA106		6J	7.8
	EPA108			0.2J
	EPA202	14	27	17
	N9809			0.5
	LEACHATE	4J		NS
1,1,2 TRICHLOROETHANE	TNH7			0.4J
	TNH8			1.3
	EPA109			0.5J
1,1 DICHLOROETHANE	TNH1			11
	TNH2			0.9
	TNH5		4J	
	TNH6		98*	130
	TNH8			0.5J
	TNH9	76	60	59
	TNH10	27	5	18
	TNH11			0.2J
	EPA103			0.8
	EPA104		2J	1.4
	EPA105			0.5J
	EPA106			4.8
	EPA108	1		0.8

TABLE 5-10
SELECTED RESULTS OF GROUNDWATER ANALYTICAL ANALYSES FOR VOLATILE ORGANIC CONSTITUENTS

CONSTITUENT	WELL	RND 1	RND 2	RND* 3
1,1 DICHLOROETHANE (CONT'D)	EPA202	4J	5	4.1
	N9809			0.6
	LEACHATE	12	6J	NS
1,2 DICHLOROETHANE	TNH6			2.1
	TNH7			0.3J
	TNH8			1.3
	N9809			0.4J
CHLOROETHANE	TNH2	11	19J	33
	TNH6		3J	6.6
	TNH9		2J	
	EPA102		3	
	EPA 103		7J	
	LEACHATE		22	NS
BENZENE	TNH1			1.7
	TNH2	2J		3.4
	TNH6	6J	4J	5
	TNH8			4J
	TNH9			1
	TNH10	2J		0.7
	TNH11			0.2
	EPA 102			0.1J
	EPA103			1.9
	EPA104			0.2J
	EPA105	1J		
	EPA106			0.4J
	EPA111			0.2J
	N4223			0.1J
	EPA202			0.4J
	N9809			0.1J
	LEACHATE	13	8	NS
TOLUENE	TNH1			0.9
	TNH6			0.1J
	TNH8			0.2J
	TNH10	2J		
	EPA105			1.2
	EPA106			0.6
	EPA107			0.6
	EPA108			0.6
	EPA110			1.5
	EPA111			0.3J*
	EPA202			6.8
	N9809			0.1J
	LEACHATE	71	48*	NS

TABLE 5-10
SELECTED RESULTS OF GROUNDWATER ANALYTICAL ANALYSES FOR VOLATILE ORGANIC CONSTITUENTS

CONSTITUENT	WELL	RND 1	RND 2	RND+ 3
TOTAL XYLENE	TNH1			0.8
(TOTAL OF O-XYLENE AND	TNH2			0.1J
P&M - XYLENE)	TNH6	21	19*	4.1
	TNH7			0.3J
	TNH8			0.6
	TNH9	2		2.6
	TNH10			4.9
	EPA103			0.2J
	EPA104			0.5J
	EPA106			0.2J
	EPA107			0.1J
	EPA108			0.1J
	EPA202			0.4J
	N4223			0.5J
	N9809			0.4J
	LEACHATE	210	160*	NS
CHLOROBENZENE	TNH1			10
	TNH2			3
	TNH6			1.3
	TNH7			0.2J
	TNH8			0.9
	TNH9			0.1J
	EPA103	3.1J	4J	3.4
	EPA105	2.0J		
	EPA106			0.2J
	N4223			0.3J
	N9809			0.2J
	LEACHATE	19	18*	NS
ETHYLBENZENE	TNH8			0.2J
	TNH10	8		
	EPA202			0.2J
	LEACHATE	26	60*	NS
CARBON TETRACHLORIDE	TNH6		4J	
	LEACHATE		8	NS
CHLOROFORM	TNH6			0.6
	TNH7			0.5
	TNH8			0.7
	TNH9	1J		0.8
	TNH10	4		3.4
	EPA105			0.3J
	EPA106			0.2J
	EPA108			0.1J

TABLE 5-10
SELECTED RESULTS OF GROUNDWATER ANALYTICAL ANALYSES FOR VOLATILE ORGANIC CONSTITUENTS

CONSTITUENT	WELL	RND 1	RND 2	RND+ 3
CHLOROFORM (CONT'D)	TNH7			0.5
	TNH8			0.7
	TNH9	1J		0.8
	TNH10	4		3.4
	EPA105			0.3J
	EPA106			0.2J
	EPA108			0.1J
	EPA110			7.6
	N9809	8		
METHYLENE CHLORIDE	TNH1			1.7
	TNH6	117		64
	TNH8			0.8
	TNH9	32		29
	TNH10			13
	EPA103		5	
	EPA104			0.8
	EPA106			1.4
	EPA110			1.6

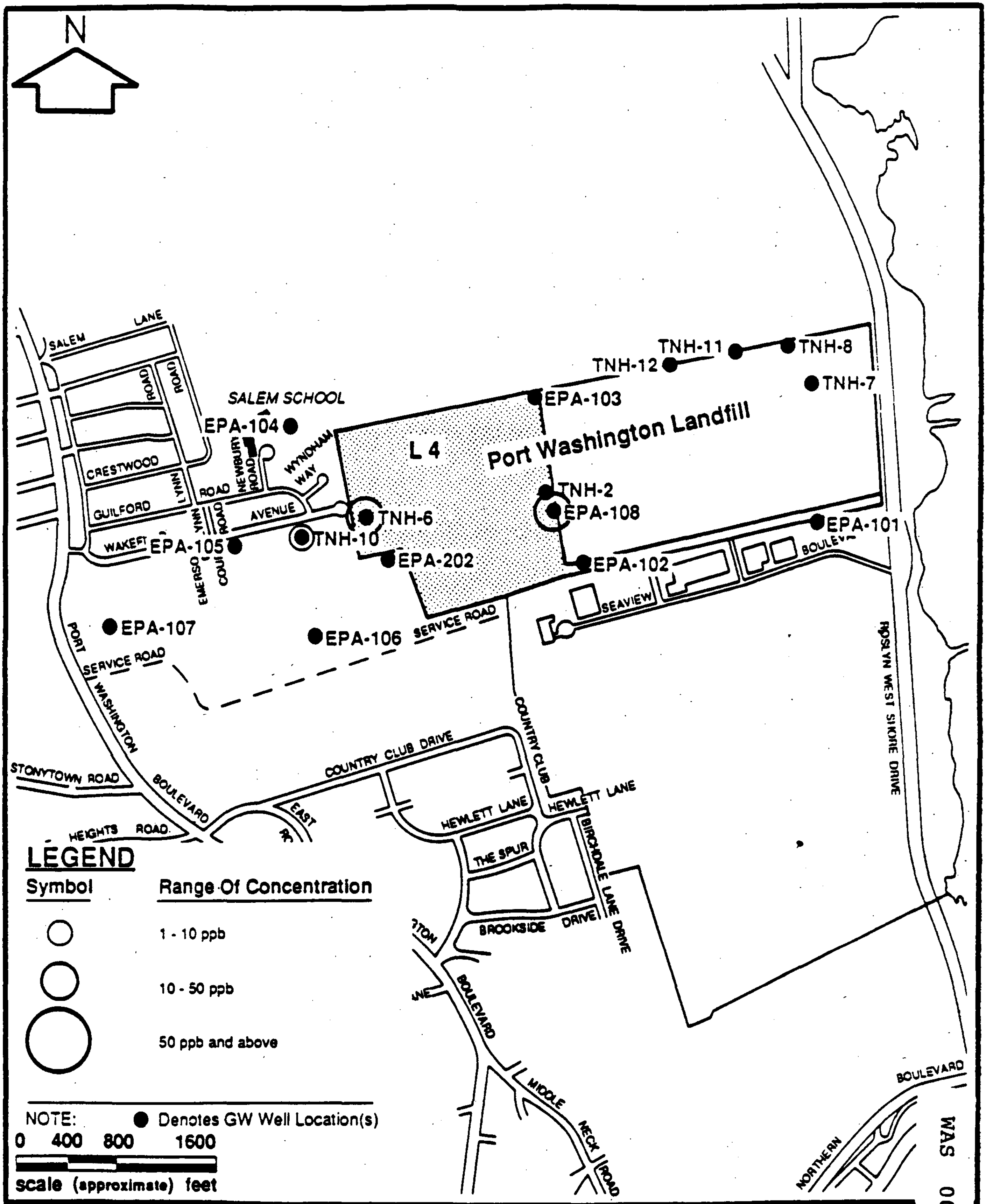
NOTES:

* - Reported values is average of sample and duplicate
NS - No sample collected
J - Reported value is estimated because it is below method detection limit
\+ - Round 3 sampling and analysis performed by Environmental Response Team (ERT). Analysis is completed using EPA method 524.2, with detection limits of 0.5 ug/L. Round 1&2 volatile organic analysis is completed using EPA method 624 with detection limits of 5 and 10 ug/L.

Figure 5-14

Detected Contaminant Distribution of Selected Volatile Organic Constituents

(Note: Figure 5-14 is comprised of 30 individual figures which follow)



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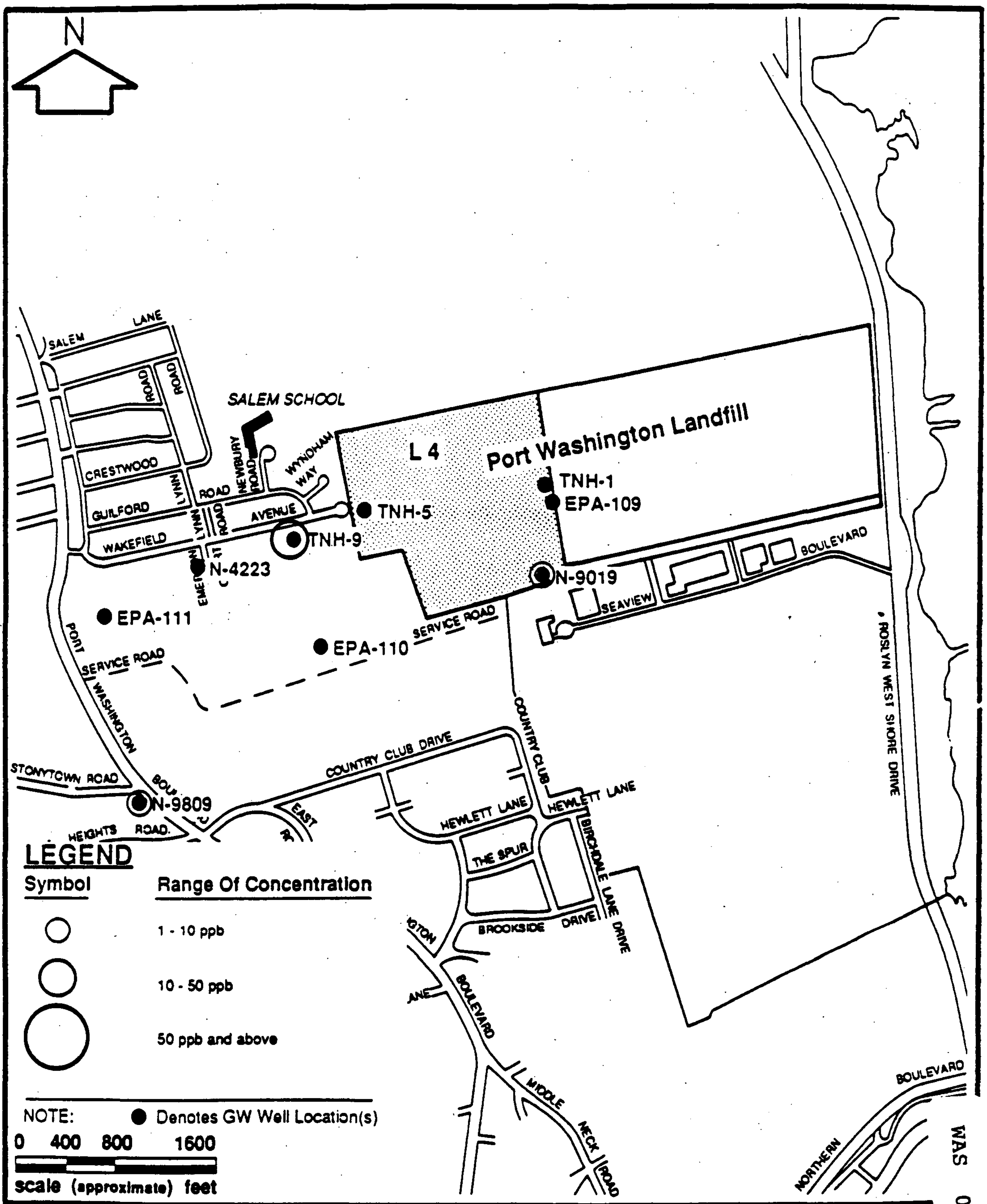

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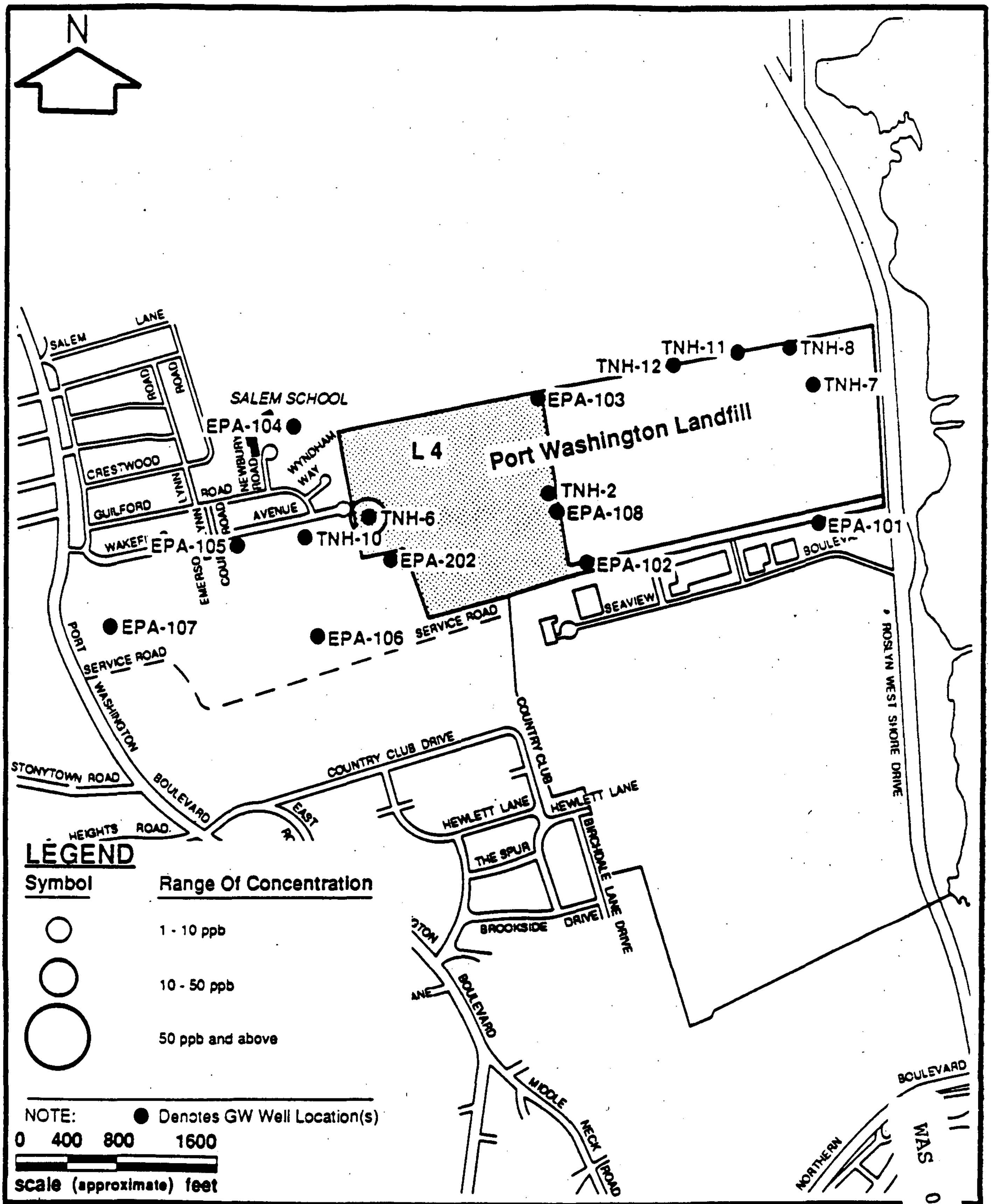

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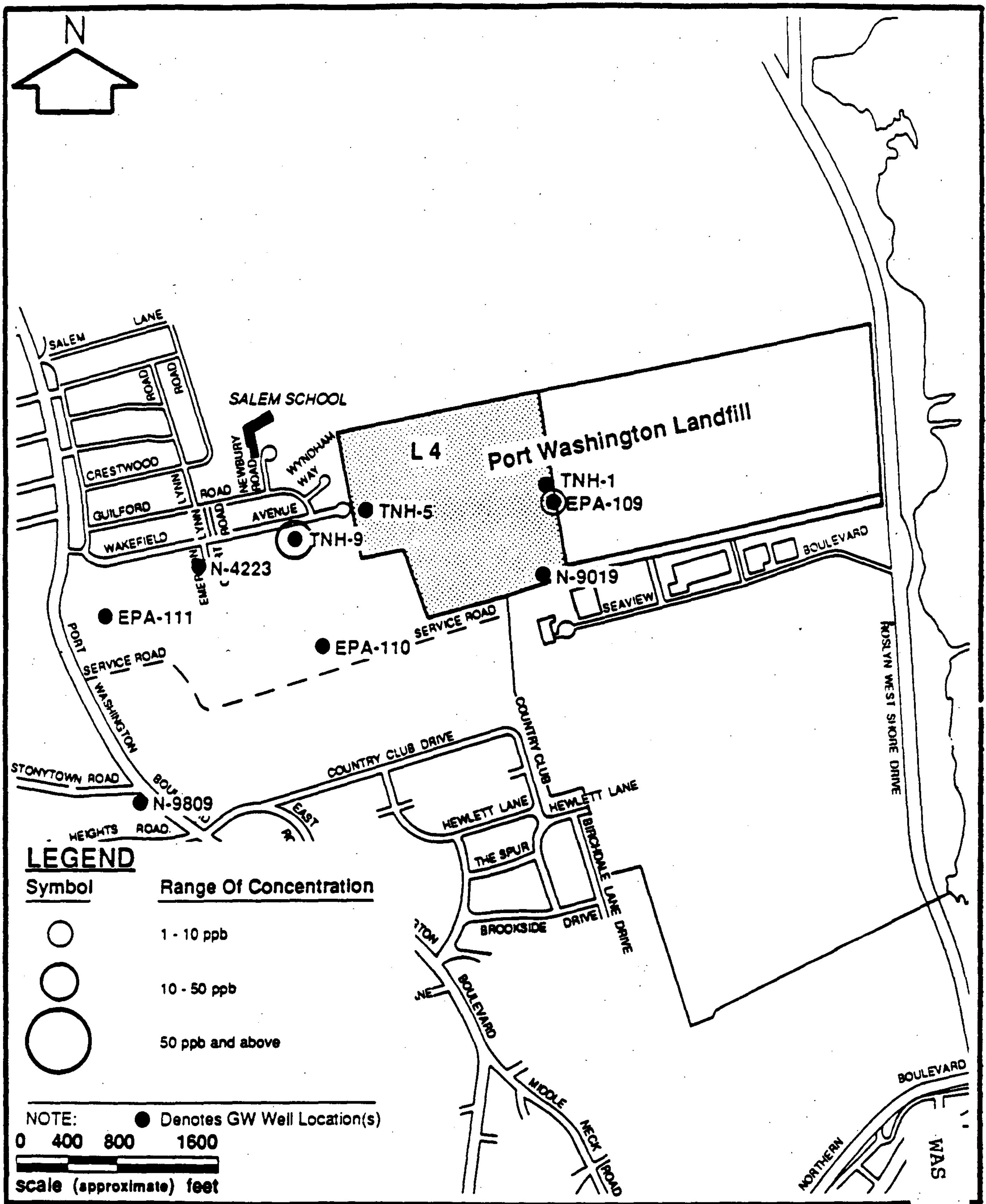

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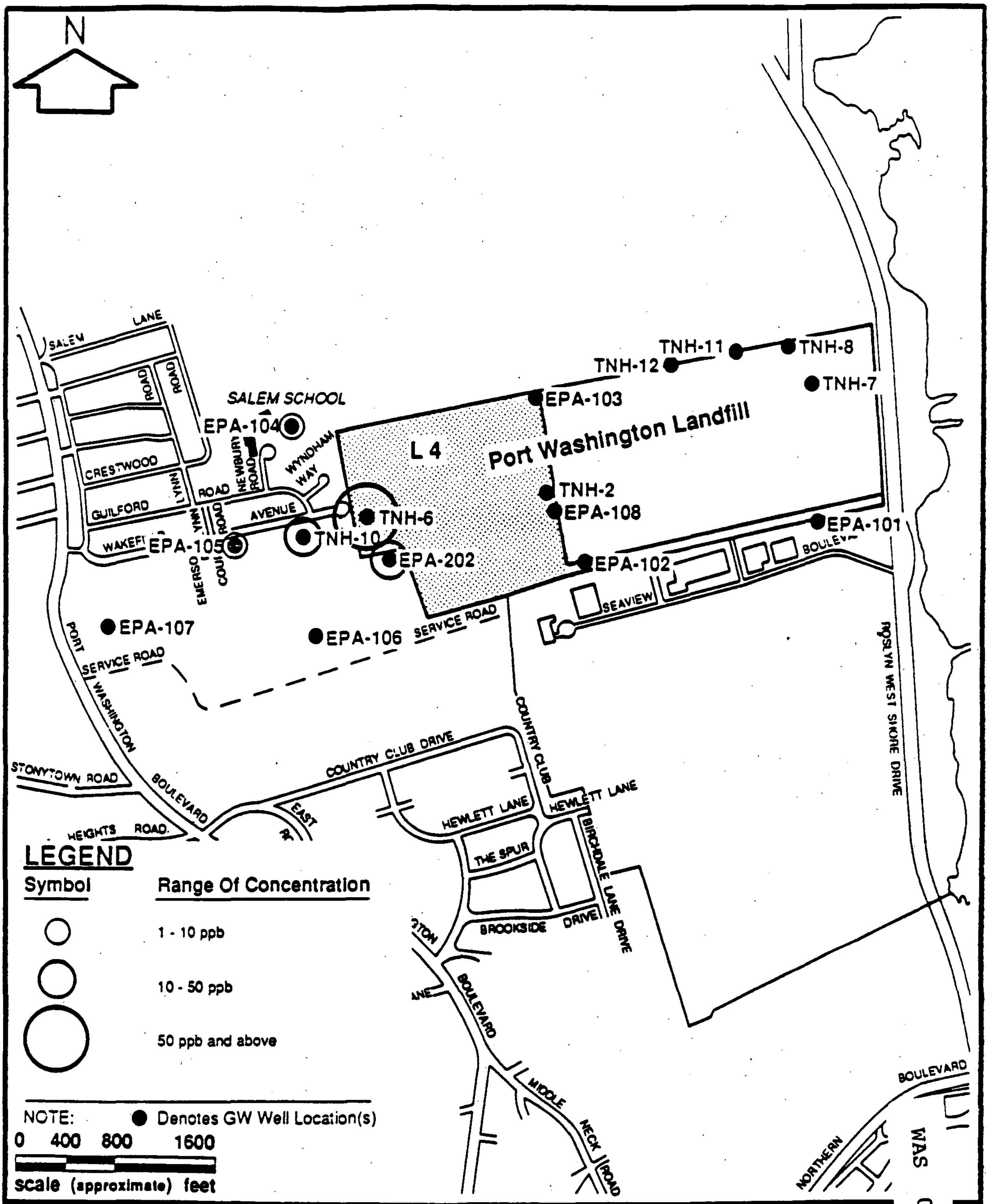

