WATER-QUALITY CONDITIONS AT SELECTED LANDFILLS IN MECKLENBURG COUNTY, NORTH CAROLINA, 1986-92

By G.M. Ferrell and Douglas G. Smith

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BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

Gordon P. Eaton, Director

For additional information
write to:

District Chief
U.S. Geological Survey
3916 Sunset Ridge Road
Raleigh, NC 27607

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CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS, TEMPERATURE, VERTICAL DATUM, AND ABBREVIATIONS

Multiply	*By*	*To obtain*
	Length	
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
acre	4,047	square meter
square mile (mi^2)	2.590	square kilometer
	Volume	
gallon (gal)	3.785	liter
	0.003785	milliliter
	Mass	
ton, short (2,000 lb)	0.9072	megagram
	Specific conductance	
micromho per centimeter at 25 degrees Celsius (µmho/cm at 25 °C)	1.000	microsiemens per centimeter at 25 degrees Celsius

Temperature: Equations for temperature conversion between degrees Celsius (°C) and degrees Fahrenheit (°F):

$$°C = 5/9\ (°F-32)$$
$$°F = 1.8\ (°C) + 32$$

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviations used in the text of this report in addition to those shown above:

cols/100 mL	colonies per 100 milliliters
ft/d	foot per day
MCL	maximum contaminant level
µg/L	microgram per liter
µg/L/yr	microgram per liter per year
µS/cm at 25 °C	microsiemens per centimeter at 25 degrees Celsius
µS/cm	microsiemens per centimeter
µS/cm/yr	microsiemens per centimeter per year
mg/L	milligram per liter
mg/L/yr	milligram per liter per year
PCB	polychlorinated biphenyl
PVC	polyvinyl chloride
units/yr	units per year
EPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

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WATER-QUALITY CONDITIONS AT SELECTED LANDFILLS IN MECKLENBURG COUNTY, NORTH CAROLINA, 1986-92

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ABSTRACT

Water-quality conditions at five municipal landfills in Mecklenburg County, North Carolina, were studied during 1986-92. Analytical results of water samples from monitoring wells and streams at and near the landfills were used to evaluate effects of leachate on surface and ground water. Ground-water levels at monitoring wells were used to determine directions of ground-water flow at the landfills. Data from previous studies were used for analysis of temporal trends in selected water-quality properties and chemical constituents.

Effects of leachate, such as large biochemical- and chemical-oxygen demands, generally were evident in small streams originating within the landfills, whereas effects of leachate generally were not evident in most of the larger streams. In larger streams, surface-water quality upstream and downstream from most of the landfills was similar. However, the chemical quality of water in Irwin Creek appears to have been affected by the Statesville Road landfill. Concentrations of several constituents indicative of leachate were larger in samples collected from Irwin Creek downstream from the Statesville Road landfill than in samples collected from Irwin Creek upstream from the landfill.

The effect of leachate on ground-water quality generally was largest in water from wells adjacent to waste-disposal cells. Concentrations of most constituents considered indicative of leachate generally were smaller with increasing distance from waste-disposal cells. Water samples from offsite wells generally indicated no effect or very small effects of leachate.

Action levels designated by the Mecklenburg County Engineering Department and maximum contaminant levels established by the U.S. Environmental Protection Agency were exceeded in some samples from the landfills. Ground-water samples exceeded action levels and maximum contaminant levels more commonly than surface-water samples. Iron and manganese were the constituents that most commonly exceeded action levels in water samples from the landfills.

Synthetic organic compounds were detected more commonly and in larger concentrations in ground-water samples than in surface-water samples. Concentrations of synthetic organic compounds detected in water samples from monitoring sites at the landfills generally were much less than maximum contaminant levels. However, concentrations of some chlorinated organic compounds exceeded maximum contaminant levels in samples from several monitoring wells at the Harrisburg Road and York Road landfills.

Trend analysis indicated statistically significant temporal changes in concentrations of selected water-quality constituents and properties at some of the monitoring sites. Trends detected for the Holbrooks Road and Statesville Road landfills generally indicated an improvement in water quality and a decrease in effects of leachate at most monitoring sites at these landfills from 1979 to 1992. Water-quality trends detected for monitoring sites at the Harrisburg Road and York Road landfills, the largest landfills in the study, differed in magnitude and direction. Upward trends generally were detected for sites near recently closed waste-disposal cells, whereas downward trends generally were detected for sites near older waste-disposal cells. Temporal trends in water quality generally reflected changes in degradation processes associated with the aging of landfill wastes.

