Remedial Investigations at the Route 8 Landfill

Volume I
Report

Prepared For:

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REMEDIAL INVESTIGATION AT THE ROUTE 8 LANDFILL

FOR AMPHENOL CORPORATION SIDNEY, NEW YORK

21 March 1989

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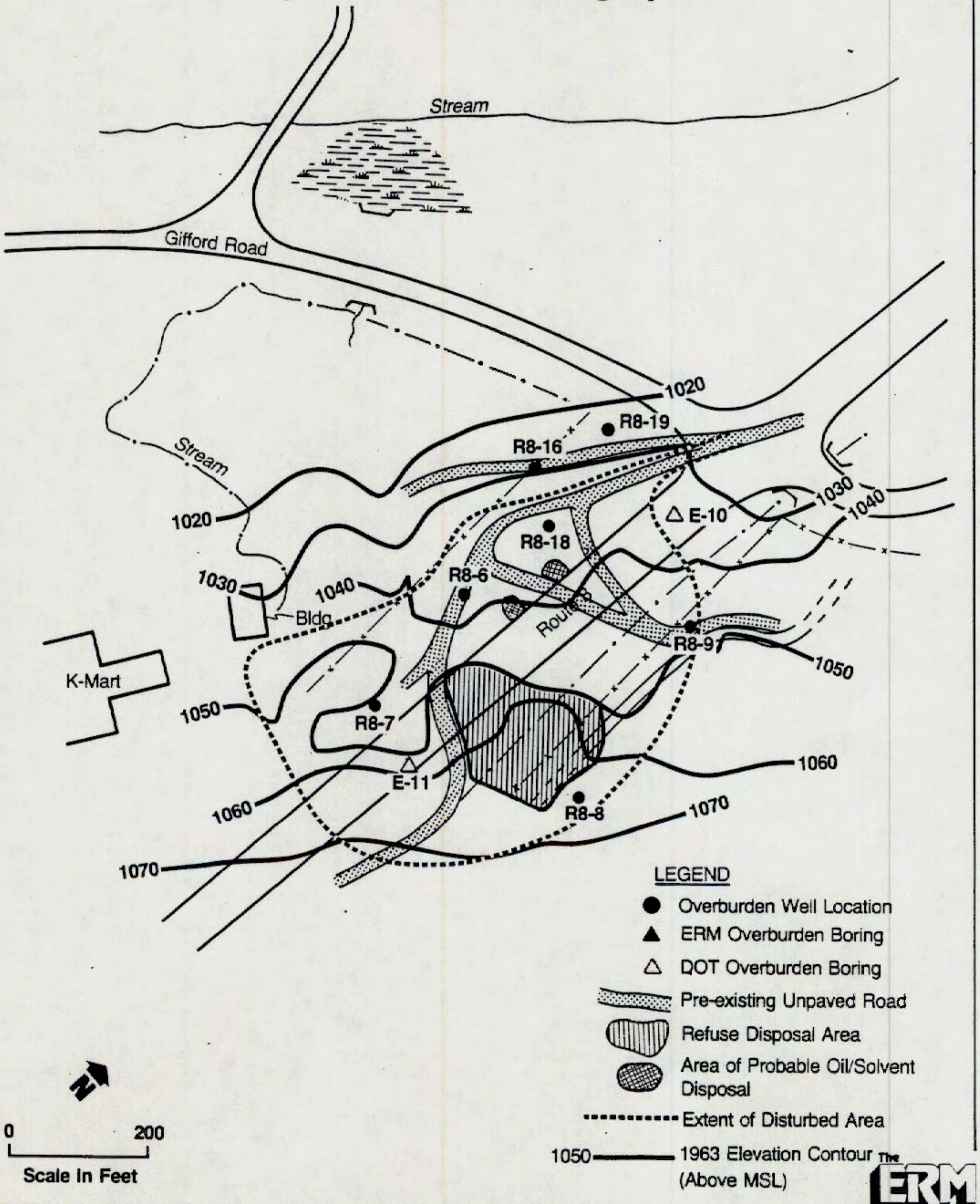


EXECUTIVE SUMMARY

Environmental Resources Management, Inc., has been retained by Amphenol Corporation to conduct investigations to define conditions associated with the Route 8 Landfill. This site was used by Bendix Corporation for disposal of trash and waste oils and solvents during the late 1950s and 1960s, and now underlies the New York State Route 8 roadway and right-of-way near Delaware Avenue and Route 8, in Sidney, New York.

The site investigations included the installation of 42 monitoring wells and 12 additional test borings over three phases of field investigation. Multiple rounds of ground water sampling and analysis were conducted, and soil and waste samples were collected and analyzed. Surface water and drainageway sediment samples were also collected and analyzed. Pump tests and slug tests were conducted at monitoring wells to define aquifer characteristics and pathways of waste constituent migration. In addition to the field studies, area ground water usage was defined, and existing literature and aerial photographs were analyzed to determine area geology and the history of the Route 8 Landfill usage.

The results of the investigations have revealed that PCBs and volatile organic compounds have migrated from the Route 8 Landfill area. The principal source area is a former disposal pit or trench which now lies beneath the west shoulder of Route 8. From this area, PCB has migrated in oil through a sand lens of limited extent, with discharge at the Gifford Road Spring approximately 300 feet west of the source area. As the PCBs have very limited solubility and adsorb onto the subsurface soils, migration in ground water and surface water has been limited, with none detected in the regional bedrock aquifer or in downgradient surface waters.

Volatile organic compounds have migrated from the source area in both a glacial overburden flow system, and the underlying regional bedrock flow system at concentrations up to several tens of thousands of ppb. The principal compounds of concern are toluene, ethylbenzene, 1,1-dichloroethane, trans 1,2 dicloroethene, trichlorethene, vinyl chloride and 1,1,1 trichlorethane. It was determined that site hydrogeologic conditions have allowed the vertical migration of the VOCs downward from the overburden, into the bedrock. In the bedrock the VOC plume is intercepted by pumping at the Unalam Corporation production well, which is used intermittently for cooling water. No wells used for potable water are affected by the Route 8 Landfill VOC plume, however.

Volatile organics are also present in seasonal site-related surface waters in the several hundred ppb concentration range. However, the Unalam Tributary, a second order tributary to the Susquehanna River, appears to receive VOCs only from the Unalam cooling water discharge. The major conclusions of this investigation are:

1. The principal source area for the waste constituents is a limited former pit or trench area which presently lies beneath the west lane and shoulder of Route 8, approximately 250 feet south of the intersection of Route 8 and Delaware Avenue.

2. PCB migration has occurred in solution in oil, and is concentrated in a permeable sand lens of limited extent, which discharges to the surface at the Gifford Road Spring and at smaller wet weather seeps.

3. PCB migration has been limited by its low solubility and adsorption onto subsurface soils, such that little migration has occurred in site-related surface waters.

4. PCBs are present in solution in shallow ground water near the source area at concentrations in the low ppb range; no PCBs were detected in the regional bedrock aquifer.

5. Migration of VOCs has occurred in the concentration range of tens of thousands of ppb in the ground water beneath and downgradient of the site in both the glacial overburden and regional bedrock aquifer.

6. No site-related VOCs are present in any well used for potable water.

7. The downgradient limit of the overburden plume is uncertain, as it appears that a second downgradient source of VOCs may be present. However, it is apparent that the presence of the lacustrine silty clay body in the path of the Route 8 Landfill-related plume limits the extent of its migration.

8. The bedrock VOC plume is diverted and almost fully contained by the cyclical pumping of the Unalam Production Well.

9. The Amphenol West Well pumping does not affect plume migration.

SECTION 1

SITE BACKGROUND

Environmental Resources Management, Inc., (ERM) has been retained by Amphenol Corporation to conduct a site investigation to define conditions associated with the Route 8 Landfill, Sidney, New York. This report and appendices contain the description and results of the hydrogeologic, soils and surface water investigations conducted at the site. The objectives of these investigations were to:

- define the nature and extent of the former landfill, and the waste characteristics;

- define the extent of migration of waste constituents in the soils, ground water, and surface water;

- define the hydrogeologic conditions and aquifer characteristics at the site; and

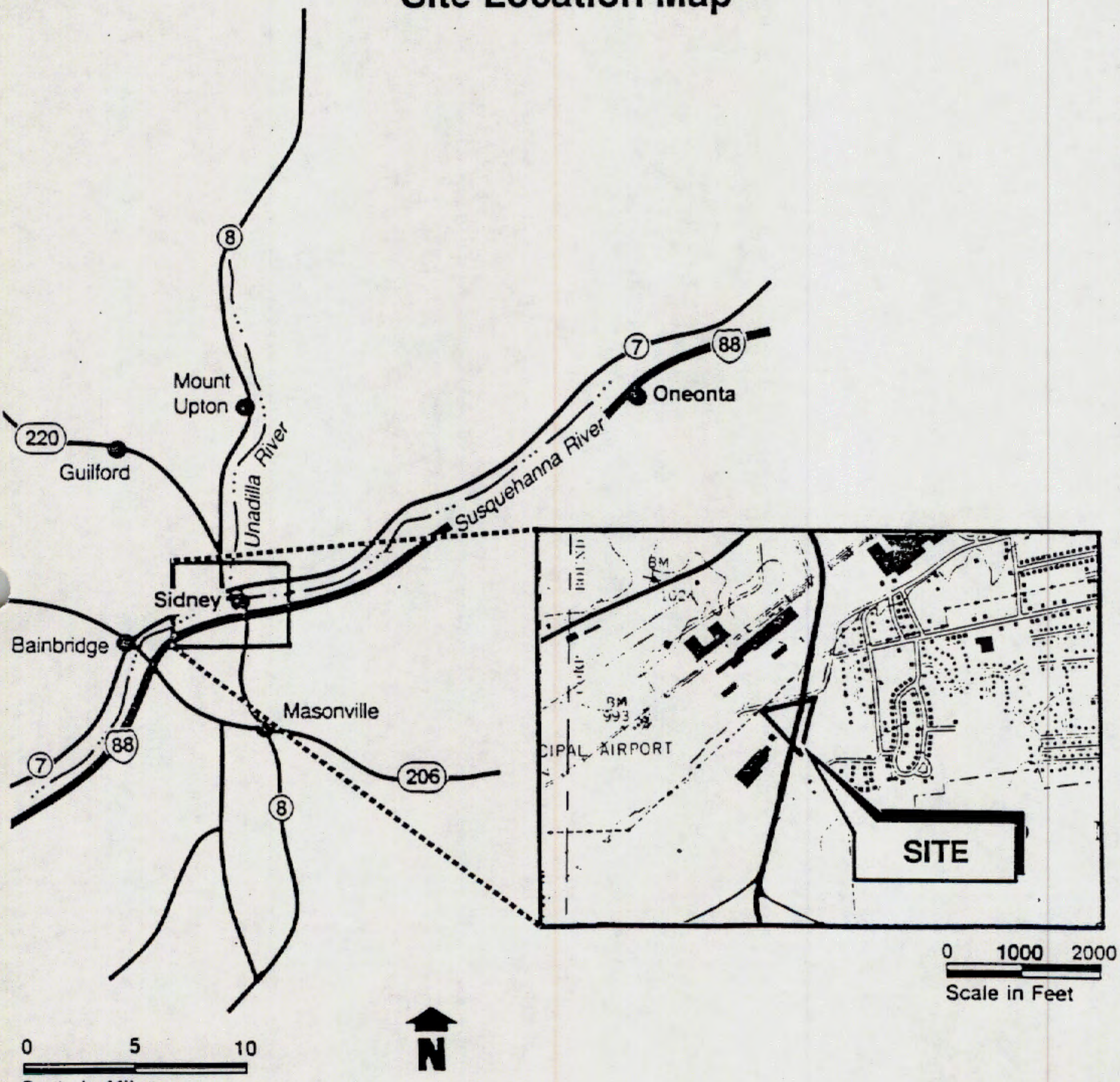
- provide a comprehensive data base for assessment of site impacts and evaluation of remedial alternatives.

1.1 Site History

The Route 8 Landfill facility was used by the Bendix Corporation (now Amphenol) for disposal and burning of solid and liquid wastes generated at the nearby Engine Products and Electrical Components divisions (now Amphenol Bendix Connectors Operations) plant. A general location map for the site is shown in Figure 1-1. It is located in Delaware County, New York, southwest of the intersection of New York State Route 8 and Gifford Road.

The Bendix plant manufactured electrical components during the time that the Route 8 Landfill was in use. The landfill was used primarily for disposal of industrial refuse. At that time the primary waste oil/solvent disposal facility was the Hill Site. However, some waste oils were disposed, and the experimental solvent burner was tested in the landfill area. The principal wastes associated with the facility were plant refuse, including waste connector parts and trash, waste oils, and waste solvents. Some of the waste oils may have been hydraulic and transformer fluids which contained polychlorinated biphenyls (PCBs). The solvents were used to degrease electrical components prior to

Figure 1-1
Site Location Map



electroplating; the principal solvent in use was trichloroethene (TCE). However, some other solvents, such as 1,1,1-trichloroethane (TCA) may also have been used in smaller quantities.

In 1981, Allied Corporation acquired the Bendix Electrical Components Division plant in Sidney. According to the updated chronology of waste disposal activities at the plant, as prepared by Allied-Bendix in 1984, the Route 8 Landfill was in use around the early 1960s. After closure of the nearby Hill Site disposal area in 1964, it appears that some waste oils and solvents may have been disposed in the Route 8 Landfill area. An experimental oil/solvent burning unit is believed to have operated adjacent to the landfill. The exact year in which the Landfill was closed is unknown; however, it appears to have been in the mid to late 1960s.

Allied-Bendix reported the existence of the former Route 8 Landfill to the USEPA and the New York State Department of Environmental Conservation (DEC) in transmittals dated 17 February 1984. At that time it was believed that only solid plant refuse had been disposed at the landfill. This appeared to be substantiated by a 1979 investigation of an oil and iron-bearing surface discharge west of the landfill area, hereinafter called the Gifford Road Spring. ETL Testing Laboratories, Inc. of Cortland, N.Y. sampled water and sediment at the discharge, and concluded that, "disturbed drainage, oil pollution from motorized vehicles, and relatively high natural content of iron and manganese in the soil have resulted in the reddish-brown 'froth' which occurs in this area" (ETL Testing Laboratories, 1979).

In December 1983, Allied-Bendix requested that ERM collect a water sample from the Gifford Road Spring for volatile organic compound (VOC) analysis. The results indicated the presence of 229 ppb total VOCs. Additionally, the presence of PCBs was detected in sediment samples obtained near the seeps. It was suspected by Allied-Bendix that these VOCs and PCBs might be related to the Hill Site disposal area, under study at the time. Subsequent installation of two monitoring wells between the Hill Site and the Route 8 Landfill indicated that the Hill Site was not the source of the discharge from the Gifford Road Spring. ERM was retained to conduct an investigation at the Route 8 Landfill, and has conducted that investigation between 1985 and 1987 in three progressive phases. This report describes these investigations and the results thereof.

1.2 Photochronology

ERM obtained aerial photographs of the Route 8 Landfill area from the years 1959, 1960, 1965, 1971, and 1981. The 1959 photography indicates some earth-moving activity at the site. To the south, the former Hill Site disposal pit is clearly visible. The 1960 photograph provided good coverage defining probable disposal activities at the site. Figure 1-2 shows the approximate refuse disposal area, two suspected oil disposal areas, and associated roads. Overlain is topography taken from a 1963 New York State Department of Transportation survey of the area. Also shown is the current location of New York State Route 8, which was built over the landfill area in the 1970s.

A Prenco waste oil incinerator was installed at the plant in 1969; thus oil/solvent disposal at the Route 8 Landfill had likely ended in the 1960s.

SECTION 2

EXISTING DATA REVIEW

ERM has defined the baseline conditions surrounding the Route 8 Landfill area through collection and review of existing data, including:

- published geology/hydrogeology reports;
- topographic maps;
- climatological information;
- knowledge gained from previous studies at the nearby Hill Site and Amphenol West Well; and
- an area well survey conducted by the New York State Department of Health (DOH).

2.1 Regional Geology/Hydrogeology

2.1.1 Geology

Southeastern New York lies within the glaciated northern portion of the Appalachian Plateaus physiographic province. This province is characterized by uplifted, nearly horizontal beds of alternating siltstone, sandstone, shale, some limestone, and seams of coal, through which rivers and streams have incised deep, narrow valleys. Later advances of Pleistocence glacial sheets widened and deepened many of these valleys. Final melting of the ice left deposits of till, a typically dense, unsorted deposit of boulders, cobbles, gravel, sand and silt; and glacial drift. Glacial drift deposits are generally subdivided by origin into glaciofluvial deposits, which consist of sorted sands and gravels deposited by meltwater, and glaciolacustrine deposits, which contain finer sand, silt, and clay deposited in lake environments created by the damming of rivers and meltwater streams by glacial ice and sediment deposits.

The Route 8 Landfill Site is located within an east-west trending section of the Susquehanna River valley. Outcrops observed in the valley walls include three interbedded yet distinct rock types:

- A dense, slightly fissile red, and gray siltstone;
- A less dense gray sandstone; and

- A dense, fissile, red shale with some gray siltstone interbeds.

Within the valley, the bedrock is overlain by deposits of glacial and alluvial origin. The composition of the overburden deposits varies from place to place, and depending upon location will include some or all of the following:

- overbank river alluvial deposits consisting of brown silt and fine sand;

- riverbed deposits consisting of rounded sand and gravel;

- glacial outwash consisting of sands and gravels;

- glacial till consisting of boulders, cobbles, gravel, sand, and silt, which varies in density depending upon location; and

- glaciolacustrine silts, sands and/or clays, deposited in lake environments.

The overbank and riverbed deposits are generally found at the land surface adjacent to the Susquehanna River. The glacially derived sediments are present throughout the valley and can also be found covering large portions of the valley walls.

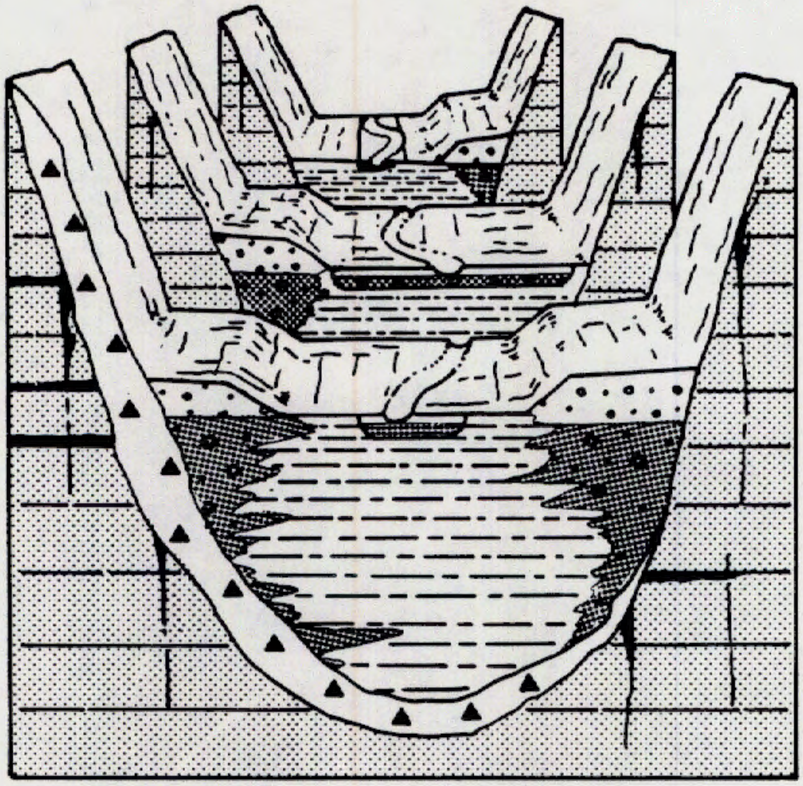
The various overburden units interfinger with one another, which adds to the geologic and hydrogeologic complexity of the area. Figure 2-1, modified from MacNish and Randall, (1982), shows the general relationship between the overburden units and the bedrock.

2.1.2 Hydrogeology

The hydrogeology of the Route 8 Landfill area can be roughly divided into two aquifer systems, the bedrock and the overburden. Within the bedrock aquifer, ground water moves primarily through joints, fractures, and along bedding planes, and to some extent through more permeable sandstone layers. At intersections of joints and fractures, joints and bedding planes, and bedding planes and fractures, ground water can move in either a horizontal or vertical direction. Yields from bedrock water supply wells in the region average about 20 to 60 gallons per minute (MacNish and Randall, 1982).

The overburden aquifer can be subdivided into the glacial till and the glacial drift aquifers. Wells constructed within the glacial till generally yield less than 0.5 gallons per minute (MacNish and Randall, 1982) because of the dense nature and amount of fine material within the till.

Figure 2-1
Simplified Geologic and Hydrologic Cross Section of the Susquehanna River Valley near Sidney, New York



LEGEND

- Sand and Gravel
- Lacustrine Silts, Clay, and Very Fine Sand
- Till
- Bedrock, with Fractures
- High-Yielding Aquifer Material
- Low-Yielding Aquifer Material

(Modified from MacNish and Randall, 1982)

Glacial drift deposits in the Susquehanna River valley provide the most important aquifer in the region. Yields of wells tapping these sediments depend upon the amount of fine materials present. Wells in sand and gravel can yield more than 1000 gallons per minute (Todd, 1983).

2.2 Area Ground Water Usage

Through the New York DOH well survey and the data accumulated in ERM studies of other Amphenol sites, the extent of local ground water use has been defined. Figure 2-2 is an area map showing the approximate locations of known existing and abandoned wells near the Route 8 Landfill. Table 2-1 lists the wells, depths where known, aquifer in use where known, and daily usage, where known. It can be seen that the major uses of area ground water are at the Amphenol plant 2500 feet northeast of the landfill, Village Well No. 1 5000 feet northeast of the landfill, and the Unalam Well 800 feet northwest of the landfill. Both the glacial overburden and bedrock aquifers are in use, with the bedrock used more toward the southern flank of the valley where glacial till and lacustrine deposits predominate, and the glacial overburden used farther out in the valley where permeable glaciofluvial deposits are available.

2.3 Ground Water Quality

The ground water quality data available came from the following sources;

- Amphenol studies at the West Well;
- Amphenol sampling at the North Well;
- Amphenol Studies at the former Wastewater Treatment Lagoons; and
- The DOH well survey, conducted in conjunction with the Amphenol Hill Site Study.

At each of these locations, wells had been sampled for VOC analyses.

It has been documented in previous studies that the West Well is affected by VOCs which originate at the Amphenol Plant site, with total VOC concentrations up to 120 ppb detected. It has also been documented that the ground water in the vicinity of the former lagoons contains VOCs of up to several hundred ppb. However, the Village of Sidney Well No. 1, approximately 700 feet east of the lagoons, has not been significantly affected, and a ground water recovery program at the lagoons now provides total protection for the Village Well.

TABLE 2-1

AREA GROUND WATER USAGE

WELL NO.	TYPE OR NAME	REPORTED DEPTH (FT)	AQUIFER	DAILY USAGE (GPD)
1	Abandoned Domestic	20	Glacial Overburden	0
2	Abandoned Domestic	15	Glacial Overburden	0
3A	Abandoned Domestic	shallow	Glacial Overburden	0
3B	Abandoned Domestic	200	Bedrock*	0
4	Village Maintenance Shop - Not Used	423	Bedrock	0
5	Unalam Products - Cooling Water	235	Bedrock	approx. 1000
6	Abandoned Airport Well	?	?	0
7	Active Domestic	?	?	350**
8	Active Domestic	?	?	350**
9	Inactive Domestic	?	?	?
10	Amphenol North Well - Process Water	155	Bedrock/Overburden	310,000
11	Amphenol West Well - Process Water	150	Bedrock/Overburden	468,000
12	Amphenol South Well - Limited Use	135	Bedrock/Overburden	<1000***
13	Limited Use Domestic	shallow	Glacial Overburden	<50
14	Domestic Spring - not used	surface	Glacial Overburden	
15	Active Domestic	178	Bedrock*	350**
16	Village of Sidney Well No. 1	approx. 200	Glacial Overburden and Bedrock	612,000

* Assumed from depth
** 350 gpd assumed for a family of 4.
*** Estimated - used only for lawn watering

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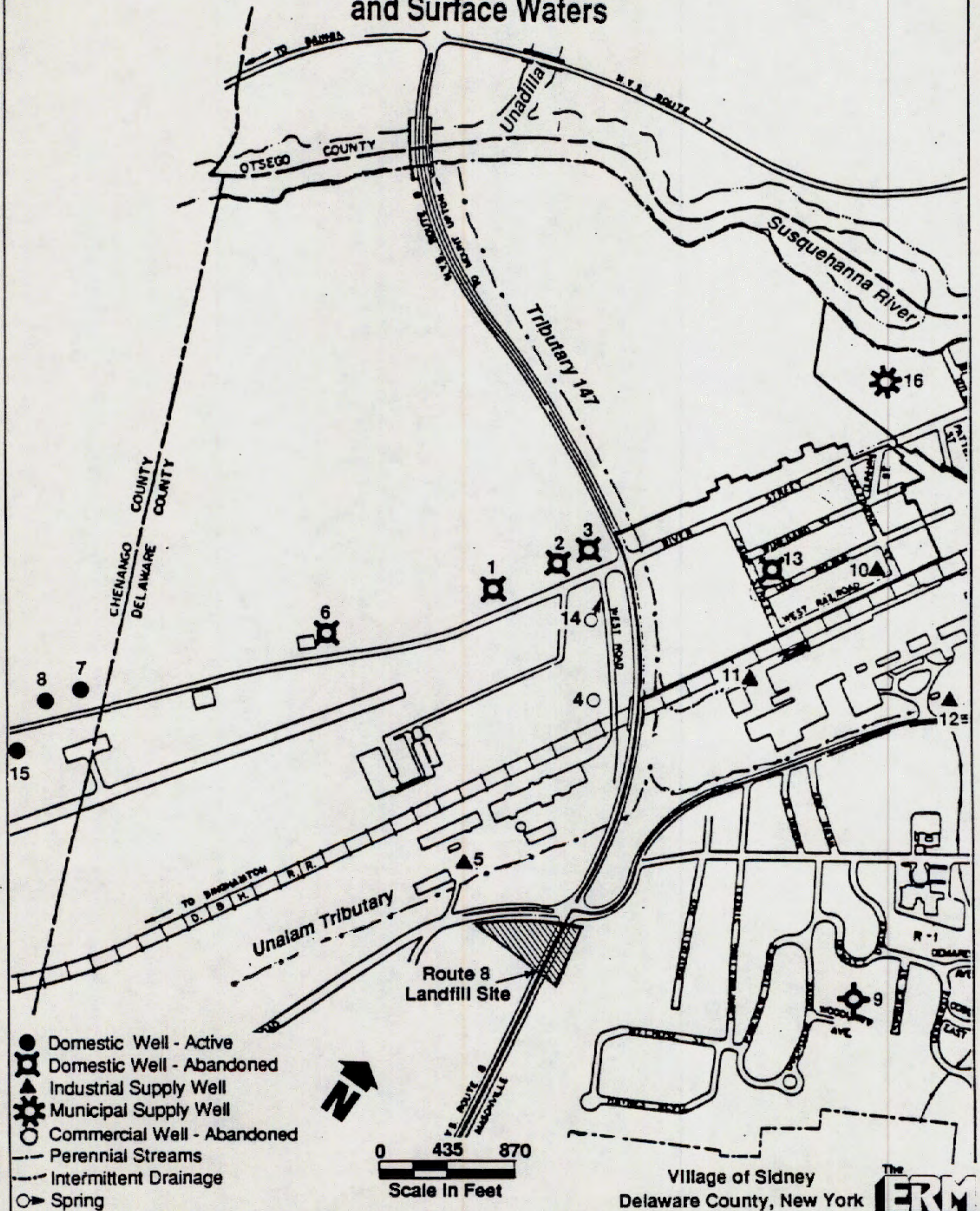
Figure 2-2
Area Ground Water Use and Surface Waters



Regarding domestic wells, well 13 (Figure 2-2) contained 3 ppb total VOC in the DOH sampling, which has been attributed to the West Well area.