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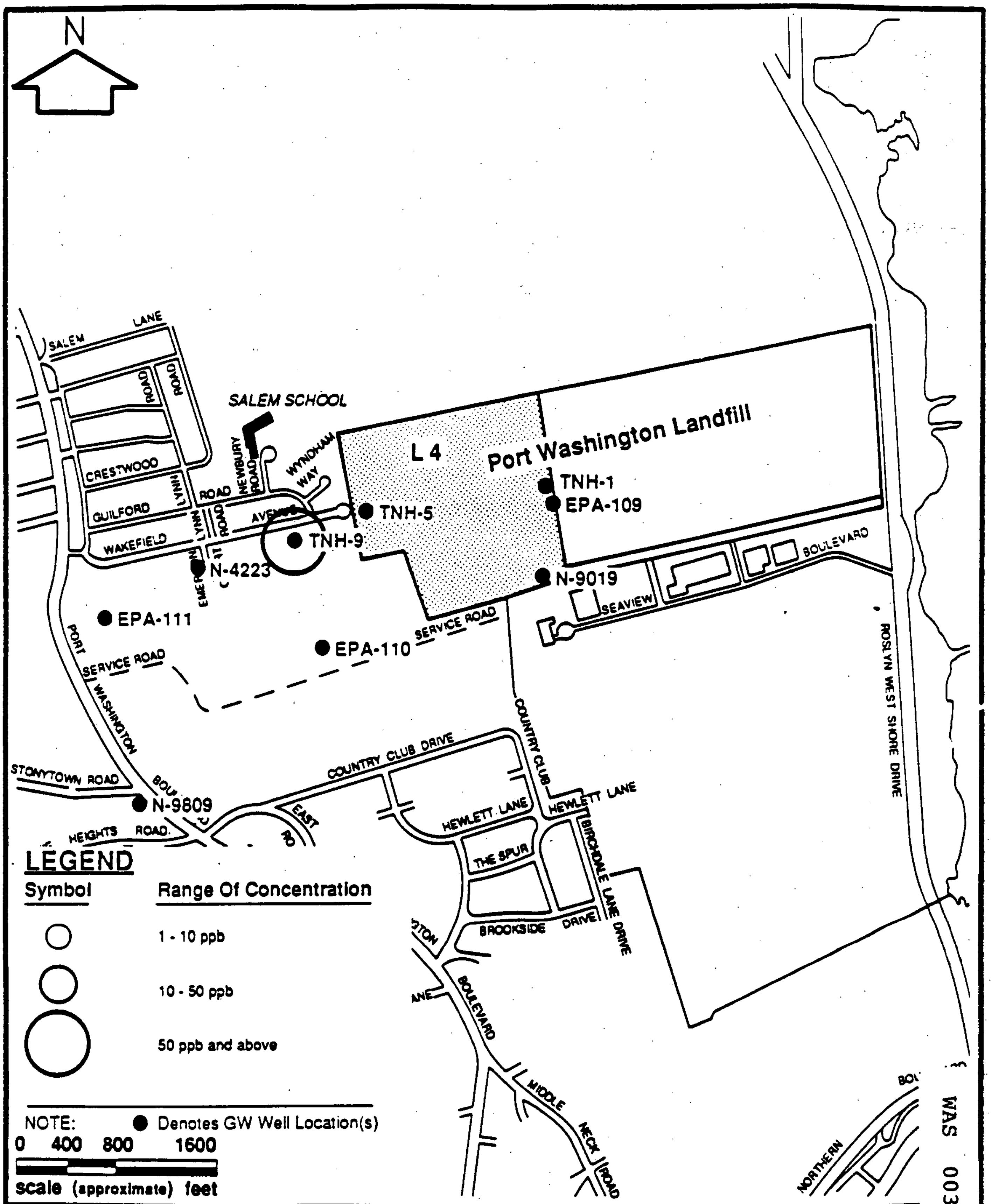

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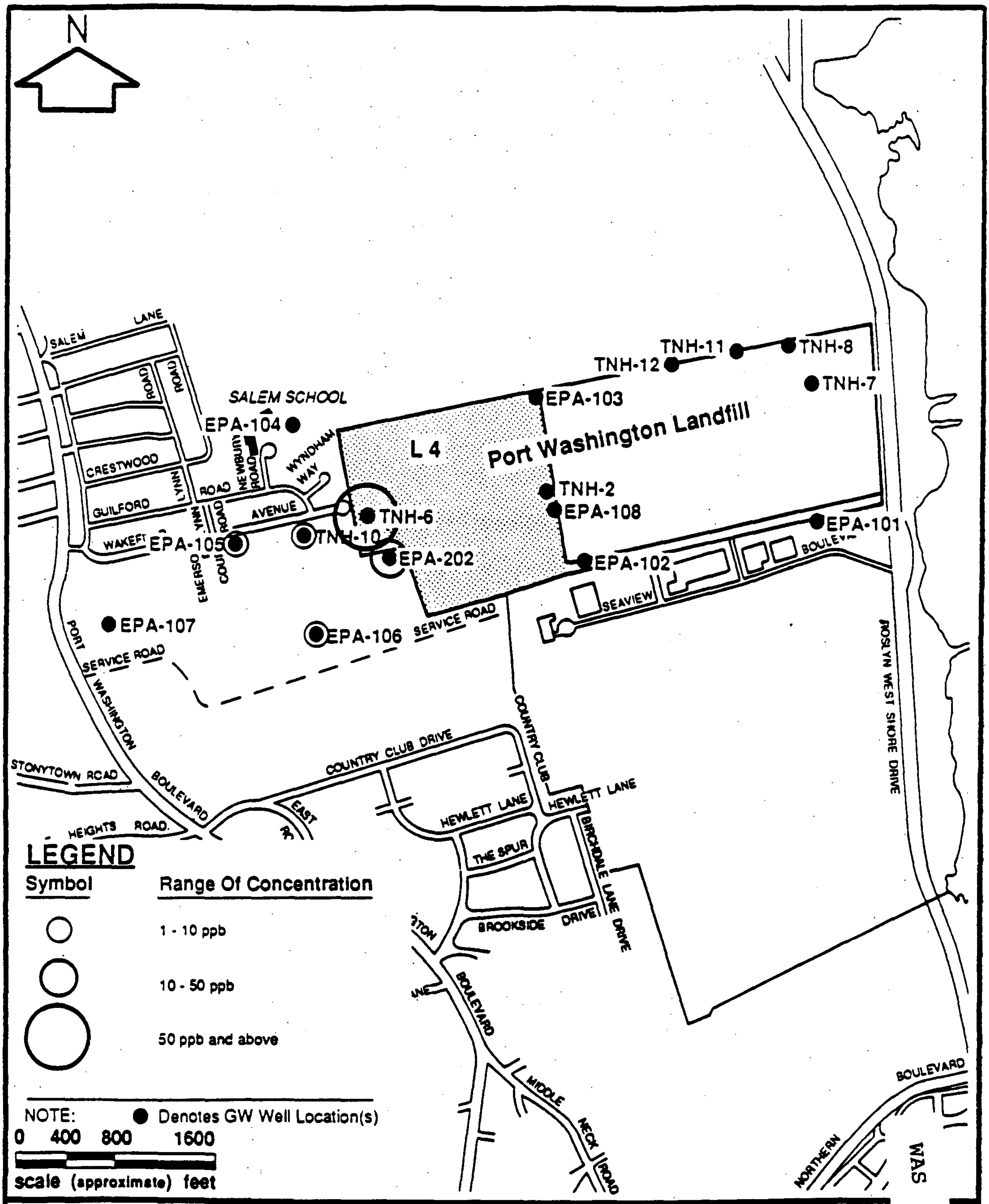

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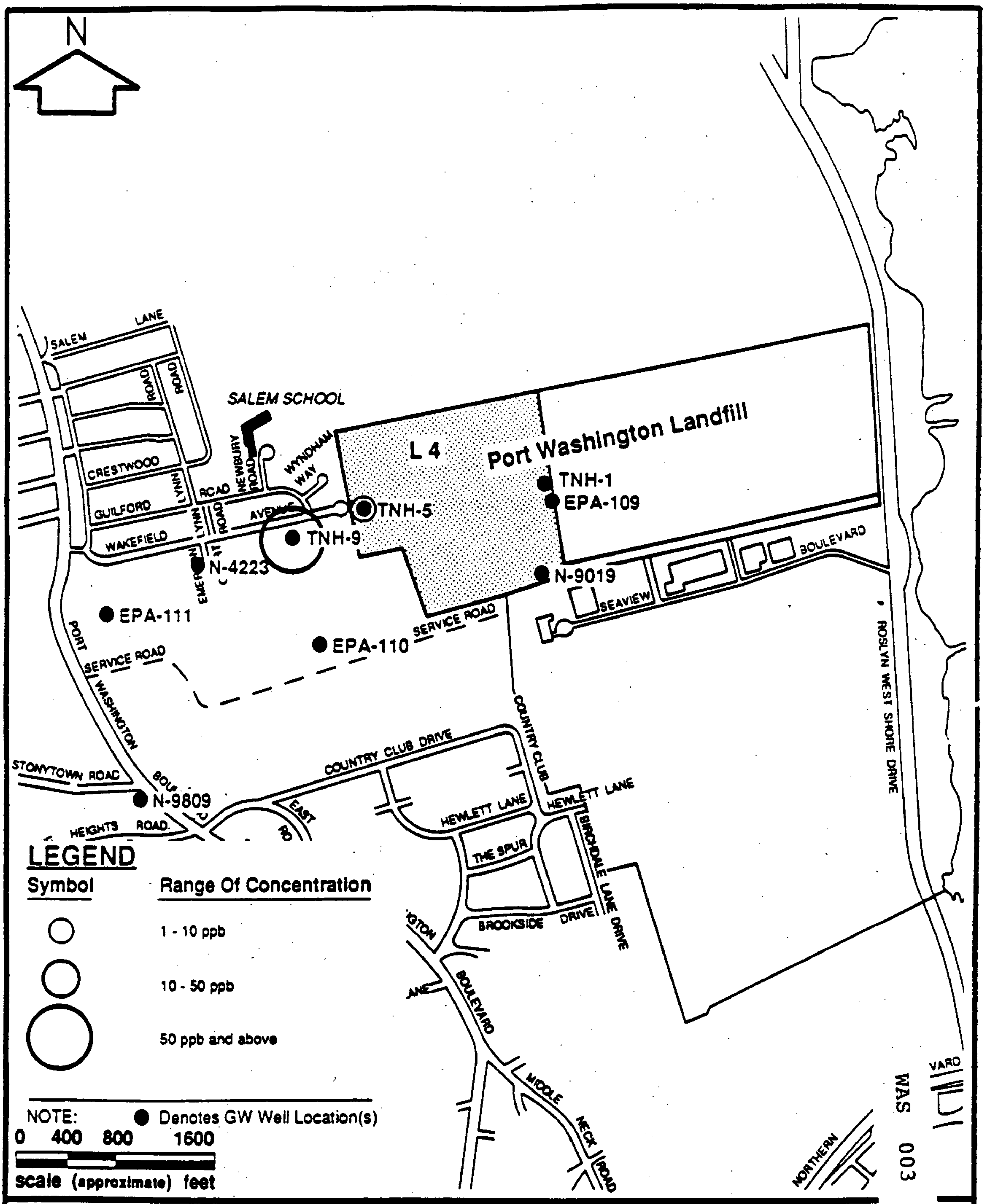

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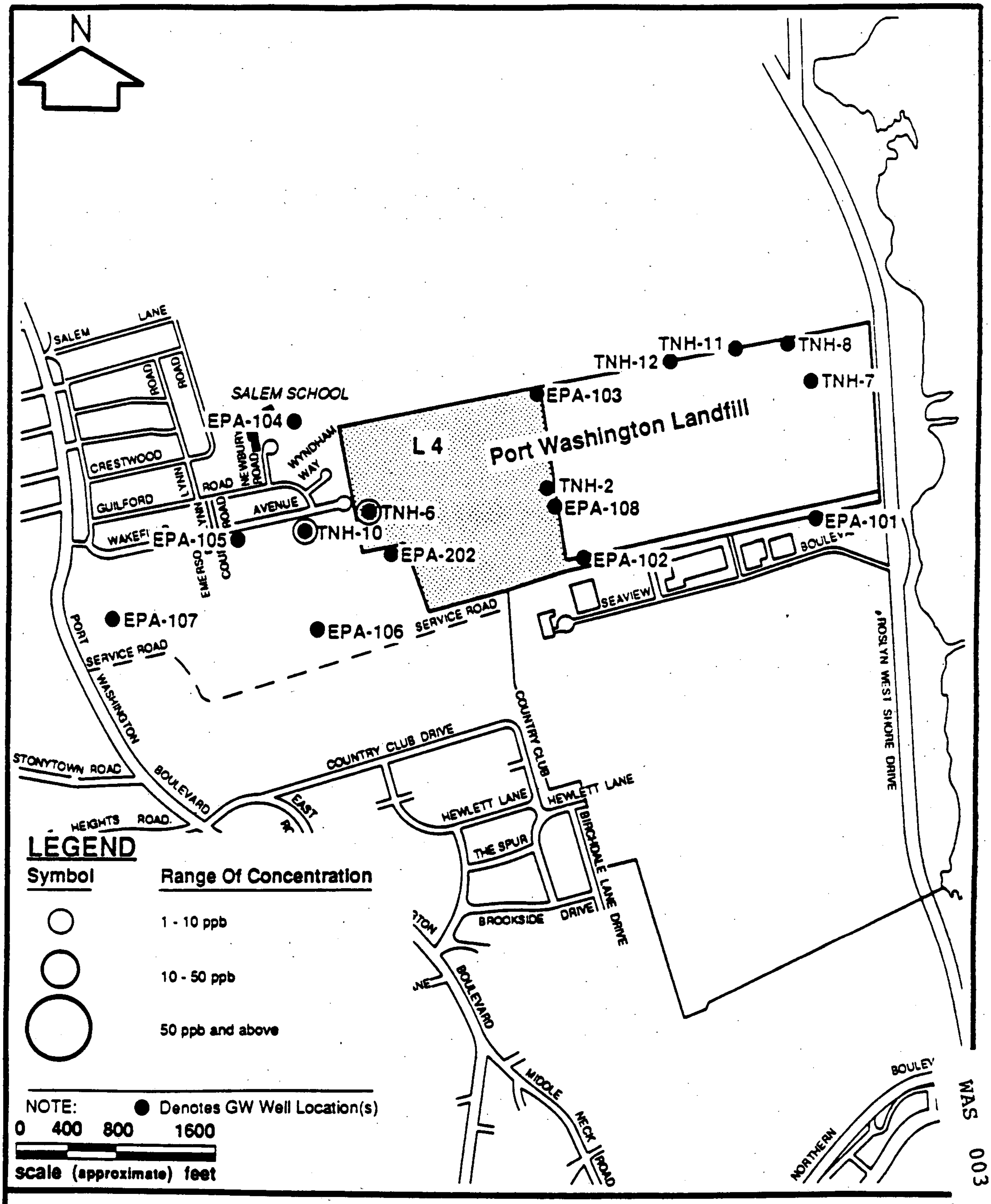

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1,1 Dichloroethene
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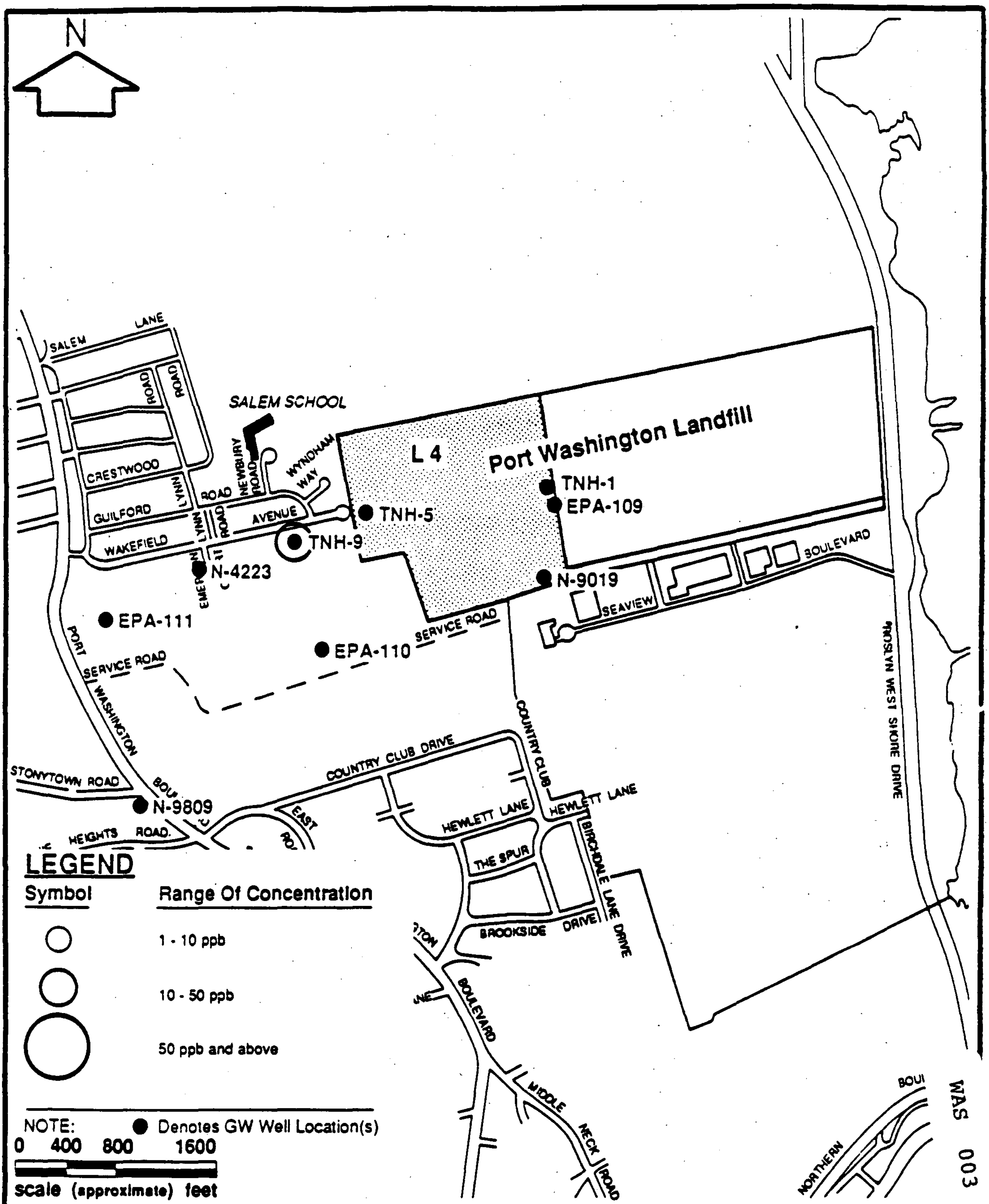

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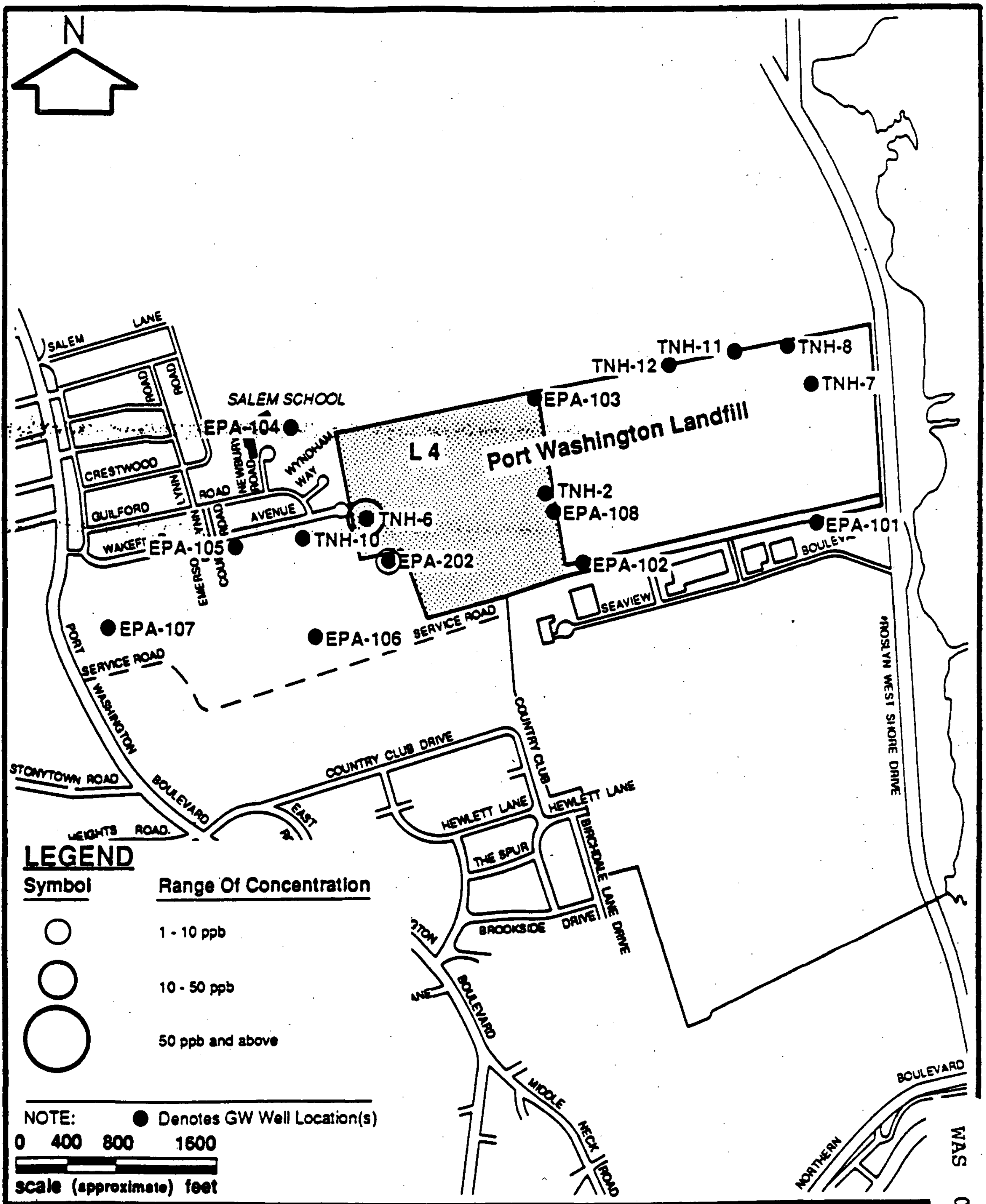