INTRODUCTION

Mecklenburg County is one of the most industrialized and rapidly growing areas in North Carolina. Charlotte, the largest city in North Carolina, is located in Mecklenburg County. From 1980 to 1990 the population of Mecklenburg County increased almost 27 percent, from 404,300 to 511,400 (U.S. Department of Commerce, 1980 and 1990). Associated with the increase in population has been an increase in residential, commercial, and industrial development, as well as corresponding increases in solid-waste production and demands for water. As a result of this growth, landfill sites and methods of waste disposal that minimize ground-water and surface-water contamination are needed.

Expansion of urban and suburban development has drawn attention to possible health risks associated with offsite migration of heavy metals and synthetic organic compounds from old, inactive landfills that originally were located in rural, sparsely populated areas. These areas have become increasingly populated since the time such landfills were placed in operation. Ground-water contamination is of particular concern in the areas not served by public water-supply systems, where residents commonly rely on domestic wells for their drinking-water supply. More than 15,500 people in Mecklenburg County, primarily in rural areas, obtain water supplies from domestic wells.

In response to concerns about the effects of landfills on water quality, the U. S. Geological Survey (USGS), in cooperation with the City of Charlotte and Mecklenburg County, collected hydrologic data in the vicinity of five public landfills in Mecklenburg County to determine the effects of these landfills on the quality of surface water and ground water. Data were collected at the Harrisburg Road landfill, Holbrooks Road landfill, McAlpine Creek at Greenway Park landfill, Statesville Road landfill, and York Road landfill (fig. 1). Except for the Harrisburg Road landfill, which accepts demolition materials for disposal, these landfills are no longer in operation. Parts of the Harrisburg Road, Holbrooks Road, McAlpine Creek at Greenway Park, and York Road landfills have been converted to recreational areas.

Purpose and Scope

This report describes water-quality conditions at five landfills in Mecklenburg County: Harrisburg Road landfill, Holbrooks Road landfill, McAlpine Creek at Greenway Park landfill, Statesville Road landfill, and York Road landfill. Effects of the landfills on surface- and ground-water quality in and near these landfills are described on the basis of data collected from 1986 to 1992.

This report primarily focuses on results of data collected after 1985; however, data collected during previous studies are used for analysis of temporal trends in surface- and ground-water quality at and near all the landfills except the McAlpine Creek at Greenway Park landfill. Because data collection at the McAlpine Creek at Greenway Park landfill did not begin until 1987, the period during which data were collected is too short to permit analysis of temporal water-quality trends at this landfill.

Water samples were analyzed for selected physical, chemical, and biological characteristics, including major inorganic constituents, nutrients, trace metals, total organic carbon, synthetic organic compounds, and bacteria. Changes in water-level fluctuations associated with landfilling procedures are described for the Harrisburg Road landfill. Descriptions of the hydrologic setting, operational history, and water-quality conditions are presented for each landfill.

Description of Study Area

Mecklenburg County is located in south-central North Carolina, in the Piedmont physiographic province (fig. 1). This area is characterized by gently rolling topography consisting of incised streams bordered by broad divides. Land surfaces in most of the county are 600-700 feet (ft) above sea level. Areas having higher elevations generally are remnants of more erosion-resistant rock. Relief generally averages less than 165 ft (Hack, 1982).

The climate of Mecklenburg County is classified as humid subtropical. Average annual precipitation in the study area is 43.1 inches (in.) (National Oceanic and Atmospheric Administration, 1990). Precipitation typically is greatest during summer and least during autumn. Although precipitation is greatest during summer, evapotranspiration is also greatest in summer resulting in a deficit in soil moisture and little ground-water recharge.

Mecklenburg County is drained by the Catawba and Rocky Rivers. These stream basins are separated by a broad ridge, which extends from Davidson in the northern part of the county to Mint Hill in the southeastern part (fig. 1). The Catawba River and its tributaries, including Sugar, Little Sugar, Irvins, McAlpine, and Irwin Creeks, drain the western, central, and southern parts of the county. The Rocky River and its tributaries, including South Prong Clarke