Northwest of the Route 8 Landfill site, domestic wells 7, 8 and 15 contained no VOCs. However, the Unalam Well 800 feet north of the landfill contained a total of 2933 ppb of total VOCs, as shown in Table 2-2. Lastly, east of the landfill at Well 9, no VOCs were detected. The results of the Unalam Well analysis are discussed in Section 4.

2.4 Surface Water Hydrology

2.4.1 Areal Hydrology

The Route 8 Landfill site is located in the Susquehanna River Valley, a little over one mile south of the river. The area drainage pattern is shown on Figure 2-3. A first order tributary to the Susquehanna, named Tributary 147, flows in a re-routed channel southwestward in front of the Amphenol plant, then northward east of Route 8 to confluence with the river. A second order re-routed unnamed tributary, hereinafter called the Unalam Tributary, flows between the Route 8 Landfill and Unalam, and through a culvert under Route 8, to confluence with Tributary 147 at the west end of the Amphenol plant property. The only other significant area surface water is an intermittent drainageway along the west end of the Amphenol plant.

2.4.2 Site Hydrology

The Route 8 Landfill site surface water drainage is affected by both human-made and natural site features. The drainage pattern is shown in Figure 2-3. The southern edge of site, adjacent to the K-Mart plaza parking lot area, is bordered by a westward flowing drainageway. This drainageway is fed by water from a subsurface parking lot drain pipe located behind the K-Mart plaza. This feature, known as the K-Mart Drain, has been shown in previous studies to be affected by concentrations of volatile organic compounds (VOCs) of about 100 ppb, which appear to originate at the Amphenol Hill Site closed disposal pit. Water from this drainageway, which flows most of the year but may be dry during prolonged dry periods, enters the constructed Gifford Road drainage pattern in a small marshy area near Gifford Road. This drainage then proceeds southwest to a culvert under Gifford Road, and through a small channel into the Unalam Tributary, southwest of the Unalam driveway.

Approximately 300 feet downgradient of the former landfill area, surface water discharge occurs at the Gifford Road Spring. Some flow is present during most of the year, except during prolonged dry periods. The actual point of initial discharge from the ground "moves" seasonally with the rise and fall of the water

TABLE 2-2

DOH ANALYSIS RESULTS - UNALAM WELL - APRIL 17, 1984
(All Results in ug/l, or ppb)

trans-1,2-Dichloroethene	1900
Benzene	400
Vinyl Chloride	280
1,1-Dichloroethane	140
Trichloroethene	94
1,1,1-Trichloroethane	52
ortho-Xylene	30
1,2-Dichloroethane	20
Chloroform	20
Toluene	10
1,1-Dichloroethene	9
Ethylbenzene	5
2,3 Benzofuran	2
N-Propylbenzene	1

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Figure 2-3
Site Surface Water Drainageways

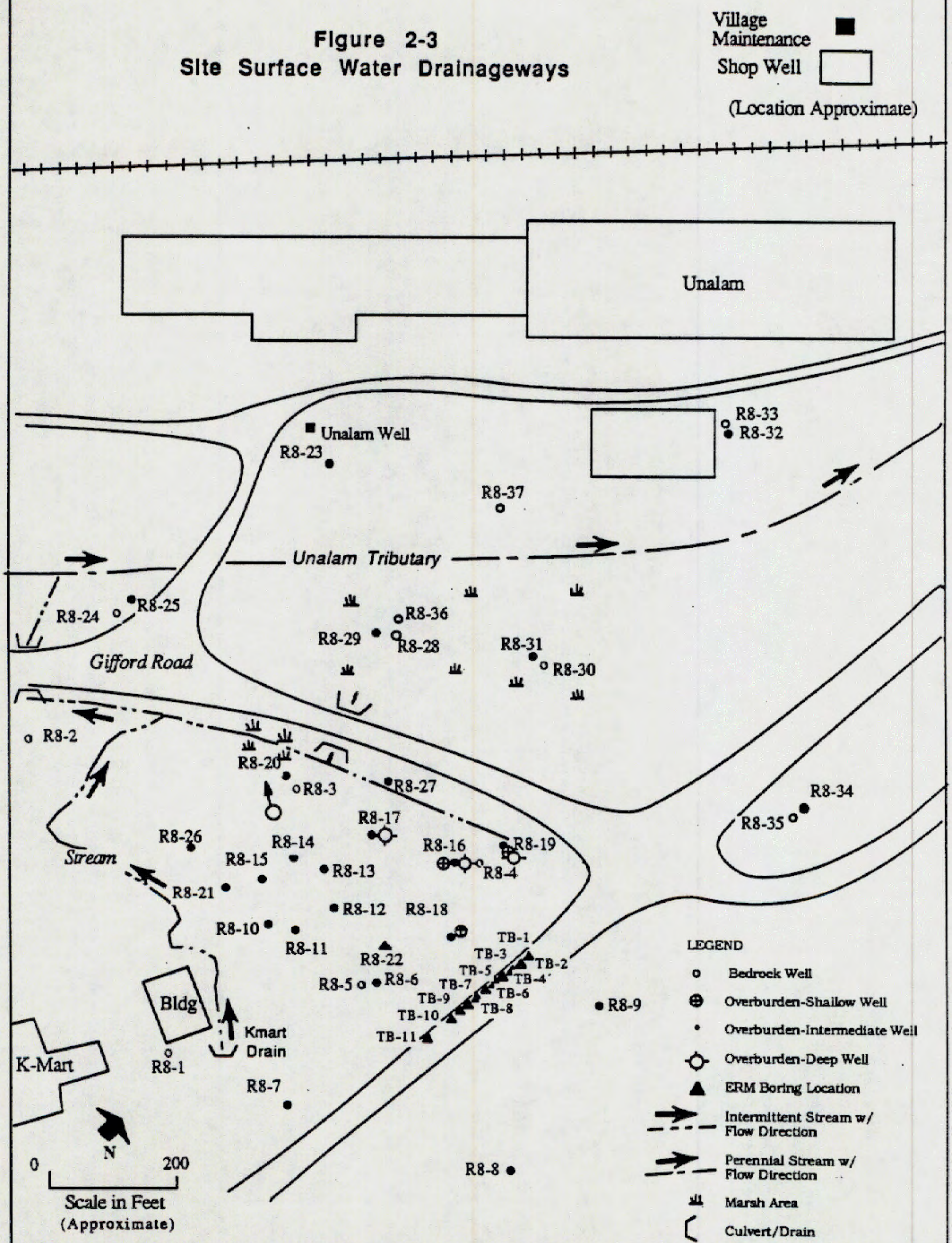

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table. Thus, during wet periods the discharge is from higher up the site topographic swale, and as drier conditions occur the discharge point moves down the swale, closer to Gifford Road.

The Gifford Road drainage has been created by the building of the steep road embankment northwest and west of the landfill area. Discharges to this area are from the Gifford Road Spring, and from seepage areas northeast and southwest of the spring which occur during wet season conditions. These discharges are channelled parallel to Gifford Road, and through a culvert northwestward, into a marshy ground water discharge area between Gifford Road and the Unalam Tributary. The discharges from the Gifford Road Spring and other seasonal seeps are discolored by iron precipitation, and the Gifford Road Spring discharge frequently contains an oil sheen.

North of Gifford Road, the culvert discharges iron discolored drainage into the marsh. In the spring of 1987, other discolored seeps were observed emanating from the north base of the Gifford Road embankment. Discharge to the marsh area is seasonal in nature, and the marsh is fairly dry during prolonged dry periods.

2.5 Climatology

The climate of the Sidney area is characterized as a humid, continental climate, with warm summers and long, cold winters. The average annual temperature ranges from 22°F in January to 69°F in July (NOAA, 1985). Average monthly temperatures during the period of 1951 to 1980 as recorded at the Bainbridge Station (approximately 5 miles from Sidney) are presented in Table 2-3.

The average annual precipitation for the Sidney area including both rainfall and the water equivalent of melting snow is 41 inches. Monthly precipitation averages during the period of 1951 to 1980 (at the Bainbridge Station) are also presented in Table 2-3. Winter snowfall is frequently heavy both in terms of individual storms and monthly amounts. Monthly snowfall in amounts in excess of 20 inches is common from December through March; yearly snowfall typically ranges from 70 to 100 inches (NOAA, 1985).

Prevailing wind is typically westerly throughout the year but there is a slight northwesterly tendency in winter and spring and a slight southwesterly tendency in summer and fall. Wind velocities are variable; however, velocities are typically less than 15 mph.

The movement of weather systems toward the northeastern part of the United States is the primary influence on the weather of the Sidney area. Weather conditions are usually cold and dry when the atmospheric flow is from the north or northwest; when the flow is from the south or southwest, it is usually warm and occasionally humid. Periodically, maritime weather sources reach

TABLE 2-3

MONTHLY NORMAL TEMPERATURE AND PRECIPITATION AT THE BAINBRIDGE, NEW YORK NOAA WEATHER STATION (1951-1980)

Month	Precipitation (inches)		Temperature (degrees F)
January	2.81		22.5
February	2.63		24.1
March	3.08		33.6
April	3.46		46.0
May	3.54		56.8
June	4.06		65.6
July	3.62		69.3
August	3.53		68.2
September	3.77		61.0
October	3.25		50.0
November	3.51		38.8
December	3.29		27.2
Totals	40.55	(Avg.)	47.0

Source NOAA, 1985.

Sidney from well developed storms and pressure systems off of the Mid- or North Atlantic Coast. This easterly air flow typically brings cloudy, damp, and relatively cool weather to the area. The Great Lakes are too distant to have a strong direct effect on the climate of this area.

SECTION 3

FIELD INVESTIGATIONS

3.1 Hydrogeology

A total of 42 monitoring wells and 12 test borings have been installed during the Phase I, II, and III field investigations by ERM. Figure 3-1 shows the locations of monitoring wells and test borings, as well as lines of geologic section presented and discussed in Section 4. The well locations were approved and in some cases selected by a New York State (DEC) representative.

3.1.1 Ground Water Monitoring Well Installation

Using the background data obtained from the study of air photographs and the Hill Site investigation, ERM designed the Phase I field investigation to define the hydrogeology and water quality associated with the immediate Route 8 Landfill area. Four monitoring wells installed during the Hill Site investigation were also incorporated into this investigation. Bedrock Wells 83-6 and 83-7 were incorporated into this investigation and were renumbered R8-1 and R8-2, respectively, and overburden wells 84-11 and 84-8 were renumbered R8-6 and R8-7.

ERM installed additional bedrock wells, overburden wells, and one additional control boring during the Phase 1 field investigation.

During Phase I (conducted in late February and early March 1985), three (3-inch I.D.) open hole bedrock wells were installed, and twenty (2-inch I.D.) PVC wells with slotted screens were installed in the glacial overburden. At locations R8-16, R8-17, R8-18, and R8-19, piezometer nests were installed in the shallow, intermediate, and deep overburden. An intermediate depth overburden well was installed at each of the remaining fourteen locations.

Upon conclusion of the Phase I field investigation, ERM implemented a Phase II investigation to address the following questions:

(1) What is the extent of the VOC plume in the western area of the site?

(2) Are the VOCs in the Unalam Well a result of Route 8 Landfill source materials?

(3) What is the full downgradient extent of the VOC plume in both the overburden and bedrock aquifers?

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Figure 3-1
Locations of Wells, Borings and Lines Of Geologic Section

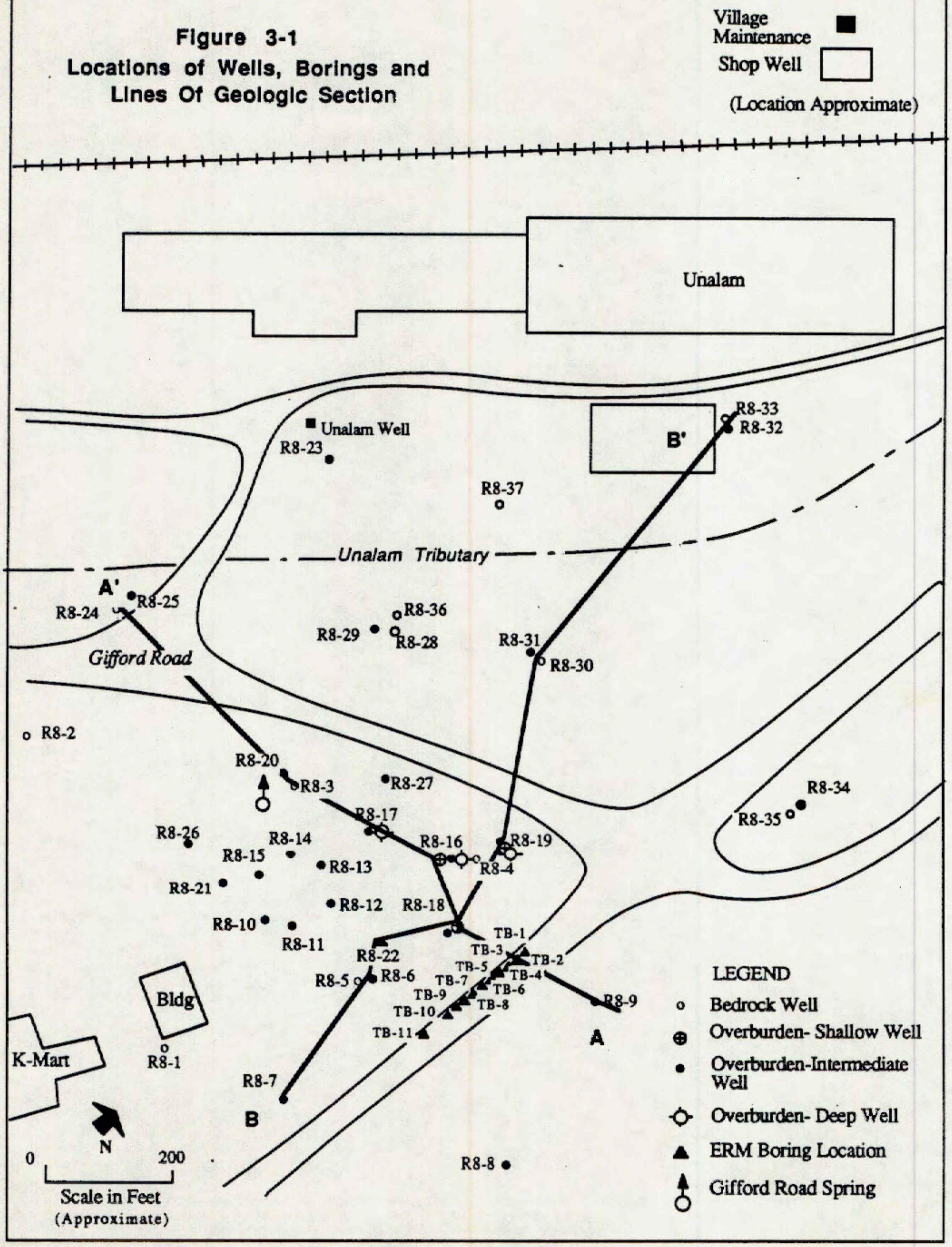

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TABLE 3-1

301.07

Monitoring Well Specifications

Route 8 Investigation
Sidney, NY

Well No.	Installation Date	Depth (feet)	Screened or Open Interval** (feet in depth)	Top of PVC Casing Elevation Measuring Point (feet above mean sea level)
R8-1	12/13-14/83(?)	116.0	20-116**	1028.51
R8-2	12/2/83	65.0	20-65**	1008.66
R8-3	2/27-28/85	49.0	20-49**	1007.15
R8-4	2/27-28/85	77.0	44-77**	1026.21
R8-5	3/1-2/85	61.0	31-61**	1039.18
R8-6	4/10/84	20.0	10-20	1039.70
R8-7	3/28/84&4/6/84	20.0	10-20	1054.07
R8-8	2/9-10/85	24.0	14-24	1066.53
R8-9	3/6/85	22.0	12-22	1047.22
R8-10	2/20-21/85	30.0	15-30	1027.69
R8-11	2/21/85	20.0	10-20	1023.98
R8-12	2/22&2/25/85	24.0	14-24	1028.12
R8-13	-	16.0	6-16	1019.08
R8-14	2/26/85	17.0	7-17	1016.85
R8-15	-	15.0	10-15	1017.65
R8-16-S*	2/27/85	10.0	5-10	1027.04
R8-16-I*	2/26/85	30.0	20-30	1024.83
R8-16-D*	2/26/85	39.0	34-39	1025.21
R8-17-I	3/4-5/85	20.0	10-20	1018.12
R8-17-D	3/4-5/85	33.0	28-33	1019.42
R8-18-S	3/5/85	12.0	7-12	1034.94
R8-18-I	3/4-5/85	24.0	19-24	1034.59
R8-19-S	3/5/85	10.0	5-10	1024.92
R8-19-I	3/5/85	24.0	19-24	1024.63
R8-19-D	3/5/85	38.0	33-38	1026.30
R8-20	3/5/85	20.0	15-20	1006.98
R8-21	3/5/85	18.0	8-18	1022.05
R8-23	6/3/85	50.0	40-50	994.67
R8-24	6/3-4/85	74.0	54-74**	1001.44
R8-25	6/4/85	30.0	20-30	1001.73
R8-26	9/4/85	20.0	10-20	1016.25
R8-27	9/4/85	25.0	15-25	1013.94
R8-28	9/6-10/85	60.0	40-60**	992.91
R8-29	9/10/85	25.0	15-25	992.68
R8-30	9/12-13/85	65.5	45-65.5**	993.32
R8-31	9/11/85	25.0	15-25	993.73

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TABLE 3-1
(Continued)

301.07

Monitoring Well Specifications
Route 8 Investigation
Sidney, NY

Well No.	Installation Date	Depth (feet)	Screened or Open Interval** (feet in depth)	Top of PVC Casing Elevation Measuring Point (feet above mean sea level)
R8-32	3/2-3/87	89.0	79-89	991.95
R8-33	2/16-20/87	120.0	95-120**	993.71
R8-34	3/4-5/87	30.0	20-30	1028.21
R8-35	3/5-6/87	59.0	39-59**	1028.50
R8-36	3/4-6/87	140.0	90-140**	992.84
R8-37	2/25-27/87	87.0	68-87**	1003.61
R8-22	3/6/85	24.0		1034.47
TB-1	4/20/87	14.0		1042.48
TB-2	4/20/87	16.0		1043.11
TB-3	4/20/87	18.0		1043.49
TB-4	4/21/87	35.5		1043.94
TB-5	4/21/87	20.0		1044.56
TB-6	4/21/87	18.0		1045.21
TB-7	4/21/87	15.0		1045.81
TB-8	4/22/87	17.5		1046.49
TB-9	4/22/87	35.0		1047.09
TB-10	4/22/87	22.0		1047.75
TB-11	4/22/87	14.0		1049.86

*

S - Shallow Glacial Overburden Well
I - Intermediate Glacial Overburden Well
D - Deep Glacial Overburden Well

To resolve questions (1) and (2) ERM installed overburden wells R8-26 and R8-23, respectively. To determine the downgradient extent of VOC plume migration, ERM installed bedrock/overburden well clusters R8-24/25, R8-28/29, and R8-30/31, and intermediate depth well R8-27. Monitoring well clusters in the overburden were not deemed necessary because of the relatively uniform vertical distribution of VOCs in the overburden, as seen during Phase I.

The Phase II monitoring wells were installed in June and September, 1985. After the wells were developed, allowed to stabilize for one week, and sampled, VOC concentrations detected in monitoring wells R8-30 and 31 led ERM to propose a limited Phase III field investigation to finalize the definition of downgradient VOC migration.

During February and March 1987, seven Phase III monitoring wells were installed. Monitoring wells R8-32 and R8-33 were installed along the downgradient axis of the VOC plume as defined in Phase II, to investigate the degree of migration in the overburden and the bedrock aquifers. Wells R8-34 and R8-35 were placed to define the eastern extent of VOC migration. Deep bedrock well R8-36 was installed adjacent to shallow monitoring well R8-28 to assess the potential for vertical VOC migration in the bedrock aquifer. Monitoring well R8-37 was installed near the Unalam Well to obtain hydrogeologic information regarding the overburden and bedrock aquifers near the Unalam Well, to monitor the effects of pumping from the Unalam well, and to determine if VOCs detected in the Unalam Well are related to the Route 8 Landfill VOC plume.

3.1.2 Drilling/Well Installation Methods

Bedrock wells R8-3, R8-4, R8-5, R8-24, R8-28, R8-30, R8-33, R8-35, and R8-37 were installed by drilling with six-inch I.D. hollow stem augers one foot into the bedrock, removing the augers, and placing four-inch I.D. steel casing into the borehole and grouting to the surface with a 90% Portland cement-10% bentonite mixture. The boring was then cored using an NX (3-inch O.D.) diamond drill bit. The wells were cored ten feet below the first significant water-bearing zone encountered in the bedrock aquifer, and finished as an open borehole.

Deep bedrock well R8-36 was installed by grouting in place four-inch casing one foot into the bedrock. To obtain continuous bedrock core for defining bedrock conditions, four-inch O.D. HQ coring was conducted to 90 feet, through which three-inch steel pipe was installed and grouted to the surface. The well was completed by NX coring to 140 feet, and finished as an open borehole.

Overburden wells R8-6 through R8-22, R8-25 through R8-27, R8-29, and R8-31 were drilled using the hollow stem auger method, while R8-23, R8-32, and R8-34 were installed by using mud rotary drilling methods due to problems with borehole integrity using augers. Inert, inorganic drilling mud was used. Two-inch I.D. PVC screens with 0.010-inch slot size and two-inch I.D. flush joint PVC risers were used in constructing the monitoring wells. The two-inch wells were screen-packed with No.1 size sand, sealed with a bentonite pellet plug, and tremie-grouted to the surface, where they were each finished with a five-foot, four-inch O.D. section of protective steel casing with a locking cap.

The newly installed monitoring wells were developed by either surging with compressed air, jetted water, pumping or bailing. Table 3-1 summarizes the monitoring well installation data for all monitoring wells installed during the Phase I, II and III field investigations.

3.1.3 Test Borings

During Phase III, eleven test borings were drilled along the west shoulder of Route 8 to investigate suspected areas of oil and solvent disposal identified in the 1960 aerial photographs of the site. These areas are depicted in Figure 1-2, and the boring locations are shown in Figure 3-1. Ten borings were spaced at twenty foot intervals, while an eleventh boring was located sixty feet south of the southernmost boring to define the margin of a landfill detected area. Nine of these borings were advanced to the water table and two others were drilled to the top of the bedrock to obtain additional information regarding the subsurface stratigraphy. All borings were backfilled with cuttings and capped with a cement/bentonite mix.

Split soil barrel samples were collected and retained by an ERM hydrogeologist for visual inspection and classification. Total volatile organic concentrations were measured from the headspace in the sample jars, using a flame ionization organic vapor analyzer (OVA). Samples were either obtained continuously, or, in the case of uniform stratigraphy, obtained when strata changes were detected by observing the drilling rig's response to augering.

Rock samples were obtained by coring with a five foot diamond bit core barrel. Each core was measured for recovery and rock quality, and retained by ERM for further inspection.

3.1.4 Slug/Pump Testing

3.1.4.1 Slug Tests

Following the completion of the Phase II well installation program, a series of rising head slug tests was performed by ERM at several wells in order to evaluate the hydraulic conductivity of the overburden and bedrock flow systems. Additional slug tests were conducted at newly installed bedrock wells as part of the Phase III field investigation. These tests were conducted by placing pressure sensitive transducers down each well, below the initial water level (H_i), and then rapidly lowering the water level to a new level (H_n). The water level was lowered by either pumping water out of the well or placing a solid tube, or slug, down well, below the water level. Both of these methods cause an instantaneous change in the water level. The rate at which each well recovered (i.e., time taken for H_n to return to H_i) was recorded by an In-Situ Model SE 1000B Hermit Environmental Data Logger. The rate of recovery yields information regarding the ability of the aquifer adjacent to the screened or open interval of the well to transmit water.

3.1.4.2 Pump Test

In mid April 1987, wells R8-23, R8-24, R8-25, R8-28, R8-36, and R8-37 were monitored over a six day period to assess the impact of the Unalam Well on the bedrock and overburden systems. In early June 1987 six additional wells (R8-4, R8-20, R8-30, R8-31, R8-32, and R8-33) were monitored over the weekend period to obtain additional information regarding the responses of the overburden and bedrock system to pumping of the Unalam Well.

The Unalam Well is an eight-inch diameter, approximately 235 foot deep bedrock well which supplies cooling water to the Unalam Plant. The well is turned on each morning and off each night, Monday through Friday. Each morning after being turned on the Unalam Well pumps steadily at 23 gallons per minute for approximately 15 minutes. After the first 15 minutes, during which the plant cooling water system is brought to operating capacity, the Unalam Well runs on twelve minute cycles consisting of four minutes on and eight minutes off.

The monitoring wells were monitored by placing pressure sensitive transducers below the water level in each well. Hermit data loggers were programmed to collect depth to water measurement from the transducers every three minutes for the first test, and every 15 minutes during the second test. These data were used to derive drawdown diagrams for the bedrock and overburden aquifer systems,and estimates of ground water conditions in the bedrock system.

3.1.5 Ground Water Sampling and Analysis

All of the monitoring wells at the Route 8 Landfill site were sampled after the completion of the Phase I and Phase II monitoring well installation programs. Phase I monitoring wells were first sampled in mid March 1985.

The wells were purged a minimum of three well volumes with an ISCO 2600 non-contact well sampler, and sampled by ERM. After the water levels recovered, PVC bailers were used to collect ground water for analysis for VOCs. Laboratory-supplied 40 ml glass vials with the teflon-lined septa were used. Also, two one-quart glass jars were also collected for analysis of PCB and oil and grease. Several wells were also sampled for priority pollutant metals analyses. Measurements of ground water pH and conductivity were taken in the field. All of the samples were submitted to O'Brien and Gere Laboratory Inc., Syracuse, New York for analysis.

After Phase II well installation was completed, ERM collected ground water samples from all of the Route 8 Landfill site monitoring wells. Phase I approved sampling procedures were followed. Phase II samples were submitted to Lancaster Laboratories Inc., Lancaster, Pennsylvania for analysis.