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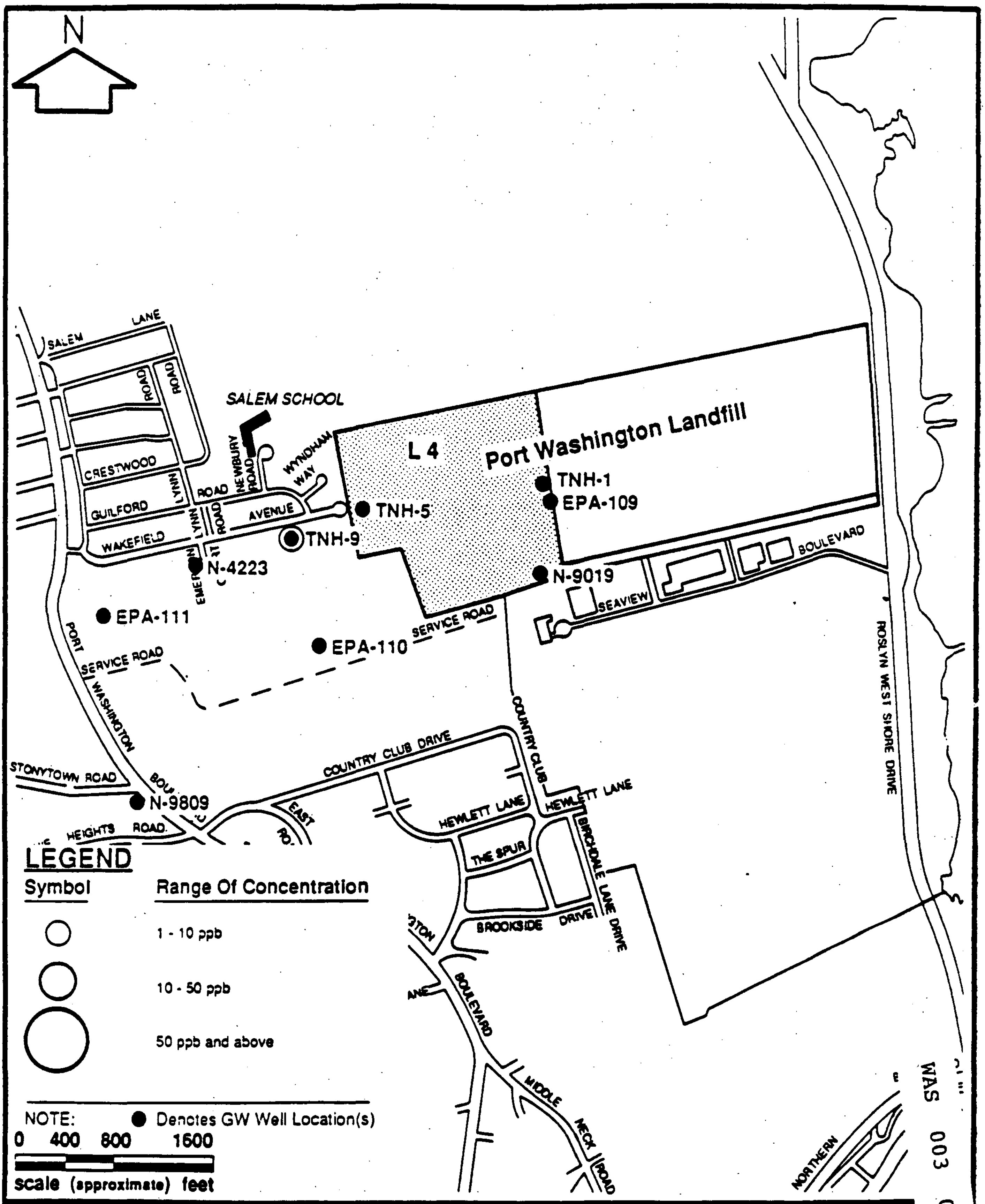

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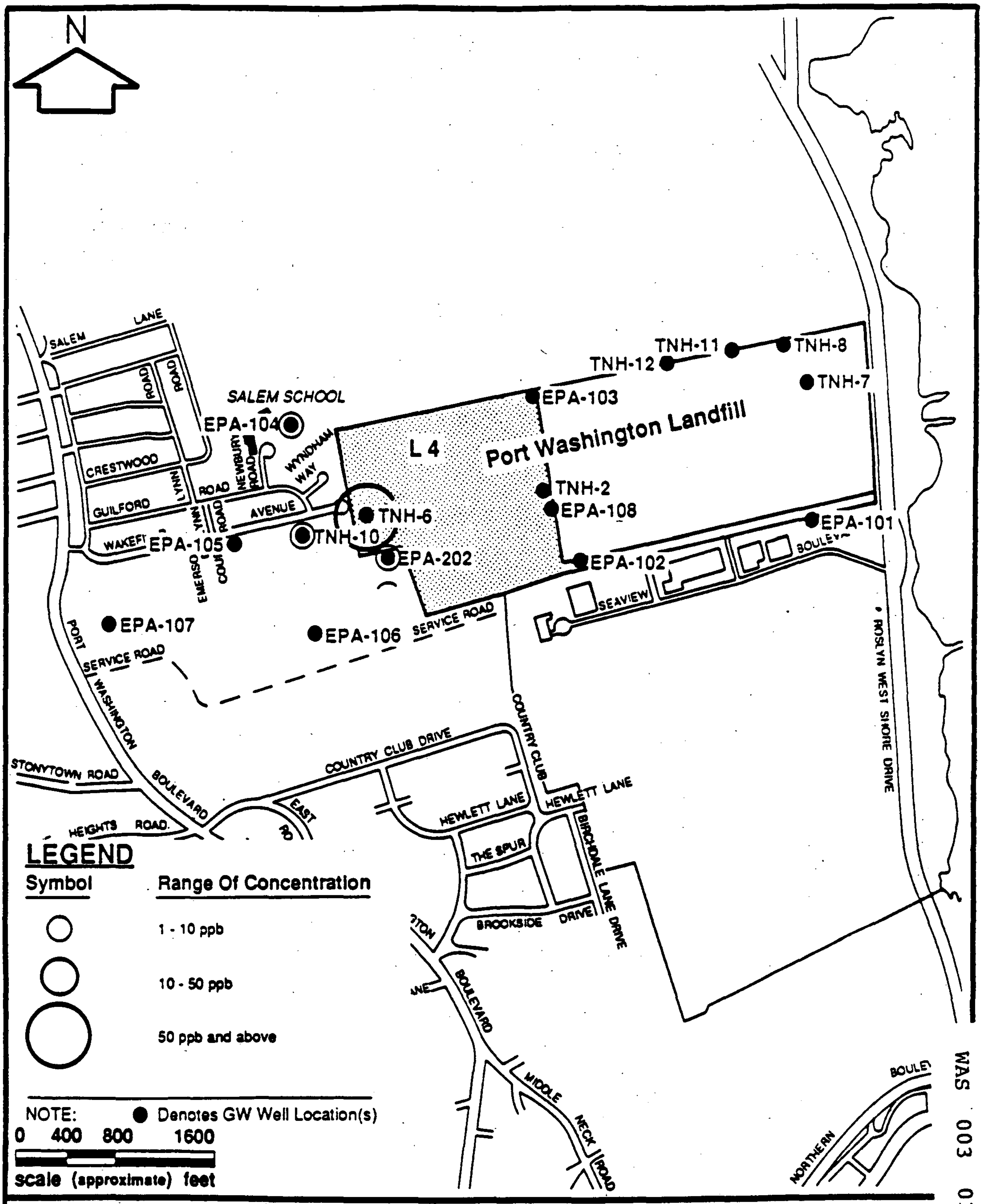

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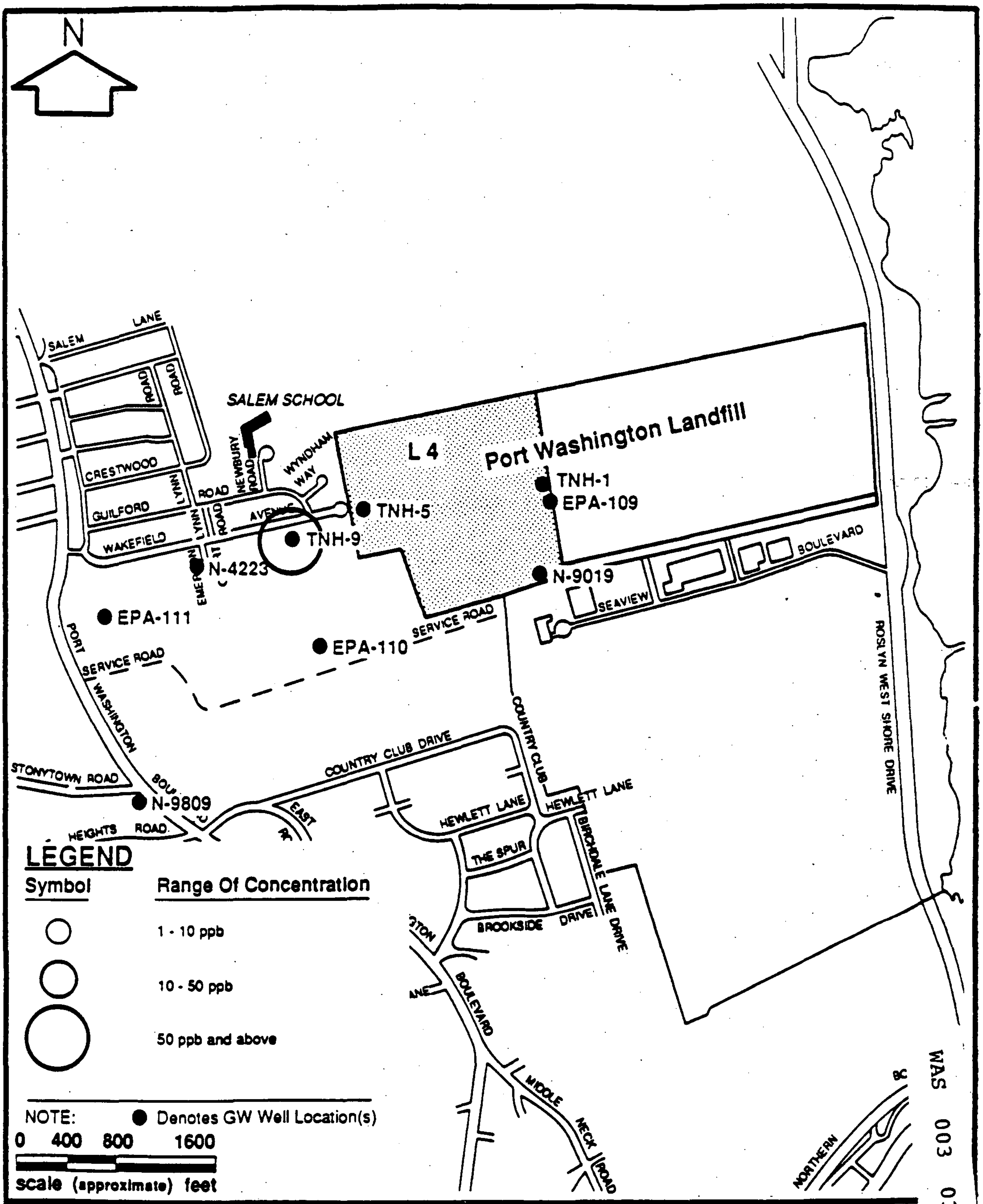

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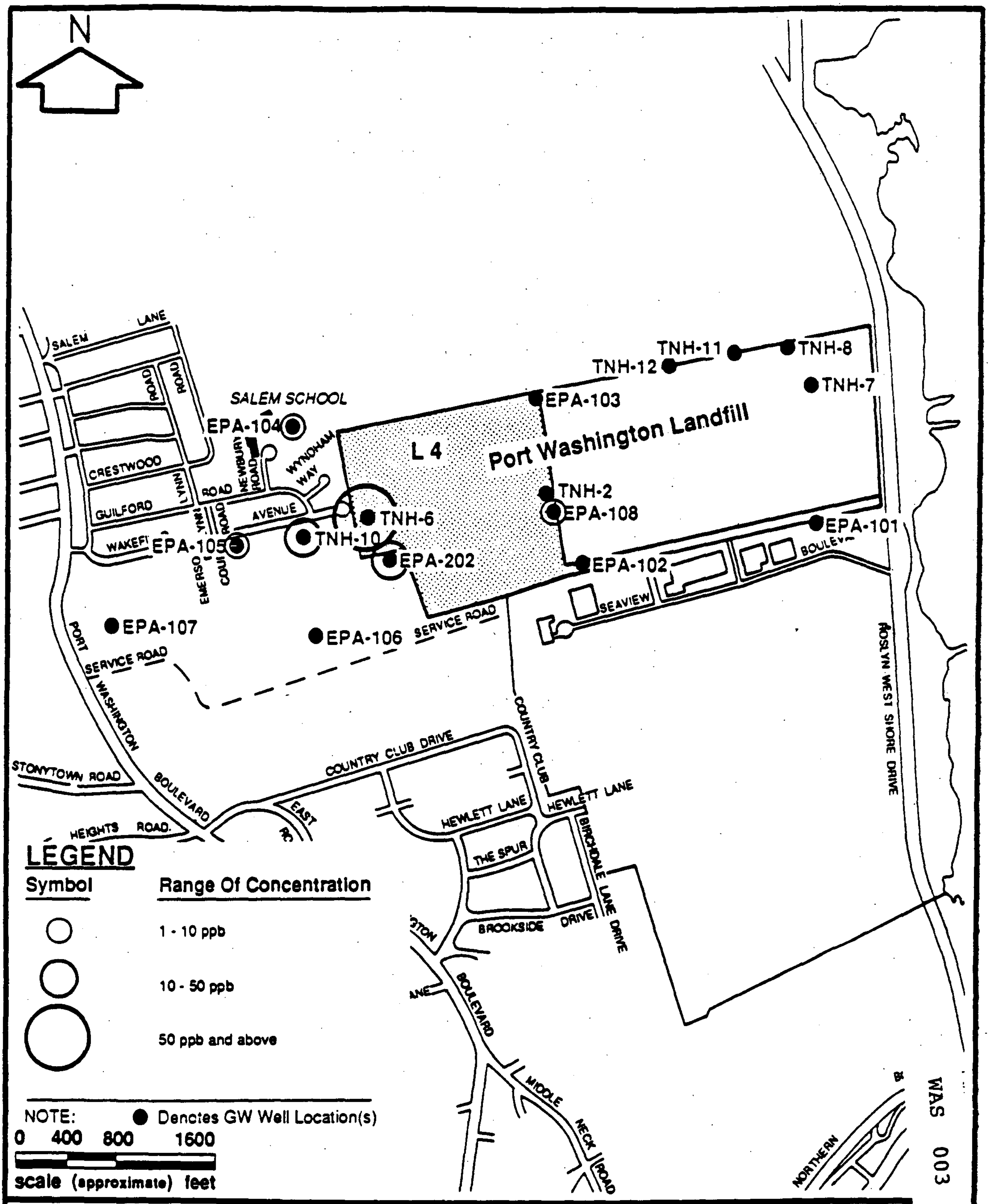

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Tetrachloroethe
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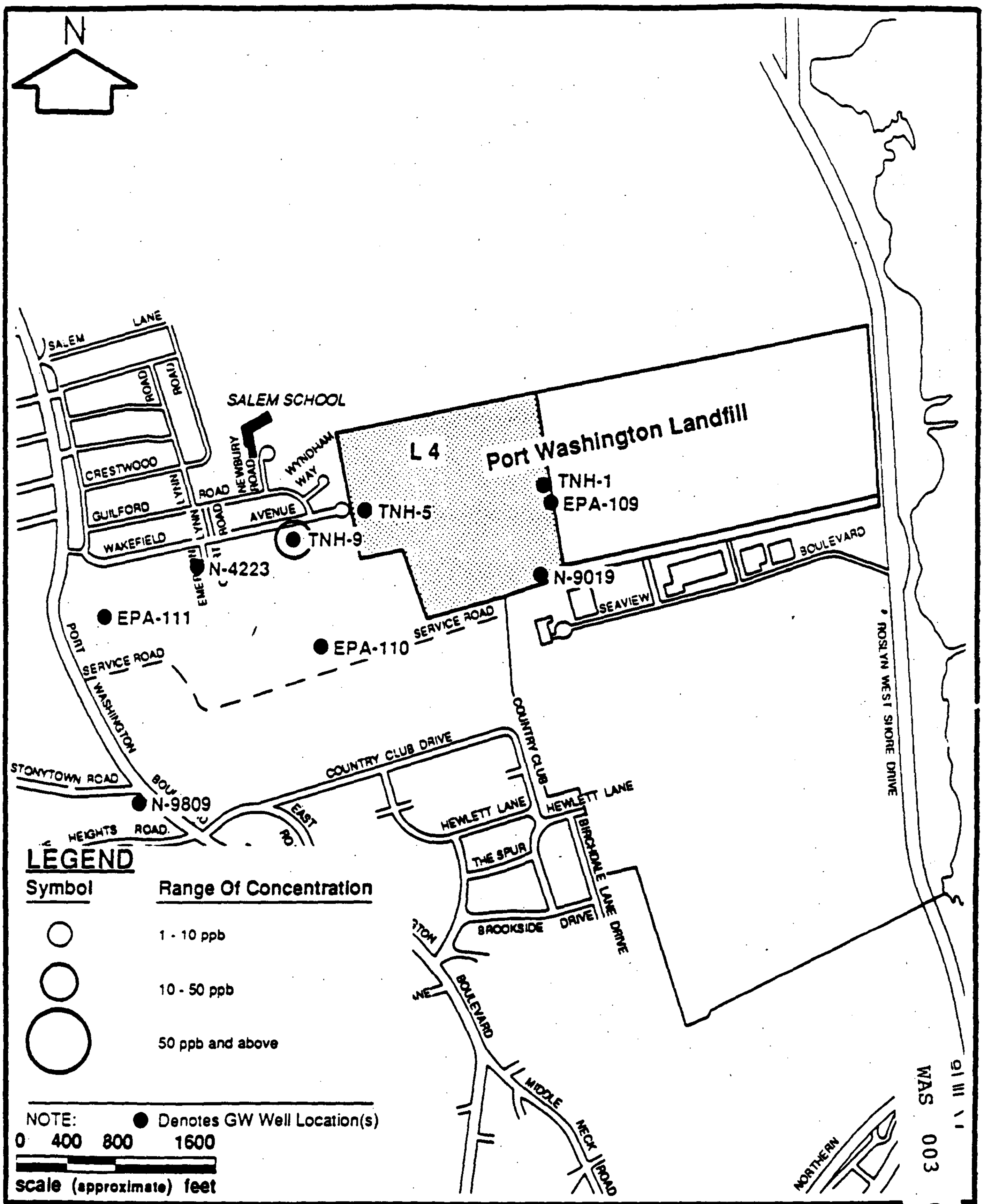

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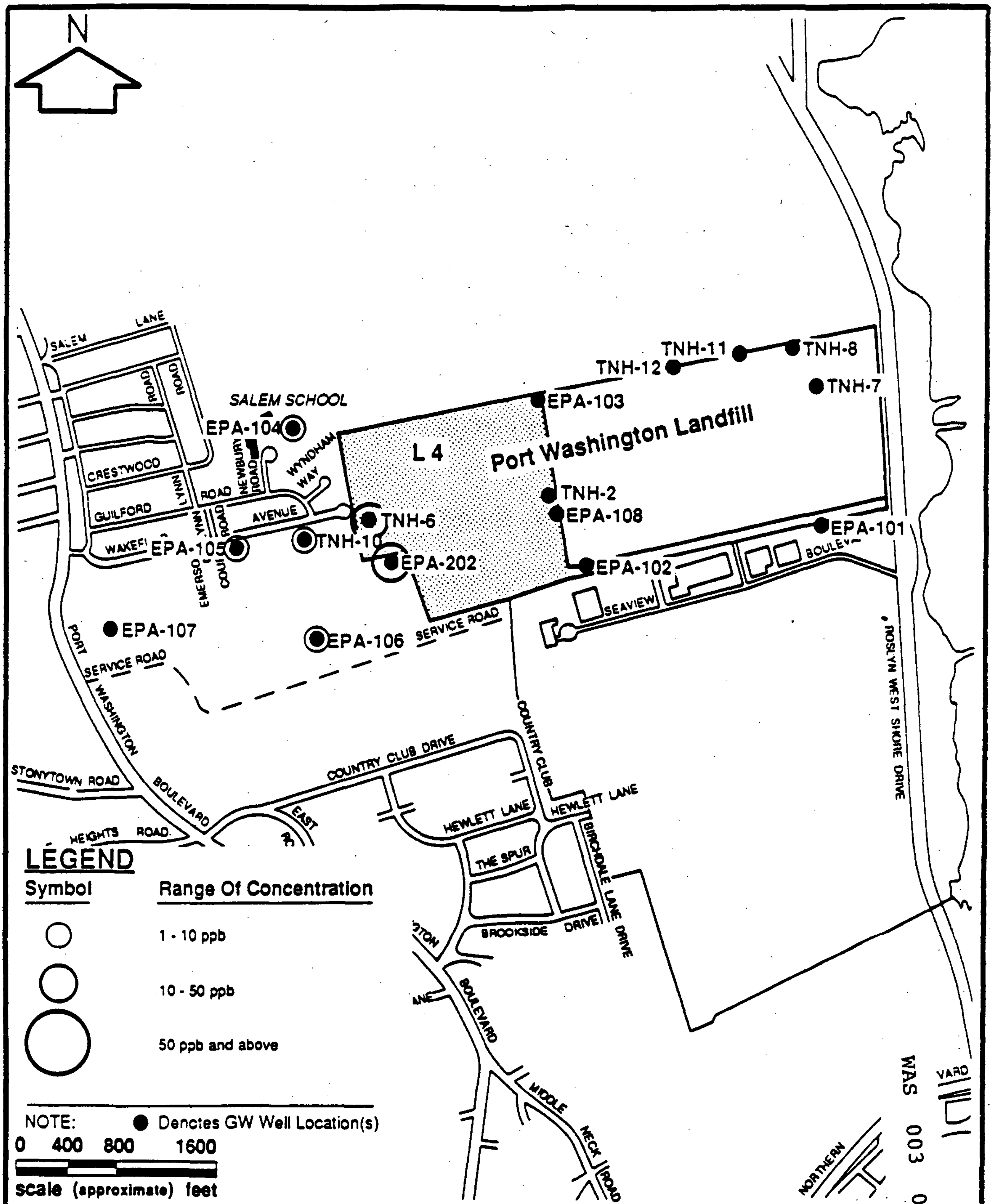
Port Washington Landfill, Port Washington, New York



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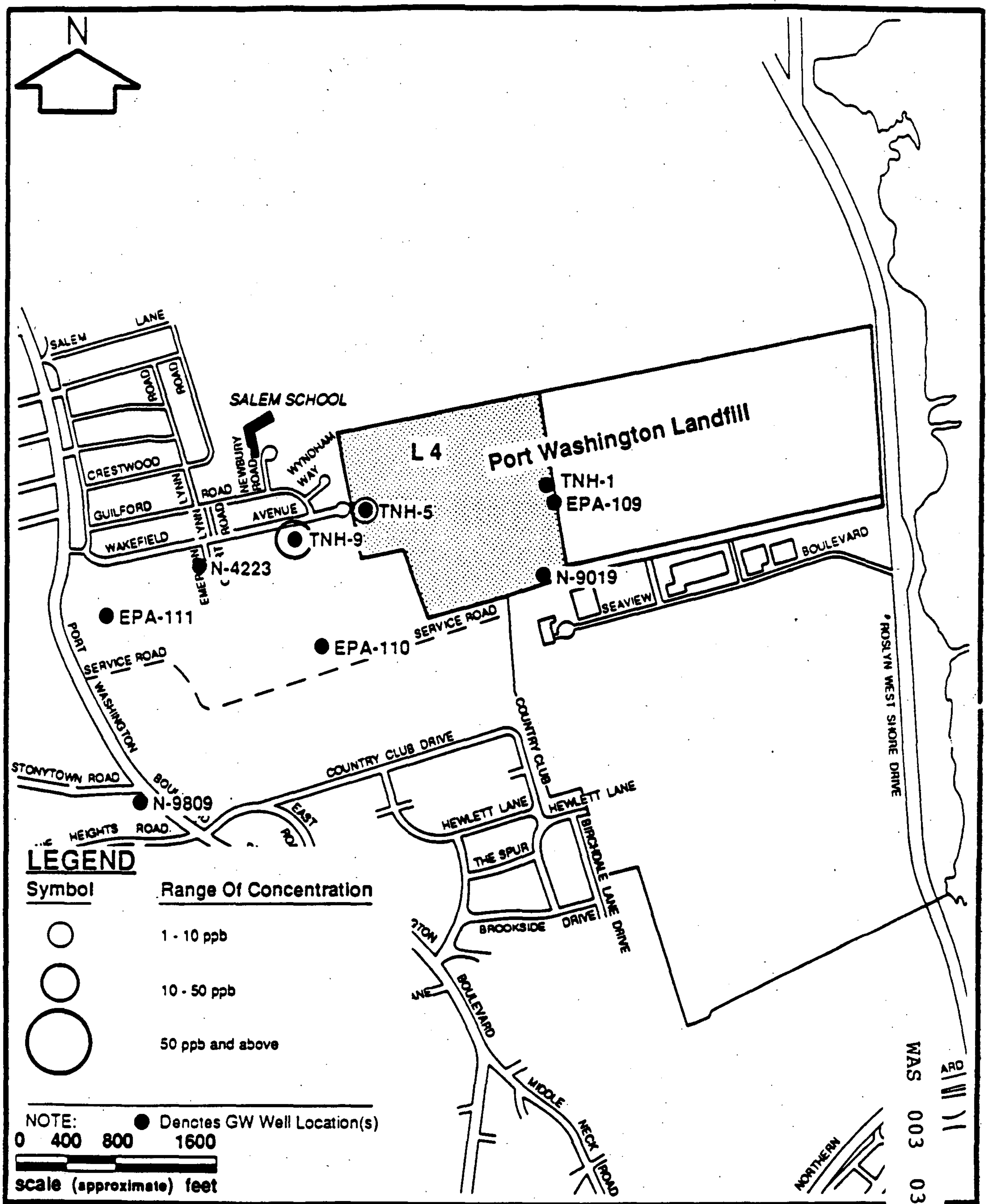