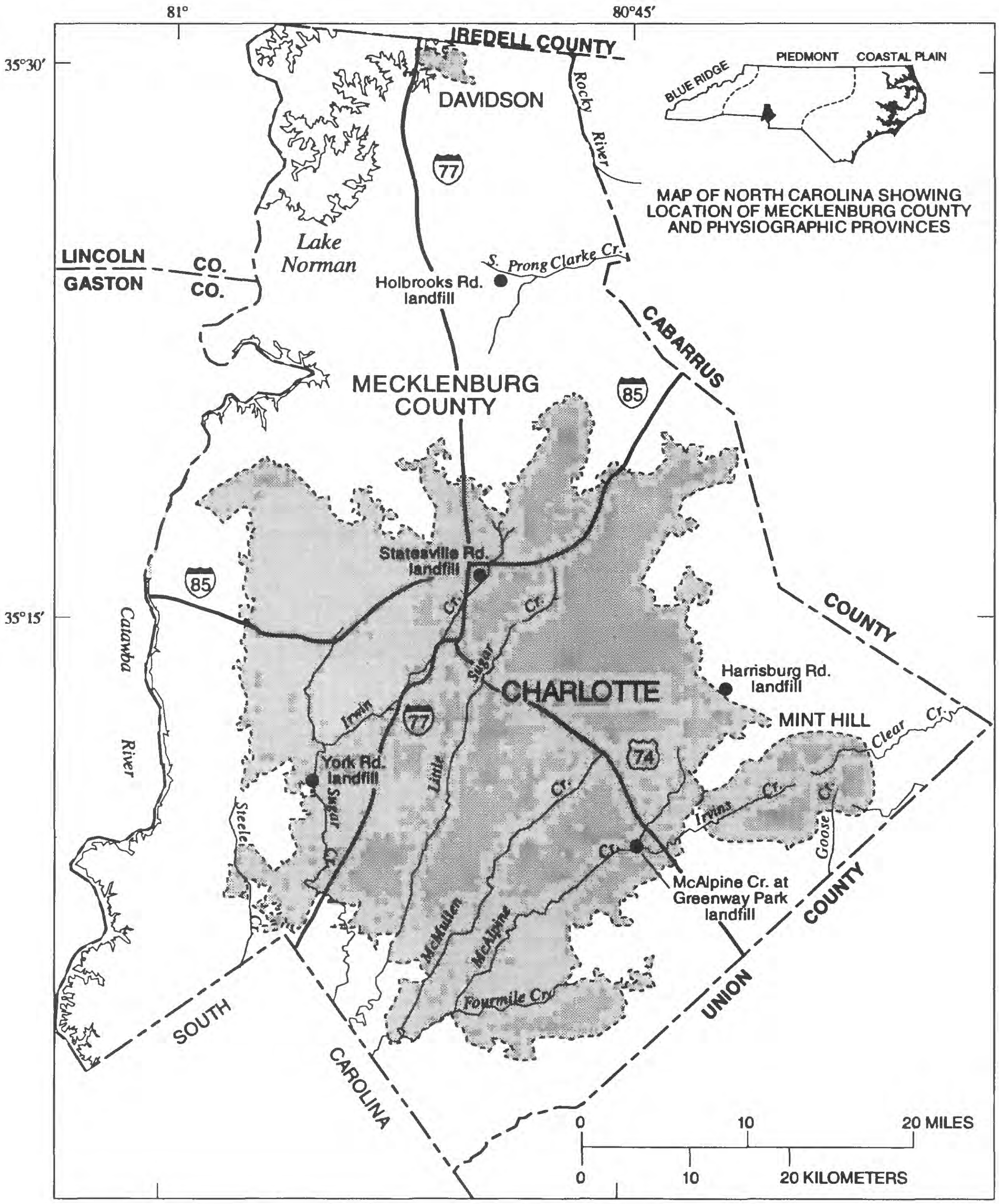

Figure 1. Landfill study sites in Mecklenburg County, North Carolina.

Creek, drain the northeastern part of the county. There are more than 400 miles (mi) of streams in the county.

Previous Studies

In 1979, a study evaluating water-quality characteristics of streams in Mecklenburg County was initiated by the USGS in cooperation with the City of Charlotte and Mecklenburg County. Results of this study indicated that seepage from landfills had affected the quality of some streams, especially during periods of low streamflow (Eddins and Crawford, 1984). As a result of these findings, a study of water-quality conditions at the Harrisburg Road, Holbrooks Road, Statesville Road, and York Road landfills began in 1980. Hydrologic conditions and chemical characteristics of ground water and surface water in the vicinity of these landfills, based on data collected during 1980-86, were described by Cardinell and others (1989). Water-quality data collected in conjunction with these previous studies and data collected from 1986 to 1992, including data collected at the McAlpine Creek at Greenway Park landfill, are listed in Smith (1993).

Hydrogeologic data obtained during preliminary site assessments by Delta Environmental Consultants (1993), Henningson, Durham, and Richardson Consultants (1982), and Law Engineering Testing Company (1980, 1983) were used to supplement data collected by the USGS. Some of the wells and borings installed during preliminary site assessments at the Harrisburg Road, Statesville Road, and York Road landfills were used as monitoring wells during this study.