In early April 1987, ERM sampled the newly installed monitoring wells and resampled previously installed wells R8-4, 6, 9, 10, 12, 16-I, 16-D, 17-I, 17-D, 18-S, 18-I, 19-I, 19-D, 20, 23, 25, 26, 27, 29, and 31. Additionally, samples were collected from the Gifford Road Spring and the Unalam Well. Before sampling, ground water was evacuated from each well with a centrifugal pump, submersible pump, or by bailing by hand until three well volumes were removed or the well ran dry. After water levels recovered, the wells were sampled with dedicated PVC bailers, using laboratory supplied 40 ml vials with Teflon-lined lids for VOC analysis and pint glass jars with Teflon lined lids for PCB and oil and grease analysis (See ERM's Standard Operating Procedures, Appendix A). The samples were kept at four degrees Celsius, and submitted for analysis to Lancaster Laboratories, Inc., Lancaster, Pennsylvania. Samples from three source area wells, R8-4, R8-18S and R8-18I, and from the Gifford Road Spring were analyzed for full Hazardous Substance List (HSL) compounds to fully characterize all constituents which might be migrating from the waste disposal area into ground water and surface waters.

During Phase III, ERM also sampled two additional wells. A sample of the non-contact cooling water pumped from the Unalam Well was obtained at a discharge valve to the system. Another well located north of the site at the Village of Sidney maintenance shop (hereinafter the VM Shop well) was sampled at two discrete depths. This well has a total depth of 423 feet, and was purged by lowering a submersible pump to 150 feet and removing three well volumes of water. A Kemmerer sampler was then used to obtain ground water samples at depths of 150 and 400 feet. This device consists of a hollow brass barrel that is lowered to a particular depth interval to be sampled. A messenger is then sent to seal the water in the barrel, and the sampler is brought forth to the surface. The Kemmerer sampler was decontaminated between sampling events, following ERM's Standard Operating Procedures (Appendix E). Table 3-2 lists the parameters analyzed for at each sampling event during the three phase investigation.

TABLE 3-2

SUMMARY OF PARAMETERS ANALYZED IN GROUND WATER

	Mar-85	Sep-85	Oct-85	Apr-87
R8-1	VOAs;PCB;Oil & Grease			
R8-2	VOAs;PCB;Oil & Grease			
R8-3	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		
R8-4	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		HSL
R8-5	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		
R8-6	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		VOAs;PCB
R8-7	VOAs;PCB;Oil & Grease;PP Metals	VOAs;PCB;Oil & Grease		
R8-8	VOAs;PCB;Oil & Grease;PP Metals	VOAs;PCB;Oil & Grease		
R8-9	VOAs;PCB;Oil & Grease;PP Metals	VOAs		VOAs;PCB
R8-10	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		
R8-11	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		
R8-12	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		VOAs;PCB
R8-13	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		
R8-14	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		
R8-15	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		
R8-16S	VOAs;PCB;Oil & Grease		VOAs	
R8-16I	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		VOAs;PCB
R8-16D	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		VOAs;PCB
R8-17I	VOAs;PCB;Oil & Grease;PP Metals	VOAs;PCB;Oil & Grease		VOAs;PCB
R8-17D	VOAs;PCB;Oil & Grease;PP Metals	VOAs;PCB;Oil & Grease		VOAs;PCB
R8-18S	VOAs;PCB;Oil & Grease;PP Metals			HSL
R8-18I	VOAs;PCB;Oil & Grease;PP Metals	VOAs;PCB;Oil & Grease	Total phenols	HSL
R8-19S	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		
R8-19I	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		VOAs;PCB
R8-19D	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		VOAs;PCB
R8-20	VOAs;PCB;Oil & Grease;PP Metals	VOAs;PCB;Oil & Grease		VOAs;PCB
R8-21	VOAs;PCB;Oil & Grease	VOAs;PCB;Oil & Grease		
R8-23		VOAs;PCB;Oil & Grease	Total phenols	VOAs;PCB
R8-24		VOAs;PCB;Oil & Grease		
R8-25		VOAs;PCB;Oil & Grease		VOAs;PCB
R8-26		VOAs;PCB;Oil & Grease		VOAs;PCB
R8-27		VOAs;PCB;Oil & Grease		VOAs;PCB
R8-28		VOAs;PCB;Oil & Grease		
R8-29		VOAs;PCB;Oil & Grease	Total phenols	VOAs;PCB
R8-30		VOAs;PCB;Oil & Grease		
R8-31		VOAs;PCB;Oil & Grease		VOAs;PCB
R8-32				VOAs;PCB
R8-33				VOAs;PCB
R8-34				VOAs;PCB
R8-35				VOAs;PCB
R8-36				VOAs;PCB
R8-37				VOAs;PCB
Unalam		VOAs;PCB;Oil & Grease	Total phenols	VOAs;PCB
VM Shop				VOAs;PCB

VOAs = Volatile Organic Analysis
PCBs = Polychlorinated Biphenyls
PP Metals = Priority Pollutant Metals
HSL = USEPA Hazardous Substance List

3.2 Soil Sampling and Analysis

To assess potential PCB migration at the site, selected split spoon soil samples from the water bearing zones were submitted for total PCB analysis during the Phase I investigation. In addition, selected soil samples obtained from continuous split spoon sampling of the Phase III test borings through the Route 8 Landfill were sent to Lancaster Laboratories for PCB, oil and grease, and total VOC analysis. Two of the samples of the landfill material were analyzed for the USEPA Hazardous Substances List (HSL) volatile organics to verify by GC/MS analytical methods the compounds associated with the site. Decontamination of the split spoon between samples consisted of washing the spoon with an Alconox solution and rinsing with deionized water, followed by an acetone rinse. The spoon was allowed to dry before a final rinse with deionized water.

Samples for total VOC analysis were collected in laboratory-provided glass jars with Teflon-lined lids, as were some of the samples analyzed for PCBs and oil and grease. Other samples were selected for PCB/and oil grease-analysis after sampling and, since they were retained in glass jars without Teflon-lined lids, VOC analysis was not conducted.

3.3 Surface Water and Sediment Sampling

Prior to the Route 8 Landfill investigation, three water samples were collected at the Gifford Road Spring and analyzed for VOCs. In addition, one sediment sample was collected and analyzed for PCBs. Also prior to the beginning of the Route 8 Landfill investigation, a surface water/sediment sampling program had been conducted in conjunction with the Hill Site Investigation. For this study, samples were collected north of Gifford Road Spring, at the end of the culvert north of Gifford Road, and in the Unalam Tributary upstream, in front of Unalam, and before the culvert under Route 8 (Figure 3-2). Both the water and sediments were analyzed for VOCs, and the sediments for PCBS also. Samples were also collected at the Gifford Road Spring in 1983, 1984, and during the Phase I investigation in March 1985.

As part of the Phase II field investigation, ERM sampled surface water for VOCs, PCBs, and oil and grease; and sediments for PCBs and oil and grease, at several locations near the Gifford Road Spring and a small, intermittent drainage originating near an abandoned block building northeast of the K-mart. During the Phase III field investigation, several areas of seepage were observed north of Gifford Road at the base of the steep roadway bank. ERM sampled three of these seeps and collected surface water and soil samples in laboratory-provided glass jars with Teflon-lined lids. Figure 3-2 shows sampling locations of the Phase II and Phase III surface water and sediment sampling

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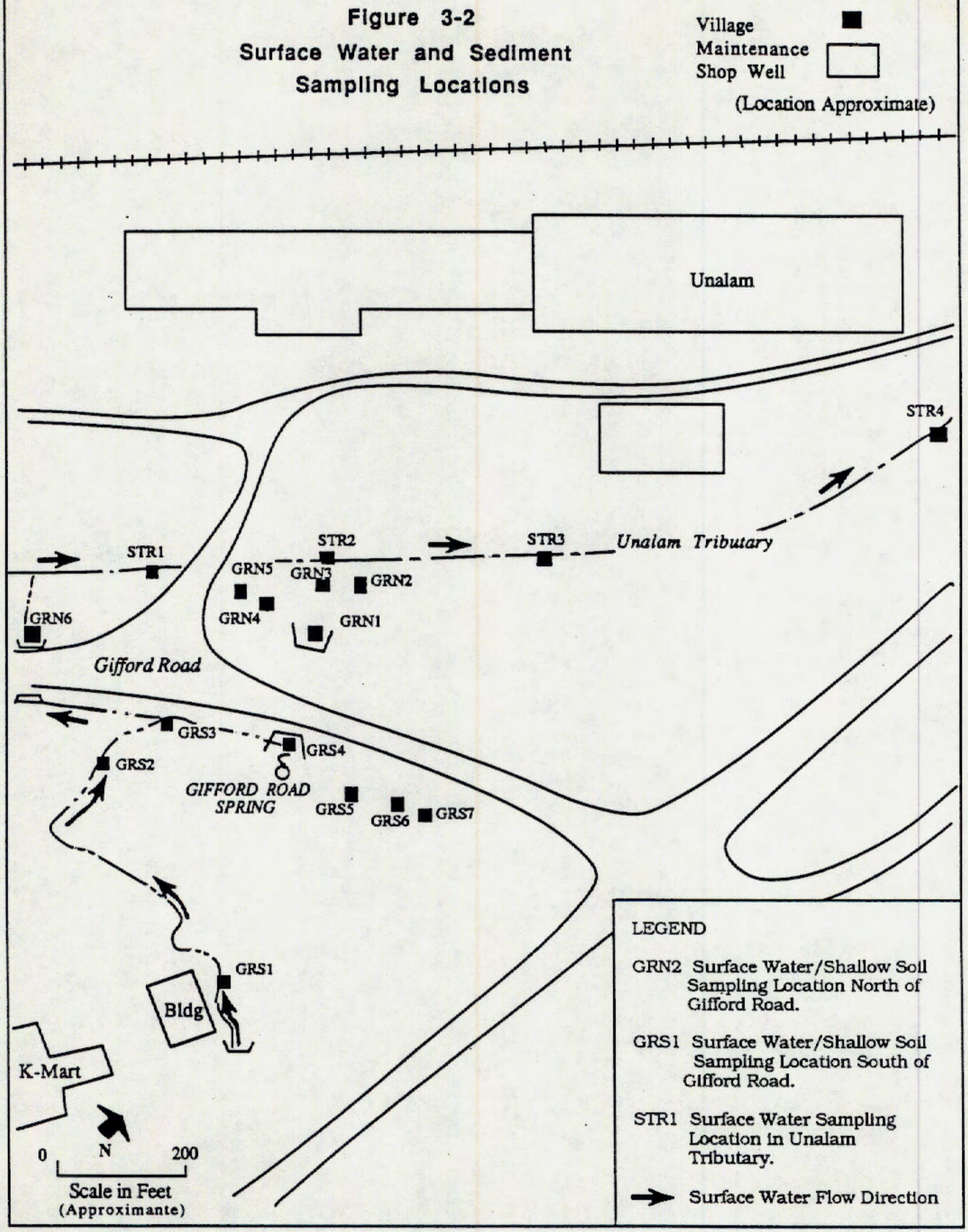
Figure 3-2
Surface Water and Sediment Sampling Locations



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locations. Sediment samples were collected with a stainless steel hand auger. The auger was decontaminated between samples with an Alconox wash, deionized water rinse, acetone rinse, and final deionized water rinse. Surface water samples were collected directly into the sample jars.

SECTION 4

RESULTS OF FIELD INVESTIGATION

4.1 Site Geology

The geology of the Route 8 Landfill site, as depicted by well and boring logs and photogeologic interpretation conducted by ERM, consists of variable amounts of glacial sediments (ranging in thickness from 8 feet at R8-1 to 95 feet at R8-32/33) overlying a north to northwestward-sloping bedrock surface.

Detailed descriptions of the materials encountered in drilling monitoring wells and borings are included as Appendix B. Figure 4-1 is an east-west geologic cross section through the Route 8 Landfill, illustrating the geologic conditions influencing the migration of site-related compounds through the subsurface. Figure 4-2 is a south-north geologic cross section depicting the site geology downgradient from the source area along the axis of VOC plume migration. The locations of the lines of geologic section are shown in the well location map presented as Figure 3-1.

The glacial deposits at the site are characterized by wide variations in composition, density, and lateral and vertical extent. The principal stratigraphic units encountered at the site, from youngest to oldest, are as follows.

- Recent Deposits - The surficial two feet near the Route 8 Landfill site generally consists of brown silty loam. Locally, bog deposits (grey silty clay and organic debris) were logged in test borings conducted in the swampy region north of Gifford Road.

- Glaciofluvial Deposits - Several borings west of Route 8 and south of Gifford Road penetrated deposits of brown, green, and grey sorted sands and gravels interpreted to be glacial outwash and till reworked by fluvial processes. The most consistent outwash is a sand unit west of Route 8 and south of Gifford Road that reaches a maximum thickness of 13 feet in overburden well R8-12. This unit extended to the area of the boreholes just north of Gifford Road.

- Glaciolacustrine Deposits - Soft, red brown silty clays were encountered in the northern region of the site while installing monitoring wells R8-32, R8-33, and R8-37. These fine-grained deposits are typical of sediments deposited in a lake environment, created by streams and meltwater dammed by glacial ice and/or

Figure 4-1
Geologic Cross Section A-A′

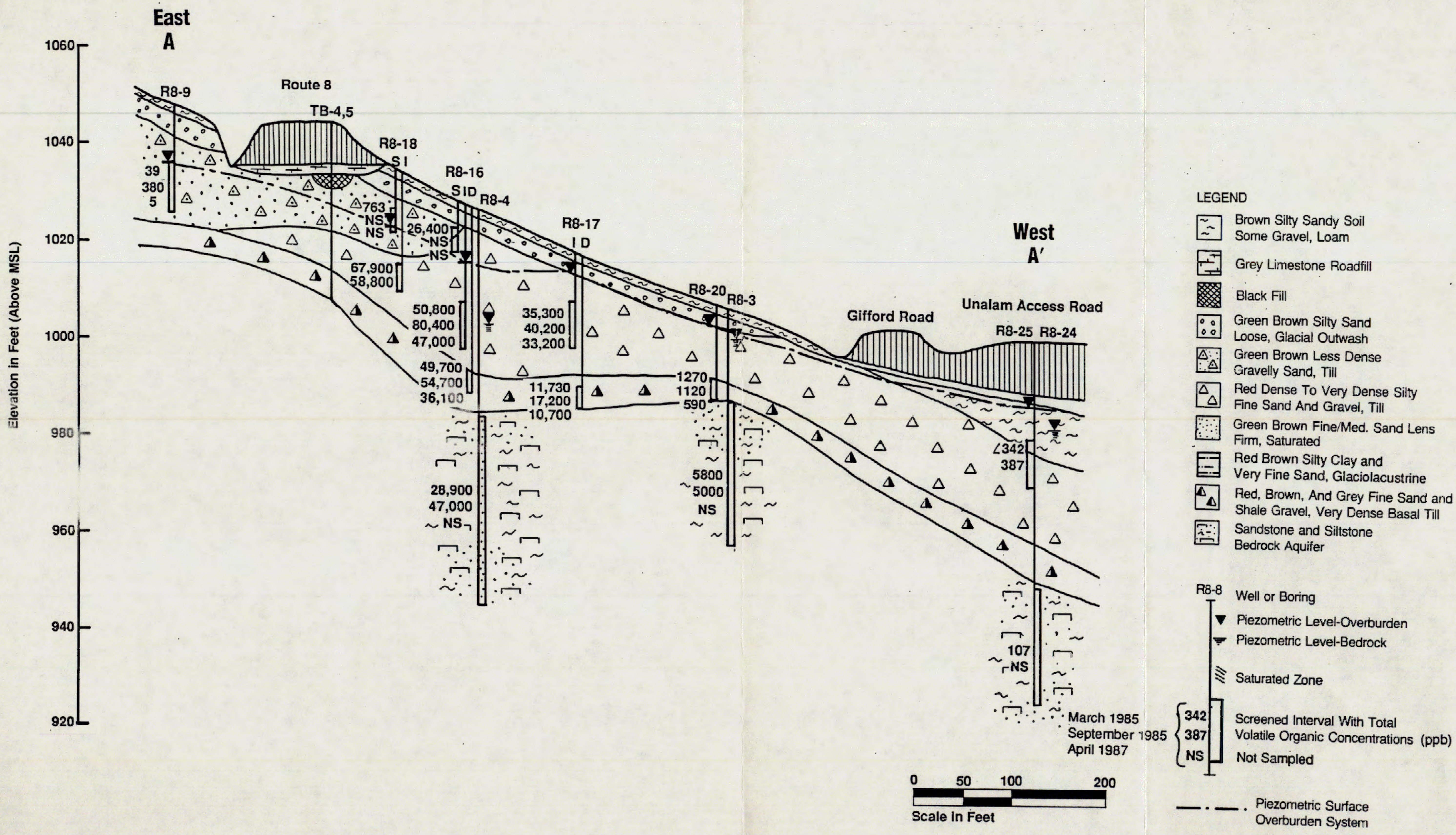

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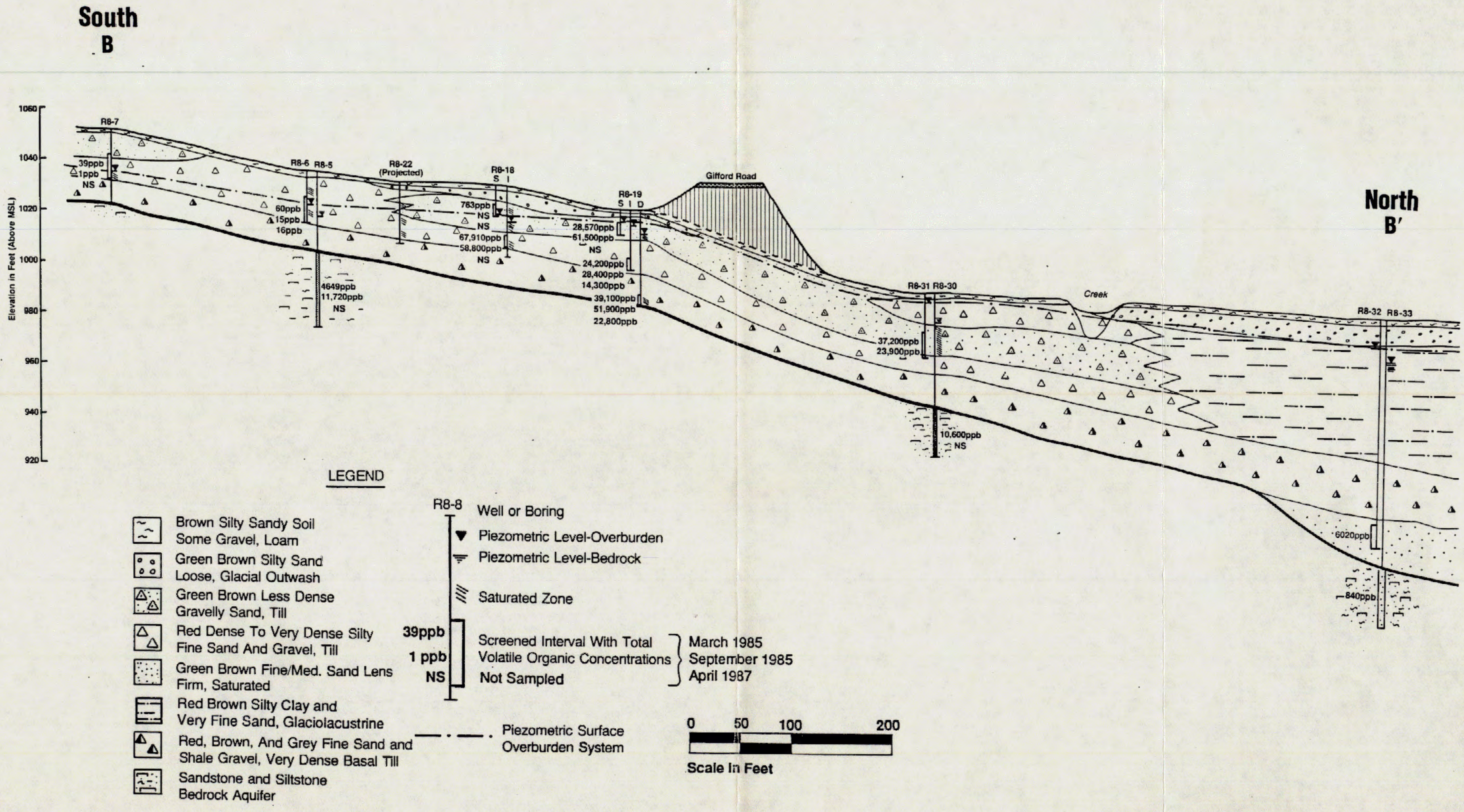
Figure 4-2
Geologic Cross Section B-B′



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deposits. A maximum thickness of approximately 45 feet of these sediments was encountered at Well R8-33. A log of the Village of Sidney Maintenance Shop Well, north of the Route 8 Landfill site, suggests that these lake deposits persist and thicken northward to over one hundred feet.

- Glacial Till - Unsorted glacial till consisting of gravel, sand, silt and clay-sized particles is present at all monitoring well and test boring locations at the site. Three major subunits were classified at the site based upon their color, density, and fine fraction:

    - A sandy-green to red brown till was encountered at well locations R8-18, R8-19, R8-30, R8-35 and in test borings TB-1,2,3,4,5,6,7, and 8 in the eastern portion of the site. This unit contains little or no silt, and amounts of fine to medium sand that increase its hydraulic conductivity relative to the other till units.

    - A dense, red till interfingers with and underlies the brown till throughout most of the site. This unit is denser, and has a higher fraction of silt and fine sand than the brown till. Ground water occurs in saturated thin lenses of gravels within the till which are separated by thick sequences of drier, finer till sediment.

    - A basal till ranging in thickness from three to ten feet represents the most consistent unit recorded at the site. This deposit appears similar to the overlying red till, except that a higher degree of compaction has increased the density of the basal till. Typically dry in the finer sections and sometimes moist to saturated in thin coarser zones, the basal till represents a lodgement till situated on top of bedrock at all locations except R8-32/33, where it overlies a sand layer perhaps related to pre-glacial Susquehanna River deposition. Large boulders (up to 9.5 feet maximum diameter) were encountered in drilling several of the monitoring wells through the basal till.

- Bedrock Unit - The bedrock underlying the Route 8 Landfill site consists of interbedded red, grey, blue-grey, and green siltstone and shale layers of the Catskill Formation of Upper Devonian age, with some sandstone lenses or stringers. Thin seams of pyrite and coal were observed in many of the core samples. The strata exhibit horizontal or very gently dipping bedding, and have fractures, joints, and bedding plane partings that locally increase the hydraulic conductivity of the rock. The bedrock is well cemented, except along certain fractures where the rock has been weathered to clay by the movement of ground water through zones of secondary permeability.

The bedrock topography at the Route 8 Landfill site provides pertinent information concerning the mechanism of glacial deposition, and consequential factors which influence ground water flow at the site. Figure 4-3 is a top of bedrock structure contour map. It shows the bedrock surface dipping towards the valley as would be expected, but with a slight flattening or depression in the area of R8-12 and R8-13. Figure 4-4 is an isopach (thickness) map showing the sand outwash unit, and the brown sandy till. The brown sandy till sits on the bedrock high while the sand outwash unit was deposited on the flatter, depressed bedrock area.

4.2 Source Area Definition

4.2.1 Results of Boring Program

Figure 4-5 is a geologic cross section through the test borings augered along the west shoulder of Route 8. The road construction fill penetrated by these borings included approximately ten feet of till borrow material on top of 0 to 3 feet of crushed limestone gravel. The till has been highly compacted by rollers during road construction, and was dry at the time of drilling. The limestone was distributed over the previously existing land surface which, at this location, was the former landfill and associated roadways.

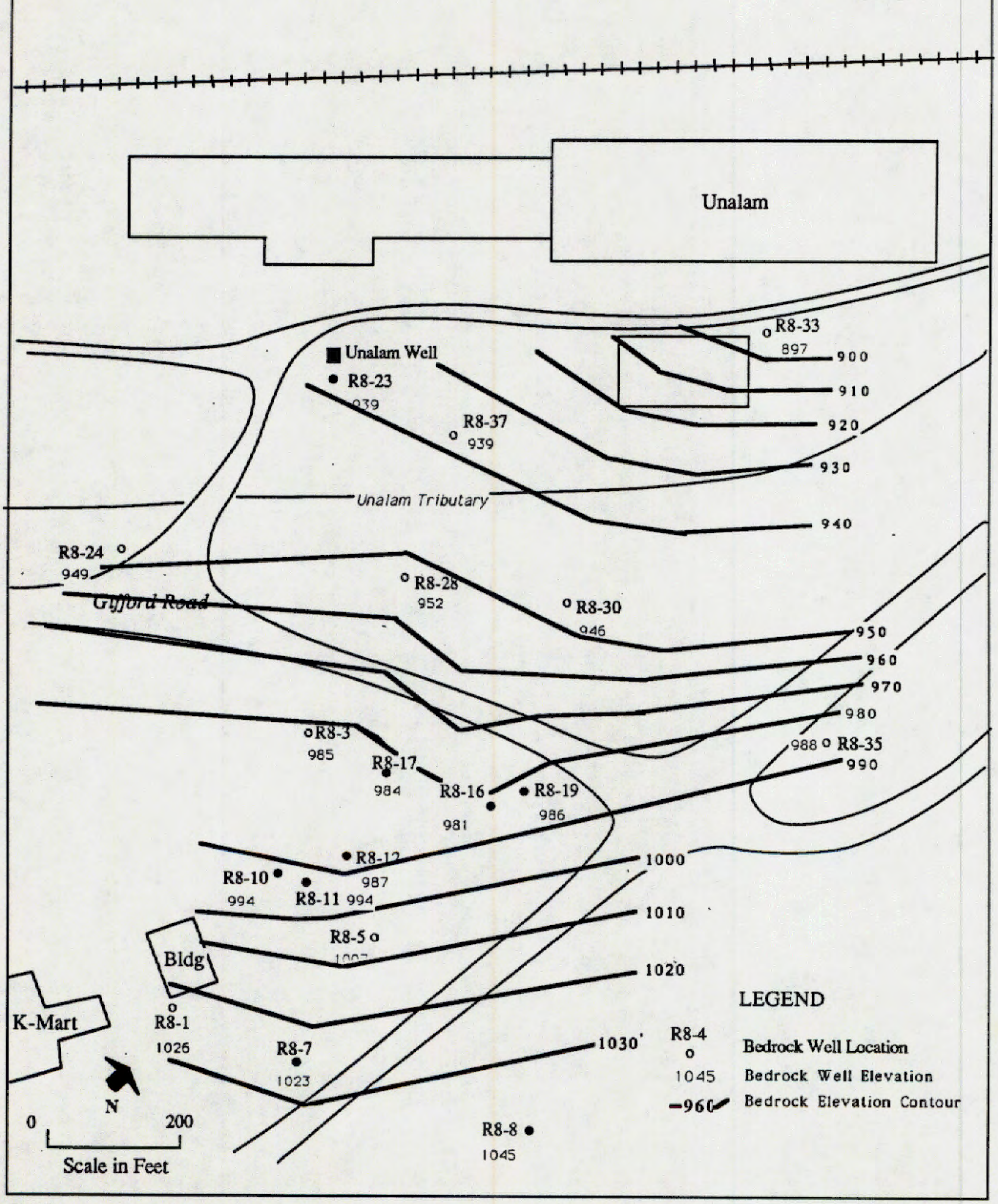
The two suspected oil disposal areas delineated by ERM from the 1960 aerial photographs (Figure 1-2) were penetrated by the borings, one at TB-5, and the other at TB-9 and TB-10. Material from both areas appeared similar: a loose, black ash containing various metal and ceramic fragments and layers of red, orange, white, and green sandy material of unknown origin. The northern area (Area 1) is about 30 to 35 feet wide, with waste materials about three feet thick; the southern area (Area 2) is larger, about 60 to 70 feet wide and ten feet thick. The appearance of these areas on the 1960 aerial photographs suggests that they are circular in shape and therefore of limited areal extent.