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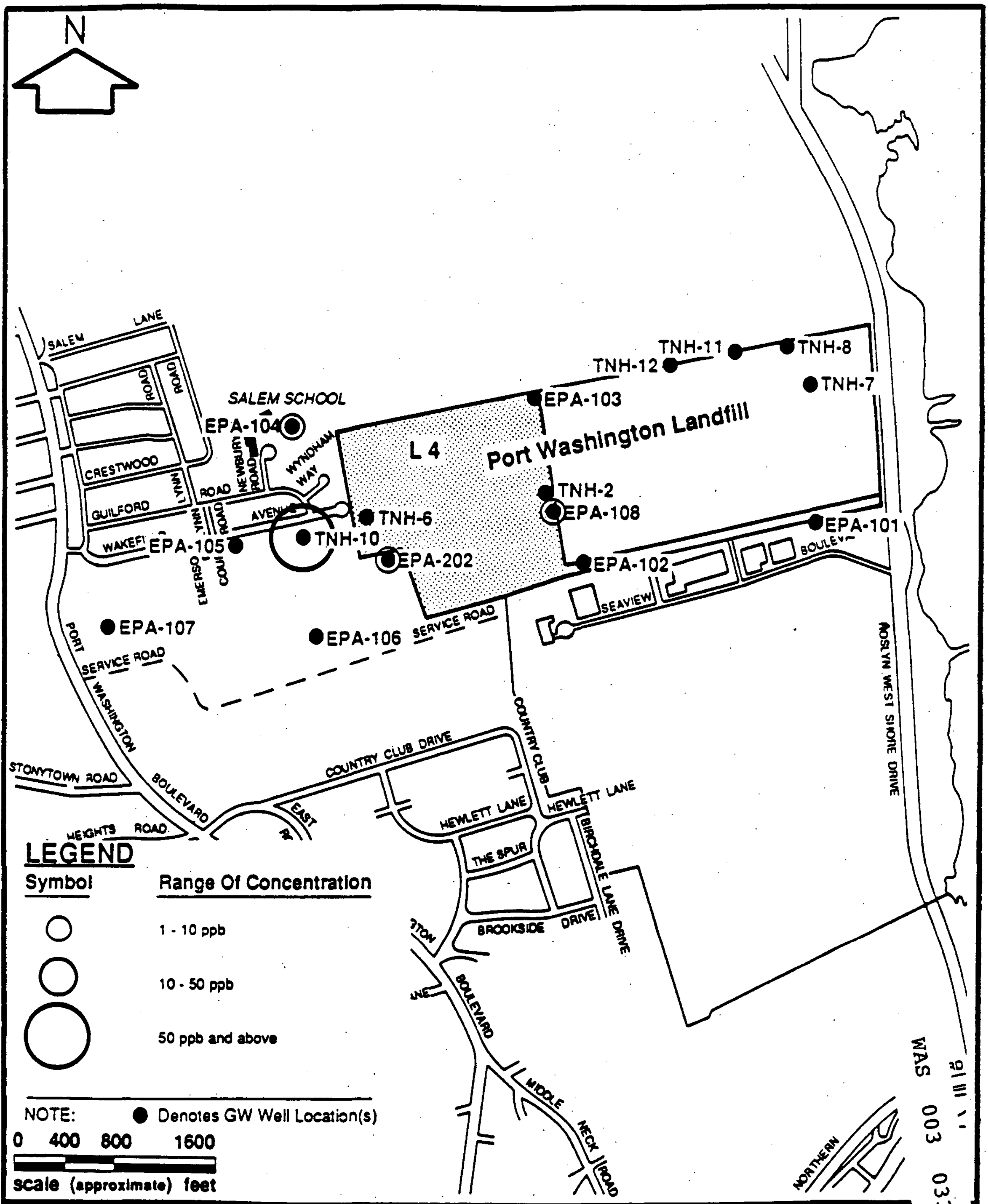

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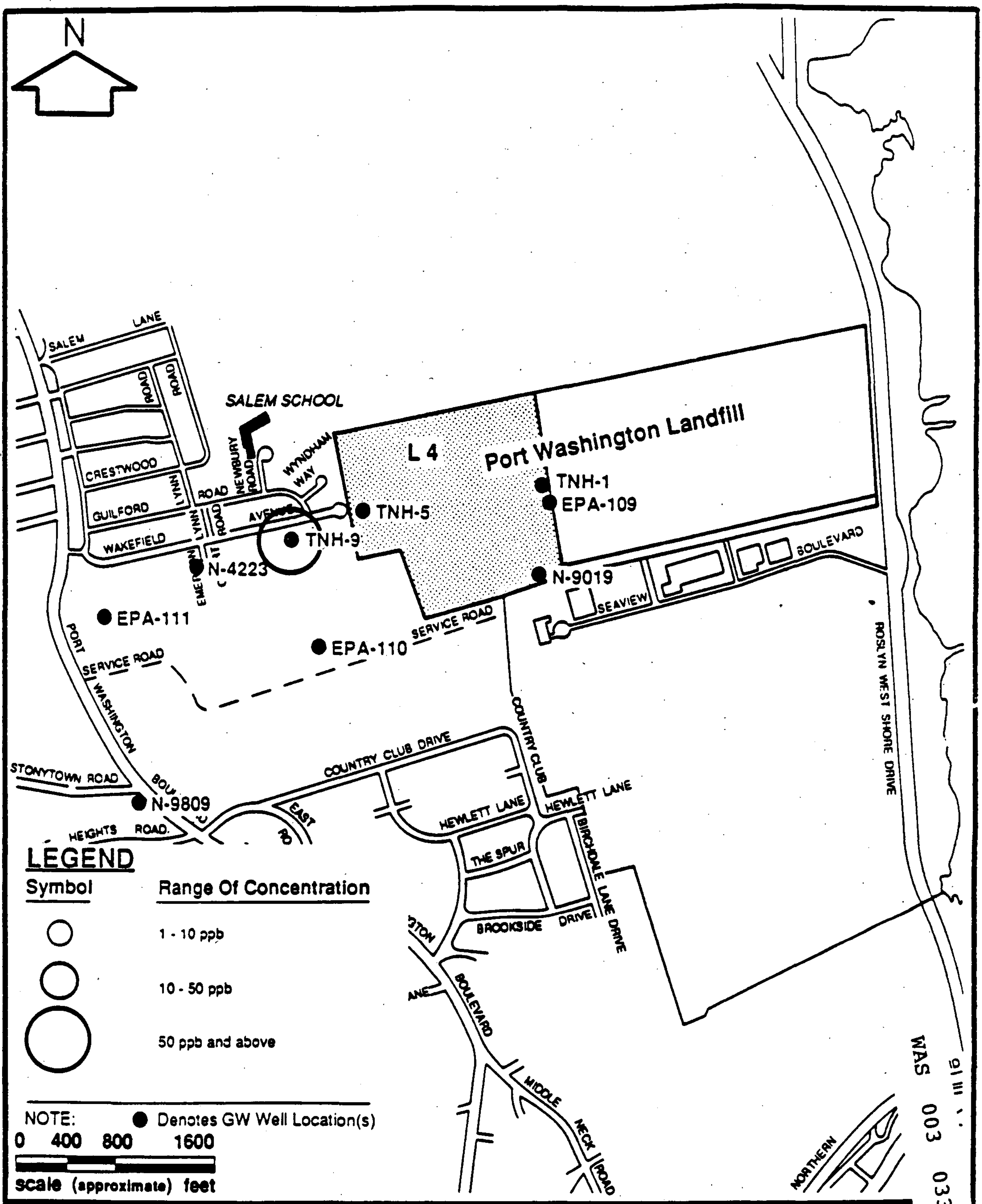
Fall 1987 - Shallow W
1,2 Dichloroethene (Total)
Port Washington Landfill, Port Washington, New York



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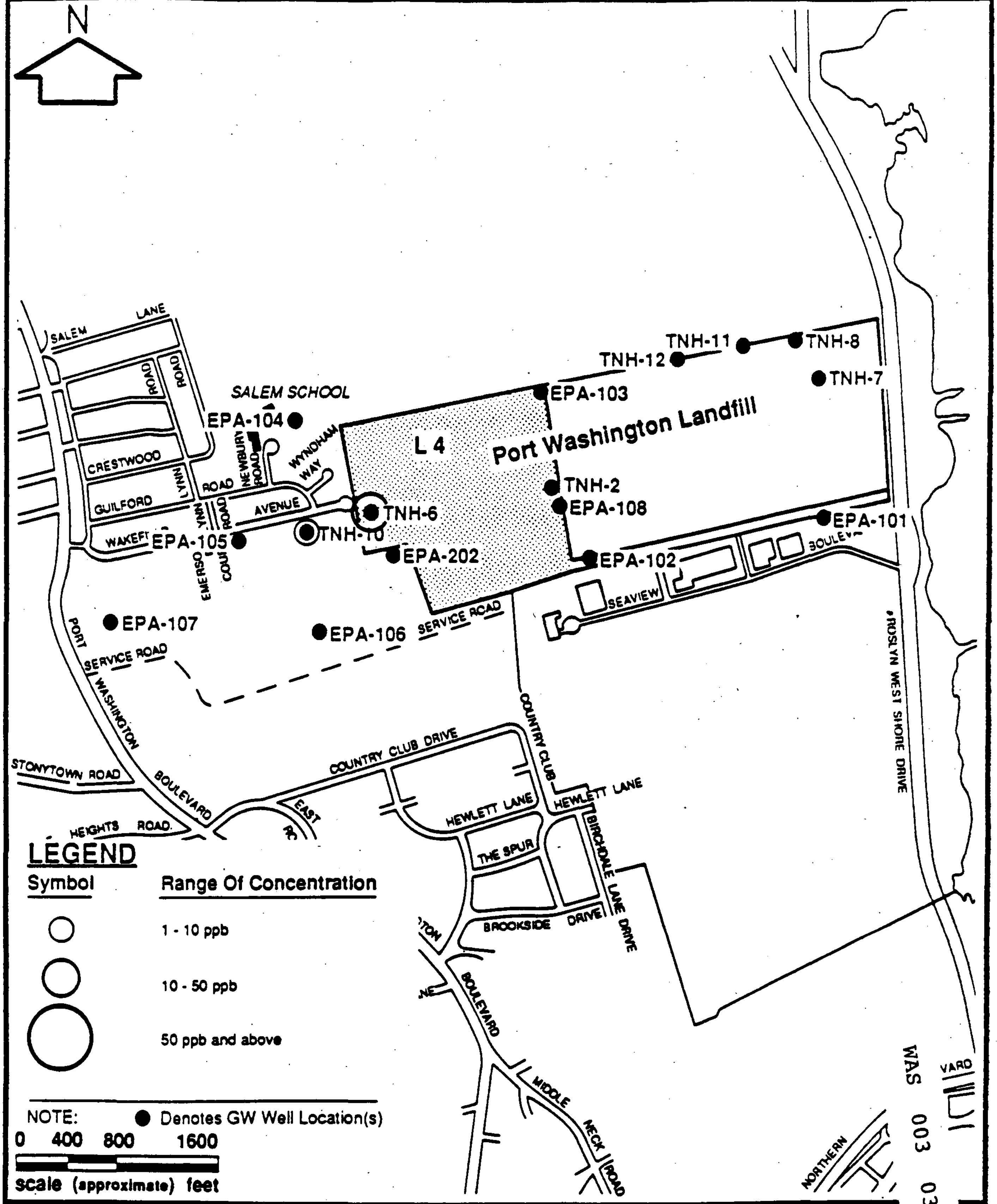

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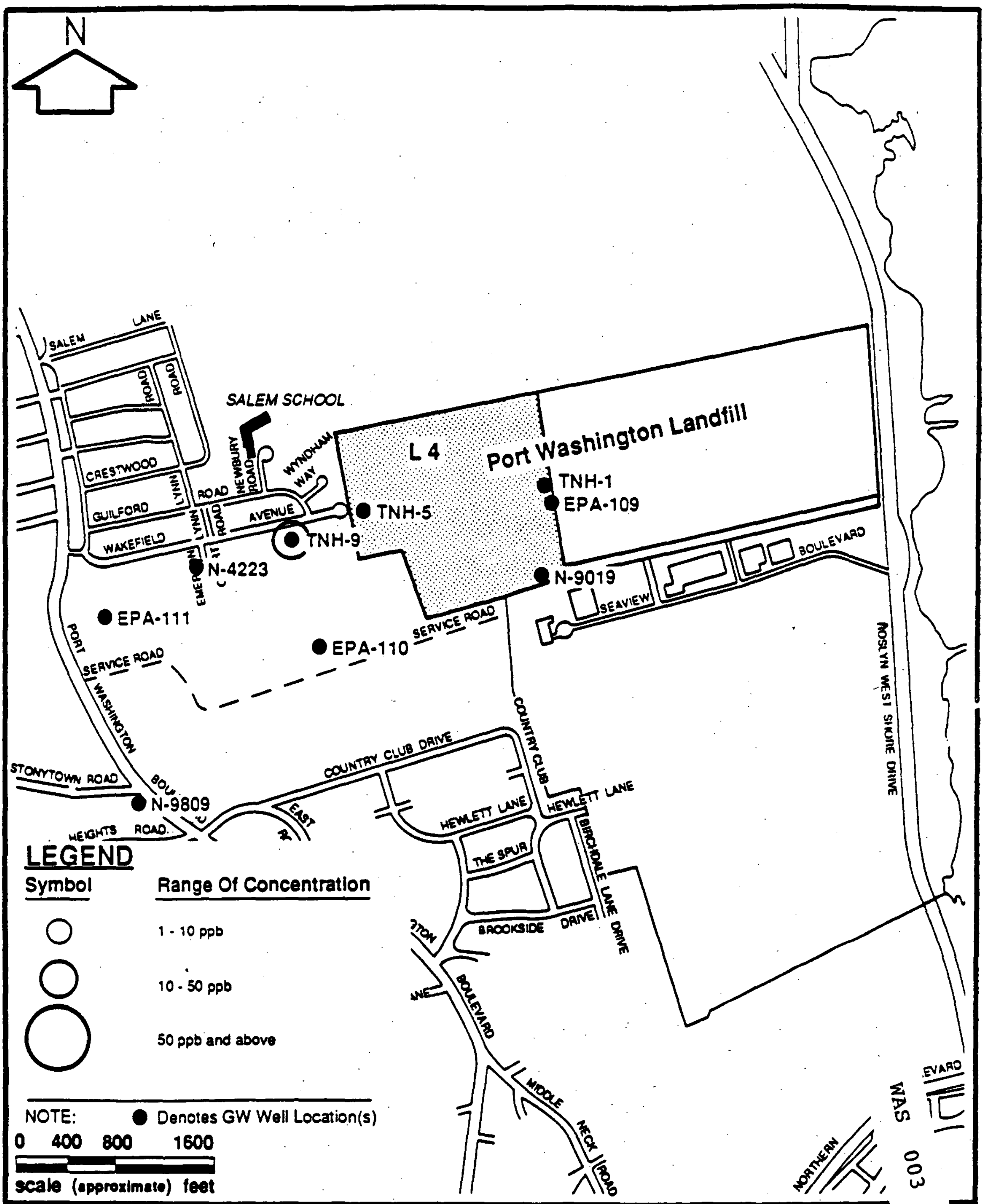
Fall 1987 - Shallow
Vinyl Chloride
Port Washington Landfill, Port Washington, New York



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Fall 1987 - Deep \
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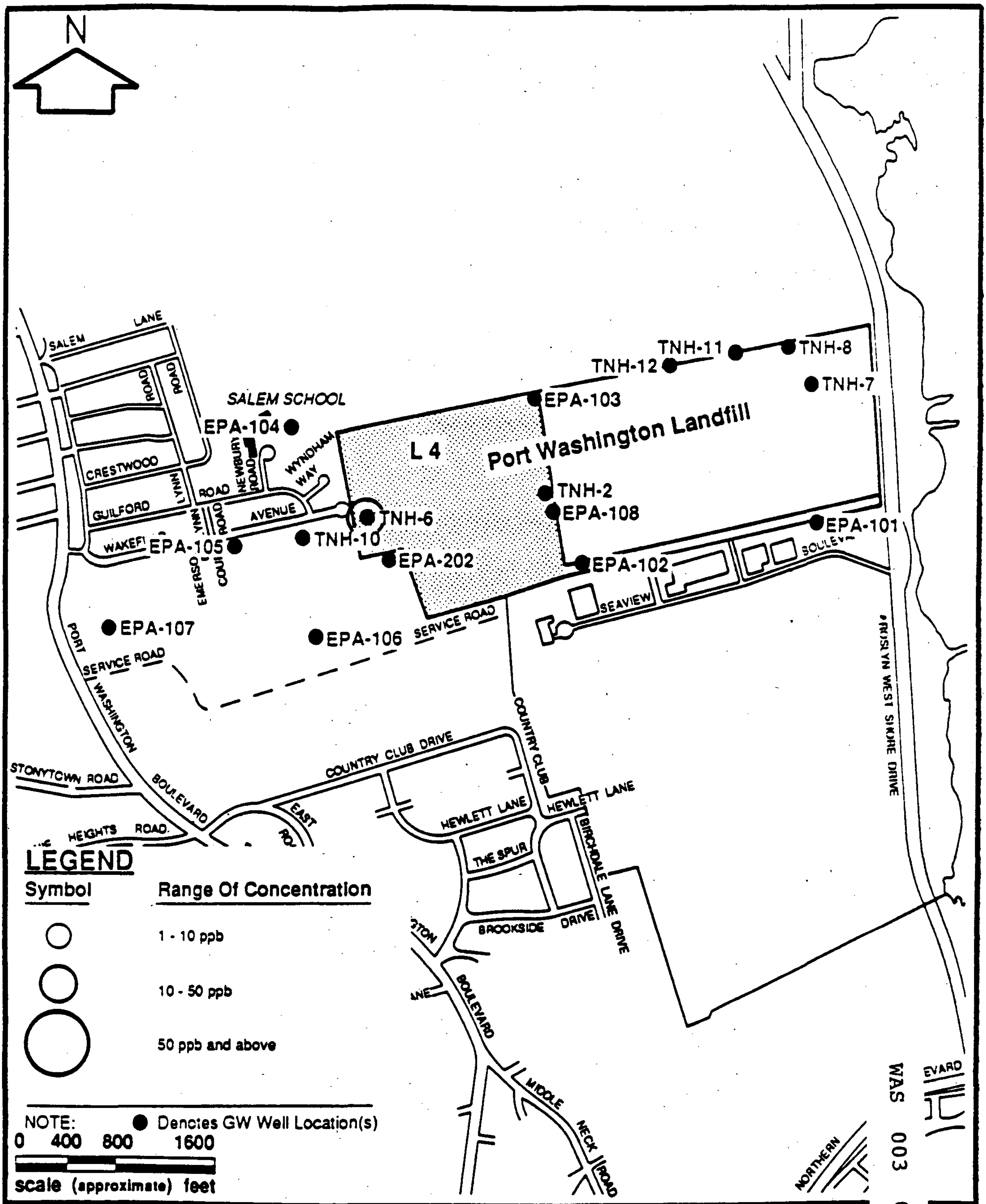
Port Washington Landfill, Port Washington, New



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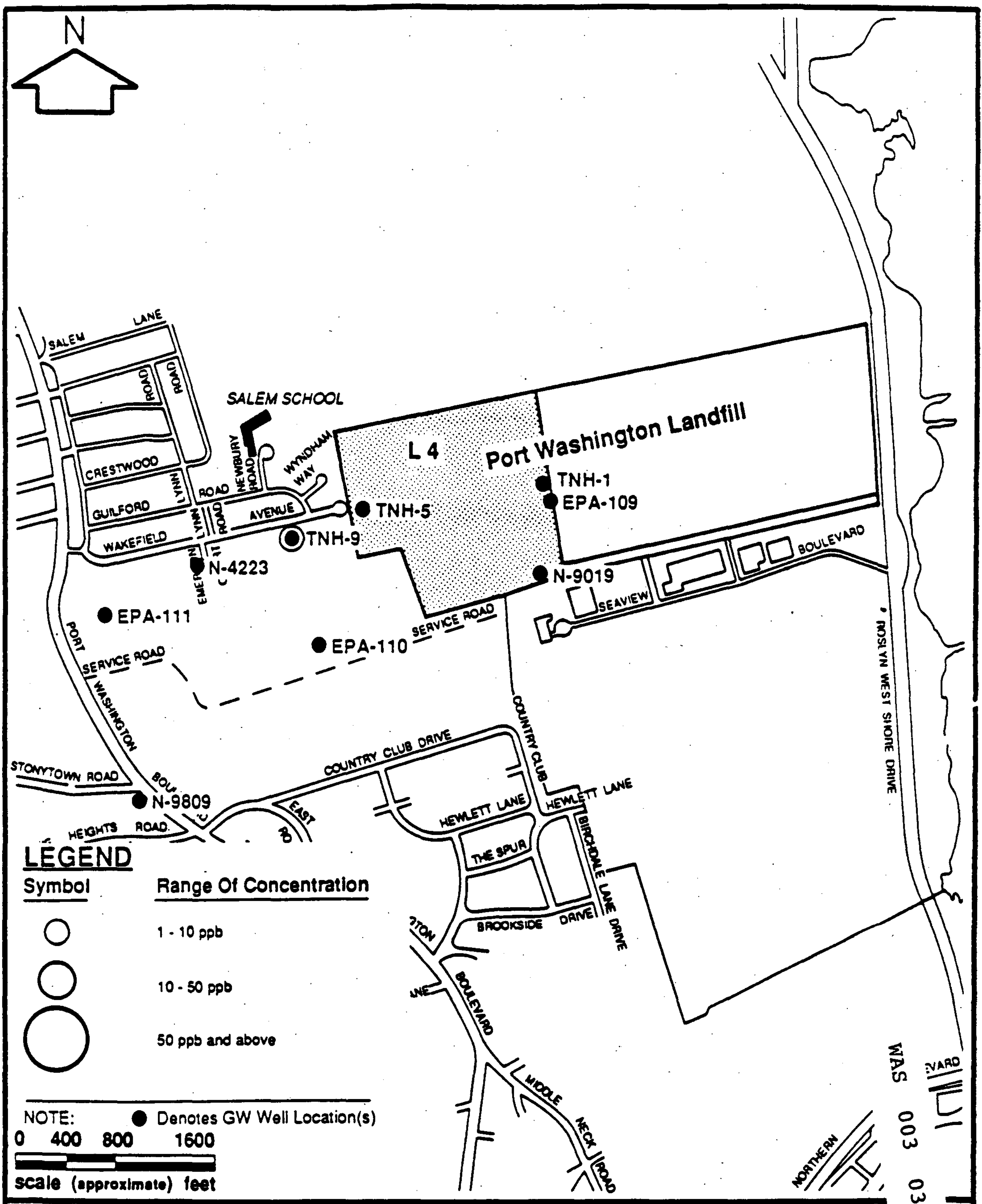