Acknowledgments

Appreciation is expressed to Mr. Clarke D. Readling, City Engineer, City of Charlotte; Mr. Bobbie Shields, Director of Engineering, Mecklenburg County; Mr. Cary Saul, Deputy Director of Engineering, Mecklenburg County; and Dr. John M. Barry, Director, Mecklenburg County Department of Environmental Protection. All had key roles in planning and coordinating this study. Mr. E. Kenneth Hoffman, former Director of Engineering, Mecklenburg County, and Messrs. Luther Bingham and Paul Joseph Manley, Sr., former employees of the Mecklenburg County Solid Waste Division, also were instrumental during early phases of this study.

Others who contributed to the successful implementation and completion of this study include Messrs. James Thomas Ward, Keith O'Neal, John Gibson, and James H. Pascal, II, of the Mecklenburg County Department of Environmental Protection; Messrs. Edmund L. Allen, Ricky W. Gray, Stephen P. Kelner, and James Queen of the Mecklenburg County Solid Waste Division; Mr. Keith Carpenter, Ms. Helen Reavis, Mr. James W. Schumacher, and Ms. Jane Suggs of the City of Charlotte Engineering Department; and Messrs. William Marlin and Stephen J. Wood of the Mecklenburg County Health Department. Engineering and geotechnical studies of the Harrisburg Road, Statesville Road, and York Road sites were conducted for the City of Charlotte and Mecklenburg County by Law Engineering Testing Company, whose staff members were helpful during this investigation. Special thanks are given to Messrs. Earl Haire and Bevo Barksdale for granting permission to install monitoring sites on their property and for permitting unlimited access to their property.

METHODS OF INVESTIGATION

Data pertaining to the hydrologic setting and history of each landfill were compiled from previous reports, engineering studies, and landfill records. Water-quality monitoring networks, including surface- and ground-water sites, were established at each landfill. Hourly records of water levels were collected at selected wells at the Harrisburg Road and York Road landfills.

Data-Collection Networks

Surface-water monitoring sites were selected to assess the effect of each landfill on surface-water quality. Where possible, surface-water sites were established upstream and downstream from the landfills. Streamflow measurements were made at five gaging stations. Two of these gaging stations were downstream from the Harrisburg Road landfill. Three gaging stations were on Irwin Creek upstream and downstream from the Statesville Road landfill and upstream from the York Road landfill. From 1986 to 1990, hourly measurements of specific conductance and temperature were collected at the gaging stations near the Harrisburg Road and Statesville Road landfills. Streamflow, specific conductance, and temperature records from these gaging stations are in USGS annual hydrologic data reports (U.S. Geological Survey, 1979-93).

Ground-water level networks were established at the Harrisburg Road and York Road landfills to provide information about the direction of ground-water movement. At the Harrisburg Road landfill, recorders were installed on three wells to evaluate the effects of landfilling on water levels. From 1986 to 1989, series of well clusters (closely spaced wells with screened intervals at different depths) were installed at the Harrisburg Road, McAlpine Creek at Greenway Park, and York Road landfills to characterize ground-water quality with respect to depth. Except for the McAlpine Creek at Greenway Park landfill, domestic water-supply wells near the landfills were sampled to supplement offsite water-quality data.

Well Construction

Most of the ground-water monitoring wells at the Harrisburg Road, Holbrooks Road, Statesville Road, and York Road landfills were established before 1986. Many of the monitoring wells in pre-1986 networks at the Statesville Road and York Road landfills were constructed as part of engineering studies. Construction methods and specifications for installation of these monitoring wells are described in reports published by Law Engineering Testing Company (1980, 1983). Most of the monitoring wells installed prior to 1986 at the Harrisburg Road and Holbrooks Road landfills were constructed by the USGS in cooperation with the North Carolina Department of Natural Resources and Community Development; Mecklenburg County; and the City of Charlotte. Construction information and descriptions of these monitoring wells are provided by Cardinell and others (1989).

Beginning in 1986, additional monitoring wells were constructed at the Harrisburg Road, McAlpine Creek at Greenway Park, and York Road landfills to further characterize differences in water quality with respect to depth. These additional wells were installed in clusters. Each cluster included 2 to 4 closely spaced wells with the screened interval of each well set at a different depth. An example of a typical well cluster is shown in figure 2.