Split spoon samples collected in those boreholes not penetrating landfill materials, but at similar depth, were of a compacted, oil stained, unsorted silt, sand, and gravel deposit. These samples penetrated landfill roadways seen in the historic aerial photographs. The oil staining is likely the result of oil spraying on the roads in summertime for dust control.

The brown sandy till unit is present beneath Area 1, underlain in turn by the dense red till and basal lodgement till. Beneath Area 2 the dense red till predominates, underlain by the lodgement till. Bedrock was encountered at about 40 feet below

Figure 4-3

Structure Contour Map - Bedrock Surface



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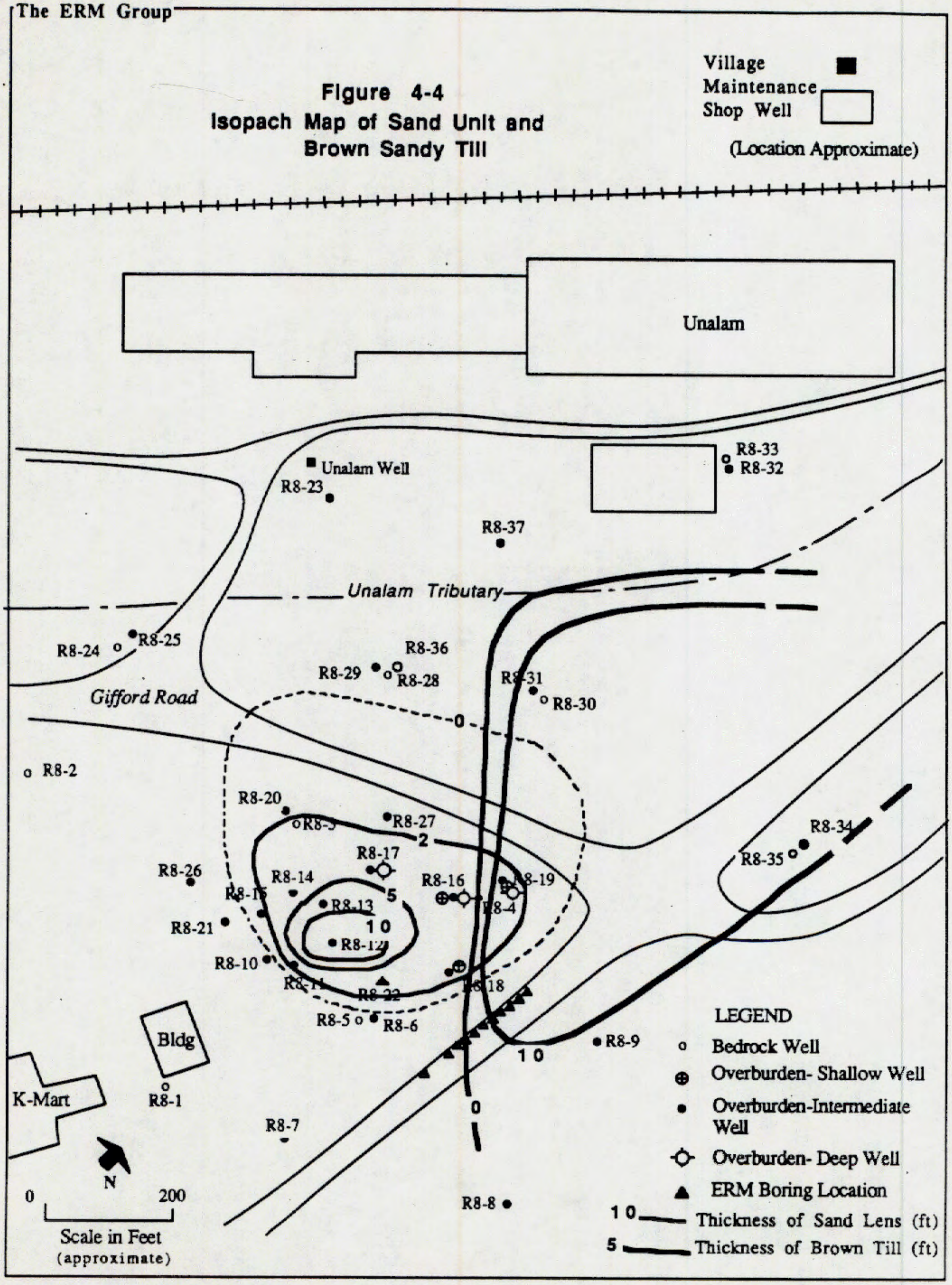
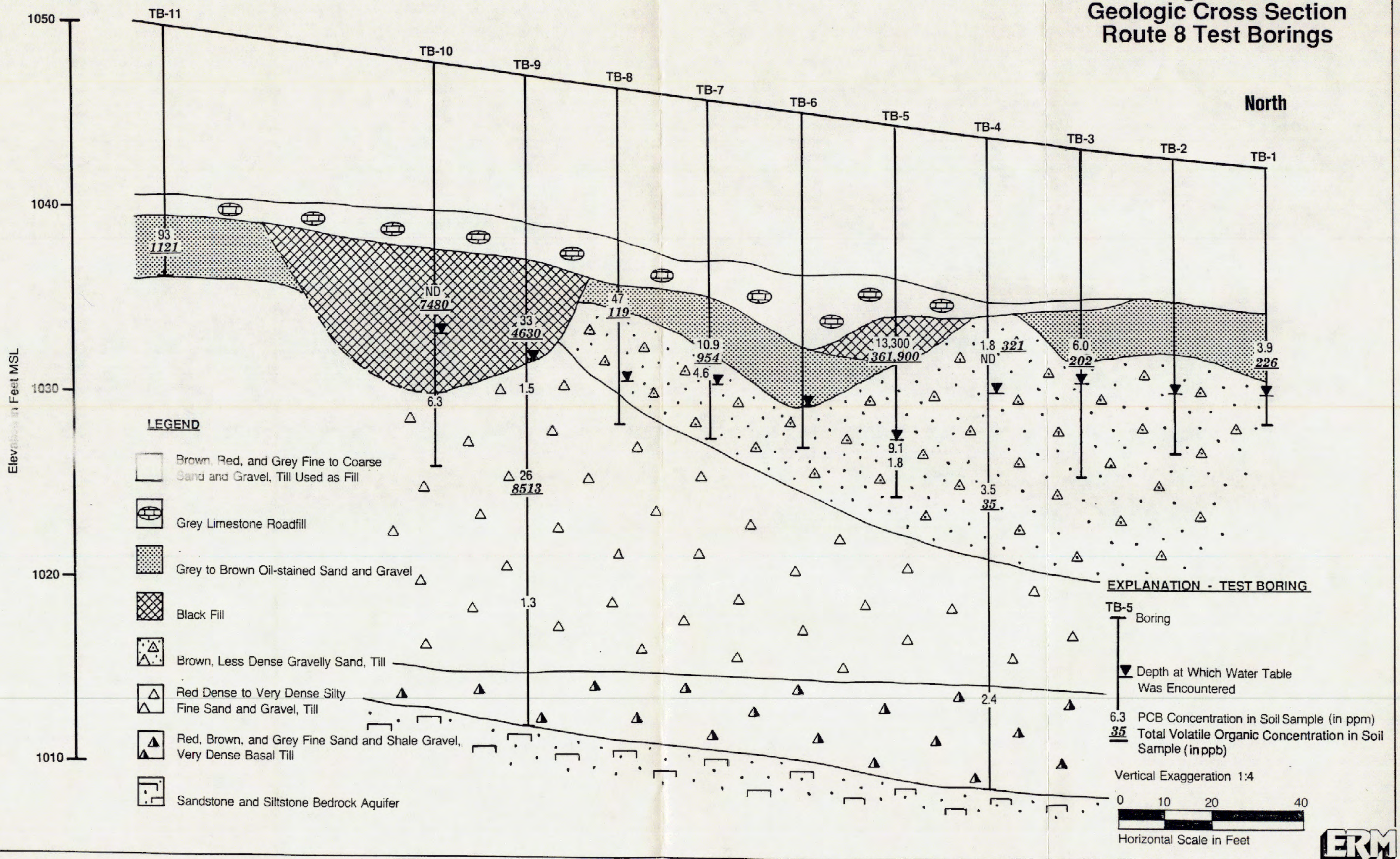


Figure 4-4
Isopach Map of Sand Unit and Brown Sandy Till

Figure 4-5
Geologic Cross Section Route 8 Test Borings



the Route 8 road surface. The ground water table was encountered at a depth of about 15 to 20 feet, and was below Area 1, but within Area 2 (Figure 4-5).

4.2.2 Waste Area Analysis Results

ERM collected soil and waste samples for analysis from the test borings through the Route 8 Landfill. Table 4-1 lists the results of these analyses. Laboratory data sheets are included in Appendix C.

Logs of the Route 8 test borings and analytical results from the samples obtained from the borings indicate that the primary source area at the site is the Area 1 industrial fill penetrated in boring TB-5. Concentrations of PCBs ranged up to a high of 13,300 ppm within the landfill material at boring TB-5. VOC concentrations in boring TB-5 totaled 361,900 ppb. The compounds detected included principally toluene, with lower concentrations of xylenes, ethylbenzene, trans-1,2,-dichloroethene, and trichloroethene. Waste disposal Area 1 appears to have been a trench or pit excavated in the brown sandy till. A primary avenue for waste constituents migration from this area is westward in the brown sandy till, and into the sand outwash unit, as depicted in cross section A-A' (Figure 4-1).

The larger disposal area, Area 2, contained thicker deposits of ash-type materials, with concentrations of PCBs ranging from 1.2 to 33 ppm and VOC concentrations averaging around 7500 ppb, orders of magnitude less than the concentrations detected in Area 1 at test boring TB-5. The VOCs detected were the same as those in Area 1, with some low ppb concentrations of 1,1,1-trichloroethane, 1,1-dichloroethane, and chlorobenzene.

Between and surrounding Areas 1 and 2, the oils detected in the subsurface may be attributed to dust control on roadways accessing the landfill. Samples of oil stained, compacted, dry fine sand and gravel encountered in all other test borings consistently showed some PCB concentrations, ranging from 1.8 ppm in TB-4 to 92.7 ppm in TB-11.

4.3 Hydrogeology

Ground water at the Route 8 Landfill site occurs in two principal aquifer systems: the glacial overburden and the bedrock flow systems. As will be discussed later, the piezometric levels and water quality data indicate that the two systems are hydraulically connected.

4.3.1 Glacial Overburden System

The Glacial Overburden system can be subdivided into two or more flow components, depending on location.

TABLE 4-1
WASTE DISPOSAL AREA CHARACTERIZATION RESULTS (PPB)

	BORING LOCATIONS	SAMPLE DATE	PCBs (ug/kg)	OIL (Soxhlet Ext. %)	TOTAL VOLATILES (ug/kg)	BENZENE	CHLORO-BENZENE	TOLUENE	ETHYL-BENZENE	TOTAL XYLENES	TRANS-1,2-DICHLORO-ETHENE	TRICHLORO-ETHENE	1,1-DICHLORO-ETHANE	METHYLENE CHLORIDE	1,1,1-TRICHLORO-ETHANE	2-BUTANONE	ACETONE
Q	TB-1 10-12'	4/20/87	3,880	0.032 B	226			66			140						
Q	TB-3 10-12'	4/20/87	5,960	0.032 B	202			117			85						
Q	TB-4 10-12'	4/21/87	1,820	0.032 B	321			278			43						
	TB-4 12-14'	4/21/87	ND	0.041	---	---	---	---	---	---	---	---	---	---	---	---	---
Q	TB-4 18-20'	4/21/87	3,510	0.187	35			35									
	TB-4 30-32'	4/21/87	2,370	0.859	---	---	---	---	---	---	---	---	---	---	---	---	---
Q	TB-5 10-12'	4/21/87	13,300,000	6.90	361,900			260,000	7,100	82,000	7,100	5,700					
	TB-5 16-18'	4/21/87	9,120	0.209	---	---	---	---	---	---	---	---	---	---	---	---	---
	TB-5 18-20'	4/21/87	1,750	0.068	---	---	---	---	---	---	---	---	---	---	---	---	---
Q	TB-7 12-14'	4/21/87	10,900	0.033 B	954			654			160	140		33 B			
	TB-7 14-16'	4/21/87	4,630	0.055	---	---	---	---	---	---	---	---	---	---	---	---	---
Q	TB-8 10-12'	4/22/87	46,700	0.086	118.6		6.6	110 J									21 B
Q	TB-9 12-14'	4/22/87	33,400	0.128	4,630			2100 J		140	1,400	990 J				1870 B	640 B
	TB-9 16-18'	4/22/87	1,600	0.086	---	---	---	---	---	---	---	---	---	---	---	---	---
Q	TB-9 22-24'	4/22/87	26,300	0.434	8,513	379	22	5,010	2,870		22				410		
	TB-9 28-30'	4/22/87	1,290	0.498	---	---	---	---	---	---	---	---	---	---	---	---	---
Q	TB-10 12-14'	4/22/87	ND	0.054 B	7,480		27	703			2400	4200	150	27 B			
	TB-10 18-20'	4/22/87	6,260	0.259	---	---	---	---	---	---	---	---	---	---	---	---	---
Q	TB-11 10-12'	4/22/87	92,700	0.138	1,121			829 J	32 J		140	120					

All of the above results are reported on a dry weight basis.
All of the results are measured in ug/kg, unless otherwise indicated.
All blanks = none detected. ND = none detected.
Dashed lines indicate sample was not analyzed for volatiles.

Qualifier Codes:
B - This result is of questionable qualitative significance since this compound was detected in blank(s) at similar concentrations.
Q - These sampling results have undergone an ERM Quality Assurance Review.
J - This result should be considered a quantitative estimate.

- Shallow Overburden - This component occurs in the shallow sand outwash unit west of Route 8 and south of Gifford Road. During wet seasons of the year, ground water flow in this unit, above the denser underlying tills, discharges as natural springs from the area of monitoring well nest R8-19 westward to the Gifford Road Spring. These seeps are intermittent, and cease flowing during the drier summer and fall seasons. Seasonal seeps on the north side of Gifford Road suggest that flow continues in the thin section of the sand unit which extends beneath the road (Figure 4-4).

- Intermediate Overburden - Wells screened in the red and brown tills monitor what is classified as the intermediate overburden component. These tills are generally compact and somewhat dense, although discontinuous local thin gravel zones significantly increase the effective hydraulic conductivities. Joints in the till (Flint (1971), P. 159) may also contribute to the hydraulic conductivity of the component, especially in the vertical direction.

- Deep Overburden - The top-of-bedrock zone in the basal lodgement till unit represents a deep overburden ground water component closely related to the bedrock aquifer system.

As suggested by the above descriptions, the hydraulic conductivity of the overburden system varies widely. Table 4-2 lists the hydraulic conductivities obtained from overburden wells during the field investigation. The slug test evaluation methods and calculations are shown in Appendix D. Slug test methods for evaluating unconfined aquifers were used.

The two hydraulic conductivity (K) values calculated for the glaciofluvial sand were very similar, averaging 23.55 ft/day. In the red till, which is the principal unit through which flow occurs in the study area, the K values ranged from 0.04 ft/day in the dense sections, to 2.22 ft/day in a sand and gravel stringer. The denser red till K values averaged 0.06 ft/day, while the more permeable, thin stringers averaged 2.0 ft/day. The brown sandy till had an average K of 1.15 ft/day, and the basal till 0.045 ft/day.

4.3.2 Bedrock System

Ground water flow within the bedrock is anisotropic, being controlled mainly by secondary permeability (joints, fractures, and along bedding planes) and, to some extent, by primary permeability in local sandstone layers. The presence of high permeability zones within the bedrock was evident during the drilling of deep bedrock well R8-36, when water introduced into the borehole during coring began flowing at a fairly high rate

TABLE 4-2
Results of Slug Tests of Overburden and Bedrock Wells

Overburden Wells

Well Number	Hydraulic Conductivity* (ft/day)	Well Elevation (TOC)	Open hole or Screened interval (ft)	Strata Description
R8-10	2.22	1028	15-30	Sand and gravel, silt and gravel, (Gravel unit in Red Till)
R8-11	1.78	1024	10-20	Sand and gravel, and silt and gravel (Gravel unit in Red Till)
R8-12	22.25	1028	14-24	Sand, silty sand, and gravel (Glaciofluvial Sand)
R8-13	24.85	1019	6-16	Sand and gravel, silt and gravel, (Glaciofluvial Sand)
R8-16I	0.57	1025	20-30	Sandy till layer (Brown Till)
R8-17D	0.01	1019	28-33	Dense, angular shale gravel (Basal till)
R8-19S	1.73	1025	5-10	Silty sand and gravel, firm (Brown till)
R8-19D	0.08	1026	33-38	Dense,fine sand and gravel (Basal till
R8-20	0.04	1007	15-20	Dense,fine sand and gravel (Red Till)
R8-27	0.08	1014	15-25	Gravelly, fine sand and silt (Red Till)

Bedrock Wells

Well Number	Hydraulic Conductivity* (ft/day)	Well Elevation (ft)	Open section of well (ft)	Strata Description
R8-33	13.00	993	95-120	alternating layers of sandstone and siltstone, two fractures
R8-35	0.11	986	39-59	alternating layers of shale and siltstone, one fracture
R8-36	23.00	993	90-140	alternating layers of siltstone and sandstone, one fracture
R8-37	0.15	982	69-87	alternating layers of siltstone and sandstone, one fracture
R8-3	2.65	1007	20.5-49	alternating layers of red and green siltstone, several fractures
R8-5	3.20	1039	31-81	alternating layers of siltstone, shale, and sandstone, several fractures

*Hydraulic conductivity calculated from method of Bouwer and Rice (1976).

out of adjacent bedrock well R8-28. This occurred as the result of a vertical fracture zone at approximately 57 feet in depth, which was seen in the cores from both boreholes.

Because of the variable nature of the secondary features (i.e., orientation and degree of interconnection) a wide range of hydraulic conductivities was found within the bedrock (see Table 4-2), ranging from 0.11 ft/day to 23.0 ft/day. The bedrock was evaluated as an unconfined aquifer, as the ground water quality data indicated direct hydraulic connection with the overburden, rather than confined conditions. Flow is predominantly along fracture zones and, as seen at R8-36, in more permeable local sandstone stringers. In the more fractured sections, K values ranging from 2.65 to 23.0 ft/day were recorded.

4.3.3 Ground Water Flow Directions

To determine the directions of ground water flow at the Route 8 Landfill site, ERM collected two sets of ground water elevations at the monitoring wells in 1985, and three sets from late March to early June 1987. The results of these measurements are listed in Table 4-3.

It should be noted that bedrock Well R8-1, originally installed as part of the Hill Site investigation in 1983, was completed as an open hole from 20-116 feet, which is deeper than subsequent bedrock monitoring wells at the Route 8 Landfill site. Downgradient at bedrock piezometer pair R8-28/R8-36, a downward vertical hydraulic gradient exists in the bedrock. Thus, R8-1 has a lower potentiometric level than would a well with an open interval of 20-40 feet, which is typical of Route 8 Landfill bedrock monitoring wells. To compensate for this condition and provide some approximate piezometric surface control at Well R8-1, ERM corrected the water level in this well to an estimated value for a well with an open hole of depth 20-40 feet. ERM assumed that the vertical hydraulic gradient at R8-1 is similar to that at R8-28/36 (calculated to be 0.131). This unit gradient was used to correct the water level in R8-1 by a correction factor of 9.98 feet. This correction factor has been added to the measurements at R8-1 to provide control for constructing piezometric contour maps of the bedrock aquifer system.

Figures 4-6 and 4-7 are piezometric contour maps for the intermediate overburden and bedrock wells, respectively, for Tuesday, March 31, 1987 when the Unalam Well was pumping. Figures 4-8 and 4-9 are piezometric surface maps for Sunday, June 21 1987, with the Unalam Well on weekend shut-down and piezometric elevations stabilized.

From these figures, it can be seen that ground water flow in both the glacial overburden and bedrock is principally northwestward, into the Susquehanna River Valley. In the overburden, the hydraulic gradient decreases between wells R8-31 and R8-32, in

TABLE 4-3

GROUND WATER ELEVATIONS
(feet above mean sea level)

Well	Ground Water Elevation 3/11/85	Ground Water Elevation 9/15/85	Ground Water Elevation 3/31/87	Ground Water Elevation 5/7/87	Ground Water Elevation 6/21/87
R8-1	1000.30	1000.86	1006.37	--*	1004.66
R8-2	999.20	996.81	1004.90	--*	--*
R8-3	1003.90	1001.10	1003.65	1003.85	1003.06
R8-4	995.56	996.36	1004.42	1005.58	1003.50
R8-5	1023.34	1020.49	1024.55	1024.88	1022.23
R8-6	1028.38	1025.46	1029.49	1029.59	1027.02
R8-7	1040.66	1037.64	1041.28	1040.90	1038.77
R8-8	1046.68	1043.93	1047.44	--*	--*
R8-9	1031.90	1025.40	1035.96	--*	--*
R8-10	1017.35	1014.64	1017.46	1017.46	1015.41
R8-11	1016.20	1008.96	1015.24	1015.98	1012.67
R8-12	1013.27	1007.99	1014.89	1015.74	1012.25
R8-13	1013.10	1007.54	1014.68	1015.47	1014.05
R8-14	1010.63	1006.01	1012.23	1012.63	1002.05
R8-15	1008.89	1005.06	1009.46	1009.80	1008.02
R8-16S	1016.95	1015.19	1018.55	1020.10	--*
R8-16I	1015.55	1012.01	1016.69	1017.54	1014.36
R8-16D	1015.72	1012.21	1016.92	1017.70	1014.49
R8-17I	1012.76	1008.25	1014.24	1014.95	1011.77
R8-17D	1005.02	1002.52	1006.31	1005.29	1004.28
R8-18S	1025.24	1021.41	1026.20	1026.59	1021.39
R8-18I	1022.07	1019.10	1023.22	1024.02	1021.21
R8-19S	1022.28	1019.14	1024.19	flowing	flowing
R8-19I	1020.43	1018.38	1023.81	flowing	flowing
R8-19D	1011.56	1014.20	1019.49	1020.11	1017.51
R8-20	1002.80	1001.10	1003.32	1003.85	1002.92
R8-21	1015.62	1012.44	1015.66	--*	1013.55
R8-23		976.87	983.79	982.43	984.52
R8-24		975.86	--*	980.25	984.59
R8-25		985.67	988.24	988.28	988.17
R8-26		1009.21	1009.65	1009.36	1006.55
R8-27		1004.10	1008.96	1009.48	1007.85
R8-28		978.64	986.17	986.32	985.55
R8-29		986.03	985.80	988.85	989.01
R8-30		980.53	986.44	987.02	986.90
R8-31		990.44	992.51	993.03	992.29
R8-32			980.35	980.55	979.18
R8-33			975.16	974.86	973.23
R8-34			1011.75	1012.76	1010.56
R8-35			1010.25	1011.12	1009.13
R8-36			976.43	976.27	974.41
R8-37			981.45	982.94	982.78

* Not located or measured due to adverse condition.