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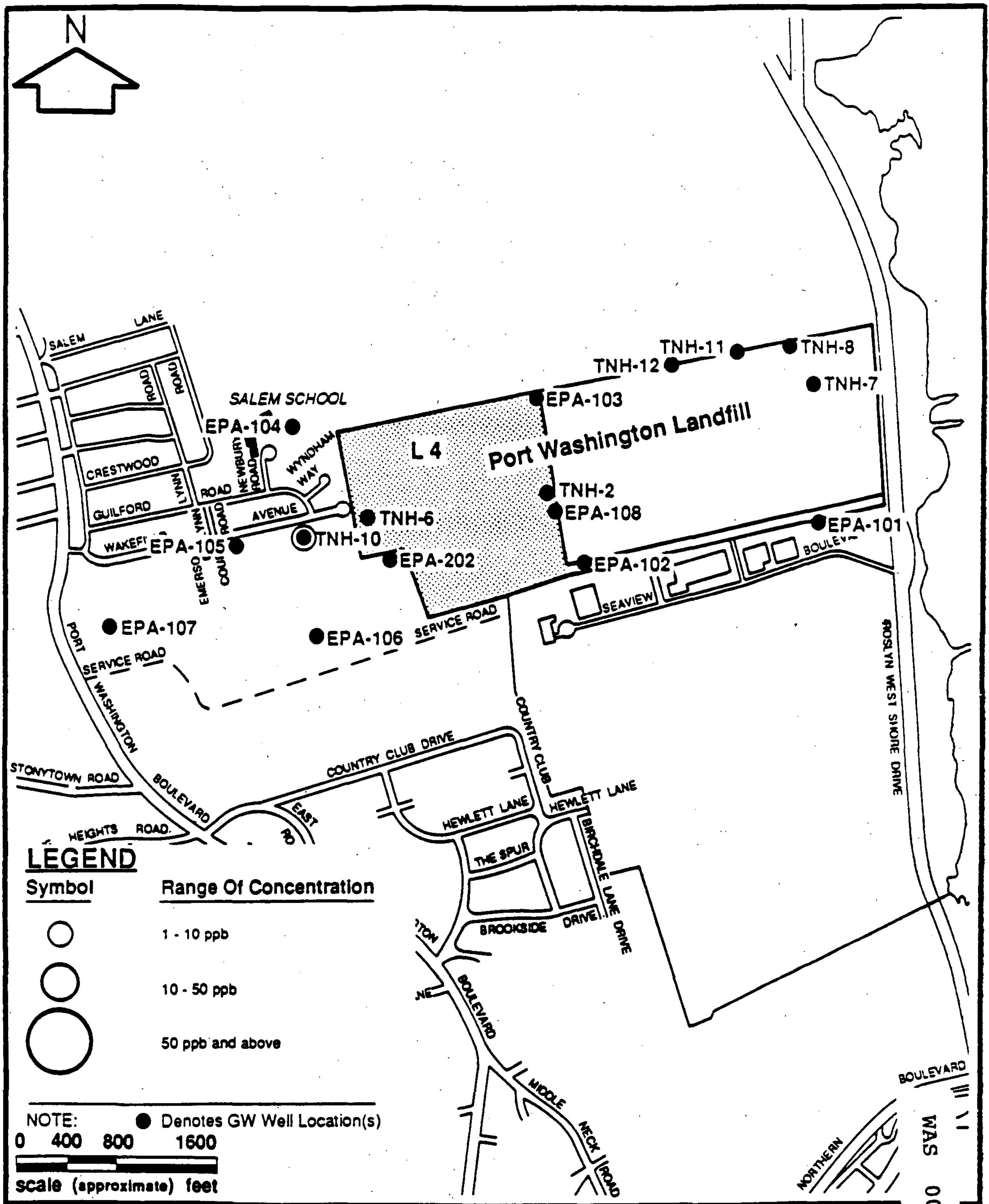

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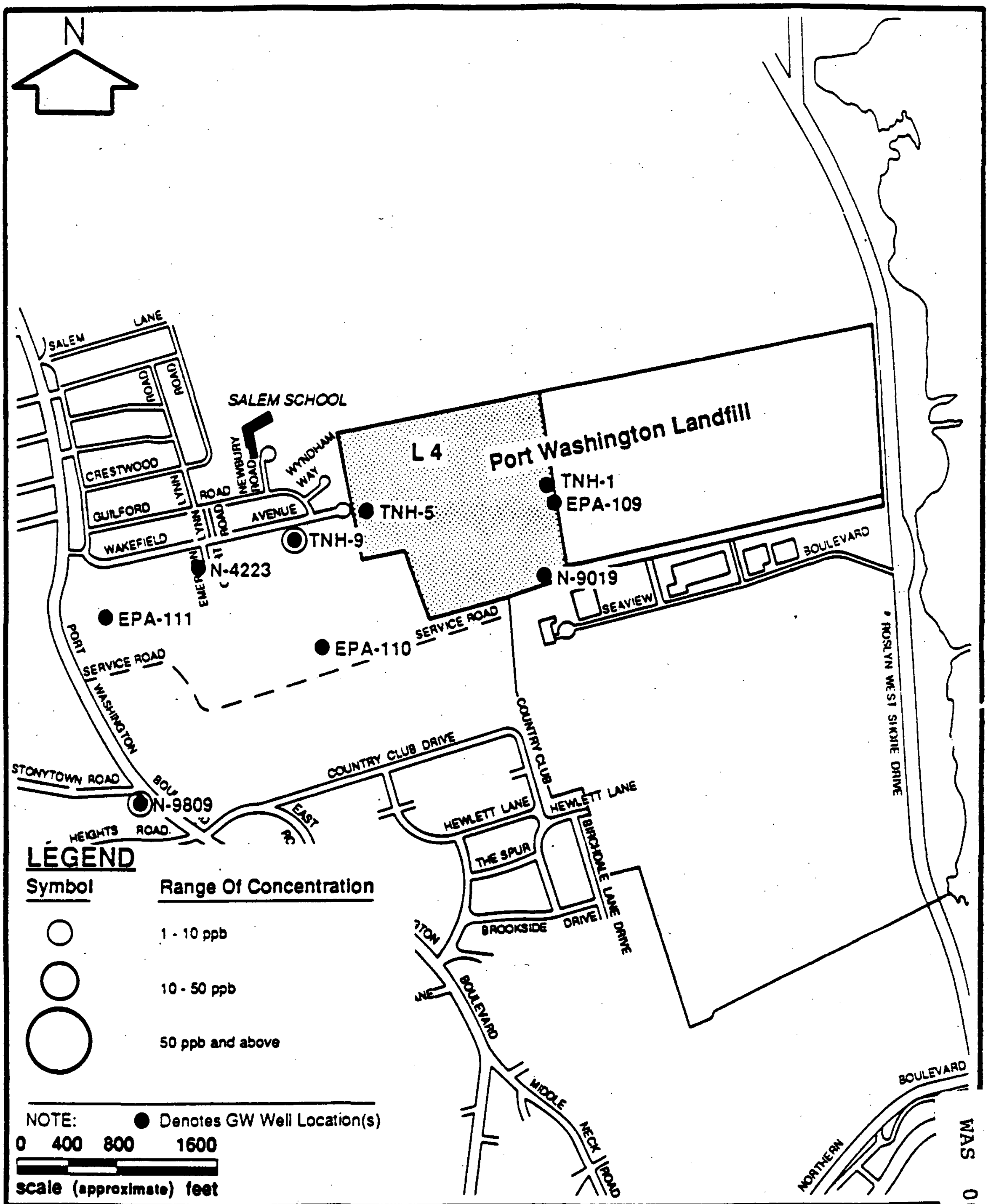

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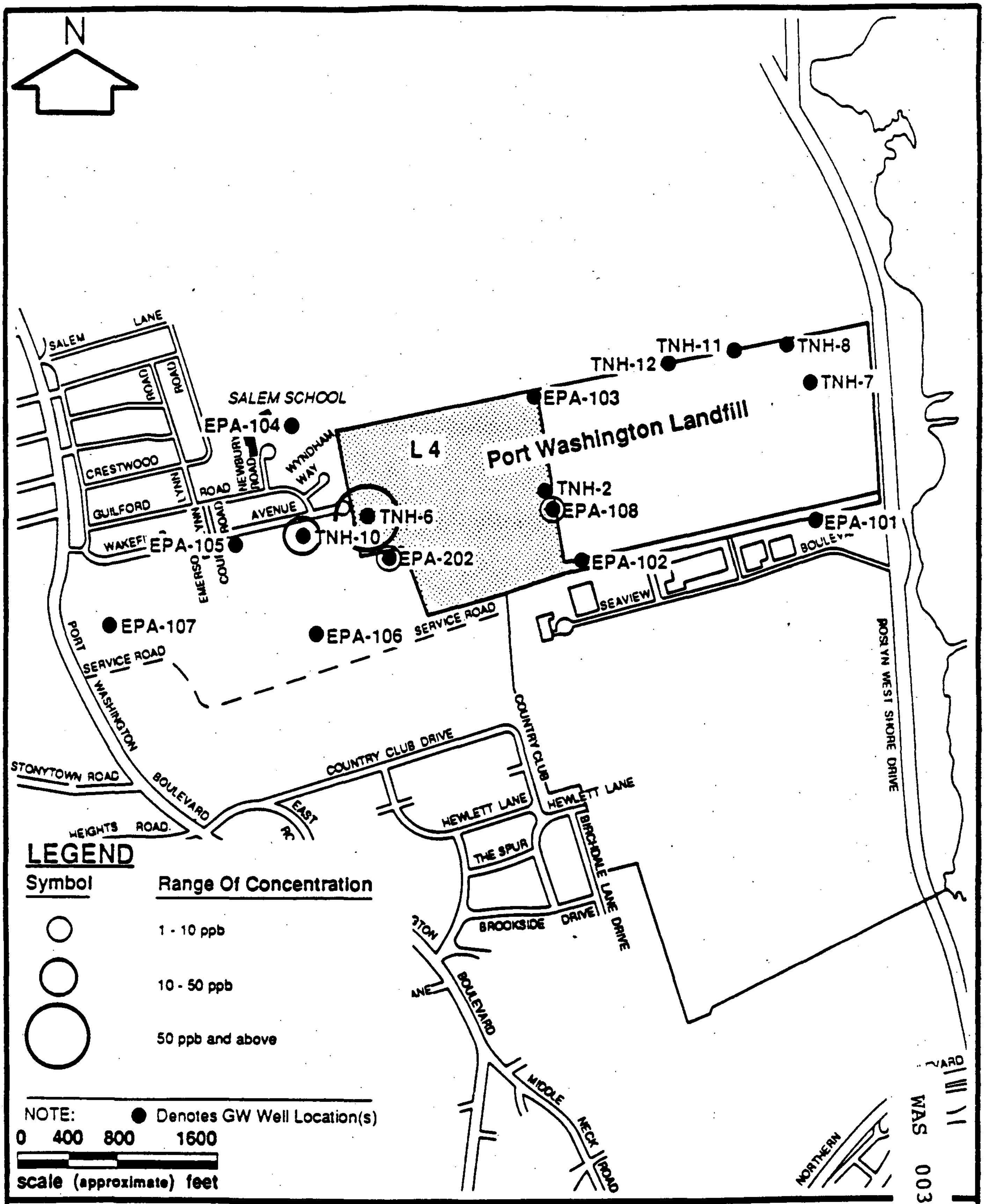

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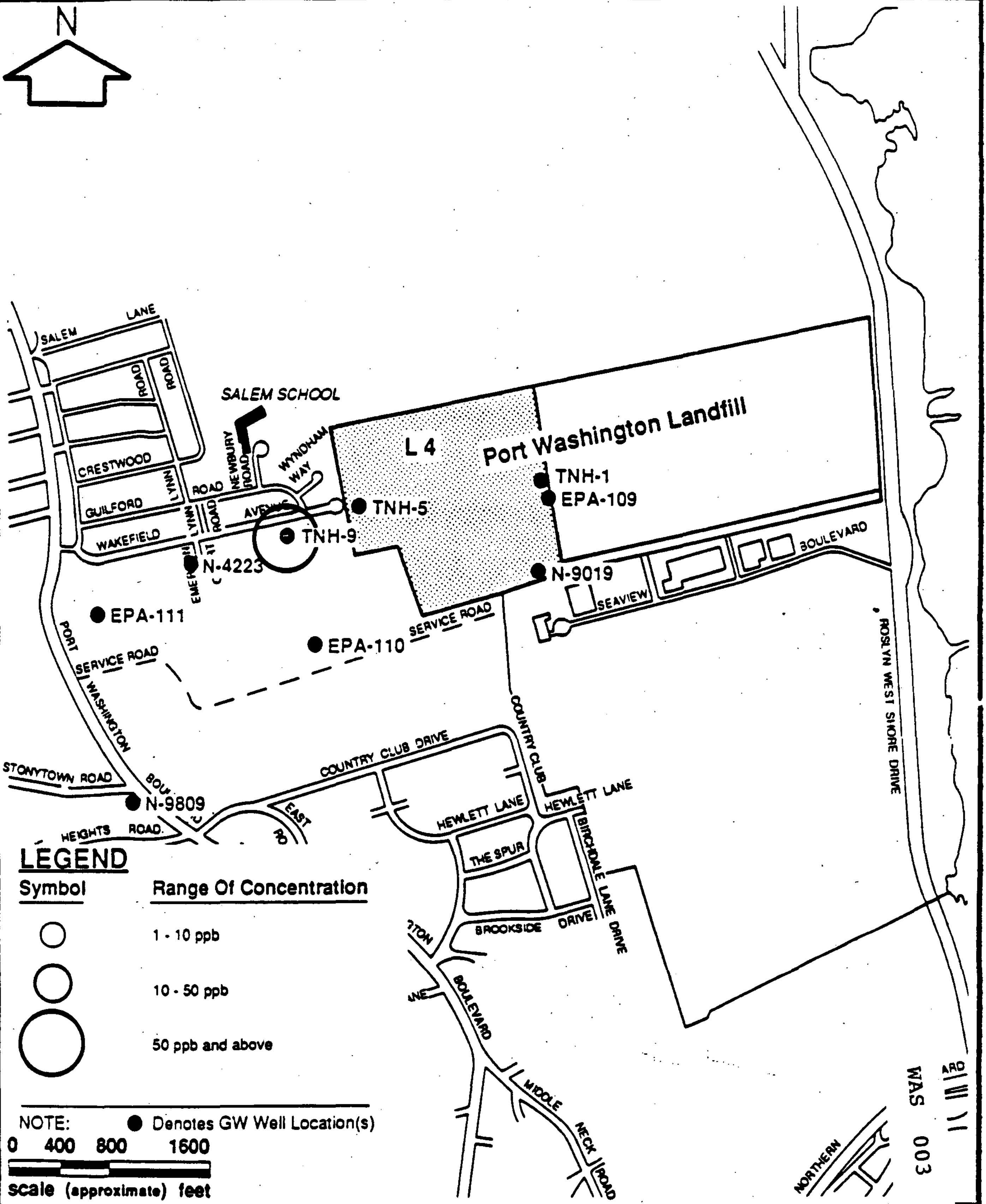

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1,1 Dichloroet
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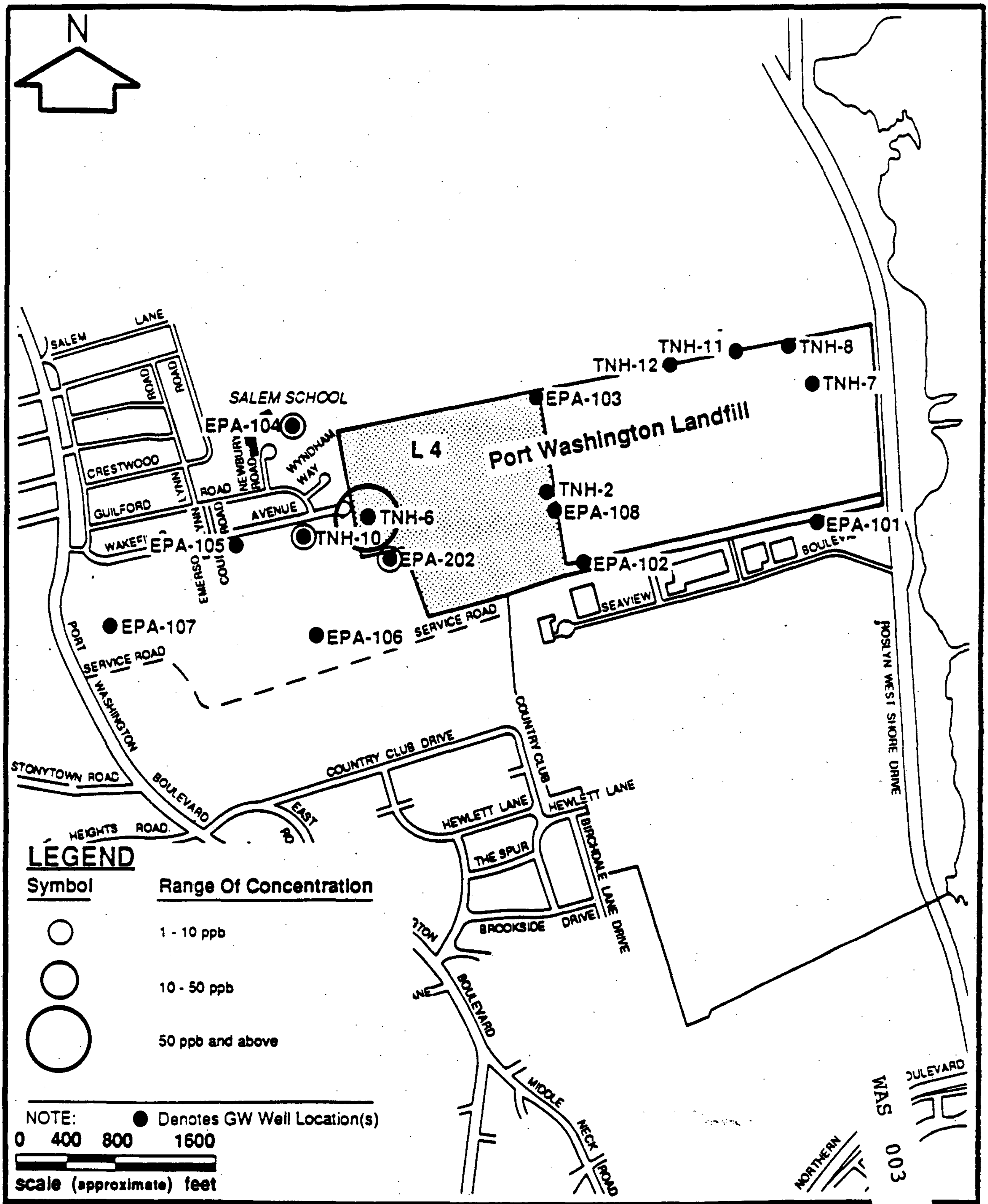

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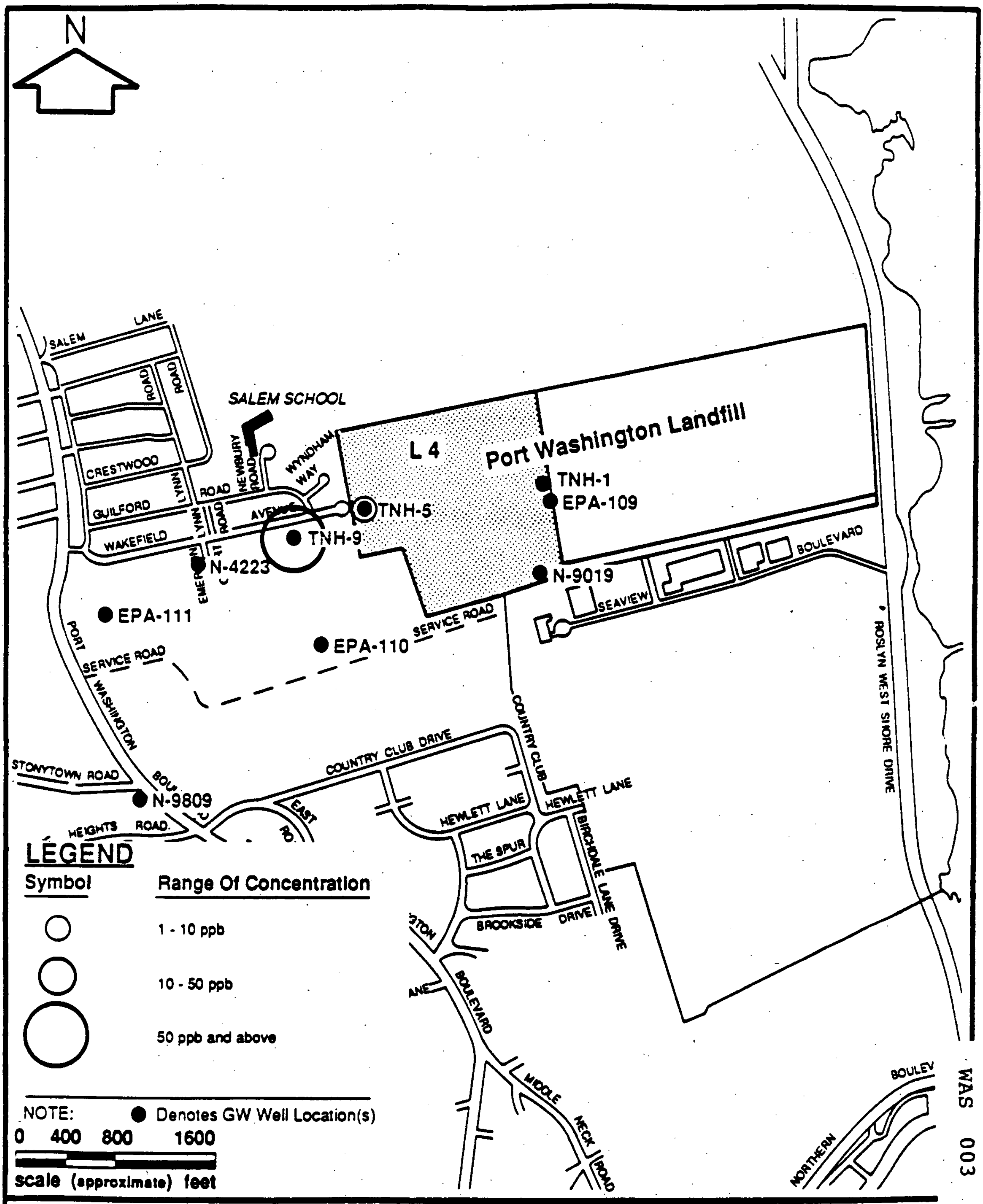

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1,1 Dichloroethan
Port Washington Landfill, Port Washington, New Yo...

that the organic constituents are sinking (see figure 5-15). However, this observation is not supported by the data collected at wells TNH-6 (screened just below the water table and TNH-5 (screened at 120 feet below the water table) in that the concentrations detected at TNH-6 are fairly constant and nothing was detected at TNH-5 by the REM II team, to date.

This trend could suggest that the organic contaminant source emanates from a location fairly close to TNH-6. In the past, under conditions when the Southport well was pumping, contamination emanating from such a source would have migrated through the saturated zone toward the pumping Southport well. When the Southport well stopped pumping, the plume between the Southport well and TNH-6 would have dissipated (similar to the observed chloride concentrations), and rainfall would have helped it to migrate deeper into the water bearing zone. (This mechanism of rainfall causing downward vertical migration is consistent with observed hydraulic gradients beneath the golf course.) Although the partitioning characteristics of the organic constituents greatly attenuate its migration rate, these general trends should persist. And in fact, at well pair TNH-9 and TNH-10 this trend does persist. However, the presence of consistently elevated levels of volatile organics at TNH-6 indicate that some other mechanism is influencing ground water quality at that monitoring point.