A truck-mounted auger rig owned by Mecklenburg County was used to construct most well clusters. Typically, the first well was installed to depth of auger refusal. Subsequent wells were installed adjacent to the first well but at shallower depths. In each well, 2-in. polyvinyl chloride (PVC) slotted well screens were set at different elevations and attached to 2-in. PVC casing with stainless-steel screws. Two to 4 ft of casing was left above land surface. Sand was placed in the annular space around each well screen, and bentonite was placed above the sand. Native soils were placed in the annular space above the bentonite seal to within 2 ft of land surface. A 6-in. PVC protective casing was placed over the original casing and embedded in concrete. A locking cover was placed on the 6-in. protective casing to prevent contamination and vandalism. These construction techniques also were used to install monitoring wells at the Statesville Road landfill in 1988.

Sample-Collection Techniques

Surface-water samples were collected at streams in the vicinity of the five landfills. Samples were collected at midstream or at multiple points in the stream cross section. Samples were collected by hand or with an epoxy-coated DH-48 hand-held sampler using depth-integrated techniques as described in Ward and Harr (1990).

Ground-water monitoring wells were completely evacuated or purged of at least three casing volumes of water 1 to 3 days prior to sampling to ensure that sampled water was representative of the ground water. Samples for analysis of nutrients, major ions, metals, bacteria, and organic compounds were collected from monitoring wells using stainless-steel or Teflon bailers. Domestic supply wells were sampled at water faucets. Before sampling, faucets were heat sterilized with a propane torch and then opened for several minutes to purge plumbing.

Sample-Processing Techniques

Water samples collected for analysis of dissolved constituents were filtered in the field using 0.45-micron membrane filters. Samples collected for analysis of inorganic constituents were placed in polyethylene bottles. Samples for metals were not filtered and were placed in acid-rinsed polyethylene bottles and preserved with nitric acid. Samples for analysis of organic compounds and bacteria were placed in glass bottles (Smith, 1993). Bottles for bacteria samples were sterilized by autoclaving (Stephen J. Wood, Mecklenburg County Health Department, oral commun., 1994). Bottles for samples of organic compounds were heated to a temperature of 450 °C to remove organic residues (Timme, 1994). All samples were stored on ice after collection. Samples analyzed by the Mecklenburg County Laboratory were delivered to the laboratory on the day of collection (Smith, 1993). Samples analyzed by other laboratories were packed in ice and shipped on the day of collection by overnight carrier (Smith, 1993).

Sample Analysis

A total of 215 constituents and properties were measured in water samples collected at the landfills (table 1). Temperature, pH, specific conductance, barometric pressure, alkalinity, and dissolved-oxygen concentration were measured in the field. Alkalinity was measured by titration to pH 4.5.