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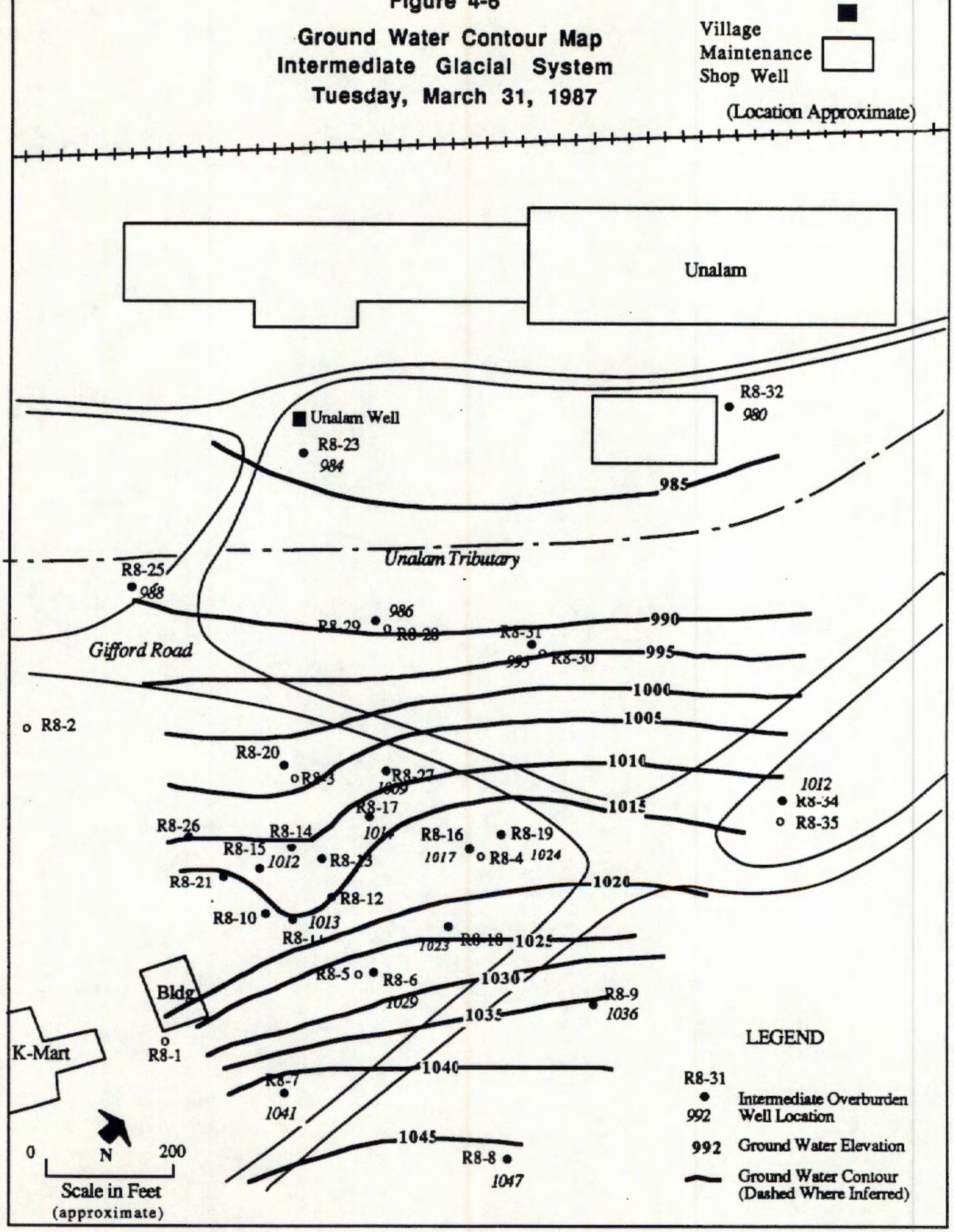
Figure 4-6

Ground Water Contour Map
Intermediate Glacial System
Tuesday, March 31, 1987



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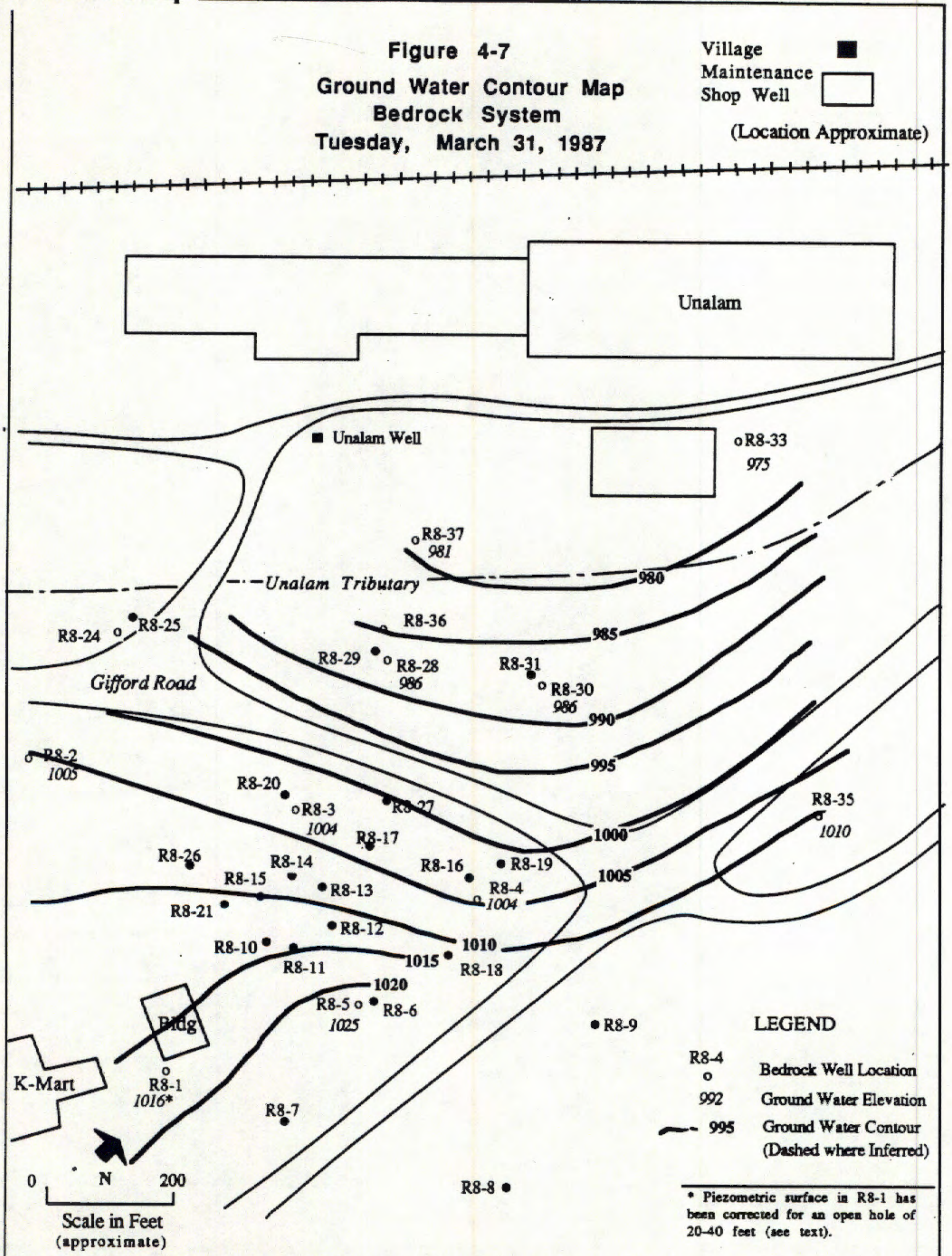

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Figure 4-8

Ground Water Contour Map

Intermediate Glacial System

Sunday, June 21,1987

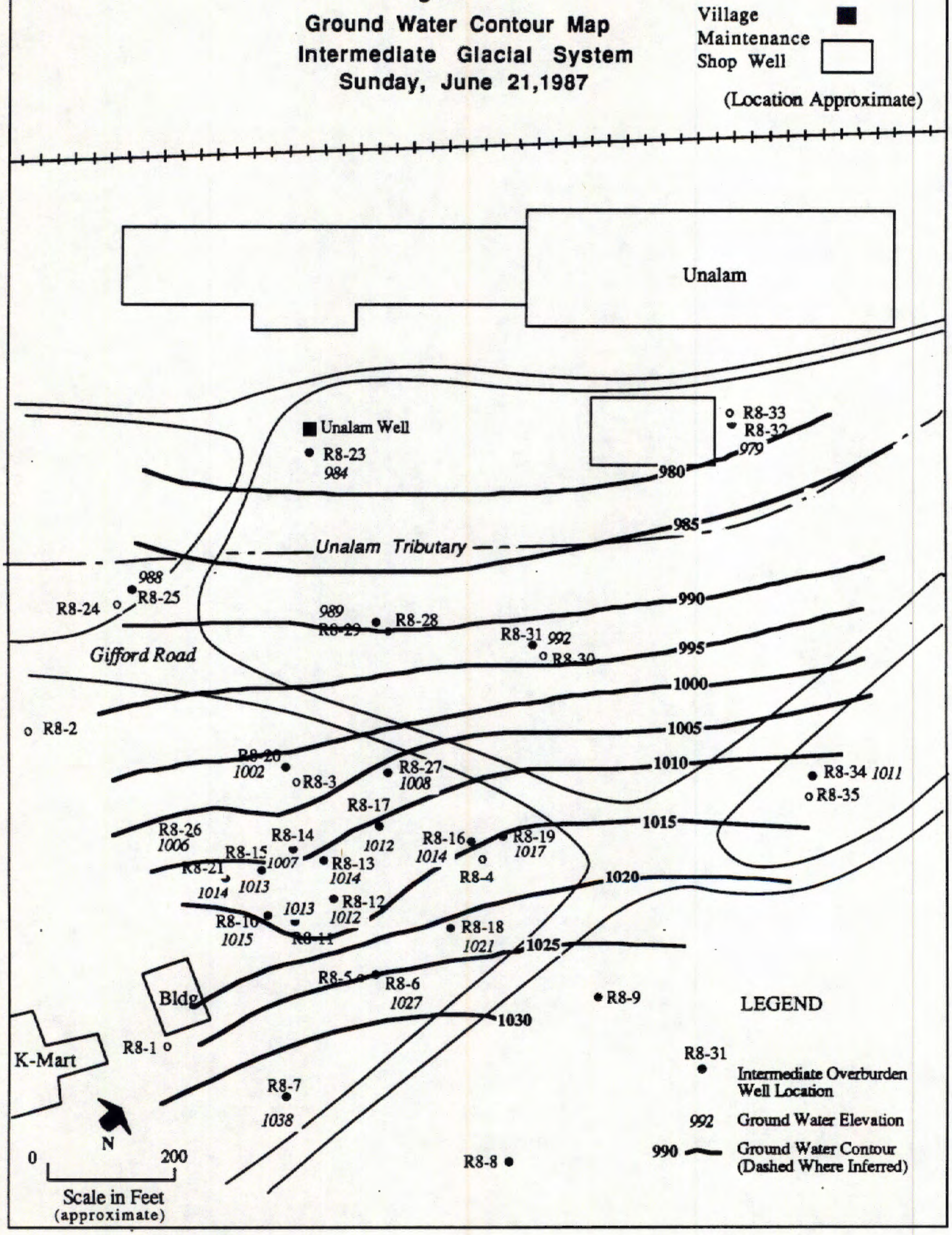

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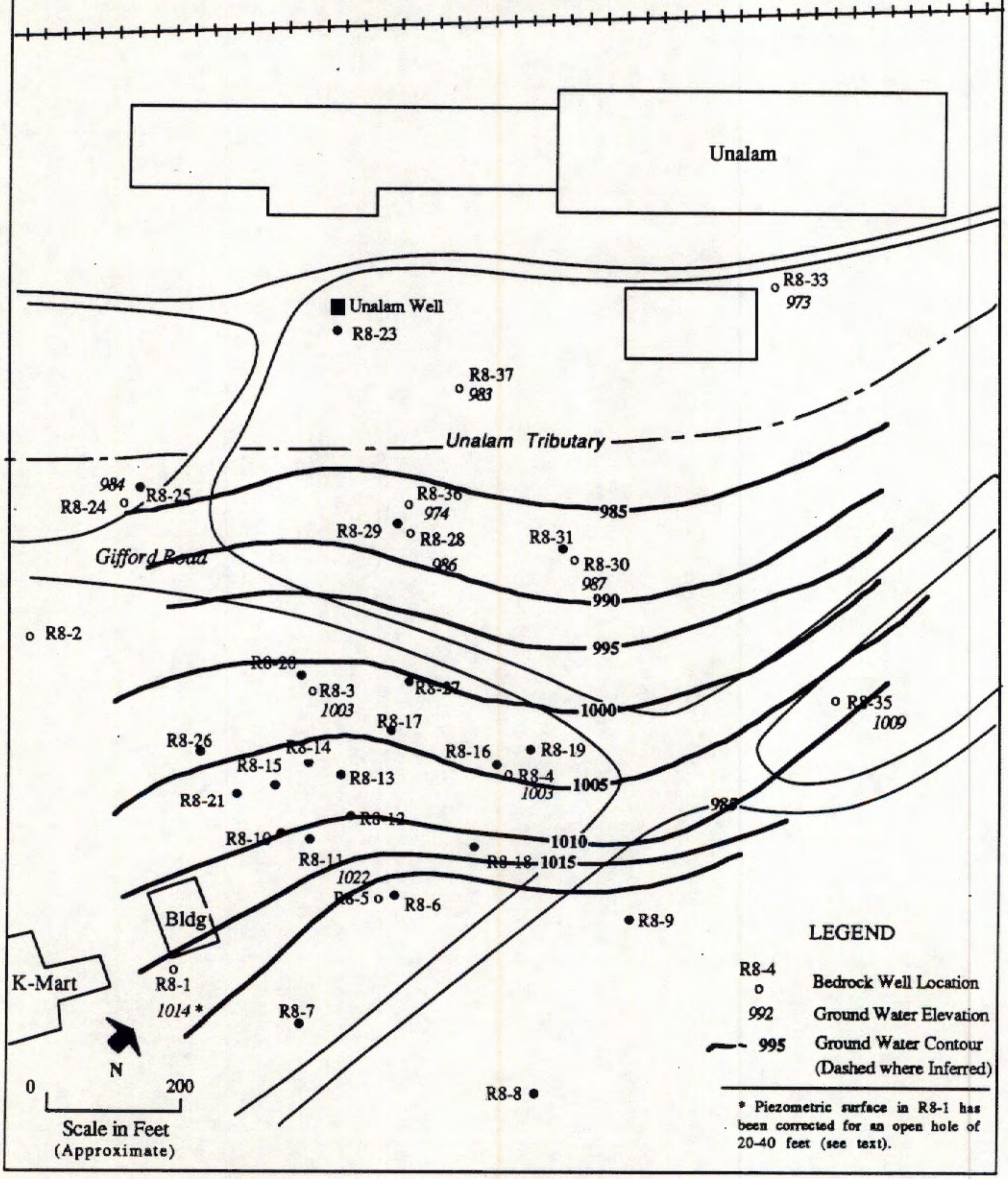
Figure 4-9
Ground Water Contour Map
Bedrock System
Sunday, June 21, 1987

Village Maintenance Shop Well ■ □ (Location Approximate)



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response to flattening topography and the presence of the silty clay unit.

The only pumping effect evident around the Unalam Well is a very slight westward perturbation upon the regional ground water flow in the bedrock (See Figures 4-7 and 4-9). Only a slight change is seen between Sunday's data (when the well was not pumping) and data when the well was active. The effect of the Unalam Well upon the two aquifer systems is discussed in greater detail, as follows.

4.3.4 Pump Test Results

To assess the impact of the Unalam Well on the overburden and bedrock aquifers, ERM placed Hermit data loggers at six monitoring wells (R8-23, 24, 25, 28, 36 and 37) for one week in mid April 1987, and at six additional wells (R8-4, 20, 30, 31, and 33) in early June 1987. After analysis of these data, to determine the potential effects to be present from pumping of the Amphenol West Well, ERM placed Hermit data loggers at eight monitoring wells (R8-1, R8-5, R8-24, R8-28, R8-30, R8-33, R8-55, and R8-37) during the annual maintenance shut-down of the West Well in late July 1987. Complete sets of hydrographs of the wells monitored are included as Appendix E.

4.3.4.1 Test 1 - June 1987

Figure 4-10 is a hydrograph of ground water elevations collected at monitoring wells R8-30 and R8-31, located north of Gifford Road. This hydrograph illustrates the responses of the bedrock and overburden aquifers to the Unalam Well pumping. The effect of the Unalam Well is readily observed in the bedrock well as the pump cycles on and off during the weekdays, and shuts down during the weeknights and weekends. The cycles are of short duration (12 minutes); thus drawdown is observed as a continuous function on the hydrograph. The drawdown in bedrock well R8-30, when the pump turns on Monday morning, is slightly over two feet. Monitoring well R8-31, set in the intermediate overburden system, shows a slight, but nevertheless distinct response to Unalam Well pumping. This confirms that the basal lodgement till unit is not acting as a fully confining unit, but that some degree of hydraulic connection exists between the intermediate overburden and bedrock aquifer.

As shown in Figures 4-11 and 4-12, other pumping wells unknown to Amphenol and ERM were seen to affect the monitored wells. Figure 4-11, a hydrograph of bedrock monitoring well R8-24, shows a "spikey" cyclic change in ground water elevation due to an unknown pump running throughout the week and the weekend. This unknown pumping well has a cycle of approximately 40 minutes, and creates a drawdown of approximately 0.4 feet in Well R8-24.

Figure 4-12 is a hydrograph of deep bedrock monitoring well R8-36. Here, a pumping well with an approximate 24 hour cycle is seen

Figure 4-10

Ground Water Hydrograph: 6/8/87 thru 6/13/87

Wells: R8-30 and R8-31

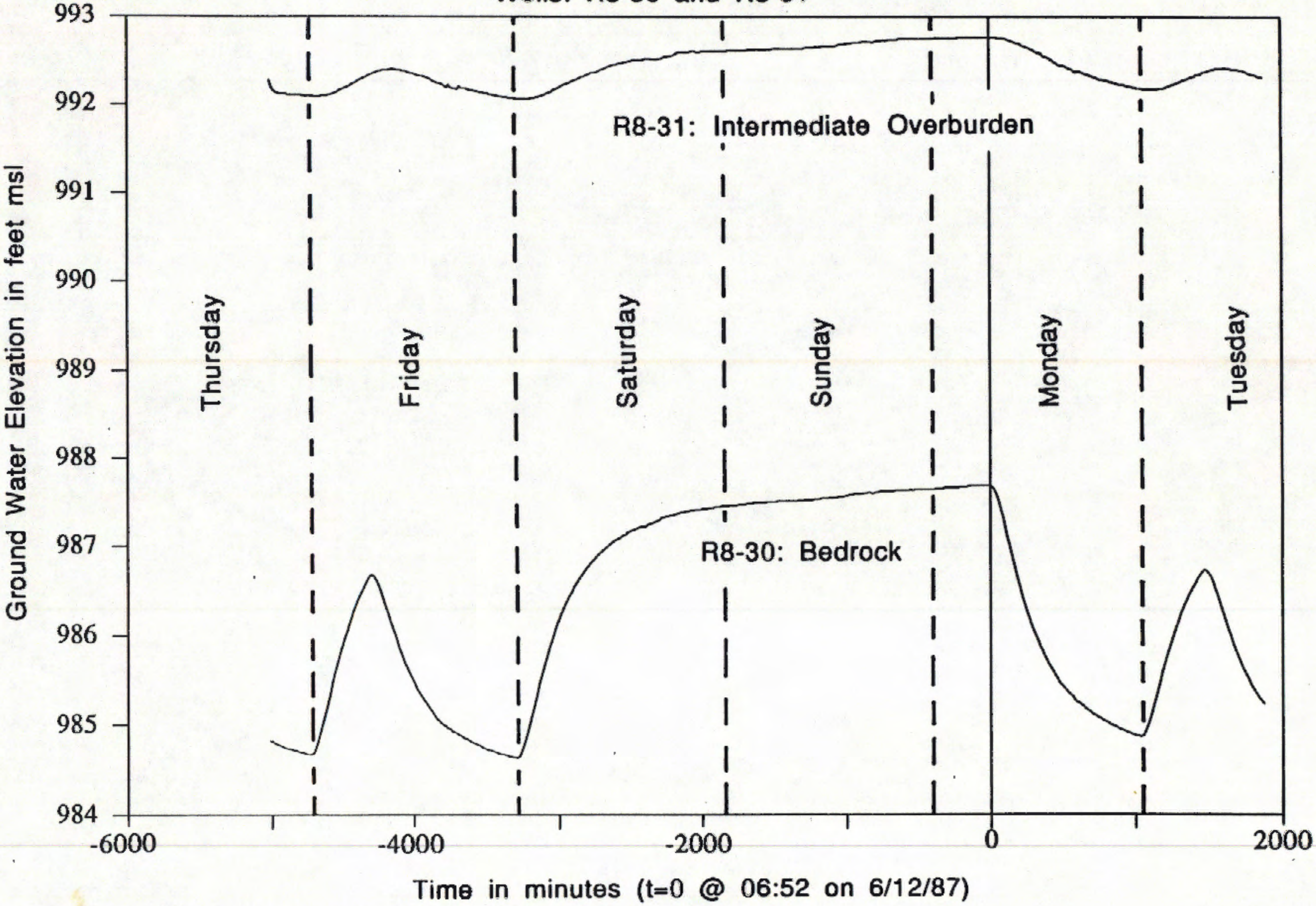


Figure 4-11

Ground Water Hydrograph: 4/16/87 thru 4/21/87

Well R8-24

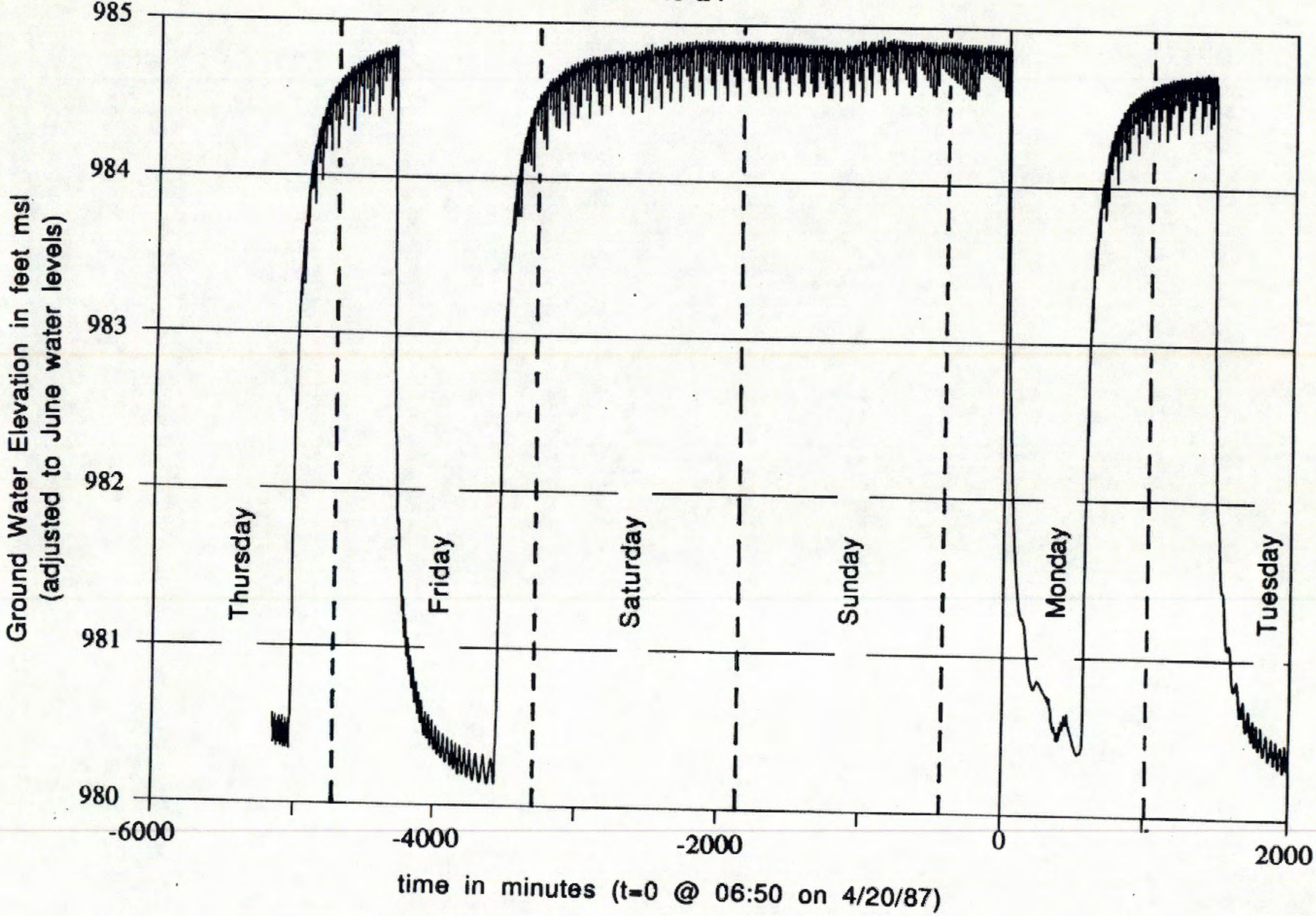
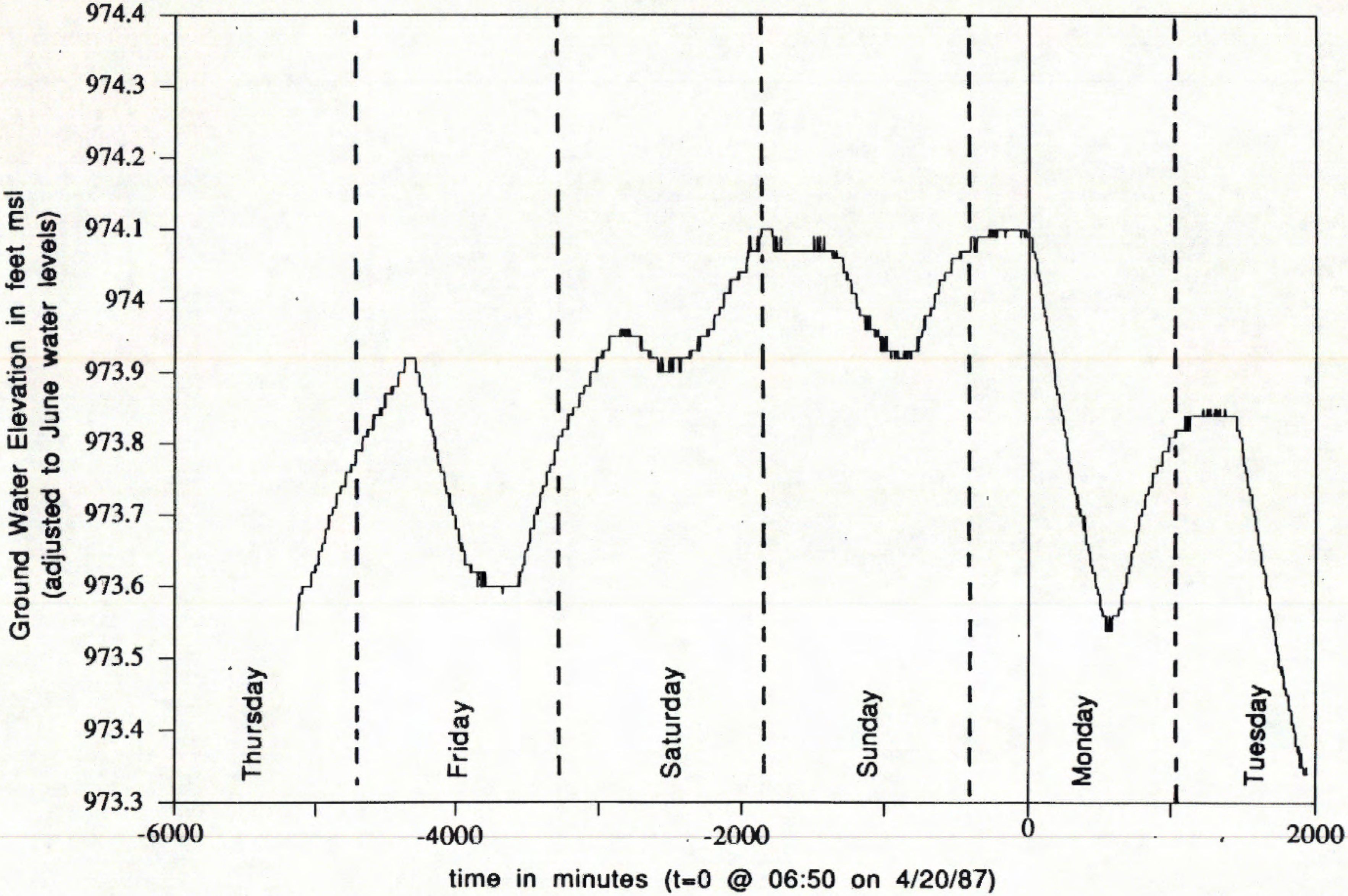


Figure 4-12

Ground Water Hydrograph: 4/16/87 thru 4/21/87
Well R8-36



operating through the weekend. This feature was not observed in shallow bedrock monitoring well R8-28, suggesting that a deep, distant pumping well is affecting the regional hydraulic head.

It is important to note that these other wells, although they affect head levels slightly in the Route 8 Landfill area, do not influence the direction of ground water flow. The regional gradients are far greater than these limited effects, and therefore prevail.

Figure 4-13 shows a contour map of the observed drawdowns and recoveries for the bedrock wells monitored. The drawdown represents the maximum daily drawdown, while the recovery is the measured maximum recovery of the well over the weekend when the Unalam Well was not pumping. The anisotropic fracture-controlled flow of the bedrock aquifer is quite discernible when examining the data. Well R8-28 is closer to the Unalam Well than bedrock well R8-30, yet experiences less than half the drawdown. In a fractured bedrock unit, water drawn from a well will come primarily from any higher permeability fracture which intersects the well. Thus maximum drawdown will occur along fractures, with little drawdown in "interfracture" areas. The results shown on Figure 4-13 clearly indicate the presence of a major east-west oriented bedrock fracture passing between wells R8-30 and R8-37, and a perpendicular north-south trending fracture passing through well R8-24.