Figure 5-14 also illustrates that rainfall percolate probably contributes a continuous low level volatile organic load to the shallow flow system as an additional source. This is evidenced by the positive detections at wells EPA 104, EPA 105 and EPA 106. These wells have had detectable levels of volatile organic contamination during all sampling rounds (with the exception of EPA 106 which had high detection limits associated with the analytical work following the Fall 1987 sampling event) at levels between 1 and 10 ppb. The constituents which have been detected in these wells have also been detected at elevated levels in the unsaturated zone both beneath the residential area and around the Landfill. The direct correlation between detected unsaturated zone and saturated zone volatile organic contamination, and the relative levels of contamination detected in each medium, is substantial. Rainfall percolate stripping volatile organic

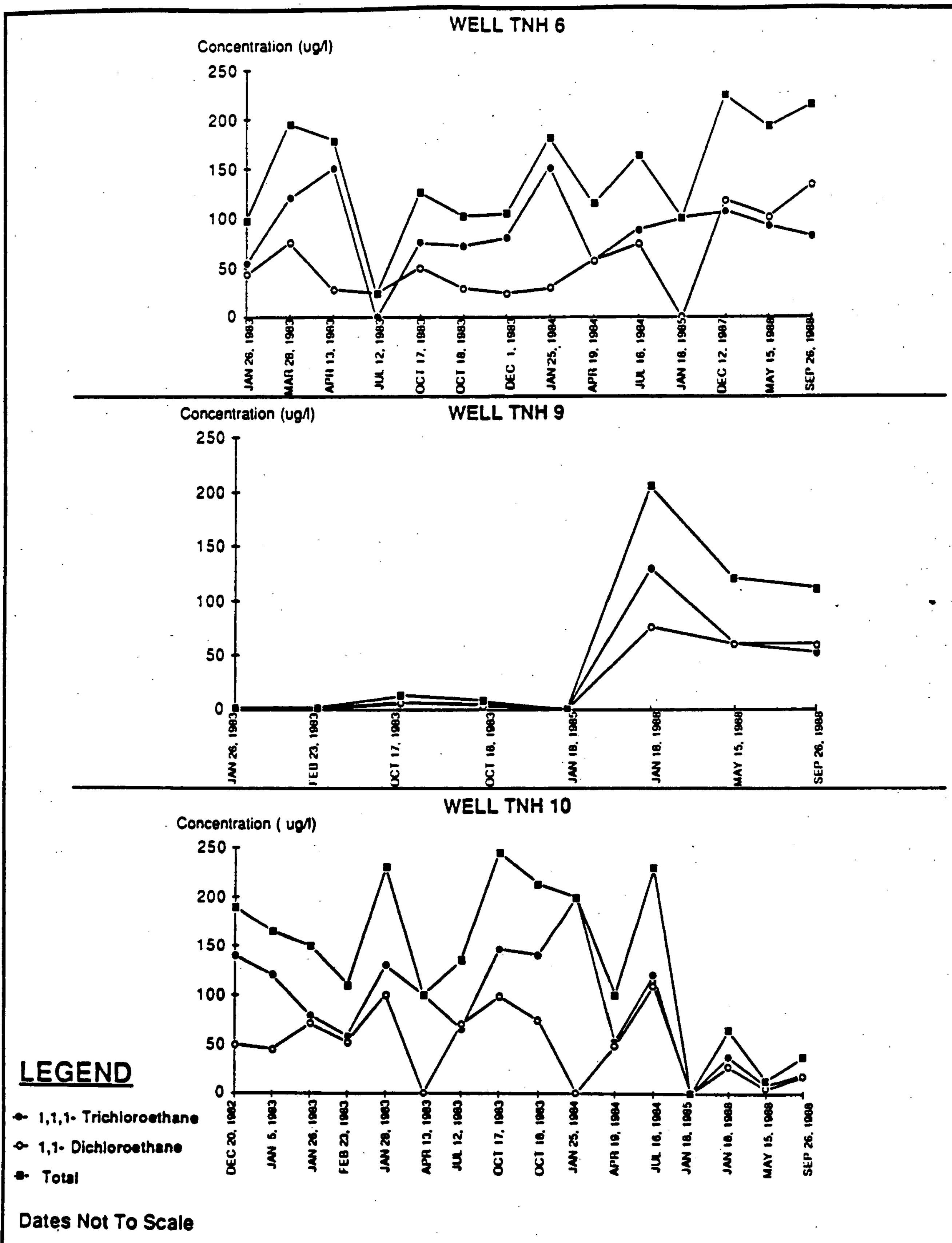

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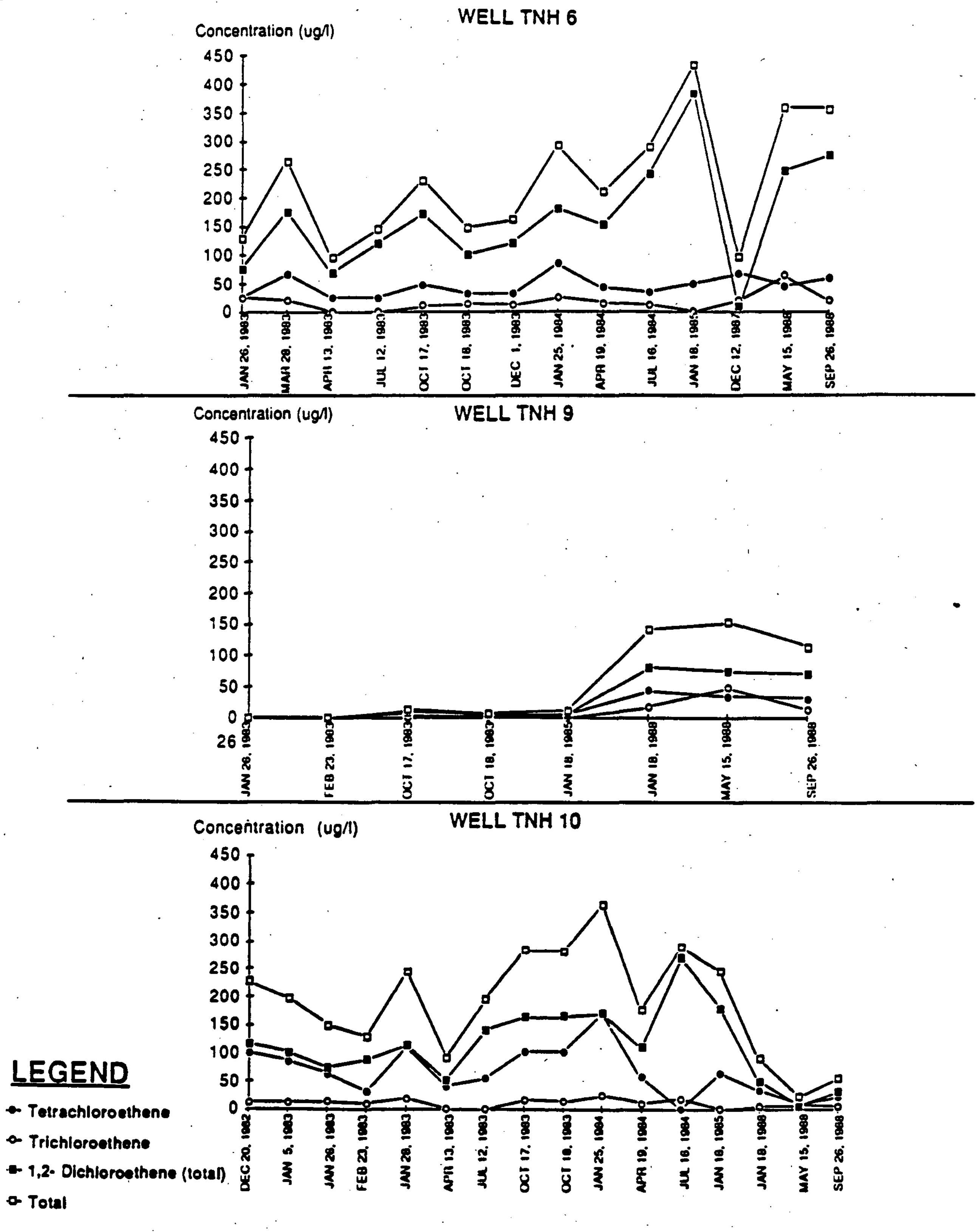
Figure 5-1

Historic Observed Concentrations Of Chlorinated Ethan
For Wells TNH 6, TNH 9 And TNH 10

Port Washington Landfill, Port Washington, New York



Dates Not To Scale

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Fig 5b

Historic Observed Concentrations Of Chlorinated ies
For Wells TNH 6, TNH 9 And TNH 10

Port Washington Landfill, Port Washington, New York

gasses residing in the vadose zone is a viable mechanism explaining the historical volatile organic contamination detected at the Southport well.

To further evaluate the potential for vapor phase contamination to "load" the ground water flow system, an analysis was performed comparing the relative concentrations of volatile organic constituents in each well location to the appropriate Henry's Law Constant. (A Henry's Law Constant, simply stated, is the equilibrium value relating the relationship between a compound's vapor pressure and its aqueous concentration. It may be approximated as the ratio of a compound's solubility in water to its vapor pressure). Based on the calculations presented in Appendix R, it can be seen that the measured ratio of vapor phase to aqueous phase contamination exceeds the expected Henry's Law Constant for all constituents at all wells along the periphery of the water-borne volatile organic plume. This indicates that the hydrocarbons in the vapor phase are not volatilizing out of the ground water; instead the volatile organics in the vapor phase could be condensing and migrating into the ground water. This phenomenon is similar to that observed by Hinchee and Reisinger (1987).

The exact mechanism producing the elevated concentrations of volatile organic contamination west of the Landfill detected at wells TNH-6, TNH-9 and TNH-10 cannot presently be determined, although it is important to note that the leachate quality is not consistent with the quality of the ground water beneath the golf course. This is most readily apparent when comparing inorganic constituents detected in the ground water versus the leachate (see table 5-11), albeit the recent organic data does not contain the same constituents either. Although historic data suggests that the leachate could be a contributor to the observed contaminant distribution beneath the golf course (based mainly on past observations that the volatile organic constituents present in the leachate are consistent with those found in the ground water) with the persistence of organic constituents at TNH-6, it appears the some other significant source of ground water contamination must exist. This "other" source, if it does exist,

TABLE 5-11

SELECTED CONVENTIONAL AND INORGANIC PARAMETERS IN GROUND WATER
December, 1987

UPGRADIENT WELLS

screen interval-MSL	-327 -413	-166 -176	18 8	-79 -132	-158 -168	-7 -17	26 16	11 1	-49-54 -68-73	+1-(-4) -18-23	14 4	-103 -113	-1 -11	LEACHATE MANHOLE
distance from L-4(ft)	3000	2040	2040	1540	1200	1200	1150	740	640	630	260	140	140	-
COMPOUND	9809	EPA-111	EPA-107	4223*	EPA-110	EPA-106	EPA-105	EPA-104	TNH-9	TNH-10	EPA-202	TNH-5	TNH-6*	L-4
Carbonate	NR	29	2.5 U	NR	10	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	NR	2.5 U	2.5 U	2.5 U
Bicarbonate	NR	69	75	NR	53	102	128	29	78	53	NR	50	138	4162
Sulfates	19.6	43	28	FQA	10 U	47	39	38	40	32	50.2	30	44.5	11
Kjeldahl Nitrogen	0.332	0.64 J	0.19 J	FQA	0.19 J	0.14 J	0.14 J	3.57 J	0.21 J	0.2 J	0.305	0.16 J	0.19 J	1092 J
Nitrates	FQA	0.93	3.2	FQA	1.69	16.4 J	16.3 J	16.6 J	15.8 J	17.9 J	FQA	6.7 J	2.95 J	0.11
Ammonia	0.01 U	0.01 U	FQA	0.01 U	FQA	FQA	FQA	FQA	FQA	0.1 J	0.24	FQA	FQA	854 J
Nitrite	FQA	0.02 U	0.02 U	FQA	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	FQA	0.02 U	0.045	0.03
Chloride	18.7	14 J	14.2 J	13	4.8 J	11 J	14 J	50 J	15 J	18 J	27 J	32.8 J	13.9 J	2605 J
Iron	FQA	1.91	4.48	FQA	0.712	4.96	5.25	3.24	4.68	6.5	99.5 J	0.512	6.715	8.9 J
Manganese	0.008 U	0.119	0.189	0.008 U	0.025	0.34	0.261	0.074	0.919	0.195	0.389	0.023	0.0397	0.008 J
Calcium	14.8 J	22.8	20.7	14.3 J	16.7	49.4	65.3	27.9	31.6	27.2	27.9	16.7	36.4	88 J
Potassium	FQA	12.2	2.97	FQA	5.87	2.36	17.4	2.25	2.32 J	1.69 J	5.14 J	2.35	2.24	500 J
Sodium	9.99 J	FQA	25.7	8.65 J	11.4 J	12.5 J	18.2 J	FQA	15.7 J	11.8 J	16.2 J	22.1	12	1680 J
Magnesium	9.51 J	5.16	4.63	8.2 J	3.05 J	13	26.8	7.16	14	13	16.5 J	10.6	17.8	110 J

All values in mg/l

U compound not detected

J estimated value, below method detection limit

* reported values are average of sample and duplicate

NR not reported

FQA sample failed quality assurance

TABLE 5-11 (con'd)

SELECTED CONVENTIONAL AND INORGANIC PARAMETERS IN GROUND WATER

December, 1987

DOWNGRADIENT WELLS

screen interval-MSL	LEACHATE MANHOLE	-27- -32	13- 8	-55- -65	-130- -140	23- 13	-323- -365	29.- 19	12.5- 8	-38 -42	14 4	12.5- 2.5	2.5 -1.5
distance from L-4(ft)	-	70	75	100	100	130	380	570	1250	1830	2350	2370	2370
COMPOUND	L-4	TNH-1	TNH-2	EPA-108 *	EPA-109	EPA-103	9019	EPA-102	TNH-12	TNH-11	EPA-101	TNH-8	TNH-7
Carbonate	2.5 U	NR	NR	7.25	4	2.5 U	NR	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
Bicarbonate	4162	NR	NR	71	30	1900	NR	368	200	140	100	56	113
Sulfates	11	7.7	251	FQA	363	70	3.3	62	126	32	16	135	271
Kjeldahl Nitrogen	1092 J	1.29	1.62	FQA	0.13 J	297 J	0.22	2.4 J	0.17 J	0.2 J	0.33 J	0.16 J	0.29 J
Nitrates	0.11	FQA	FQA	FQA	2.05 J	0.2 U	FQA	0.2 U	1.2	2	0.75	1.7	1
Ammonia	854 J	6.56	19 J	0.34 J	FQA	165 J	0.48	1.3 J	FQA	FQA	FQA	FQA	0.21 J
Nitrite	0.03	FQA	FQA	FQA	0.05	0.02 J	FQA	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
Chloride	2605 J	280 J	138 J	FQA	2960 J	696 J	10.2	48 J	718 J	114 J	13.8 J	516 J	1546 J
Iron	8.9 J	40.4 J	62.6 J	1.77	0.964	0.057 J	12.6	8.69	15.1	2.25	5.01	0.711	9.52
Manganese	0.008 J	2.01 J	1.99 J	0.042	0.024 J	FQA	0.363 J	8.22	0.126	0.033	0.106	0.028	0.348
Calcium	88 J	29.9 J	123.8 J	51.6	152	9.3 J	8.73 J	86.1	3.53	9.29	29.4	26.4	59.1
Potassium	500 J	30.5 J	54.1 J	FQA	29	154 J	7.96 J	12.8	15.5	16.7	4.33	10	21.4
Sodium	1680 J	339.2 J	124.3 J	FQA	1410 J	480 J	FQA	65	220	164	13.2	297	735
Magnesium	110 J	51.9 J	40.8 J	FQA	86.6	82.2 J	3.29 J	30	47.4	14.2	9.98	29.2	58

All values in mg/l

U compound not detected

J estimated value, below method detection limit

* reported values are average of sample and duplicate

NR not reported

FQA sample failed quality assurance

TABLE 5-11 (con'd)

SELECTED CONVENTIONAL AND INORGANIC PARAMETERS IN GROUND WATER
Spring, 1988

	UPGRADIENT WELLS													
screen interval-MSL	-327 -413	-166 -176	18 8	-79 -132	-158 -168	-7 -17	26 16	11 1	-49-54 -68-73	+1-(-4) -18-23	14 4	-103 -113	-1 -11	LEACHATE MANHOLE
distance from L-4(ft)	3000	2040	2040	1540	1200	1200	1150	740	640	630	260	140	140	-
COMPOUND	9809	EPA-111	EPA-107	4223*	EPA-110	EPA-106	EPA-105	EPA-104	TNH-9	TNH-10	EPA-202	TNH-5	TNH-6*	L-4*
Carbonate	1 U	50	NR	1 U	56 !	NR	NR	NR	NR	NR	NR	NR	NR	1 U
Bicarbonate	36	7	NR	43	!	NR	NR	NR	NR	NR	NR	NR	NR	3780
Sulfates	17	FQA	NR	12	24	33	33	26	32	26	32	23	27	10 U
Kjeldahl Nitrogen	FQA	FQA	11	FQA	1.1	1.1	0.8 J	2	1.1 J	0.6 J	0.8	1	0.8	FQA
Nitrates	0.3	0.05 U	0.36 J	0.58	0.46 J	0.56 J	2.7 J	1.2 J	0.26 J	4.1 J	0.24 J	1.9 J	FQA	0.05 U
Ammonia	0.05 U	0.05 U	0.01 U	0.05 U	0.01 U	0.1	0.05	0.01 U	0.01 U	0.1	0.26	0.01 U	FQA	790
Nitrite	0.3	0.05	NR	0.04	FQA	FQA	FQA	FQA	FQA	FQA	FQA	FQA	0.03 J	0.03 U
Chloride	18	4.7	7.5	14	4.8	10	14	28 J	18	23 J	16	28 J	13	2015
Iron	0.042	0.519	1.55	0.03	0.5	7.07	5.51	9.39	3.22	0.167	38.7	0.386	3.2	7.94
Manganese	0.002	0.109	0.082	0.003	0.021	0.222	0.296	0.141	0.277	0.086	3.39	0.014	0.065	0.101
Calcium	15.1	19.3	16.7	15.1	19.7	35.1	41.7	28.2	28	25.5	21.5	16	33.6	84.4
Potassium	0.4 U	8.49	2.55	0.708	2.83	2.74	5.32	2.18	2.22	2.01	5.56	2.37	2.16	499
Sodium	9.37	10.1	10.4	8.02	8.15	11.3	10.4	14.6	12.9	15.7	17.6	24.1	12.4	1230
Magnesium	9.41	4.21	3.63	8.3	2.61	10.8	14.4	7.25	11.7	10.6	12.1	10	16	104

All values in mg/l
U compound not detected
J compound detected, estimated value
* reported values are average of sample and duplicate
NR not reported
! value repr [illegible] is total for carbonate and bicarbonate
FQA sample [illegible] ance

TABLE 5-11 (con'd)

SELECTED CONVENTIONAL AND INORGANIC PARAMETERS IN GROUND WATER
SPRING, 1988

DOWNGRADIENT WELLS

screen interval-MSL	LEACHATE MANHOLE	-27- -32	13- 8	-55- -65	-130- -140	23- 13	-323- -365	29.- 19	12.5- 8	-38 -42	14 4	12.5- 2.5	2.5 -1.5
distance from L-4(ft)	-	70	75	100	100	130	380	570	1250	1830	2350	2370	2370
COMPOUND	**L-4***	**TNH-1**	**TNH-2**	**EPA-108**	**EPA-109**	**EPA-103**	**9019**	**EPA-102**	**TNH-12**	**TNH-11**	**EPA-101**	**TNH-8**	**TNH-7**
Carbonate	1 U	1 U	1 U	1 U	3	1 U	1 U	1 U	1 U	1	1 U	1 U	1 U
Bicarbonate	3925	468	566	61	46	1810	42	300	194	117	78	60	94
Sulfates	10 U	21	474 J	180	342 J	47	10 U	34	90 J	34 J	12	81 J	234 J
Kjeldahl Nitrogen	FQA	5.5 J	24 J	FQA	FQA	155 J	FQA	1.6 J	FQA	FQA	1.8 J	FQA	FQA
Nitrates	0.05 U	0.05 U	0.05 U	0.35	0.27	0.05 U	0.68	0.08	0.64	0.37	0.45	0.33	0.47
Ammonia	790	3.9	28	0.05 U	0.05 U	196	0.1	1.5	FQA	0.07	0.05 U	0.05 U	0.05 U
Nitrite	0.03 U	0.07	0.23	0.31	0.16	0.14	0.68	0.04	0.17	0.06	0.17	0.09	0.08
Chloride	2015	487	177	1110	2400	644	5.5	38	258	196	8.1	364	1200
Iron	7.94	54.2	71.5	1.67	0.448	33	9.36	58.3	9.27	0.623	7.97	0.553	1.81
Manganese	0.101	4.97	2.41	0.057	0.014	2.88	0.623	5.55	0.065	0.021	0.082	0.014	0.029
Calcium	84.4	81.7	160	45.9	131	162	7.65	53.3	25.8	8.35	22.3	20.8	51.2
Potassium	499	31.4	68.8	17	26	157	3	11.8	13.7	16.9	3.45	7.49	20.5
Sodium	1230	306	140	541	545	438	4.4	46.6	180	142	9.62	209	633
Magnesium	104	54.1	53.3	54	123	95.9	3.08	22.2	35.9	13.5	10.1	22.7	72.9

All values in mg/l
U compound not detected
J compound detected, estimated value
* reported values are average of sample and duplicate
NR not reported
! value reported is total for carbonate and bicarbonate
FQA sample failed quality assurance

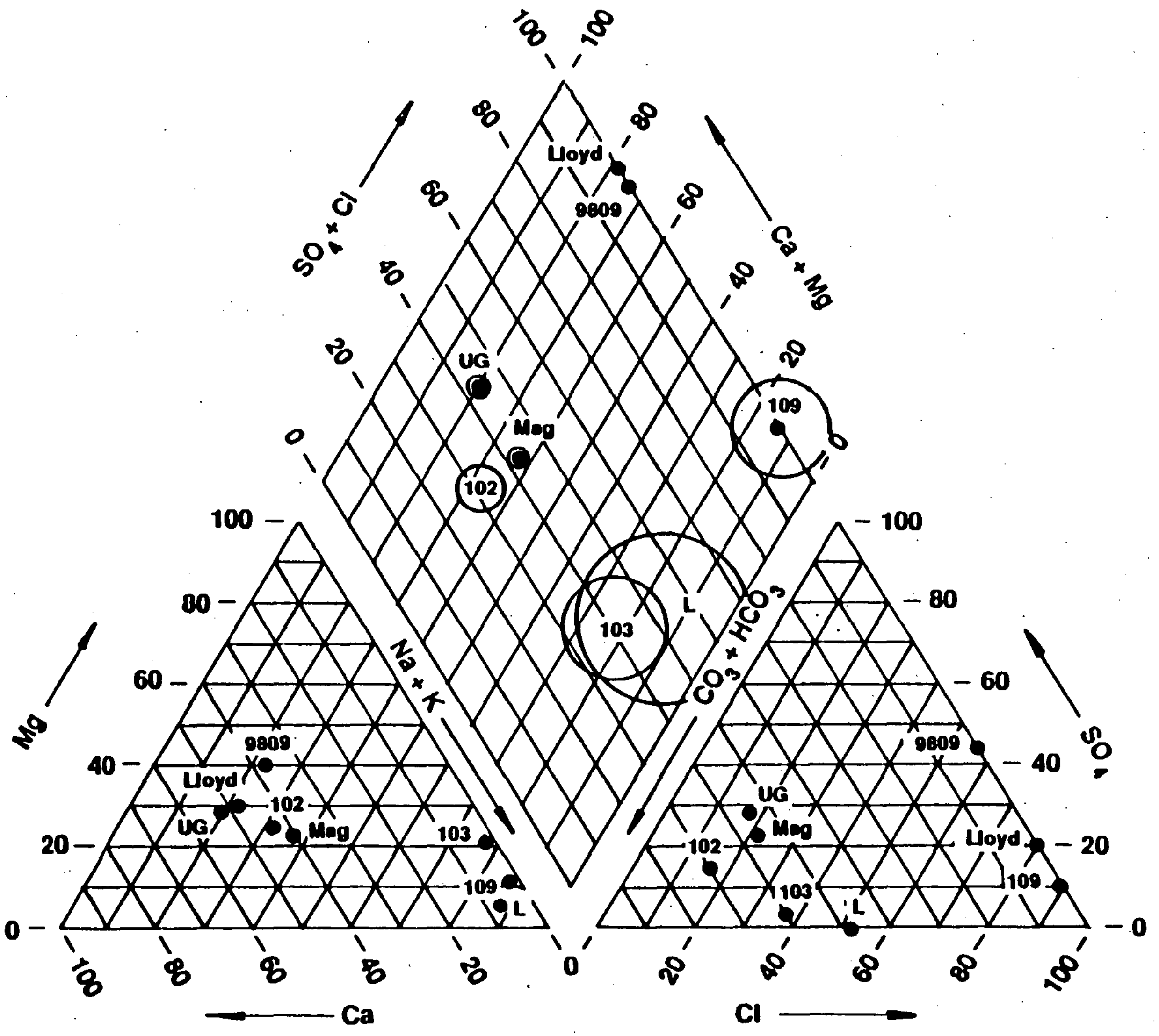
must contain only volatile organics, be concentrated along the western boundary of L-4, and continue to load contaminants into the flow system.