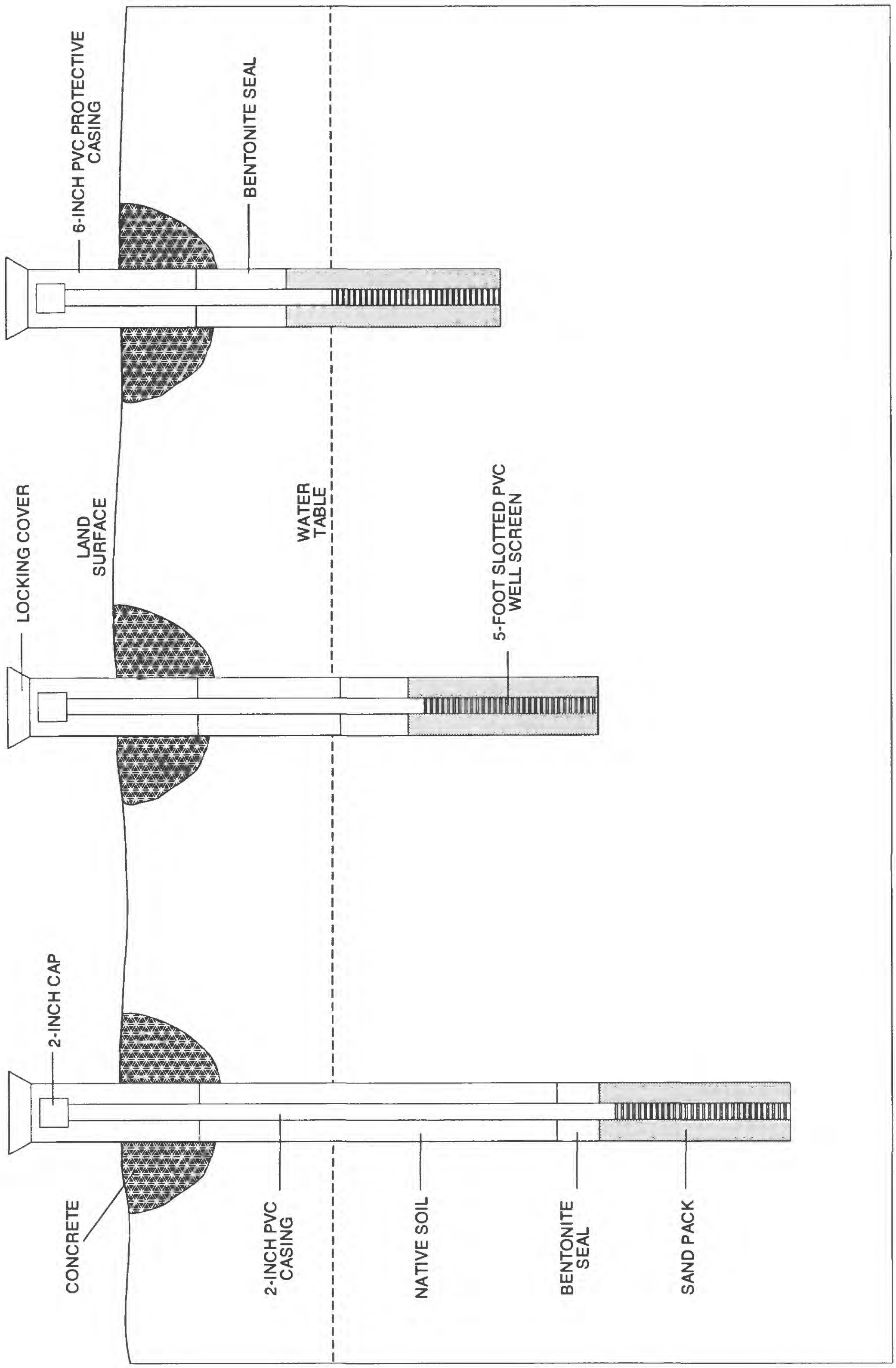

Figure 2. Diagrammatic sketch of well cluster.

Table 1. Constituents or properties measured in surface- and ground-water samples collected at or near five municipal landfills in Mecklenburg County, North Carolina, 1986-92

Physical and biological characteristics and properties		
Acidity	Dissolved oxygen	pH
Alkalinity	Total coliform	Specific conductance
Biochemical-oxygen demand	Fecal coliform	Suspended sediment
Chemical-oxygen demand	Fecal streptococcus	Temperature
Color	Hardness	Total solids
Major inorganic ions		
Calcium	Magnesium	Sodium
Chloride	Potassium	Sulfate
Fluoride	Silica	Sulfide
Nutrients		
Ammonia	Nitrite	Total organic carbon
Dissolved organic phosphorus	Nitrite plus nitrate	Total phosphorus
Nitrate	Orthophosphate	
Trace elements		
Aluminum	Cobalt	Nickel
Antimony	Copper	Selenium
Barium	Iron	Silver
Beryllium	Lead	Thallium
Cadmium	Manganese	Zinc
Chromium	Mercury	
Pesticides		
Alachlor	DDE	Mirex
Aldrin	DDT	Perthane
alpha-BHC (benzene hexachloride)	Dieldrin	Prometone
Ametryne	Endosulfan	Prometryne
Atrazine	Endrin	Propazine
Chlordane	Heptachlor	Silvex
Cyanazine	Heptachlor epoxide	Simazine
2,4-D	Lindane	Simetryne
2,4-DP	Methoxychlor	2,4,5-T
DDD	Metolachlor	Toxaphene
	Metribuzin	Trifluralin
Semivolatile and volatile organic compounds		
Acetone	2-Chloroethyl vinyl ether	1,2-Dichloroethane
Acrylonitrile	Chloroform	*cis*-1,2-Dichloroethylene
Benzene	Chloromethane	*trans*-1,2-Dichloroethylene
Bromobenzene	Dibromochloromethane	1,1-Dichloroethylene
Bromoform (tribromomethane)	Dibromochloropropane	1,2-Dichloroethylene
Bromomethane	1,2-Dibromoethane	1,2-Dichloropropane
Carbon disulfide	1,2-Dibromoethylene	1,3-Dichloropropane
Carbon tetrachloride	Dibromomethane	2,2-Dichloropropane
Chlorobenzene	Dichlorobromomethane	*cis*-1,3-Dichloropropylene
Chlorodibromomethane	Dichlorodifluoromethane	*trans*-1,3-Dichloropropylene
Chloroethane	1,1-Dichloroethane	1,1-Dichloropropylene

Table 1. Constituents or properties measured in surface- and ground-water samples collected at or near five municipal landfills in Mecklenburg County, North Carolina, 1986-92--Continued