4.3.4.2 Test 2- July 1987

Hermit data loggers were installed Sunday 26 July 1987, and removed Friday 31 July, to record the effects of the annual maintenance shut down of the West Well. This task was performed because the results of Test 1 indicated that pumping wells in the bedrock system can have widespread effects.

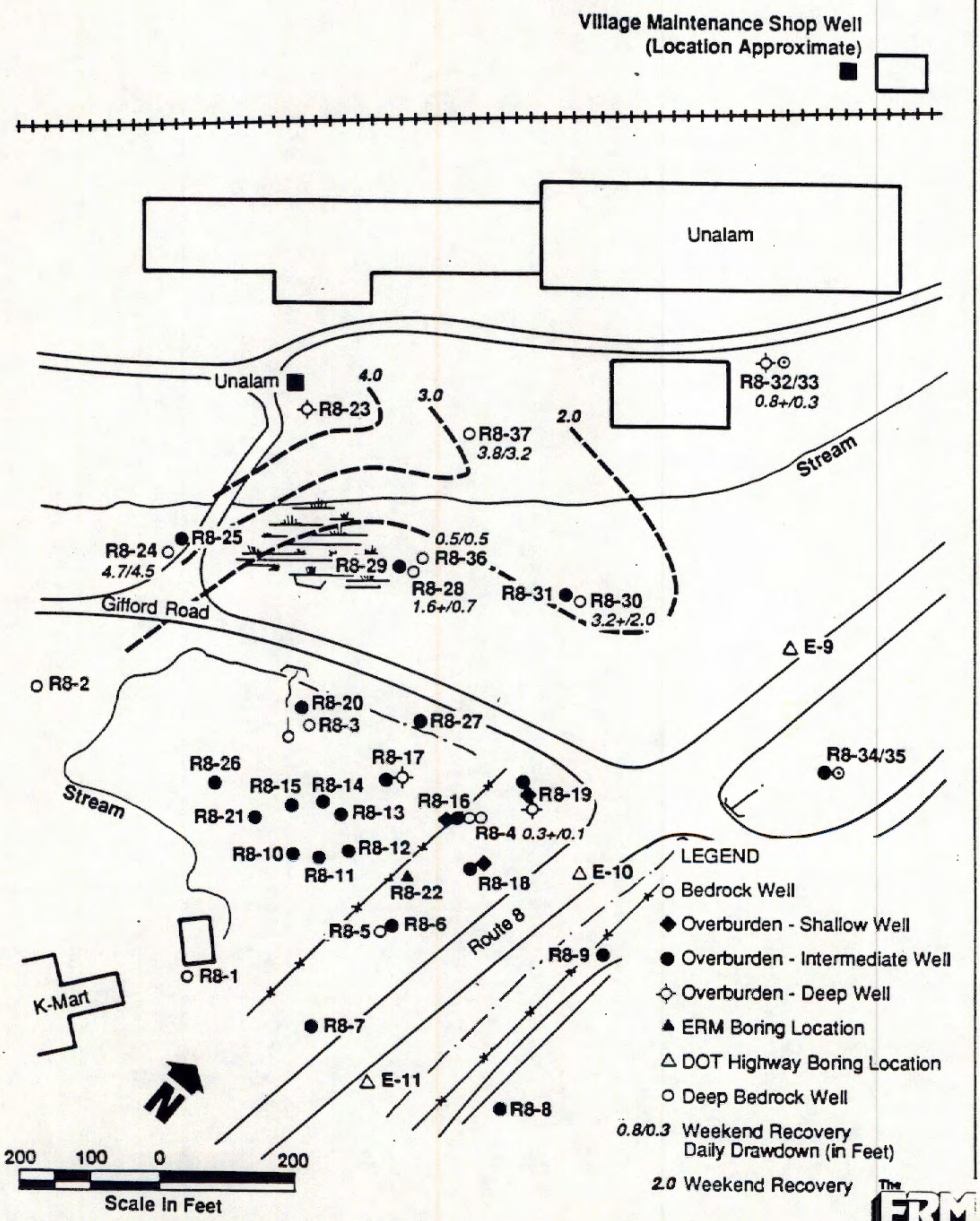
The West Well is located approximately 2200 feet from the Route 8 Landfill source area, and currently pumps water from the glacial overburden and bedrock at about 300 gpm continuously. By contrast, the Unalam Well, located about 750 feet from the source area, pumps cyclically at an average rate of about 6 gpm during the day. Drawdown from a pumping well has been described mathematically by Theis as:

$$h_o - h = \frac{Q}{4\pi T} W(u)$$

where h_o-h is the drawdown, Q is the flow, T is the transmissivity, and W is the well function, which is a function of $1/r^2$, r being the radius to the point of drawdown from the pumping well. The drawdown at any distance in a homogeneous, isotropic aquifer, is therefore, proportional to the pumping rate Q and the radial distance, or:

$$h_o - h \sim Q/r^2$$

Figure 4-13
Observed Recovery and Drawdown in Bedrock Wells



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Calculating the Q/r^2 factor for the Unalam Well at Well R8-33 yields 0.00001, while the Q/r^2 factor for the West Well is 0.00006. Thus the West Well, although located 3 times further from the Route 8 Landfill than the Unalam Well, would exert an influence approximately 6 times as great as the Unalam Well in a homogeneous aquifer. In a non-homogeneous aquifer such as the bedrock this influence of the West well could be greater locally along fracture zones, or could be less in interfracture areas.

Figure 4-14 is a hydrograph illustrating the response of bedrock well R8-33 during Test 2. Drawdown from the Unalam Well cycling on Monday is readily observable. When the West Well was shut down Tuesday, the water level in the well slowly recovered until Thursday, when pumping of the West Well resumed. The "diurnal" pumping nature of the Unalam Well can be seen superimposed on this section of the hydrograph. Recovery from the West Well pumping was just under one foot when the West Well resumed pumping. Although recovery was not complete when pumping resumed, it is clear that the West Well does not have a major effect on the piezometric level at R8-33. No significant West Well effects were recorded in the remaining wells monitored during West Well shutdown.

Unfortunately, a Hermit Data Logger installed at Well R8-35 malfunctioned, and no data were obtained at that location. It is possible that some effects might have been present there, given the anisotropy of the aquifer, However, as will be seen in Section 4.4, ground water quality data do not indicate flow from the Route 8 Landfill in this direction.

4.3.5 Vertical Hydraulic Relationships

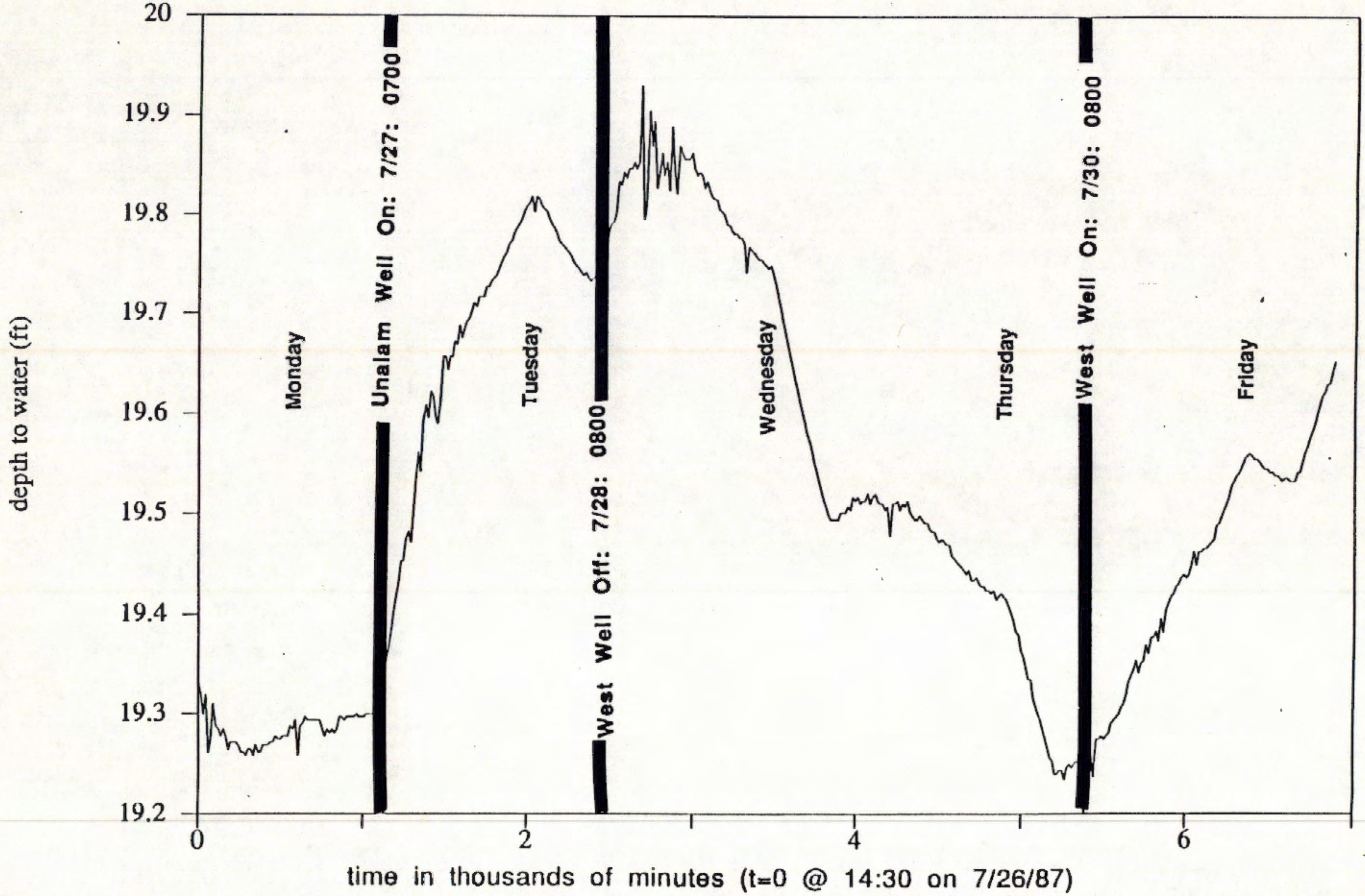
4.3.5.1 Components of Flow

The site hydrogeology has been defined to consist of permeable glaciofluvial sands and compacted tills separated from the fractured bedrock aquifer by a partially confining dense basal lodgement till. The degree of hydraulic connection which exists between the overburden and bedrock aquifers is important to VOC migration in the ground water system, and to the potential for ground water recovery to succeed in remediation of the aquifer. The recharge of ground water from the overburden aquifer into the bedrock aquifer, through the basal till, is an important control on the migration of site related compounds into the bedrock system. ERM evaluated this problem by evaluating the glacial till and basal lodgement till system as if it were a one layer, homogeneous system. By this method, the vertical and horizontal hydraulic conductivities can be approximated using the following expressions (Freeze and Cherry 1979).

Figure 4-14

Ground Water Hydrograph: 7/26/87 thru 7/31/87

Well R8-33



vertical $$K_v = \frac{t}{\sum_{i=1}^{n} t_i/K_i} \qquad (4-1)$$

horizontal $$K_h = \sum_{i=1}^{n} \frac{K_i t_i}{t} \qquad (4-2)$$

where K_i and t_i are the hydraulic conductivities and thicknesses of each geologic unit and t is the total thickness of the saturated section of overburden aquifer at the site.

The hydraulic conductivities calculated from the slug test data (Table 4-2) were averaged to obtain K_i values for the upper till and basal till. Wells R8-17-D and R8-19-D, screened in the basal till unit, collectively had an average hydraulic conductivity of 0.045, ft/day, while for wells R8-16-I, R8-19-S, R8-20, and R8-27, screened in the upper till (brown and red units), an average conductivity of 0.61 ft/day was obtained.

ERM analyzed the lithologic descriptions in the well logs and arrived at a typical site stratigraphy of 28 feet of saturated upper till and 6 feet of saturated basal lodgement till. Applying equations (4-1) and (4-2) yields:

$$K_v = 0.19 \text{ ft/day}$$

$$K_h = 0.51 \text{ ft/day}$$

Next, the horizontal and vertical components of ground water flow velocity were calculated using Darcy's Law, the formula:

$$Q = KiA$$

where Q represents the ground water flow volume, i the hydraulic gradient, and A an assumed 1000 ft^2 cross section of aquifer.

The vertical hydraulic gradients within the overburden were calculated from head differences observed at well nests, and horizontal hydraulic gradients were calculated between wells screened within the same aquifer interval.

To determine the vertical hydraulic gradient through the lodgement till, ERM calculated average vertical hydraulic gradients between the intermediate and deep overburden wells at well clusters R8-17 and R8-19 (Table 4-2). The average vertical gradient in the overburden was calculated as follows:

Well	Average Vertical Gradient
17-I - 17-D	0.497
19-I - 19-D	0.413
Average =	0.455

From the ground water contour maps, ERM measured the average horizontal overburden gradient to be approximately 0.085 (Figures 4-6 and 4-8).

Thus, for the horizontal component of flow,

$$Q_h = 0.51 \times 0.085 \times 1000 = 43.4 \text{ ft}^3/\text{day}$$

and for the vertical component of flow

$$Q_V = 0.19 \times 0.455 \times 1000 = 86.45 \text{ ft}^3/\text{day}$$

The higher vertical flow indicates that significant recharge to the upper bedrock aquifer is occurring, despite the low hydraulic conductivity of the basal till unit. Thus, approximately 2/3 of total ground water flow through the overburden is moving vertically into the bedrock aquifer at the site.

4.3.6 Ground Water Flow Velocities

Velocities of ground water flow can be calculated for the vertical and horizontal overburden flow components using the formula:

$V=Ki/n$ where:

- V = flow velocity in ft/day
- K = hydraulic conductivity in ft/day = 0.51 horizontal, 0.19 vertical.
- i = hydrualic gradient = 0.085 horizontal, 0.455 vertical.
- n = effective formation porosity, estimated to be in the range of 20 to 30 per cent in the shallow tills and outwash, and 10 percent in the basal lodgement till.

For the horizontal component of flow,

V_h = 0.14 to 0.2 ft/day

For the vertical component of flow,

V_v = 0.86 ft/day.

The anisotropy of the bedrock system precludes accurate evaluation of flow velocities. However, it is known that flow through bedrock fractures can be very rapid, i.e. perhaps hundreds of feet per day, under the influence of ground water pumping.

4.3.7 Effects of the Unalam Well

Evaluation of the drawdown/recovery data from June, 1987 indicate that in some areas the Unalam Well pumping increases the hydraulic gradient from the glacial overburden into the bedrock, and in other areas it does not. For example, the hydrographs (shown in Appendix B and Figure 4-10) indicate that drawdown/recovery were approximately equal at well nests R8-24/25 and R8-32/33, while at R8-30/31 recovery in the bedrock was 3.2 feet but only 0.7 feet in the overburden. Although it appears that the Unalam Well pumping may somewhat increase downward recharge from the overburden into the aquifer in some areas, it is evident that the downward recharge is also a natural condition which would not be mitigated by cessation of pumping.

4.4 Ground Water Quality and Waste Constituent Migration

4.4.1 PCB and Oil Migration

During the Phase I, II and III investigations numerous ground water and soil samples were collected for analysis for PCB and oil content. The results are shown in Tables 4-4 and 4-5, respectively. As previously noted, oil has been observed in the Gifford Road Spring area, and at other wet weather seeps. During ground water sampling in April 1987, an oil film was visually observed in samples from all of the overburden wells sampled south of Gifford Road. Well R8-17 was particularly affected. No oil was observed in shallow or intermediate wells north of Gifford Road; nor was oil observed in in any bedrock wells. Water from bedrock Well R8-4 south of Gifford Road, however, had a dark gray coloration. The reason for this is unknown, as no highly elevated compounds other than VOCs were detected in the full HSL analyses, as discussed in Section 4.4.3.

Subsurface migration of PCB occurs principally in solution in oil because PCBs have a very limited solubility in water. Movement of the PCB-containing oil through the subsurface is limited by its low density and high viscosity. PCB migration is further limited by its affinity for adsorption on soil organics and clay components.

Figure 4-15 is an isoconcentration map showing the maximum PCB concentrations detected in the soil samples taken from the test borings and well borings. This figure shows that PCB migration has occurred preferentially through the sand outwash lens at the site, with the highest concentrations centered at borings R8-12 and R8-13 (2 to 15 ppm). The affected area corresponds to the source areas, and the sand outwash unit shown in Figure 4-4. Thus, it is apparent that the oil and PCBs have migrated preferentially in the permeable sand lens, and have collected in the area where that lens is the thickest (at well locations R8-12 and R8-13).

The results from the boring R8-16 show that PCBs in soil are concentrated in the shallow sediments and have not migrated significantly into the till downgradient from the site. Directly beneath the source area materials, PCB and oils have migrated downward into gravel lenses within the dense red till. Since the oils are of low density, and "float" on the ground water table, they must have migrated downward during the drier seasons. Increases in the water table elevation have trapped oil in the permeable gravel lenses, making available the small quantities of dissolved PCBs detected in the overburden monitoring wells near the source area (see Table 4-5).

In the overburden, PCBs were detected in ground water samples at all wells south of Gifford Road, except Well R8-27. The concentrations generally ranged from 0.2 ppb to 44 ppb, with up to 370 ppb at R8-6 and 2320 ppb at R8-13. At concentrations above the solubility limits of a few tens of ppb, the excess PCB is related to oil in the sample. North of Gifford Road, no PCB was detected in the overburden wells. Nor was any PCB detected in any of the bedrock wells. However, limits of detection varied from 0.2 to 10 ppb due to the nature of some samples.

Oil was detected in most of the wells where analyses were conducted, including 8 ppm at the Unalam Well. Concentrations in the monitoring wells ranged from about 1 to a maximum of 750 ppm. The relative absence of PCBs in most of the wells attests to the tendency of PCBs to adsorb onto the soil as the oil migrates.

In addition to the above, one phenol analysis was conducted at Well 18-I. A total of 19 ppb were detected (Table 4-4). Subsequent analyses at Wells R8-4, R8-18S, and R8-18I for the Hazardous Substances List compounds detected no phenols, as will be further discussed in Section 4.4.3.

Figure 4-16 shows the approximate extent and thickness of subsurface PCBs greater than 10 ppm at the site. The 10 ppm level is the New York State DEC guideline for remediation of PCB-containing soils. Although Figure 4-16 should be considered somewhat schematic due to the potential for some channeling of oil/PCB through the subsurface, the permeability, homogeneity and continuity of the sand outwash lens indicates that the schematic provides a good guideline at this site for occurrence of PCBs in excess of 10 ppm. Beneath Route 8 and east of it, PCB occurrence is expected to be very limited. First, the sand lens through which migration occurs west of Route 8 is above the saturated zone. Second, the source area, from the photochronology and the boring program, was apparently limited to the western side of the Route 8 right-of-way. The east side of the roadway is thus hydraulically upgradient of the PCB source area.

4.4.2 VOC Migration

Table 4-6 lists the analytical results for ground water analyses for VOCs for the Phase I, Phase II, and Phase III assessments, as well as 1984 analyses for the previously-designated Hill Site wells. This table shows that the principal VOCs detected in the site ground water are 1,2-dichloroethene (DCE), toluene, 1,1,1-trichloroethane (TCA), vinyl chloride (VC), ethylbenzene, 1,1 dichloroethane (DCA), and trichloroethene (TCE). The ethylbenzene and toluene are non-chlorinated aromatic VOCs which are often used as industrial solvents, but are also present in refined petroleum hydrocarbon products and so may be related to disposal of waste oils. The other compounds are chlorinated aliphatic (or straight chain) hydrocarbons, of which TCE and TCA are very commonly used as degreasers. The other aliphatic compounds have two potential origins:

- impurities in either TCE or TCA; or
- transformation of TCE and/or TCA by reductive dehalogenation in the environment.

The process of reductive dehalogenation occurs when anaerobic microbes present in the subsurface biodegrade TCE by "stripping off" chlorine atoms. The breakdown sequence for TCE is:

$$\text{TCE} \longrightarrow \begin{bmatrix} \text{cis 1,2-DCE} \\ \text{trans 1,2-DCE} \\ \text{1,1-DCE} \end{bmatrix} \longrightarrow \text{VC}$$

Thus, it can be seen that the DCE compounds are the first intermediate step, and VC is the next. Beyond VC, some limited laboratory data indicate that further breakdown may occur, possibly yielding ethylene or CO_2, and perhaps water.

It is interesting to note that the reductive dehalogenation process occurs only by co-metabolism in the presence of a carbon source other than the TCE molecule. The most frequently cited carbon source is also associated with the presence of methanogenic microbes, which are almost always associated with refuse disposal in a landfill. It is ERM's experience that less reductive dehalogenation occurs at waste sites without a potential alternate carbon source, i.e. where refuse disposal has not occurred. A good example is the Amphenol Hill Site, where TCE presently constitutes up to 50 percent of the residual total alkenes, and no VC production has occurred.

For purposes of overall assessment of VOC migration, the compounds will be considered together as total VOCs. This is appropriate, as all of these compounds are soluble in water in

TABLE 4-4
GROUND WATER ANALYSIS
PCBs / OIL & GREASE/PHENOLS

WELL	PCBs (ppb)			OIL & GREASE (ppm)		PHENOLS (ppm)
	DATE			DATE		DATE
	Mar-85	Sept. 1985	Apr-87	Mar-85	Sep-85	Oct-86
R8-1	ND	ND	NA	2	19	NA
R8-2	ND	ND	NA	ND	22	NA
R8-3	ND	ND	NA	1	5	NA
R8-4	ND	ND	NA	ND	26	NA
R8-5	ND	ND	NA	2	8	NA
R8-6	100	180	370	26	26	NA
R8-7	2.6	30	NA	ND	44	NA
R8-8	1.3	ND	NA	ND	6	NA
R8-9	44	NA	3.9	ND		NA
R8-10	2.3	ND	NA	ND	4	NA
R8-11	3.9	10	NA	ND	7	NA
R8-12	0.6	80	21.3	ND	30	NA
R8-13	190	2320	NA	270	268	NA
R8-14	0.9	ND	NA	ND	ND	NA
R8-15	0.2	ND	NA	ND	ND	NA
R8-16 S	6.5	NA	NA	4		NA
R8-16 I	0.6	ND	ND	ND	14	NA
R8-16 D	0.2	ND	ND	ND	ND	NA
R8-17 I	6.1	72	13.2	23	61	NA
R8-17 D	20	4	4.2	750	35	NA
R8-18 S	15	NA	NA	5		NA
R8-18 I	8.9	7	NA	18	10	0.019
R8-19 S	5.6	180	NA	7	617	NA
R8-19 I	2.6	ND	9	11	8	NA
R8-19 D	6.6	ND	ND	52	5	NA
R8-20	0.7	ND	ND	ND	5	NA
R8-21	0.2	ND	NA	3	7	NA
R8-23		ND	ND		14	ND
R8-24		ND	NA		13	NA
R8-25		ND	ND		14	NA
R8-26		ND	ND		ND	NA
R8-27		11	11.4		27	NA
R8-28		ND	NA		5	NA
R8-29		ND	ND		6	ND
R8-30		ND	NA		5	NA
R8-31		ND	ND		5	NA
R8-32			ND			NA
R8-34			ND			NA
R8-35			ND			
R8-36			ND			
R8-37			ND			
Unalam Well	NA	ND	ND	NA	8	ND

ND = none detected. NA = not analyzed. Blank spaces indicate that the well was not installed at that time.

TABLE 4-5
PCB ANALYSIS RESULTS IN SOILS (PPB)

BORING LOCATIONS	SAMPLE DATE	PCBs (ug/kg)
R8-9 10-12'	3/6/85	
R8-9 15-16'	3/6/85	1600
R8-10 12-14'	2/20/85	
R8-10 14-16'	2/20/85	3900
R8-11 12-14'	2/21/85	
R8-11 14-16'	2/21/85	2000
R8-12 14-16'	2/22/85	4200
R8-12 18-20'	2/22/85	9400
R8-13 5-7'	2/25/85	12000
R8-13 7-9'	2/25/85	15000
R8-13 13-15'	2/25/85	9400
R8-14 10-12'	2/26/85	
R8-14 16-17'	2/26/85	
R8-15 12-14'	2/26/85	
R8-16 6-8'	2/27/85	5300
R8-16 8-10'	2/27/85	5000
R8-16 18-20	2/27/85	
R8-16 20-22'	2/27/85	
R8-17 6-8'	3/4/85	4300
R8-17 8-10'	3/4/85	6100
R8-18 6-8'	3/5/85	
R8-18 14-16'	3/5/85	8600
R8-19 2-4'	3/5/85	1500
R8-19 4-6'	3/5/85	3100
R8-20 4-6'	3/5/85	
R8-20 16-18'	3/5/85	
R8-21 10-12'	3/5/85	
R8-22 12-14'	3/6/85	13000
Q TB-1 10-12'	4/20/87	3,880
Q TB-3 10-12'	4/20/87	5,960
Q TB-4 10-12'	4/21/87	1,820
TB-4 12-14'	4/21/87	ND
Q TB-4 18-20'	4/21/87	3,510
TB-4 30-32'	4/21/87	2,370
Q TB-5 10-12'	4/21/87	13,300,000
TB-5 16-18'	4/21/87	9,120
TB-5 18-20'	4/21/87	1,750
Q TB-7 12-14'	4/21/87	10,900
TB-7 14-16'	4/21/87	4,630
Q TB-8 10-12'	4/22/87	46,700
Q TB-9 12-14'	4/22/87	33,400
TB-9 16-18'	4/22/87	1,500
Q TB-9 22-24'	4/22/87	26,300
TB-9 28-30'	4/22/87	1,290
Q TB-10 12-14'	4/22/87	ND
TB-10 18-20'	4/22/87	6,260
Q TB-11 10-12'	4/22/87	92,700

All of the above results are reported on a dry weight basis.
All of the results are measured in ug/kg, unless otherwise indicated.
All blanks = none detected. ND = none detected.
Dashed lines indicate sample was not analyzed for volatiles.

Qualifier Codes:
B - This result is of questionable qualitative significance since this compound was detected in blank(s) at similar concentrations.
Q - These sampling results have undergone an ERM Quality Assurance Review.
J - This result should be considered a qualitative estimate.