Due to the prevailing hydraulic gradients, and the resulting velocity of ground water, neither the organic constituents detected west of the Landfill or those contained in the leachate have been consistently detected at high levels due east of the Landfill. However, the more mobile conservative constituents (eg. nitrate, ammonia, chloride, sulfate, etc.) contained in the leachate have been observed in well EPA 103. Figure 5-16 is a trilinear plot which depicts the conventional cation and anion composition of the leachate along with the ground water samples collected from individual wells east of the L-4 site and from a composite of wells west of the Landfill. Additionally, the average of upgradient monitoring wells located in the Upper Glacial, Magothy and Lloyd Aquifers is presented. The direct correlation of well EPA 103 with the leachate, and the lack of other wells having the same correlation indicates that EPA 103 is downgradient of the leachate source. This observation further distances the organic constituents west of the Landfill from a source defined by the leachate.

Therefore, some other mechanism for the organic contamintion detected at TNH-6 must exist.

Additional observations which should be made concerning figure 5-16 are as follows:

- the Upper Glacial Aquifer and Magothy Formation have similar "background" water quality.
- the Lloyd Aquifer contains water which is considerably different than the aquifers which lie above the Raritan Clay, mainly due to the low levels of carbonates detected at that depth.
- the Stonytown well lacks the carbonate fraction found in the shallower wells, aligning it with waters found in the Lloyd Aquifer. The Stonytown well does have slightly different combinations of cations and anions than those observed in the Lloyd Aquifer, however, overall it is closer to the Lloyd waters than the Magothy waters.



LEGEND

UG - Average Upper Glacial Water
Mag - Average Magothy Water
Lloyd - Average Lloyd Water
L - Average Leachate

Note: Circle indicates concentration in parts per million.

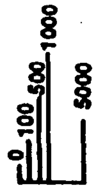


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Figure 5-16

Trilinear Plot Of Cation And Anion Composition Of Selected Ground Water Monitoring Locations

Port Washington Landfill, Port Washington, New York

Ground water flow simulations were made to better characterize the organic contamination detected in the Upper Glacial Aquifer west of the Landfill. Figure 5-17 presents the expected path of flow for contamination detected at monitoring wells at TNH-5, TNH-6, TNH-9 and TNH-10, EPA 104 and EPA 202 in both plan view and cross-section using the ground water flow fields for averaging conditions in the area from 1984 through 1987.

The resultant paths of flow for contamination detected west of the Landfill illustrates two important points. First EPA 202 (adjacent to an area where condensate is collected from the active and passive vent systems and is sometimes allowed to drained onto the ground) lies directly upgradient of TNH-6. Therefore, if contaminants were getting into the subsurface at the condensate vent, they would migrate directly toward TNH-6. Since the condensate would probably contain only volatile organic constituents (i.e., no conventional constituents or inorganics), this location presents itself as a potential source of ground water contamination.

Second, the migration of the elevated levels of detected volatile organic contamination is generally to the northwest and downward through the Upper Glacial Aquifer into the Magothy Formation. If left unchanged, the existing flow field may carry the organic contaminants downward into the Port Washington Aquifer, and perhaps even the Lloyd Aquifer (it should be noted that the observed chloride concentrations at EPA 104 (which lies along the flow path directly downgradient of TNH-6) of 50 and 28 mg/l are above background levels (between 10-20 mg/l) which perhaps is associated with the past elevated chloride levels detected west of the Landfill migrating north and northwest).

To summarize, the ground water quality analyses performed before and during the Remedial Investigation conclude the follow:

- The contamination detected west of the Landfill in the Upper Glacial Aquifer contains similar volatile organic constituents found historically in the Landfill leachate.
- Although the source of the volatile contamination found in the Southport Well was most probably the Landfill, the contamination did not migrate from L-4 to the well solely through the ground water flow field.

■ [illegible]

— [illegible]

■ [illegible]

■ LOWER MAGOTHY

■ UPPER MAGOTHY

— [illegible]

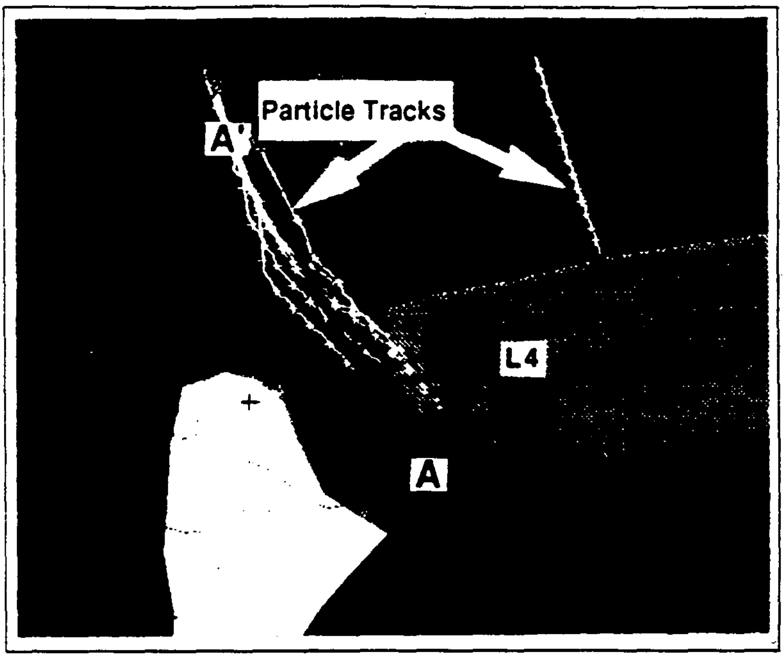
■ UPPER GLACIAL

■ [illegible]

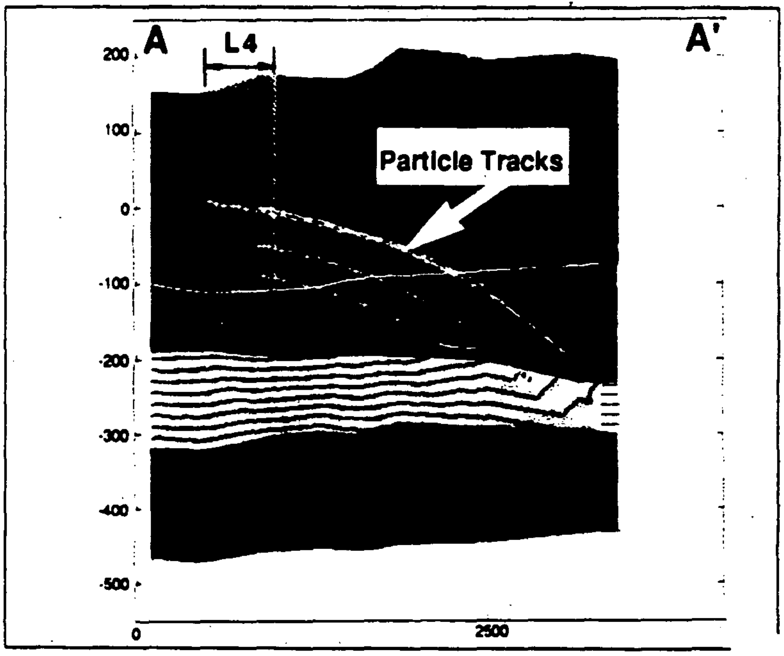
▨ LANDFILL

■ [illegible] CONFINING

☰ [illegible] AQUIFER



PLAN VIEW



CROSS SECTION VIEW

LEGEND

+ **Pumping Centers**

——— **Equipotential Lines**

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Figu

Particle Tracks For Conservative-Contaminant Mig
Through Existing Ground Water Flow Field West

Port Washington Landfill, Port Washington, Ne

- o Elevated levels of chloride historically found west of the Landfill have dissipated since the Southport well closed.
- o Elevated levels of volatile organic contamination detected just west of L-4 at TNH-6, TNH-9 and TNH-10 indicates that some source of contamination along the western boundary of the Landfill must persist.
- o Vapor phase volatile organic contamination stripped by percolating rainfall may create a contaminant loading into the water table aquifer.
- o Unchanged, the elevated levels of volatile organic contamination identified west of L-4 will probably migrate north of the Landfill and downward through the Magothy formation ultimately discharging into the Port Washington and Lloyd Aquifers. This migratory route should be examined further to determine the extent of contamination and its potential impacts.

5.4 OVERVIEW OF THE DRUM EXCAVATION

During the month of September, 1987, the REM II team performed technical oversight of Town of North Hempstead subcontractors conducting soil, water and drum sampling at the Port Washington Landfill. This activity was focused in characterizing an approximately one acre site located between L-4 and L-5 where buried drums were found.

At the time that the excavations began, the REM II team was in the process of installing ground water wells EPA 108 and EPA 109 at the toe of the L-4 landfill. EPA requested that the REM II team split samples with the Town's consultant and observe the excavation operations. Beginning in September, H_2M (consultant for the Town of North Hempstead) and Marine Pollution Control, (H_2M's contractor) performed a subsurface excavation activity. The contractor uncovered more than sixty buried 55 gallon drums of an unknown origin. Some of these drums contained a black sludge-like material. The objectives of the REM II team's involvement was to determine if the drums contained hazardous materials and evaluate whether the site was a source of ground water contamination.

The analytical results for the soil, water and drum sampling are contained in Appendix Q. A summary of the constituents detected in each of the mediums sampled is presented in [redacted]

TABLE 5-12

ORGANIC CONSTITUENTS DETECTED IN THE DRUM EXCAVATION AREA

	Medium		
	Soil	Ground Water	Drums
Chloroform	✓		
Trichloroethane	✓		
t-methyl-2-pentanone	✓	✓	✓
Toluene	✓		✓
Ethylbenzene	✓	✓	✓
Total Xylenes	✓	✓	✓
2-methylnaphthalene			✓
Naphthalene	✓	✓	✓
Benzo(2) anthracene	✓		
Penanthrene	✓		
Fluoroanthrene	✓		
Anthracene	✓		
Pyrene	✓		
di-n-butyl phthalate	✓		
Bis (2-ethylhexyl) phthalate	✓		
Chrysene	✓		
Benzo (b) fluoranthene	✓		
Benzo (2) pyrene	✓		
Isophorone	✓	✓	✓
Phenol		✓	
2-methly phenol		✓	

(564)

It can be seen from the table that many constituents present in the drum excavation area have been detected in the ground water. However, it is not certain as to whether contaminants detected on the ground surface or in the soils adjacent to this site have migrated into the ground water flow system. Additionally, the present ground water monitoring well network does not have sampling points located in appropriate positions to detect contamination emanating from the portion of the landfill where the drum disposal site is located.

The results of these efforts suggest that although the drum excavation area contained constituents found in the ground water, the migration rate of contamination downward through the unsaturated zone is uncertain. Therefore, the impact of the disposal practices in this area on the ground water quality beneath the Landfill is unclear. The potential for contamination to migrate into the water bearing zone from this locale exists, however, and requires that the source be further addressed during remediation activities.

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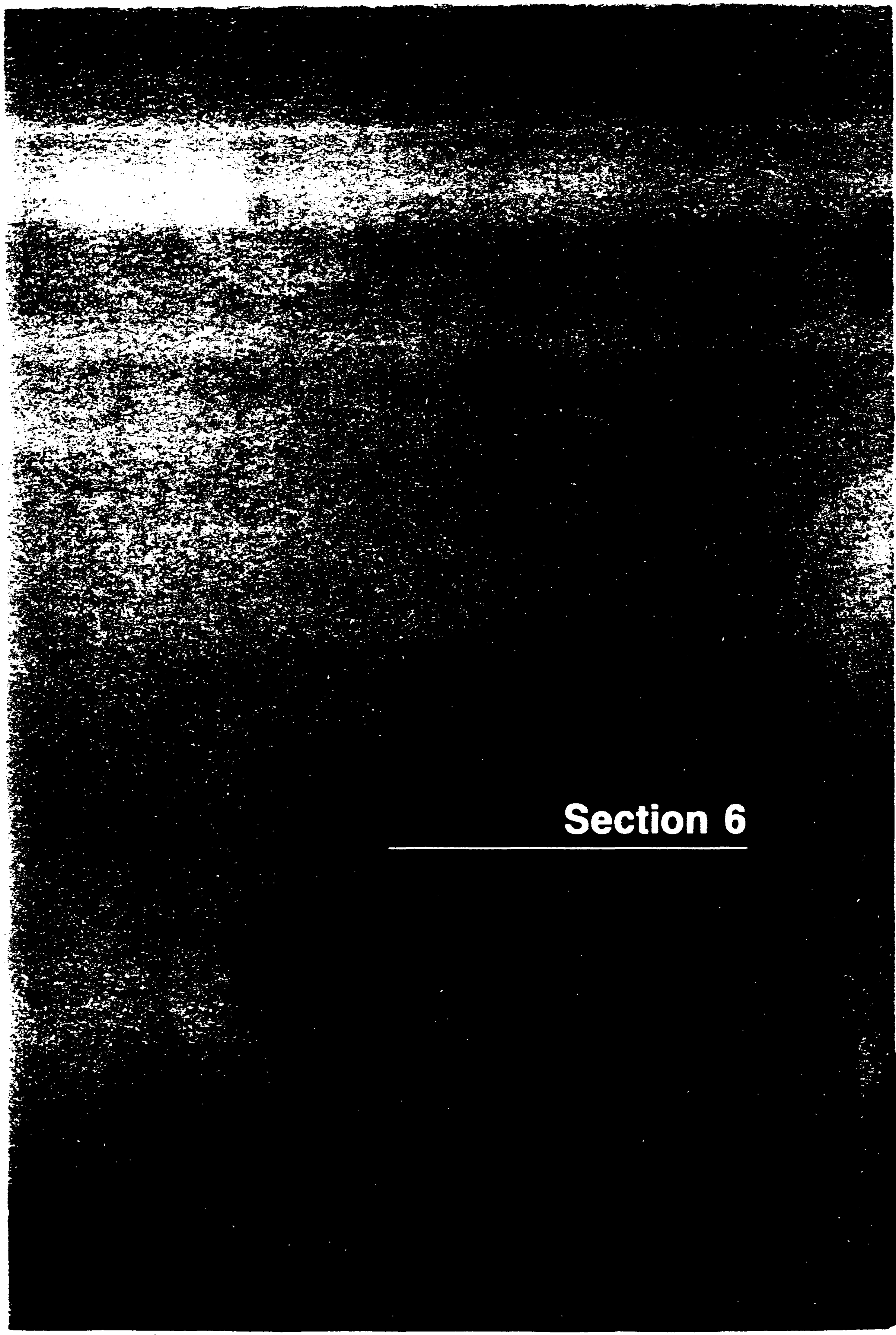


Section 6

6.0 CONCEPTUAL CONTAMINANT TRANSPORT MODEL

The purpose of this section is to summarize the information collected during the REM II team's remedial investigation with respect to the nature of the contaminant sources, both historically and as they exist today, and the impact of the sources on receptors in the vicinity of the Landfill. The first subsection will overview historical contaminant sources and the associated distribution of subsurface contamination. Included will be a discussion of the various locations where the contamination has historically impacted residents in the Landfill's vicinity. The second subsection will present a characterization of existing contaminant sources and review the previously discussed extent of vapor phase and water-borne pollutants. Additionally, the potential impacts of the existing subsurface contamination on area residents will be discussed.

The impacts discussed in this section are not to be confused with the Public Health Evaluation, which is presented in section 7.0. This chapter identifies potential receptors - people who may come in contact with the contamination - and the route by which an exposure will occur, but does not determine the risk associated with an exposure.

6.1 HISTORICAL CONTAMINANT SOURCES AND THE ASSOCIATED DISTRIBUTION OF SUBSURFACE CONTAMINATION

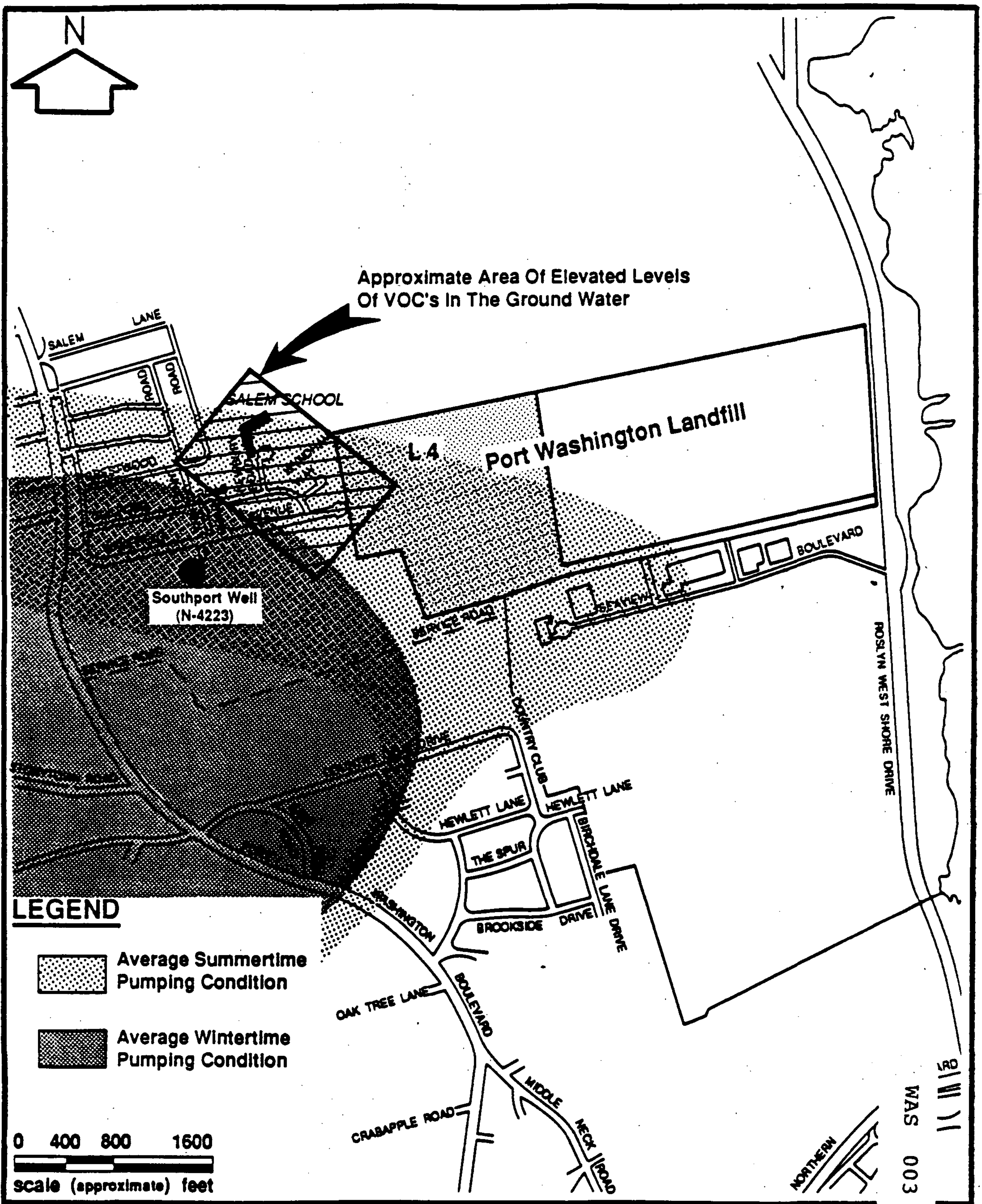
Before landfilling operations began, the ground water beneath the L-4 site contained elevated levels of chloride and sodium presumably originating from the waters of Hempstead Harbor. These waters were historically pumped inland to aid with the mining of the area's sands and gravels. This salt water may have eventually degraded the quality of the water extracted at the Southport well (given the historical record of pumping and the resultant zone of influence) had volatile organic contamination not reached the well first, resulting in the well's closure.

The volatile organics which did reach the Southport well in early 1981 were not accompanied by inorganic constituents such as sodium and chloride.

However, based on water quality data collected at TNH ground water monitoring wells located on the North Hempstead Country Club, the salt water front had apparently moved to within a few thousand feet of the Southport well at the time of its closure due to the influence of pumping at this location. The observation that the volatile organic constituents found at the Southport well were found at these same TNH ground water monitoring wells at even greater concentrations indicated that the probable source of the contamination was the Landfill. (This fact is further supported by recently collected data presented in Chapters 3 and 5). However, it is well documented in the literature that inorganics, such as chloride, migrate faster through the ground water than do organics which tend to stick (or adsorb) onto the soil through which the ground water moves. Therefore, the question raised was how can the Southport well be contaminated with only slow-moving organics if the ground water contamination existing in the vicinity is characterized as containing both organics and inorganics? If the contamination found at the Southport well originated at the Landfill and was carried by the ground water, elevated levels of inorganic constituents would also be expected to be present at that location. Therefore, either another source of organics or some migratory pathway other than the ground water flow system (such as vapor phase transport) must exist to describe the observed distribution of water-borne contamination at the Southport Well.

Landfill operations began at L-4 in 1974 and were permitted and approved by the New York State Department of Environmental Conservation. Over the first three years of operations, the Landfill generated an estimated 10 to 20 million gallons of leachate which entered the ground water beneath the site due to an incomplete liner system and the lack of a proper leachate collection system. Subsequent upgrading of the landfill liner and leachate collection system greatly reduced the amount of leachate entering the ground water flow system.

Could this leachate source have contaminated the Southport well with the observed levels of volatile organics? Although the cone of depression around the Southport Well extended to beneath the Landfill (see Figure 6-1) this scenario is unlikely since the leachate generated by a municipal



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environmental engineers, scientists planners & management consultants

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Historic Seasonal Zones Of Conti on
To The Southport Well 197 31
Port Washington Landfill, Port Washington, ork

landfill such as L-4 contains high levels of inorganic constituents (eg. ammonia, sulfate, etc.), and these inorganic constituents would have preceded the organics to the well. This is not to say that the leachate, which was known to contain significant levels of organic constituents, did not impact the quality of the area ground water. However, the historical pathway of migration of the leachate to the Southport well did not exist long enough for the well's water quality to be impacted by inorganic constituents, for once the well was discontinued from service, the direction of ground water flow changed, carrying the leachate north, not west (see figure 5-17). Therefore, volatile organic contamination detected at the Southport Well must have migrated from the Landfill to the well through some means other than the ground water flow system.