Semivolatile and volatile organic compounds (Continued)		
Ethylbenzene	1,1,1,2-Tetrachloroethane	Trichloroethylene
Freon 113	1,1,2,2-Tetrachloroethane	Trichlorofluoromethane
Methyl bromide	Tetrachloroethylene	1,2,3-Trichloropropane
Methyl chloride	Toluene	Vinyl chloride
Methylene chloride	1,1,1-Trichloroethane	Xylene
Styrene	1,1,2-Trichloroethane	
Other synthetic organic compounds		
Acenaphthalene	4-Chlorophenyl phenyl ether	*p*-Isopropyltoluene
Acenaphthene	*o*-Chlorotoluene	Mesitylene
Acrolein	*p*-Chlorotoluene	Methyl ethyl ketone
Anthracene	Chrysene	Methyl isobutyl ketone
Benzidine	1,2,5,6-Dibenzanthracene	2-Methyl naphthalene
Benzo(*a*)anthracene	Dibenzofuran	Naphthalene
Benzo(*a*)pyrene	1,2-Dichlorobenzene	Nitrobenzene
Benzo(*b*)fluoranthene	1,3-Dichlorobenzene	2-Nitrophenol
Benzo(*g,h,i*)perylene	1,4-Dichlorobenzene	4-Nitrophenol
Benzo(*k*)fluoranthene	3,3'-Dichlorobenzidine	N-Nitrosodimethlyamine
Benzoic acid	2,4-Dichlorophenol	N-Nitrosodi-N-propylamine
Benzyl alcohol	Diethyl phthalate	N-Nitrosodiphenylamine
beta-BHC (benzene hexachloride)	2,4-Dimethylphenol	Di-*n*-octyl phthalate
delta-BHC (benzene hexachloride)	Dimethyl phthalate	Gross PCB's (polychlorinated byphenyls)
4-Bromophenyl phenyl ether	4,6-Dinitro-*o*-cresol	
n-Butylbenzene	2,4-Dinitrophenol	Gross PCN's (polychlorinated naphthalenes)
sec-Butylbenzene	2,4-Dinitrotoluene	
tert-Butylbenzene	2,6-Dinitrotoluene	Pentachlorophenol
n-Butylbenzyl phthalate	1,2-Diphenyl-hydrazine	Phenanthrene
tert-Butyl methyl ether	Bis(2-ethylhexyl) phthalate	Phenols
Dibutyl phthalate	Fluorene	*n*-Propylbenzene
Di-*n*-butyl phthalate	Fluoroanthene	Pseudocumene
4-Chloroaniline	Hexachlorobenzene	Pyrene
Bis(2-chloroethoxy) methane	Hexachlorobutadiene	2,3,7,8-Tetrachlorodibenzo-*p*-dioxin
Bis(2-chloroethyl) ether	Hexachlorocyclopentadiene	
2-Chloroethyl vinyl ether	Hexachloroethane	Total organic halogens
Bis(2-chloroisopropyl) ether	2-Hexanone	1,2,3-Trichlorobenzene
p-Chloro-*m*-cresol	Indeno(1,2,3-*c,d*) pyrene	1,2,4-Trichlorobenzene
2-Chloronaphthalene	Isophorone	2,4,6-Trichlorophenol
2-Chlorophenol	Isopropylbenzene	Vinyl acetate

Inorganic constituents were primarily analyzed by the Mecklenburg County Department of Environmental Protection Environmental Laboratory in Charlotte, North Carolina, from 1979 to 1990 and from October 1991 to December 1992. The USGS National Water-Quality Laboratory in Atlanta, Georgia, analyzed some of the samples for inorganic constituents during 1979-82. The USGS Central Laboratory in Denver, Colorado, analyzed inorganic constituents from October 1990 to September 1991. Organic constituents were primarily analyzed by the USGS National Water-Quality Laboratory from 1979 to 1985 and by the USGS Central Laboratory from 1986 to 1992. Analysis of total organic halogen concentration was performed by the National Environmental Testing Laboratory, formerly the Burmah Laboratory, in Gulfport, Mississippi. All bacteriological analyses were performed by the Mecklenburg County Laboratory (Smith, 1993).