Figure 4-15
Maximum PCB Concentrations Detected in Soil Borings
(Concentration in ppm)

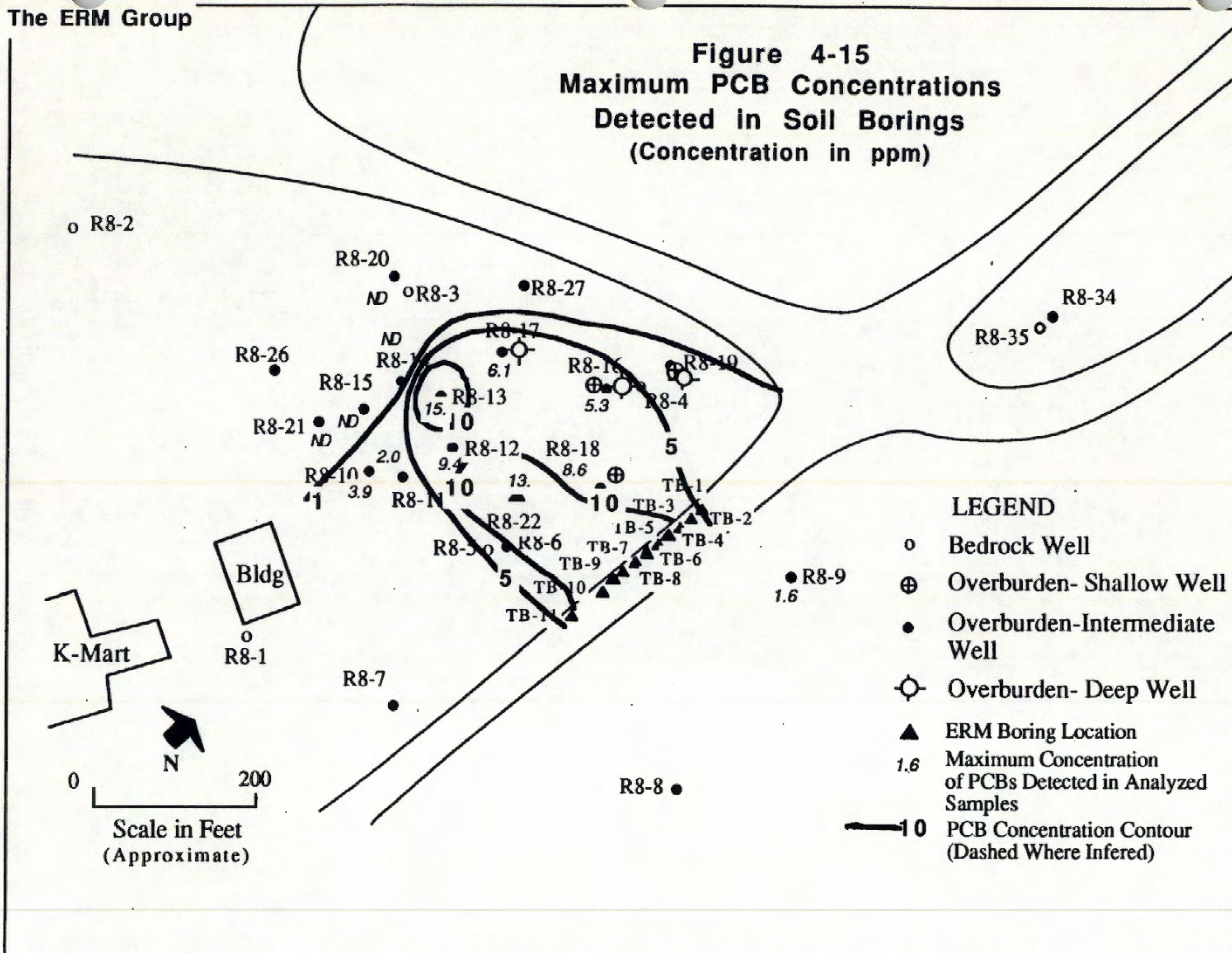


Figure 4-16
Isopach Map Of PCB In Soils Greater Than 10 ppm

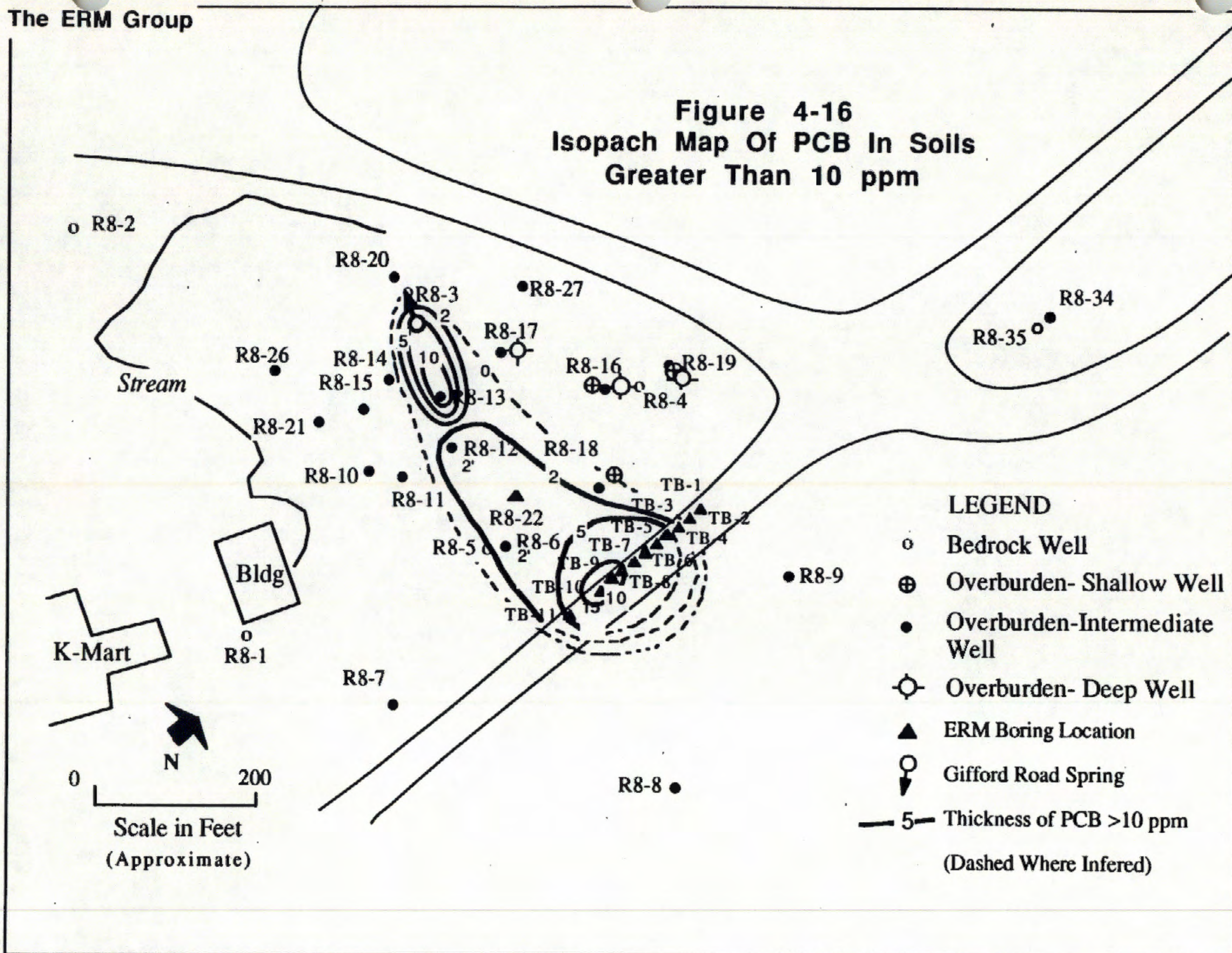


TABLE 4-6
GROUND WATER ANALYSIS
OVERBURDEN WELLS - VOLATILE ORGANIC RESULTS (PPB)

Overburden Wells	Lab *	Date Sampled	Total Volatiles	Benzene	Toluene	Ethylbenzene	1,1-dichloroethene	1,1-dichloroethane	trans-1,2-dichloroethene	Chloroform	Trichloroethene	Methylene Chloride	Vinyl Chloride	1,1,1-Trichloroethane	1,2-Dichloroethane	Chloroethane	Tetrachloroethene	Dibromochloromethane	Carbon Tetrachloride
R8-6	F	4/18/84	117						88		8	21							
	O	3/13/85	60		11				33		16								
	L	9/12/85	15		3			4	5		3								
	L	4/2/87	16		3			3	5		6								
R8-7	F	4/18/84	ND																
	O	3/13/85	39						39										
	L	9/12/85	1						1										
R8-8	O	3/13/85	39						39										
	L	9/12/85	5						1	2	2								
R8-9	O	3/13/85	39						39										
	L	9/17/85	300					20	280										
	L	4/2/87	5						2		3								
R8-10	O	3/13/85	5,970		1,200			160	2,200		1,100		440	870					
	L	9/17/85	4,240		1,350			150	1,800				280	660					
R8-11	O	3/13/85	1,005		22			130	430		13		220	190					
	L	9/16/85	4,310		1,260	20		410	1,600				550	580	20				
R8-12	O	3/13/85	590					110	210				160	110					
	L	9/16/85	520					260	60				120	80					
	L	4/2/87	371					190	12				140	27	2				
R8-13	O	3/13/85	319		78	110		63	67				11						
	L	9/18/85	594		27			220	97				170	80					
R8-14	O	3/13/85	88					57	31										
	L	9/13/85	900					340	210				290	60					
R8-15	O	3/13/85	101					47	28					26					
	L	9/13/85	1,514		67			330	650		2		320	140	6				
R8-16S	O	3/12/85	26,440		14,000	290		410	9,700				440	1,600					
		10/16/85						400	2,700					1,200					
R8-16 I	O	3/13/85	58,770		26,000	1,800	140	930	26,000				1,300	2,900					
	L	9/18/85	80,400		33,800	3,300		1,300	36,000				2,100	3,900					
	L	4/2/87	47,800		19,700	800		900	21,000	700			1,900	2,600					
R8-16 D	O	3/12/85	49,700		16,000	1,400	350	1,300	23,000		4,700	670	880	1,400					
	L	9/18/85	54,700		11,500	2,600		1,500	34,000		1,800		1,500	1,800					
	L	4/2/87	36,100		8,900	1,000		1,000	19,000	600	100		3,500	2,000					
R8-17 I	O	3/12/85	35,290		17,000	770		620	12,000				2,500	2,400					
	L	9/17/85	40,200		14,400	1,100		900	19,000				2,200	2,600					
	L	4/2/87	33,200		17,900	1,000		1,000	7,000	300			3,900	2,100					
R8-17 D	O	3/12/85	11,730		2,100	960		520	4,700				3,100	350					
	L	9/17/85	17,200		1,300	400		900	7,900				6,300	400					
	L	4/2/87	10,700		700	300		1,300	2,800	200			5,100	300					
R8-18S (A)	O	3/12/85	763					15	180		470			98					
R8-18I (A)	O	3/12/85	67,910		33,000	1,500	210	800	26,000		450		650	5,300					
	L	9/18/85	58,800		32,000	1,000		1,000	18,000				1,200	6,600					

* Lab
F - Friend Laboratory, Inc.; Waverly, NY
O - O'Brien & Gere Engineers, Inc.; Syracuse, NY
L - Lancaster Laboratories, Inc.; Lancaster, PA
H - NY Department of Health

(A) - These samples were tested for additional HSL parameters (See Table 4-8).

the thousands of ppm range, and none of them are readily adsorbed in the soil (i.e., they are very mobile in the subsurface).

Whereas the PCB/oil migration detected in monitoring wells at the Route 8 Landfill site is primarily contained in the shallow and intermediate overburden aquifers, VOC migration has occurred in both the overburden and bedrock aquifers.

4.4.2.1 Glacial Overburden System

Figure 4-17 is an isoconcentration map of total VOCs in the intermediate glacial overburden system. Although the data are from two separate monitoring events (September, 1985 and April, 1987), all results from wells sampled at both times were consistently within the same order-of-magnitude. Given the high concentrations near and downgradient of the source area, the data can be used together to show the configuration of the plume. As seen in Figure 4-17, VOC plume migration in the overburden is principally northwestward. The influence of the sand outwash unit can be seen, however, in a more westward plume component. The "lobate" character of this plume migration appears to suggest that separate plumes emanate from the Area 1 and Area 2 sources. However, the presence of greater volumes of water in the permeable sand lens provides dilution of the plume in that area, resulting in the "lobate" characteristic.

The geologic cross sections in Figures 4-1 and 4-2 show the distribution of total VOCs in the glacial overburden both westward, perpendicular to the plume and northward, along the plume axis. It can be seen that near source Area 1, and immediately downgradient (at wells R8-16, 17, 18, and 19), VOC concentrations are present throughout the overburden at concentrations in the tens of thousands of ppb. These cross sections also show that downward hydraulic heads exist within the overburden. As indicated in Section 4-3, downward flow occurs at the site, resulting in the observed vertical migration of VOCs. The relationship of the total VOCs in the intermediate and top of bedrock systems indicates a fairly uniform distribution vertically, near the source area.

Figure 4-17 shows that the overburden VOC plume extends beyond the Unalam Tributary, to Well R8-32, where the total VOC concentration is over 6000 ppb. The results of stream sampling in the Tributary are shown on Figure 4-17, as well. It can be seen that along the axis of the VOC plume, no VOCs were detected in the tributary at stream location STR3. Downstream at STR4, approximately 366 ppb of VOCs were detected; however, between these two locations the cooling water from the Unalam Well is discharged, possibly accounting for the VOCs at STR4. These data indicate that the Unalam Tributary is not a regional discharge area for the water in the glacial overburden; to the contrary, the VOC plume underflows the tributary.

TABLE 4-6 (CONTINUED)
GROUND WATER ANALYSIS
OVERBURDEN WELLS - VOLATILE ORGANIC RESULTS (PPB)

Overburden Wells	Lab *	Date Sampled	Total Volatiles	Benzene	Toluene	Ethyl-benzene	1,1-dichloro-ethene	1,1-dichloro-ethane	Trans-1,2-dichloro-ethene	Chloroform	Trichloro-ethene	Methylene Chloride	Vinyl Chloride	1,1,1-Trichloro-ethane	1,2-Dichloro-ethane	Chloroethane	Tetrachloro-ethene	Dibromochloro-methane	Carbon Tetrachloride
R8-196	O	3/12/85	28,570		15,000	430		370	11,000		470		200	1,100					
	L	9/18/86	61,500		35,000	6,000		800	17,000		400	400	1,200	1,700					
R8-19 I	O	3/12/85	24,200		9,400	1,100		500	12,000		180		330	690					
	L	9/18/85	25,400		11,600	500		600	11,000				800	900					
	L	4/2/87	14,266	3	2,500	2	26	500	8,600		19		1,700	900	33		3		
R8-19 D	O	3/12/85	39,100		14,000	1,600	690	660	20,000		1,900		130						
	L	9/18/85	51,900		9,300	1,200	400	1,200	27,000		11,000	900		300	600				
	L	4/2/87	22,780		2,400		40	800	17,000	520	70		1,200	680	70				
R8-20	O	3/12/85	1,270		92	18		320	47				700	93					
	L	9/16/87	1,120					490	50				530	50					
	L	4/2/87	669		2			470	13	2			88	10	4				
R8-21	O	3/12/85	2,841		420			72	1,300	39			220	490					
	L	9/16/87	2,090		400			80	960				240	410					
R8-23	L	9/12/86	5					3	2										
	L	4/2/87	230					76	37		2		110	4	1				
R8-25	L	9/12/86	342					98	170		21		44	3	3	6			
	L	4/2/87	387					210	120		26		31						
R8-26	L	9/16/86	180		1	2		18	74		12		47	25	1				
	L	4/2/87	227			3		32	70		9		86	26	1				
R8-27	L	9/18/85	5,242	6	1,250	136	31	770	1,100		33	2	1,800	110			4		
	L	4/2/87	16,900		4,100	4,900		700	2,000	100			4,100	1,000					
R8-29	L	9/18/85	11,400					1,200	5,100		600		4,200	300					
	L	4/2/87	8,422	8	13		19	1,300	3,800	84	220	2	2,700	220	29	27			
R8-31	L	9/18/85	37,200					1,200	24,000		200		11,000	800					
	L	4/2/87	23,868	9	2		46	1,000	13,000		75	12	9,000	700			3	21	
R8-32	L	4/2/87	6,020				10	180	4,300	210	1,100	50		60	40			60	10
R8-34	L	4/2/87	21		2				3		16								

* Lab
F - Friend Laboratory, Inc.; Waverly, NY
O - O'Brien & Gere Engineers, Inc.; Syracuse, NY
L - Lancaster Laboratories, Inc.; Lancaster, PA
H - NY Department of Health

(A) - These samples were tested for additional HSL parameters (See Table 4-8).

TABLE 4-6 (CONTINUED)
GROUND WATER ANALYSIS
BEDROCK WELLS - VOLATILE ORGANIC RESULTS (PPB)

Bedrock Wells	Lab *	Date Sampled	Total Volatiles	Benzene	Toluene	Ethyl-benzene	1,1-Dichloroethane	1,1-Dichloroethene	Trans-1,2-Dichloroethene	Chloroform	Trichloroethene	Methylene Chloride	Vinyl Chloride	1,1,1-Trichloroethane	1,2-Dichloroethane	Chloroethane	Tetrachloroethene	Dibromochloromethane	Carbon Tetrachloride
RB-1	F	12/15/83	169								169								
	F	4/25/84	867								800			67					
	O	3/13/85	ND																
	L	9/12/85	326				5	16	160		95		39	8	4				
RB-2	F	12/15/83	63 (U)								51			12					
	F	4/25/84	132						67		64			11					
	O	3/13/85	61						39		22								
	L	9/12/85	140					12	62		17		28	17	2	2			
RB-3	O	3/12/85	5,831		950	270		650	1700				1,900	350	11				
	L	9/17/85	5,000		1,200			1100	1200				1,500						
RB-4 (A)	O	3/12/85	28,930		1,300	470	190	930	9300	710	12,000	170	130	830	2,900				
	L	9/18/85	47,000		13,000	1,100	500	1500	12000	1500	14,000	1,400	600	800	600				
RB-5	O	3/11/85	9,059		1,200	21	28	220	4900		200		590	1,900					
	L	9/17/85	11,720		4,590	260		280	4500				490	1,600					
RB-24	L	9/12/85	107					26	59		4		15	2	1				
RB-28	L	9/18/85	820		150	20		50	350				130		20		100		
RB-30	L	9/18/85	10,600		700	200		500	5900	500	600		1,900	100	200				
RB-33	L	4/2/87	840					50	650	40	90		10						
RB-35	L	4/2/87	136	1	16	4		3	32	1	77			2					
RB-36	L	4/2/87	12					2	5		3			2					
RB-37	L	4/2/87	1,740		190			120	680				760						
Unalam Well	H	4/17/85	2,930	400	10	5	9	140	1900	20	94		280	52	20				
	L	9/18/85	2,420					190	1800		60		370						
	L	4/2/87	1,720					190	1,200		20		280	30					
Village Maintenance Shop Well (150')	L	3/4/87	14					2	9		2		1						
Village Maintenance Shop Well (400')	L	3/4/87	ND																

* Lab
F - Friend Laboratory, Inc.; Waverly, NY
O - O'Brien & Gere Engineers, Inc.; Syracuse, NY
L - Lancaster Laboratories, Inc.; Lancaster, PA
H - NY Department of Health

(U) - Some minor additional compounds were reported.

(A) - These samples were tested for additional HSL parameters (See Table 4-8).

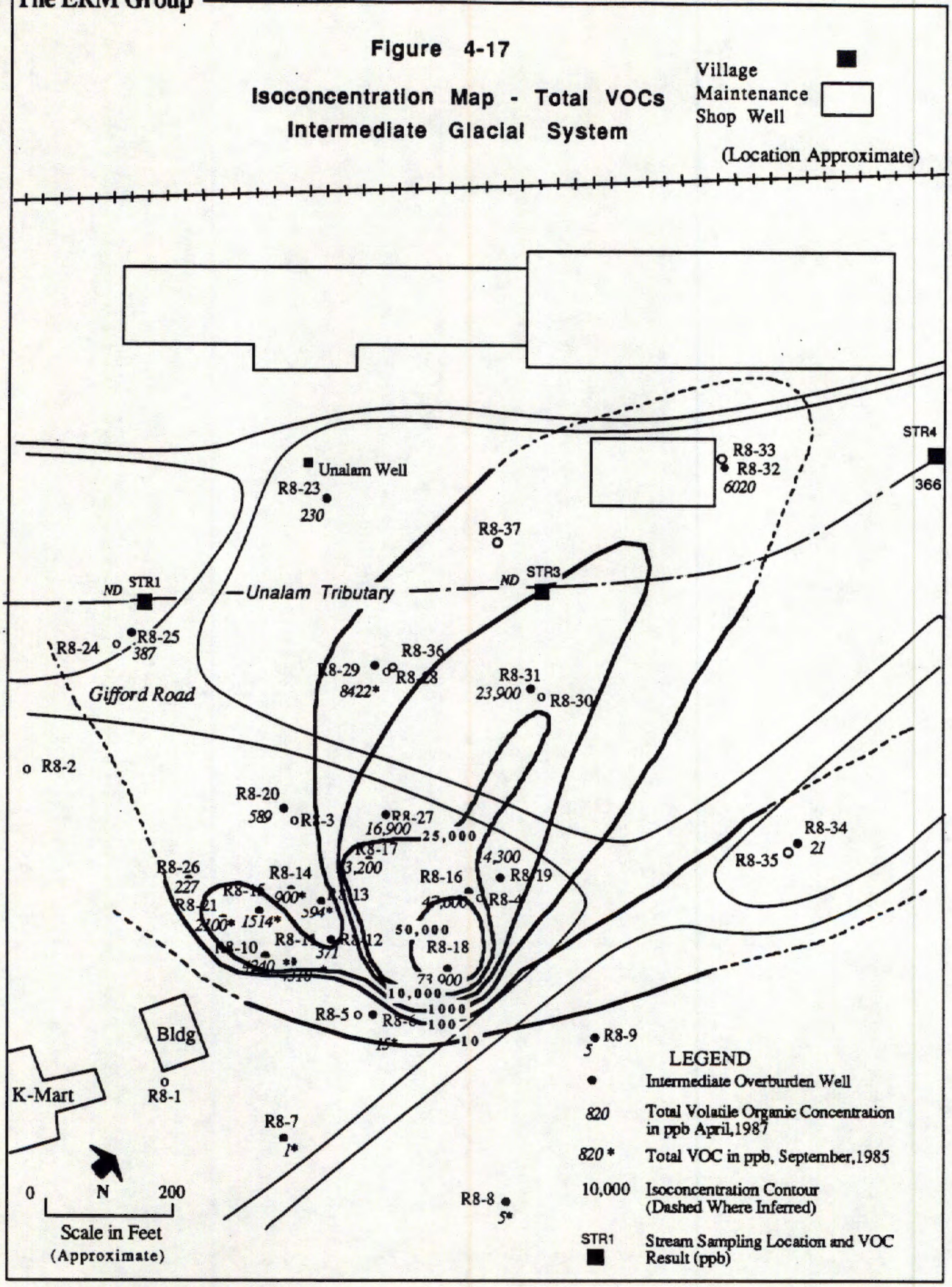


Figure 4-17
Isoconcentration Map - Total VOCs
Intermediate Glacial System
Village Maintenance Shop Well
(Location Approximate)
Unalam Well
R8-23
230
R8-33
R8-32
6020
STR4
366
R8-37
ND
STR1
Unalam Tributary
ND
STR3
R8-24
R8-25
387
Gifford Road
R8-29
8422*
R8-36
R8-31
23,900
R8-30
R8-2
R8-20
589
R8-27
16,900
25,000
R8-17
3,200
14,300
R8-19
R8-34
21
R8-35
R8-26
227
R8-14
R8-16
R8-4
R8-21
2100*
1514*
R8-13
594*
R8-10
R8-11
R8-12
371
50,000
R8-18
73,900
10,000
1000
100
10
R8-5
R8-6
15*
R8-9
5
Bldg
K-Mart
R8-1
R8-7
1*
R8-8
5*
0
N
200
Scale in Feet
(Approximate)
LEGEND
Intermediate Overburden Well
820
Total Volatile Organic Concentration in ppb April,1987
820*
Total VOC in ppb, September,1985
10,000
Isoconcentration Contour (Dashed Where Inferred)
STR1
Stream Sampling Location and VOC Result (ppb)

An evaluation of the ratios of TCE and its degradation compounds indicates that the Route 8 Landfill may not be the sole source of the VOCs at Well R8-32. Figure 4-18 shows the ratio of TCE to total alkenes at each of the overburden wells containing VOC concentrations over approximately 1000 ppb. It can be seen that TCE dominates only at the source area (Well R8-18) in the overburden. Degradation of TCE to DCE and VC occurs extensively near the source area, resulting in downgradient TCE/Total Alkene ratios ranging from .002 to .14, and averaging 0.02 south of the Unalam Tributary. Thus, the transformation of TCE by reductive dehalogenation averages 98 percent complete downgradient of the source area in the glacial overburden, and is greater than 99 percent at 9 of the 13 wells. By comparison, the ratio at Well R8-32, north of the Unalam Tributary, is 0.20, indicating a TCE transformation of only 80 percent. Furthermore, this is the only overburden well downgradient of the source area at which no vinyl chloride was detected. Upgradient DCE to VC ratios suggest that VC should be present in R8-32 at greater than 1000 ppb, and possibly two to three times that, if the source area is the Route 8 Landfill.

These data indicate that the Route 8 Landfill may not be the source of the VOCs at Well R8-32, suggesting the presence of an alternate source north of the Unalam Tributary. The Route 8 Landfill plume has likely been "retarded" and/or diluted upon entering the glaciolacustrine silty clay body between wells R8-31 and R8-32. The hydraulic gradient in this area is reduced to about 0.05. Furthermore, hydraulic conductivities in such "plastic" clays are commonly on the order of 1×10^{-6} cm/sec (.0027 ft/day) or lower and have high porosities (up to 50 percent), which would dilute the plume and reduce the rate of flow in the clay to:

$$V = \frac{.0027 \times .05}{.5} = .0003 \text{ ft/day}$$

or less than 1 foot per year. Thus, the plume front may not have reached Well R8-32. Furthermore, in the area north of R8-31, where the pumping of the Unalam Well maximizes the hydraulic gradient between the overburden and bedrock, the Route 8 Landfill plume may be migrating predominantly downward, thus effectively preventing migration into the low permeability silty clay body.