It is important to note that the released leachate can continue to be a "passive" source of ground water contamination due to the propensity of organic constituents contained in the leachate to adsorb onto the soil particles as they migrate through the unsaturated and saturated zone. This passive source, which can persist long after an active source ceases to emanate contamination, could play a significant role in existing conditions contaminant migration, and will be discussed in the following subsection.

It is also important to note that other area water wells could be impacted by the contamination believed to be associated with the Landfill (both the water-borne and vapor phase). The Stonytown well and the Hewlett wells are potentially at risk in that during certain pumping conditions their zones of capture could extend into an area presently receiving volatile organic contamination believed to emanate from the Landfill. Additionally, the Bar Beach well could be at risk in the future given the present south to north migration pathway in the area of elevated volatile organic contaminants.

Beginning in the winter of 1977, an apparently unrelated phenomenon occurred in that area residents began to experience furnace "puff backs", caused presumably by the build-up of methane (a volatile organic) in their homes to concentrations above the lower explosive limit (LEL). This situation persisted until the TNH installed landfill gas venting systems along the western perimeter of the L-4 Landfill. In addition to the offsite migration of methane, historical data from TNH wells in the vicinity of Wakefield Drive and the North Hempstead Country Club (NHCC) showed that volatile organic constituents have migrated west of the Landfill toward the Southport Well through the unsaturated zone.

In understanding the nature of this vapor phase contaminant migration in the subsurface it is important to review the mechanics of landfill digestion and decomposition discussed earlier in this report. As the landfill ages, bacteria digest the refuse under anaerobic conditions - meaning under conditions without oxygen. This digestion produces methane and heat. In a sense, therefore, the landfill becomes a very large, single celled organism which maintains a fairly constant temperature of about 110°F year round. This temperature is not high enough to boil water, however, it is high enough that numerous organic constituents (e.g. trichloroethene, dichloroethane, etc.) which are typically liquids at room temperature, evaporate (or volatilize) and become vapor. What the landfill does, therefore, is separate a portion of the volatile organic constituents (including those found at the Southport Well) from the rest of the leachate which originated from rainfall percolating downward through the refuse, picking up inorganic and organic substances. This separation process caused by the heat generated by the bacteria digesting the refuse is an important historical contaminant transport mechanism. This process allows for the migration of two separate ground water contaminant plumes - the first consisting mainly of inorganic constituents migrating north (as detected at EPA 103) and the second consisting mainly of vapor phase and its related condensate of volatile organic constituents migrating north and northwest (as detected at TNH-6 and TNH-10/9). Due to the separation process, these two plumes apparently are emanating from opposite sides of L-4 (inorganic from the east and organic from the west).

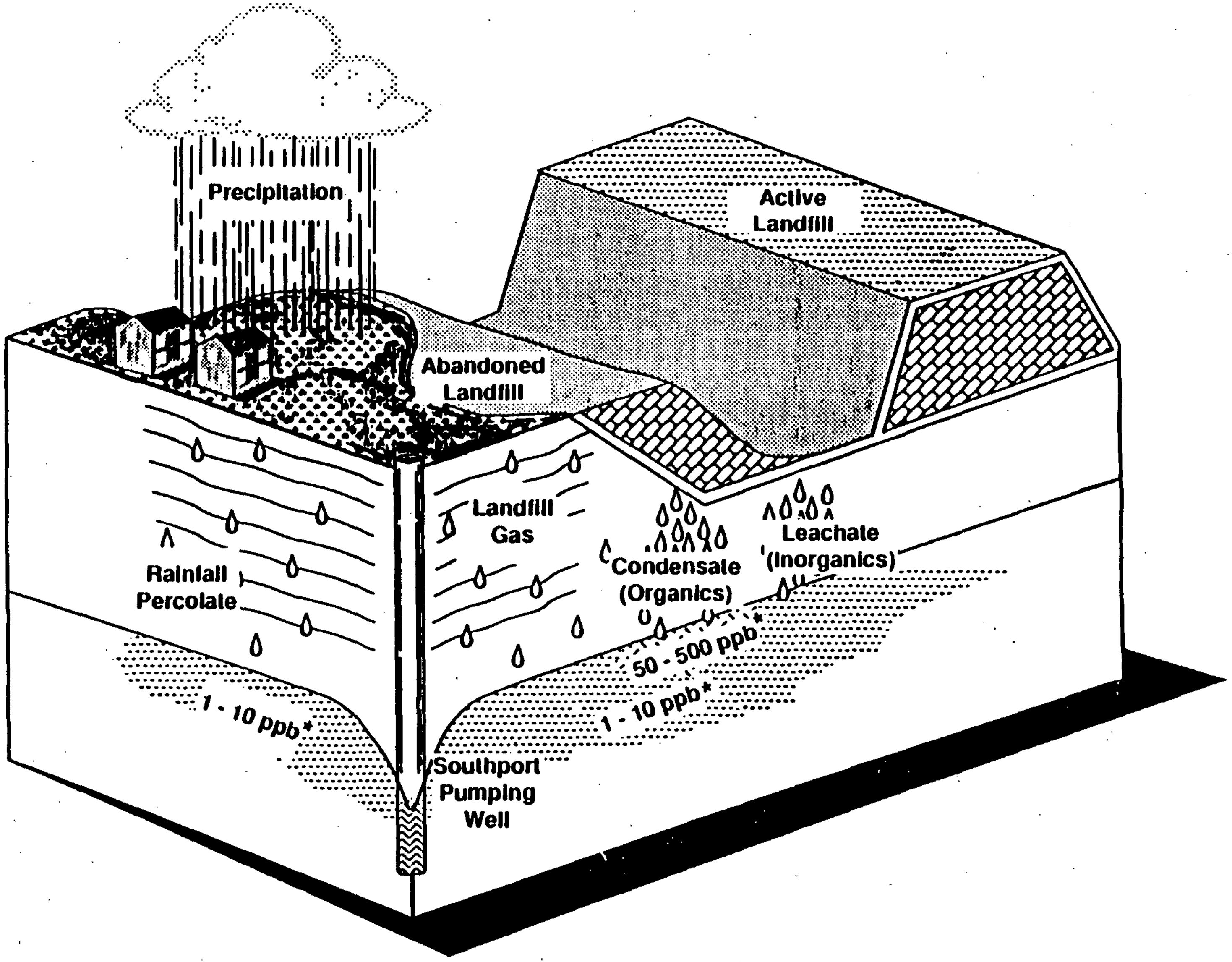
The migration of the vapor phase constituents through the subsurface west of the Landfill has historically impacted the Wakefield Avenue residential area. Also, the vapors found in the subsurface off-site are continuously available to be in contact with infiltrating water (originating from either rainfall or irrigation sources) percolating downward through the unsaturated zone to the water table. Therefore, the vapor phase migration of volatile organic constituents is perhaps the most wide spread source of low level contaminant loading into the ground water flow system at the site.

It should be noted that the persistence of the landfill gas in the unsaturated zone west of L-4 has not been determined. It is distinctly possible that migrating gas could be retained in the spaces between soil particles for an undetermined amount of time. As such, "old gas" which migrated off-site prior to the installation of the active venting system must be regarded as a possible passive source of ground water contamination. This old gas would exist "trapped" in the interstitial spaces of the soil column and would potentially not be quantified by soil sampling techniques due to its volatile state.

The mechanism of vapor phase organics migrating off-site through the unsaturated soil, contacting percolating water, and ultimately impacting the ground water table, and the Southport Well, coupled with the more obvious ground water flow migration pathway may explain the historical distribution of volatile organic and inorganic contamination observed in the vicinity of the Landfill (see figure 6-2).

In summary the following items can be noted:

- Three sources of "contamination" have historically impacted either residents or the environment in the vicinity of the Port Washington Landfill. These sources are Landfill leachate, vapor phase volatile organics originating at the Landfill, and salt water originating from sand and gravel soil washing operations.
- The most significant historical impacts from these sources have been identified as the build-up of methane and other volatile organic vapors in homes adjacent to the Landfill and the migration of volatile organic constituents into the Southport Well which was used for public drinking water supply.
- The historical direction of ground water flow beneath the Landfill when the Southport was in operation was from east to west (especially when irrigation pumping also occurred at the NHCC). Since the Southport Well was removed from service due to volatile organic contamination, however, the ground water now flows from the southwest to the north and northeast beneath the Landfill.



NOTE: * – Concentrations Representative Of Total Volatile Organic Priority Pollutants

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Figure 6-2

Conceptual Block Diagram Of Contaminant Transport

Port Washington Landfill, Port Washington, New York

- The impact of other unknown sources of volatile organics on the observations noted in this remedial investigation are potentially important. Nonetheless, the constituents measured in the Southport Well have historically been found in the Landfill leachate and gases.
- Migration of vapor phase volatile organic constituents from the Landfill may be responsible historically for the ground water impacts observed in the vicinity of the Landfill. However, the other "passive" sources identified in this subsection (adsorbed Landfill leachate and "old" Landfill gas) have significance as potential sources under today's conditions.

6.2 EXISTING CONTAMINANT SOURCES AND THEIR EXPECTED IMPACT ON THE COMMUNITY

Nearly all of the historical sources of contamination discussed in the previous subsection persist today with the possible exception of the salt water from the soil washing operations which are no longer practiced. The salt water front continues to be detected in the Magothy Formation east of the Landfill at EPA 109 and possibly northwest of the Landfill at EPA 104, however, at these locations, there is little or no impact on the existing public water supply wells in the area.

Therefore, at least three previously identified sources of contamination may potentially impact the area citizenry under existing conditions. These sources are the leachate which was discharged before the Landfill leachate collection system was improved, the leachate which continues to seep from the Landfill, and the vapor phase volatile organic constituents which have been generated by the Landfill since at least 1977 (i.e., old or new gas). To better understand the impact of each of these sources, it is beneficial to review the existing distribution of contamination.

West of the Landfill, in the shallow ground water system, inorganics associated with the soil washing operations and elevated levels of volatile organic constituents have been historically detected. The inorganics, such as chloride, have dissipated since the closing of the Southport Well. This is due to the shift in prevailing ground water flow from southwest to northeast. Presently, the inorganic and metal concentrations observed in the shallow wells west of the Landfill are consistent with background levels measured in the Upper Glacial Aquifer and Magothy Formations (with the possible exception of chloride in EPA 104).

The volatile organic contamination has not followed the same trend, meaning that it has not dissipated. One explanation, which is consistent with the one used to explain the observed contamination at the Southport well, is as follows: heating within the Landfill separates volatile organic constituents (VOC) from the remaining leachate and distributes the VOCs in the unsaturated and saturated zones west of the Landfill as detected in the Landfill gas wells and the shallow ground water monitoring wells.

During the period of time when the ground water flow field was stressed by the pumping at the Southport Well (before 1981), the TNH-10/9 and TNH-6 wells indicated the presence of a volatile organic contaminant source to their east. This source created more than single digit levels of detected volatile organics at TNH-10/9 and TNH-6 presumably due to its proximity and strength.

Noteworthy is the observation that the constituents detected at TNH-10/9 and TNH-6 are generally consistent with those constituents found in the leachate (historically) and the landfill gas (see table 6-1). The strength of the volatile organics detected at TNH-10/9 and TNH-6 is also of importance. Since more concentrated levels of landfill gas at EPA LFG 202, EPA LFG 203 and TNH LFG 7 only produced corresponding single digit detection levels in the ground water, it follows that the contaminant levels at TNH-10/9 and TNH-6 were caused by more than just rainfall percolating through vapor phase contamination in the vadose zone.

Keeping that information in mind, EPA 106 and EPA 105 also listed in table 6-1 were minimally impacted, if at all, by the pumping of the Southport Well. EPA 106 was always upgradient of the Landfill; and EPA 105 was presumably far enough west of the Landfill to not have received direct loading of the contaminants observed at TNH-10/9 and TNH-6. After the pumping ceased, EPA 105 and EPA 106 remained far from the area which might be impacted by either a leachate plume emanating from the Landfill, or a residual plume emanating from the area where elevated levels of organic

TABLE 6-1

CORRELATION BETWEEN DETECTED LANDFILL GAS AND GROUNDWATER CONTAMINATION

COUPLET			OBSERVED CONCENTRATIONS							
GROUNDWATER MONITORING WELL	LANDFILL GAS WELL	CONSTITUENT	GROUNDWATER QUALITY (ug/l)				VAPOR PHASE QUALITY (ppbv)*			
			RND 1	RND 2	RND 3		RND 1	RND 2	RND 3	
EPA 106	EPA 203	1,1 Dichloroethane			4.8		25	12	13	
		Trichloroethene			1.0		24	9	5	
		1,1,1 Trichloroethane		6 J	7.8		198	90	73	
		1,1 Dichloroethene			0.8				6	
		Tetrachloroethene		6 J	8.8		478	105	121	
		Chloroform			0.2J			1 J	3	
		total 1,2 Dichloroethene			3.4			4		
		Vinyl Chloride			0.8					
		1,2 Dichloroethane								
EPA 105	EPA 204	1,1 Dichloroethane			0.5J					
		Trichloroethene			0.1J					
		1,1,1 Trichloroethane		2 J	4.3		79	46	22	
		1,1 Dichloroethene			0.2J					
		Tetrachloroethene		3 J	6.4		131	75	63	
		Chloroform			0.3J			4	3	
		total 1,2 Dichloroethene								
		Vinyl Chloride								
		1,2 Dichloroethane								
EPA 104	TNH LFG7	1,1 Dichloroethane		2 J	1.4			54	26	
		Trichloroethene			0.6					
		1,1,1 Trichloroethane	2 J	5 J	4.3		152	692	252	
		1,1 Dichloroethene			0.6			1 J	9	
		Tetrachloroethene	1 J	5 J	3.7			62	90	
		Chloroform						8	7	
		total 1,2 Dichloroethene		9 J	5.6					
		Vinyl Chloride			1.0					
		1,2 Dichloroethane							30	
TNH 10/9**	TNH LFG 1	1,1 Dichloroethane	52	33	38.5			27	26	
		Trichloroethene	12	14	8.5			5	3	
		1,1,1 Trichloroethane	184	34	35.5			83	87	
		1,1 Dichloroethene	7	9	5.7			2	3	
		Tetrachloroethene	39	22	26			101	116	
		Chloroform	3		2.1		2 J	2		
		total 1,2 Dichloroethene	65	35	44.7			17		
		Vinyl Chloride	11	7	10.4					
		1,2 Dichloroethane								
TNH 6	TNH LFG4	1,1 Dichloroethane	117	100	130				8	
		Trichloroethene	20	18	20					
		1,1,1 Trichloroethane	108	91	81				22	
		1,1 Dichloroethene	9	13	11				1	
		Tetrachloroethene	67	46	60			20	6	
		Chloroform			0.6					
		total 1,2 Dichloroethene		230	130.3				1	
		Vinyl Chloride	19	42	25				6	
		1,2 Dichloroethane			2.1					
EPA 202	EPA 202	1,1 Dichloroethane	4 J	5	4.1		385	326	138	
		Trichloroethene				0.5		119	34	14
		1,1,1 Trichloroethane	14	27	17		612	310	147	
		1,1 Dichloroethene		1 J	0.6			31	19	
		Tetrachloroethene	10	32	23.		614	292	116	
		Chloroform						1 J	3	
		total 1,2 Dichloroethene	2 J	2 J	1.1			68		
		Vinyl Chloride								
		1,2 Dichloroethane								

J - estimated values

* - reported value is highest detected for date at any of three probes sampled

** - reported value for TNH 10/9 is geometric mean of concentrations measured at date for both monitoring points contamination persist (see figure 6-1) near TNH-10/9 and TNH-6. However, the data in table 6-1 illustrates that the water-borne contamination, as well as the vapor phase contamination, persist at these locations. Based on the historically observed contaminant levels in the ground water at the Southport Well, and presently at EPA 105 and EPA 106, it can be surmised that rainfall percolating through the unsaturated zone containing elevated levels of volatile organic vapors (as detected at EPA LFG 203 and EPA LFG 204), contributes to the contamination of the underlying water-bearing zone with what appears to be single digit levels of those same volatile organic constituents. This observation is supported by the fact that at every location where vapor phase contamination was detected, similar constituents were found in the ground water as well. This observation is further supported by the method described by Hinchee and Reisinger (1987) to ascertain whether contaminants could be condensing from the vapor phase into the ground water.

EPA 104 coupled with TNH LFG-7 could also be an indication of this same percolation phenomenon. However, EPA 104 is downgradient of TNH-10/9 and TNH-6 under existing flow conditions (i.e. with no pumping at the Southport Well), and therefore the detected contamination at this spot could be associated with the migration of volatile organic constituents from the area of elevated levels of organic constituents.

The only well cluster presented in table 6-1 which has not been discussed is at EPA 202 where both ground water and unsaturated zone sampling points have been constructed. This well is located immediately adjacent to the Landfill but is not located on the direct line from the suspected source to the pumping center. Also, under the existing flow field (north-northeast under the Landfill), this well is upgradient of the Landfill. The mechanism of rainfall percolate loading the ground water at the observed contaminant levels does not appear unreasonable at this location although some of the detected concentrations are above single digits. The proximity of the well to the Landfill may account for the elevated landfill gas levels observed in that the vapor is presumably at its highest strength immediately adjacent to its source. (This observation that the Landfill gas would be of highest strength at the source is consistent with detected concentrations of volatile organic constituents at EPA 202 as presented in table 6-1). Also, the direct correlation between constituents found in the vapor phase and those found in the ground water presents some evidence implicating the percolate pathway as the mechanism of contaminant transport observed at this location.

However, the observed concentrations of volatile organic contamination observed at TNH-10/9 and TNH-6 are anomalies unexplained by the percolate pathway. Concentrations of volatiles at these wells are found in the double and triple digit part per billion range; too high to be explained by landfill gas being the source. It is possible that the leachate which escaped from the Landfill during its early years of operation tainted the unsaturated and saturated zone beneath the western border of the Landfill and continues to emanate organic constituents which had adsorbed onto the soil particles. Some other localized source of volatile organic contamination in the immediate vicinity of TNH-6 might also explain this observed phenomenon. (It had been surmised at one point that contaminants carried in the sanitary sewer lines tributary to the lift station at the end of Wakefield Avenue were leaking into the shallow flow system. This potential scenario has since been dismissed due to the absence of detected nitrogen based constituents - which serve as indicators of sewage - at TNH6.) Unauthorized dumping off the end of the pavement of Wakefield Avenue years ago may explain the observed distribution of volatile organic contamination just west of the Landfill. This type of source cannot be substantiated.

The production of landfill gas condensate generated by the cooling of hot gases migrating off-site and coming in contact with the adjacent soils is another possible source of the observed contaminant concentrations at TNH-10/9 and TNH-6. At this time, however, data characterizing the impact of such possible condensate formation on ground water quality has not been collected. Nonetheless, an area of elevated volatile organic contamination does exist in the vicinity of TNH-10/9 and TNH-6 which does not fit into the two previously discussed ground water contaminant loading processes of rainfall percolation through vapor phase contamination or direct leakage of Landfill leachate.

Lastly, it should be noted that the composition of the ground water at EPA 103 indicates (because of the ammonia content) that some Landfill leachate has been discharging into the ground water system at some time either historically or presently. It is also noteworthy that the shallow ground water wells due east of the Landfill (EPA 108 and TNH-2) have not demonstrated constituent composition consistent with the known Landfill leachate quality. This observation is perhaps consistent with the understanding that under existing conditions ground water flows from southwest to northeast beneath the eastern portion of the L-4 Landfill.

To review, the following <u>active</u> sources of ground water contamination are thought to exist today:

- Vapor phase volatile organic constituents in off-site areas (be they "new" or "old" gases) which are "stripped" by percolating rain water.
- Landfill leachate which existed historically and presumably continues to leak today. Although this source appears to only have created an inorganic loading on the flow system as detected northeast of L-4, organic constituents have been detected in the leachate and these constituents could potentially migrate into the water bearing zone beneath the Landfill.
- Finally, a more concentrated source of volatile organic contamination has influenced the quality of ground water west of the Landfill at TNH-10/9 and TNH-6, be it unauthorized dumping, condensate, or some other source.

It is important to understand that the presence of organic constituents, especially at levels such as those observed just west of L-4 in both the saturated and unsaturated zones, potentially create another type of contaminant source - the passive source. This type of source is caused b either: the propensity of organic constituents to partition onto soil particles as a solvent front moves through an area, and to partition from soil particles into the ground water as clean water comes into an area previously contaminated; or the physical trapping of the contamination within the interstitial spaces of the soil. Such passive sources can persist for very long periods of time consistently loading trace levels of contamination into passing ground waters. Therefore, elimination of activ organic contaminant sources is most likely only part of the required remediation to a ground water contamination problem - containment and elimination of passive contaminant sources is also important. Given that clean-up requirements for eliminating public health risks from contaminated drinking waters are defined in the single digit part per billion range, passive source control is paramount to sucessful ground water remediation because contaminant loading caused by these sources is often within that range.

Sufficient data at the Landfill does not exist to fully and completely characterize the passive sources; however, the widespread existence of volatile organic constituents in the ground water indicates their presence. The reported leachate loss during the early years of the Landfill operation could have potentially created a significant passive source, however, the location of such a source is directly beneath the Landfill in a location which is difficult to sample. Sampling the interstitial spaces between the soil particles in the unsaturated zone can be performed to determine the quality of trapped gases, however, the length of time the obtained gas had been retained at a particular sampling point cannot be easily established. Regardless of the lack of site specific data defining the nature and extent of the passive sources, their existence can be reliably inferred and must be dealt with during remedial actions.

To summarize, vapor phase organic constituents present in the subsurface off-site are widespread. These vapors are available to seep into neighborhood homes, and by the natural percolation of rain and irrigation water downward through the unsaturated zone may be carried into the ground water rendering the public water supply source non-potable. This impact may be remedied by the prevention of off-site migration and by the removal of the vapor phase constituents from the unsaturated zone; however, the residual of the vapors in the soil interstices could continue to impact ground water quality into the future, albeit at very small quantities.

The concentrated volatile organic constituents influencing the shallow ground water quality just west of the Landfill is of concern to maintaining potable water at the Southport Well. This is due to the fact that the area containing elevated levels of volatile organic constituents falls within the area tributary to the Southport Well under nearly any pumping scenario, and the elevated levels of volatile organic contamination detected insure that some residual passive source will persist within that area. The Landfill leachate which was discharged into the ground water during the early years of operation could also constitute a passive source impacting ground water quality at the Southport Well.

Lastly, the existing inorganic contamination detected downgradient, to the northeast of the Landfill, is representative of Landfill leachate. At this time its presence should not significantly impact ground water withdrawals at the Southport Well. However, during dry periods when water demand is high, and in conjunction with irrigation pumping at the NHCC, it is possible that this inorganic contamination could migrate toward the Southport Well.

In conclusion:

- the existing distribution of ground water contamination may be the product of at least three active sources: vapor phase volatile organic constituents in the unsaturated zone; concentrated volatile organic constituents localized near TNH-10/9 and TNH-6; and Landfill leachate.

- the organic constituents present in the saturated and unsaturated zones may create passive sources of contamination due to partitioning phenomenon characteristic of such contaminants, and these passive sources could persist in the subsurface far into the future.

- the subsurface vapor phase organic constituents appear to impact the existing ground water quality and may impact the air quality in homes west of the Landfill (see section 7.0).

- all of the sources listed above will potentially impact the quality of water extracted at the Southport Well with the concentrated organic contamination perhaps having the greatest impact, and the inorganic contaminants contained in the Landfill leachate perhaps only influencing the water quality at the well under increased pumping scenarios (e.g., dry seasons when the Southport Well and gc course irrigation wells are pumping simultaneously).

- other supply wells in the vicinity of the Landfill, including the Stonytown, Bar Beach and Hewlett wells, are potentially at risk fro volatile organic contamination believed to be associated with the Landfill.

- if wells are placed east of the Landfill for the purposes of water supply, most, if not all, of these sources may impact the extracted ground water quality. However, the chloride remnants from the soil washing operations will most probably exclude any water extracted from the upper water bearing zones from potable usage.

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