4.4.2.2 Bedrock System

The VOC results from the bedrock wells are shown in Table 4-6. It can be seen VOC concentrations ranged from 76,930 ppb at R8-4 near the source areas to close to 10 ppb on the plume margins. Again, data from two monitoring events (September, 1985 and April 1987) are combined to define the plume on an order-of-magnitude basis. Figure 4-19 shows the configuration of the bedrock plume. Migration has occurred northward, and somewhat westward, similarly to the overburden plume. The approximate limit of the

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Figure 4-18

Ratio of Trichloroethene to Total Alkenes Overburden and Bedrock Wells

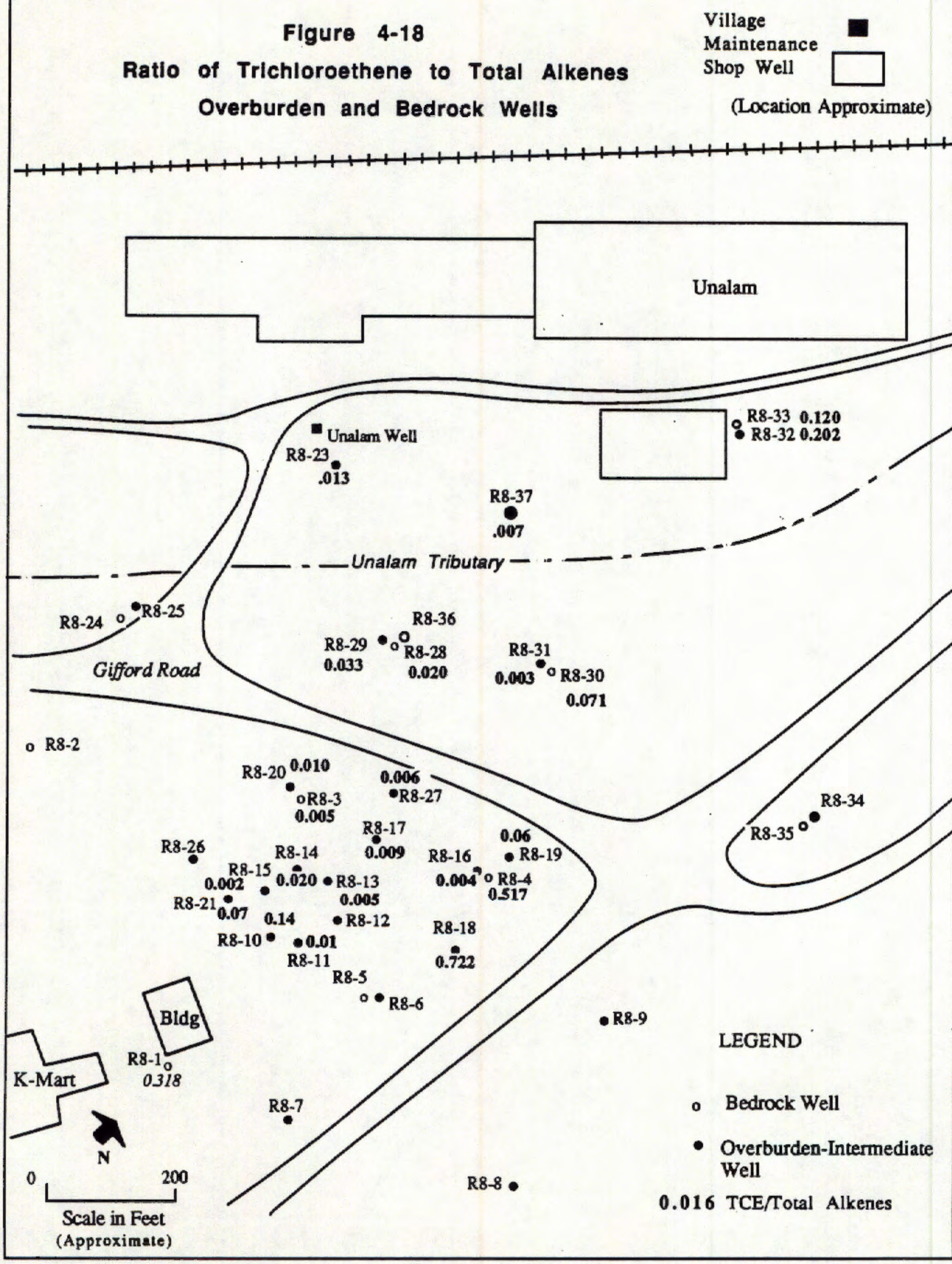

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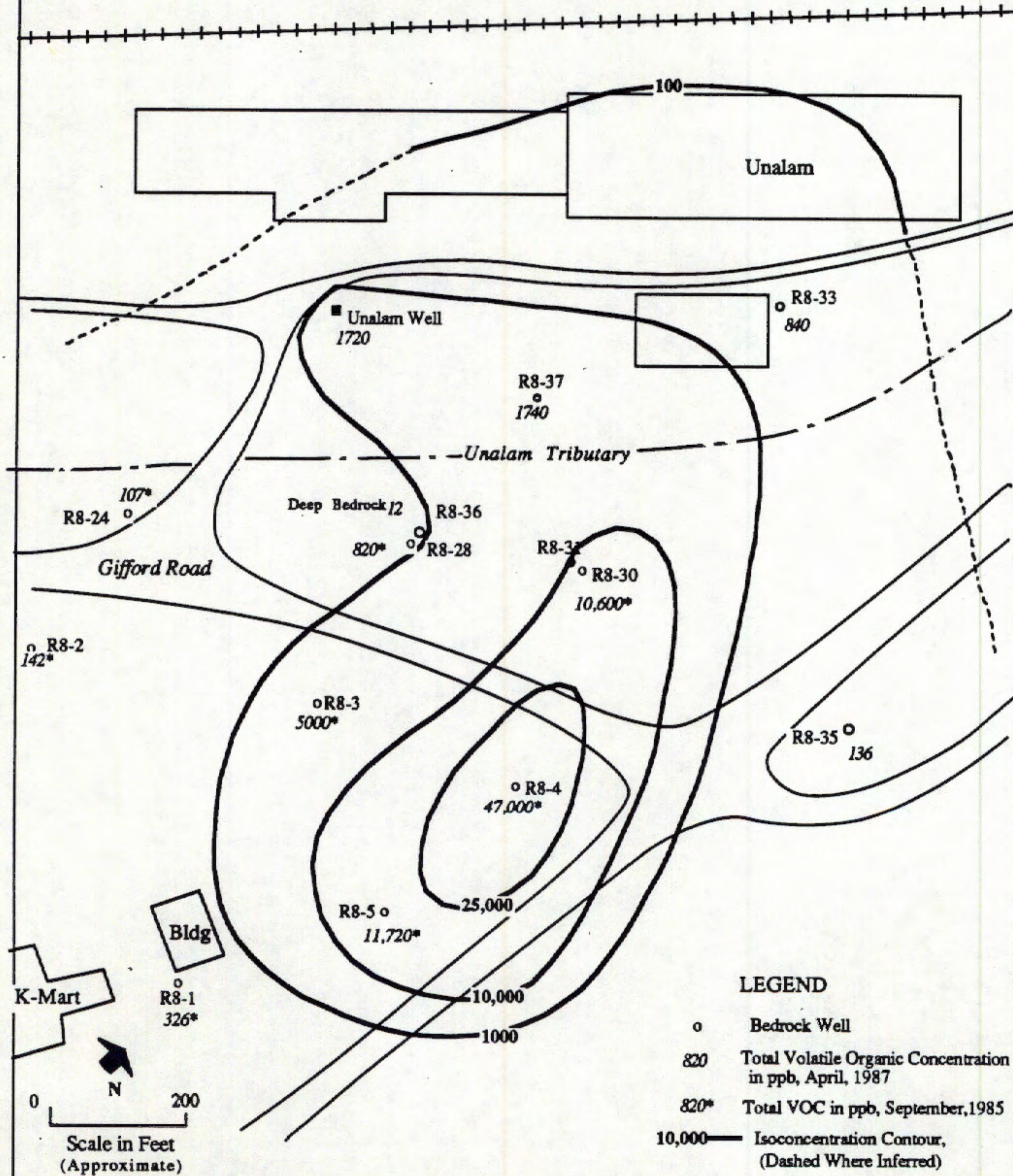
Figure 4-19
Isoconcentration Map - Total VOCs
Bedrock System



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plume along its axis was defined at the Village Maintenance Shop well, where 14 ppb total VOCs were detected.

As discussed in Section 4.3, the bedrock flow system receives substantial recharge from the glacial overburden system. This is reflected in the VOC concentrations, which range from less than 100 ppb on the plume edges at R8-1, to approximately 76,000 ppb at R8-4 immediately downgradient of source Area 1. Figure 4-1 shows that near the source area at Well R8-4, the bedrock concentrations are close to the overburden concentrations, with dilution less than two-fold. Thus, the recharge contribution of the overburden to the shallow bedrock zone is greater than 50 percent, with inflow from upgradient providing the remainder. This inhibits the ability of the bedrock system to decrease plume concentrations by dilution and dispersion, as the plume is continually recharged by VOCs from the overburden plume above.

At the Unalam Well, the compounds detected and their ratios are mostly similar to those detected in the Route 8 Landfill monitoring wells. However, the DOH analysis of April 17, 1984 indicated the presence of benzene at higher concentrations than would be expected, and also of 2,3 benzofuran and N-propylbenzene. This raises the possibility that a source other than the Route 8 Landfill contributes to the VOCs detected in the ground water from the Unalam Well.

However, Figure 4-19 shows the effects of the Unalam Well pumping on the bedrock VOC plume. Basically, the plume travels northward until the area east of Well R8-37, where it makes a 90 degree angle turn toward the Unalam Well. This is consistent with the pumping responses seen during the Unalam Well pump test, as shown in Figure 4-13. Thus, when the migrating plume encounters the east-west trending fracture zone (as defined at R8-30 and R8-37), the Unalam Well pumping draws it westward, toward that well. The residual bedrock plume, as seen at Well R8-33 and the Village Maintenance Shop Well, is the result of the intermittent pumping cycle at the Unalam Well, and the combined effects of the apparent additional source area, north of the Unalam Tributary.

It is important to note that analytical data indicate that no significant vertical migration of VOCs appears to be occurring in the bedrock aquifer, despite the downward hydraulic gradient seen between Wells R8-28 and R8-36. The VOC results from these wells indicate the presence of 820 ppb in the shallow bedrock, and only 12 ppb in the deeper zone. In addition, at the Village Maintenance Shop Well, no VOCs were detected in the sample collected from the deep section of the well. Three factors are likely responsible for this:

- The near horizontal bedding of the unit does not favor vertical transport in interfracture areas;

- In the fracture zone which intercepts the plume, the depth of Unalam Well pumping limits the vertical migration, as water is drawn preferentially sub-horizontally toward that well; and

- larger volumes of water recharged from upgradient of the Route 8 Landfill likely circulate through the deep system, providing dilution capacity.

Thus, the principal bedrock aquifer impacts of the site are limited to a zone of perhaps 50 feet or less in thickness, as seen at R8-28/36.

4.4.3 Other Analyses

In addition to the VOC, PCB, and Oil/Grease analyses, four samples were analyzed for metals in 1985 (from wells 17I, 17D, 18S, and 18I), and four for the Hazardous Substances List (HSL) compounds in 1987. The results are shown in Tables 4-7 and 4-8. It can be seen that in 1985 arsenic was detected at 20 ppb, below its Primary Drinking Water Standard (PDWS) of 50 ppb. Lead was detected ranging from 50 to 150 ppb, above its PDWS of 50 ppb. However, in 1987, no lead was detected. Other HSL metals detected in 1987 were principally major ions and common trace ions such as barium and zinc, which are normally detected in ground water.

The HSL volatile analyses detected the same compounds as detected previously, with the addition of low ppb acetone, 2-butanone, and 4-methyl-2-pentanone at Well R8-4. Xylenes were detected at R8-18I, and are compatible with the detection of toluene and benzene compounds associated with refined petroleum products.

The HSL semi-volatiles series analysis indicated only the presence of 40 to 100 ppb of naphthalene, and the PCB analyses were compatible with others collected near the source area (Table 4-8).

4.5 Surface Drainageways

The surface water analysis results are shown on Table 4-9, and the associated drainageway sediment sample analysis results on Table 4-10.

4.5.1 Surface Water Analysis Results

The VOC results from the surface water samples range from none detected to 486 ppm (Figure 4-20). South of the source areas, where the small drainageway emerges from the K-Mart Drain, 109 ppb total VOCs were detected. Downstream, at Location GRS3, this increased to 376 ppb and at GRS4 to 486 ppb. This increase is due to the effects of shallow ground water discharge from the Route 8 Landfill area. South of the Gifford Road Spring, no VOCs were detected in the intermittent surface drainageway.

TABLE 4-7
GROUND WATER ANALYSIS
INORGANIC ANALYTICAL RESULTS (PPM)

Well	Sample Date	Antimony	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
R8-1	3/13/85													
R8-2	3/13/85													
R8-3	3/12/85													
R8-4	3/12/85													
R8-5	3/11/85													
R8-6	3/11/85													
R8-7	3/13/85	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
R8-8	3/13/85	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
R8-9	3/13/85	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
R8-10	3/13/85													
R8-11	3/13/85													
R8-12	3/13/85													
R8-13	3/13/85													
R8-14	3/13/85													
R8-15	3/13/85													
R8-16 D	3/12/85													
R8-16 I	3/12/85													
R8-16 S	3/12/85													
R8-17 D	3/12/85							0.05						0.03
R8-17 I	3/12/85		0.02					0.15						
R8-18 I	3/12/85		0.02					0.10						
R8-18 S	3/12/85	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
R8-19 D	3/12/85													
R8-19 I	3/12/85													
R8-19 S	3/12/85													
R8-20	3/13/85	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
R8-21	3/13/85													
Gilford Spring	3/13/85		0.01											

All of the above inorganic results were supplied by O'Brien & Gere Engineers, Inc.
ND = none detected.
Blank spaces = not analyzed.

TABLE 4-8
GROUND WATER ANALYSIS-HSL RESULTS
APRIL 1-3, 1987

Compound	Sample Location			
	R8-4	R8-18 S	R8-18 I	* Gifford Road Spring
Volatile Organics (PPB)				
Total Volatiles	108.78	2530	73900	442
Vinyl chloride	0.7	30	2100	70
Methylene chloride	1.6	8		
Acetone	48			
1,1-Dichloroethene			100	
1,1-Dichloroethane	1.1	250	940	190
Trans-1,2-Dichloroethene	15	1900	32000	32
Chloroform	0.48	7	370	
1,2-Dichloroethane		20		
2-Butanone	5.8			
1,1,1-Trichloroethane	0.75	290	5000	9
Trichloroethene	16	25	90	
4-Methyl-2-pentanone	1.8			
Toluene	16		28000	11
Ethylbenzene	0.65		1900	
Total Xylenes	0.9		3400	130
Semi Volatile Organics (PPB)				
Naphthalene	40		200	40
Pesticides (PPB)				
Heptachlor Epoxide		0.8		
PCB-1242			38	
PCB-1254		19	39	
PCB-1260		3	5	
Metals (PPM)				
Arsenic			0.031	0.027
Barium	0.3		0.2	0.2
Calcium	19.9	72.8	53.5	25.7
Iron			5.75	23.1
Magnesium	3.24	24.1	33.4	22.1
Manganese	0.01		15.5	5.94
Potassium	5.99	3.85	5.23	3
Sodium	11.8	58.2	40.3	31.9
Zinc			0.02	

* Gifford Road Spring - Ground Water Discharge
Blank Spaces = none detected

TABLE 4-9
SURFACE WATER RESULTS

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VOLATILE ORGANICS (ppb)

Location Designation		Laboratory Designation *	Sample Date	Total Volatiles	Toluene	Benzene	Ethylbenzene	1,1,2-Trichloroethane	Vinyl Chloride	Chloroethane	1,1-Dichloroethene	1,1-Dichloroethane	Trans1,2-Dichloroethene	Chloroform	1,2-Dichloroethane	1,1,1-Trichloroethane	Trichloroethene	PCBs (ppb)	Oil/Grease (ppm)
GRN1		DW-18	7/19/84	126					2			36	57				31	NA	NA
GRN1		DW2	9/12/85	176			10			24		140			2			3.4	25
GRN1		SW2	4/21/86	393					28			110	210	8		37			NA
GRN2	Q	L3	5/12/87	52						37		15							
GRN3		SW3	4/21/86	42								18	19			5			NA
GRN4	Q	L2	5/12/87	167						8		140	14		1	4			
GRN5	Q	L1	5/12/87	280						47		230			3				3 B
GRN6		SW5	4/21/86	7									2			2	3		NA
GRS1		DW6	9/12/85	109							3	4	19		2	30	51	NA	NA
GRS3		SW4	4/21/86	376	8		56		62			200	28			22			NA
GRS4		DW4	9/12/85	2								2						0.23	26
GRS4		SW1	4/21/86	486					32			146	243	11		54			NA
GRS5	Q	L4	5/12/87	0															3 B
STR1		DW-17	7/19/84	0														NA	NA
STR1		DW1	9/12/85	0														NA	26
STR3		DW-16	7/19/84	0														NA	NA
STR4		DW-15	7/19/84	366				18	8			23	280			22	15	NA	NA
Gifford Spring		Gifford Spring	12/06/83	49								36				13		NA	NA
Gifford Spring		Gifford Spring	12/15/83	299								89	56			154		NA	NA
Gifford Srping		Gifford Spring	5/2/84	0														NA	NA
Gifford Srping		DW-19	7/19/84	145					17			92				36		NA	NA
Gifford Srping		Gifford Spring	3/13/85	183					20			81	34			48		4.2	39

NOTES: Blank Spaces = none detected.
NA - Parameter not analyzed.

QUALIFIER CODES:

Q - These samples have undergone an ERM Quality Assurance Review.
B - This result is of questionable qualitative significance since these compounds were detected in blank(s) at similar concentrations.
J - This result should be considered a quantitative estimate.

* See Appendix F

Amphenol-Rt 8
301.07

TABLE 4-10
SEDIMENT ANALYSIS RESULTS

VOLATILE ORGANICS (PPB)

Location Designation	Laboratory Designation *	Sample Date	Total Volatiles	Toluene	Benzene	Ethyl-benzene	1,1,2-Tri-chloro-ethane	Vinyl Chloride	Chloro-ethane	1,1-Dichloro-ethene	1,1-Dichloro-ethane	Trans1,2-Dichloro-ethane	Chloro-form	1,2-Dichloro-ethane	1,1,1-Trichloro-ethane	Trichloro-ethene	PCBs (ppb)	Oil/Grease (ppm)	Moisture % by wt.
GRN1	DS-18	7/19/84															ND	0.02	
GRN1	DS-18A	7/19/84															ND	1.4	
GRN2 Q	Q L3	5/12/87	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6680J	2.4 J	49.1 J
GRN4 Q	Q L2	5/12/87	32	ND	ND	ND	ND	ND	ND	ND	32	ND	ND	ND	ND	ND	ND	0.095 B	37.1
GRN5 Q	Q L1	5/12/87	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.181	72.4
GRS1	DS 6A 0"-6"	9/12/85															ND	0.06	
GRS1	DS 6B 10"-16"	9/12/85															ND	0.03	
GRS2	DS 5A 0"-6"	9/12/85															ND	0.02	
GRS2	DS 5B 10"-16"	9/12/85															ND	0.04	
GRS4	DS 4A 0"-6"	9/12/85															ND	0.04	
GRS4	DS 4B 10"-16'	9/12/85															ND	0.06	
GRS6 Q	L5	5/12/87	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.05 B	0.4
GRS7	DS 3A 0"-6"	9/12/85															ND	0.03	
STR1	DS-17	7/19/84															ND	0.06	
STR1	DS-17A	7/19/84															ND	0.13	
STR3	DS-16	7/19/84															ND	1.4	
STR3	DS-16A	7/19/84															ND	0.73	
STR4	DS-15	7/19/84															ND	ND	
STR4	DS-15A	7/19/84															ND	0.15	
Gifford Spring		1983															2,500	55,000	
Gifford Spring	DS-19	7/19/84															ND	0.67	
Gifford Spring	DS-19A	7/19/84															ND	0.02	

NOTES: ND = none detected.
Blank Spaces = analysis for these compounds was not conducted.
All sediment samples are reported on a dry weight basis with the exception of % moisture.

* See Appendix F

QUALIFIER CODES:

Q - These samples have undergone an ERM Quality Assurance Review.
B - This result is of questionable qualitative significance since these compounds were detected in blank(s) at similar concentrations.
J - This result should be considered a quantitative estimate.

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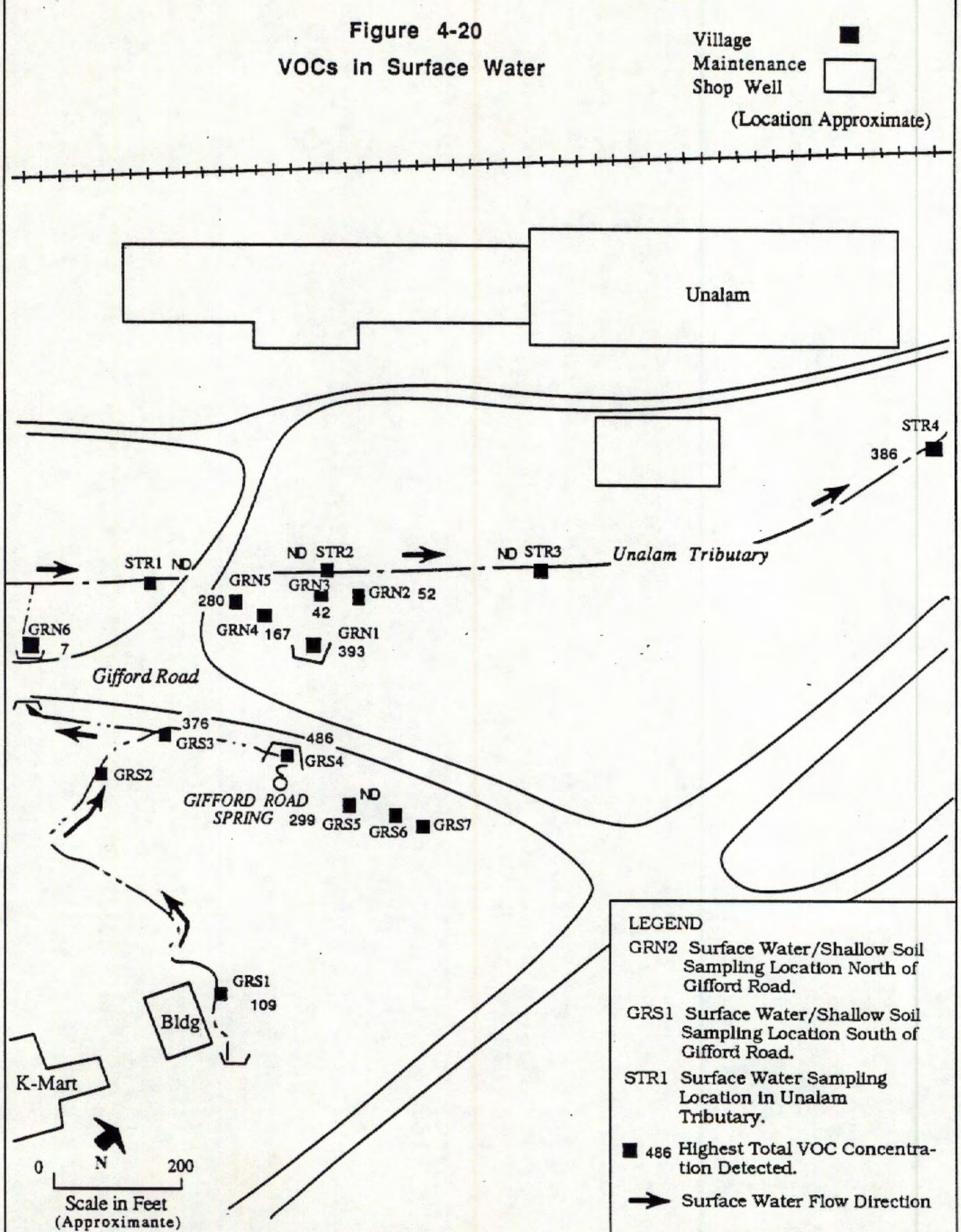
Figure 4-20
VOCs in Surface Water



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North of Gifford Road, 393 ppb were detected at the culvert outlet. In the marsh between the culvert and the Unalam Tributary, total VOCs ranged from 42 to 280 ppb. To the west at GRN6, 7 ppb total VOCs were detected. North and south of Gifford Road, PCBs were detected once at the Gifford Road Spring, once at GRS1, and once at GRS4, at less than 5 ppb levels. Oil and grease were also detected at those locations.

In the Unalam Tributary, VOCs were not detectable at STR1 and STR3. At STR4, just downstream from Unalam, 366 ppb were detected. As noted previously, this may be due to discharge of cooling water drawn from the Unalam Well. The ratio of TCE to total alkenes in this analysis result was 0.003, which confirms that the source area is the Route 8 Landfill, and not an alternate source north of the tributary.

4.5.2 Drainageway Sediment Analysis Results

The drainageway sediment analysis results are shown in table 4-10. The results from seeps and the marsh north and south of Gifford Road indicate that VOCs are generally absent from the drainageway sediments, except for one low ppb detection of 1,1-dichloroethane. Low levels of oil and grease were detected in most samples, ranging from 0.02 to 2.4 mg/l. PCBs were detected at only one location (detection limits ranging from 0.2 to 4 ppm) in the marsh north of Gifford Road, at 6.7 ppm.

At the Gifford Road Spring, 2.5 ppm of PCBs were detected, along with 55,000 ppm of oil and grease, directly at the highest elevation seasonal discharge point. Further down slope, along the spring discharge route, no PCB was detected in the 1984 sampling/analysis event, and less than 1 ppm of oil and grease was detected.

Overall, the results of the surface drainageway investigations do not indicate widespread surface migration of compounds related to the Route 8 Landfill site. In regard to PCBs and oil, the tendency of PCBs to adsorb to the subsurface soils has prevented their migration into surface drainageways, and the viscosity of the oil has limited its migration as well. Thus, it is evident that much of the discoloration observed at seasonal seeps, in the Gifford Road Spring and along site drainageways, is due to iron precipitation.

SECTION 5

CONCLUSIONS

As a result of investigations at the Route 8 Landfill, ERM has reached the following conclusions:

1. The principal waste constituents associated with the Route 8 Landfill are PCBs and volatile organics (VOCs) including toluene, ethylbenzene, 1,1 dichloroethane, trans-1,2 dichloroethene, trichloroethene, vinyl chloride, and 1,1,1-trichloroethane.

2. The principal source area for the waste constituents is a limited former pit or trench area which presently lies beneath the west lane and shoulder of Route 8, approximately 250 feet south of the intersection of Route 8 and Delaware Avenue.

3. PCB migration has occurred in solution in oil, and is concentrated in a permeable sand lens of limited extent, which discharges to the surface at the Gifford Road Spring and at smaller wet weather seeps.

4. PCB migration has been limited by its low solubility and adsorption onto subsurface soils, such that little migration has occurred in site-related surface drainageway waters or sediments.

5. PCBs are present in solution in shallow ground water near the source area at concentrations in the low ppb to ppm range; no PCBs were detected in the regional bedrock aquifer.

6. Migration of VOCs has occurred in the concentration range of tens of thousands of ppb, in the ground water beneath and downgradient of the site, in both the glacial overburden and regional bedrock aquifers.

7. No site-related VOCs are present in any well used for potable water.

8. The downgradient limit of the overburden plume is uncertain, as it appears that a second downgradient source of VOCs may be present. However, it is apparent that the presence of the lacrustine silty clay body in the path of the plume limits the extent of its migration.

9. The bedrock VOC plume is diverted and almost fully contained by the cyclical pumping of the Unalam Production Well.

10. The Amphenol West Well pumping does not affect plume migration.

11. VOCs discharge from the overburden sand lens at the Gifford Road Spring, at wet weather seeps, and into the marsh north of Gifford Road at concentrations ranging up to about 500 ppb.

12. The Unalam Tributary receives VOCs at the north end of Unalam from cooling water discharge from the Unalam Well.

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