Data Analysis

Selected water-quality data collected from 1986 to 1992 are summarized by range and median values. Summaries of water-quality constituents exceeding action levels identified by the Mecklenburg County Engineering Department (table 2) and summaries of synthetic organic compounds detected in water samples are provided for monitoring sites at each landfill. Temporal trends in selected water-quality constituents were calculated using the seasonal Kendall test, a non-parametric procedure developed to detect monotonic trends over time in water-quality data (Hirsch and others, 1982; Schertz and Hirsch, 1985). Magnitudes of trends were quantified by the seasonal Kendall slope estimator (Hirsch and others, 1982). Significance levels and average annual rate of change are provided for trend tests that were statistically significant at a probability level of 0.10 ($p=0.10$). Average annual rate of change is also expressed as a percentage of the seasonal median value for all properties and constituents except pH. Water-quality data from surface-water sites for which corresponding streamflow data were available were adjusted for streamflow if a statistically significant correlation between streamflow and the water-quality constituent could be developed. Trends were calculated for the entire period of record. Absence of statistically significant trends does not necessarily indicate constant or unchanging water-quality conditions. Non-monotonic trends in water quality are not always detected by the seasonal Kendall test.

Table 2. Mecklenburg County action levels for selected water-quality constituents and properties (from Mecklenburg County Engineering Department, written commun., 1992)

[<, less than or equal to; ≥, greater than or equal to]

Constituent or property	Action level
Specific conductance (microsiemens per centimeter)	1,000
pH (standard units), minimum	≤6.5
pH (standard units), maximum	≥8.5
Chemical-oxygen demand (milligrams per liter)	25
Biochemical-oxygen demand (milligrams per liter)	5
Sulfate (milligrams per liter)	250
Chloride (milligrams per liter)	250
Fluoride (milligrams per liter)	2.0
Nitrate, as N (milligrams per liter)	10.0
Arsenic (micrograms per liter)	50
Barium (micrograms per liter)	1,000
Cadmium (micrograms per liter)	5.0
Chromium (micrograms per liter)	50
Copper (micrograms per liter)	1,000
Iron (micrograms per liter)	300
Lead (micrograms per liter)	50
Manganese (micrograms per liter)	50
Mercury (micrograms per liter)	1.1
Selenium (micrograms per liter)	10
Zinc (micrograms per liter)	5,000
Total organic carbon (milligrams per liter)	10
Total organic halogens (milligrams per liter)	0.1

HYDROGEOLOGIC SETTING OF MECKLENBURG COUNTY

Mecklenburg County lies within the Charlotte Belt, one of several northeast-southwest oriented litho-tectonic belts in the North Carolina Piedmont (Butler, 1971; North Carolina Department of Natural Resources and Community Development, 1985). Unconsolidated surficial materials are underlain by folded and fractured metamorphic and igneous rocks, predominantly granite and diorite. Detailed discussions of the geologic setting of Mecklenburg County are provided by Gilbert and others, 1982; Goldsmith and others, 1982; Ragland and others, 1983; Farrar, 1985; Pavish, 1985; Russell and others, 1985; and Wehr and Grove, 1985.

The ground-water system consists of three zones: the upper regolith, an intermediate transition zone, and underlying fractured crystalline bedrock (fig. 3). The regolith consists of an unconsolidated or semi-consolidated mixture of clay and rock fragments and includes saprolite, alluvium, and soil. The shallow regolith primarily is saprolite, which has been derived from in-place weathering of the parent rock. Alluvial deposits are restricted to valleys. Soils formed primarily from chemical weathering of saprolite constitute the uppermost part of the regolith (Daniels and others, 1984). Soils in Mecklenburg County typically are acidic, highly weathered and leached, and have a clay subsoil (U.S. Department of Agriculture, 1980). Except for soil, which generally has high permeability, the permeability of the regolith is primarily related to the degree of weathering and generally decreases with increased weathering (fig. 3). Heath (1980) reported that hydraulic conductivity of saprolite generally ranges from 1 to 20 feet per day (ft/d). Hydraulic conductivity in alluvium, which commonly contains a large proportion of silt and sand, generally ranges from 1 to 100 ft/d (Heath, 1980).

The transition zone includes the base of the regolith and the top of the underlying bedrock (fig. 3). This zone primarily contains mechanically weathered bedrock with some saprolite; little chemical weathering has occurred. Permeability of the transition zone generally is greater than that of the overlying regolith because chemical weathering is less advanced. Permeability generally increases with depth (Stewart, 1962; Stewart and others, 1964; Nutter and Otton, 1969). The greatest permeability generally is near the base of the transition zone, just above bedrock (fig. 3). Thus, because of its large permeability, the transition zone is considered a potential conduit for rapid movement of contaminants in ground water (Harned and Daniel, 1989).

Below the transition zone is crystalline bedrock, the upper part of which typically contains numerous, closely spaced, stress-relief fractures formed in response to erosion of overlying materials. Fractures generally are less abundant as depth increases (LeGrand, 1967). Water in the bedrock primarily moves through fractures. Porosity of bedrock in the Piedmont typically is low and

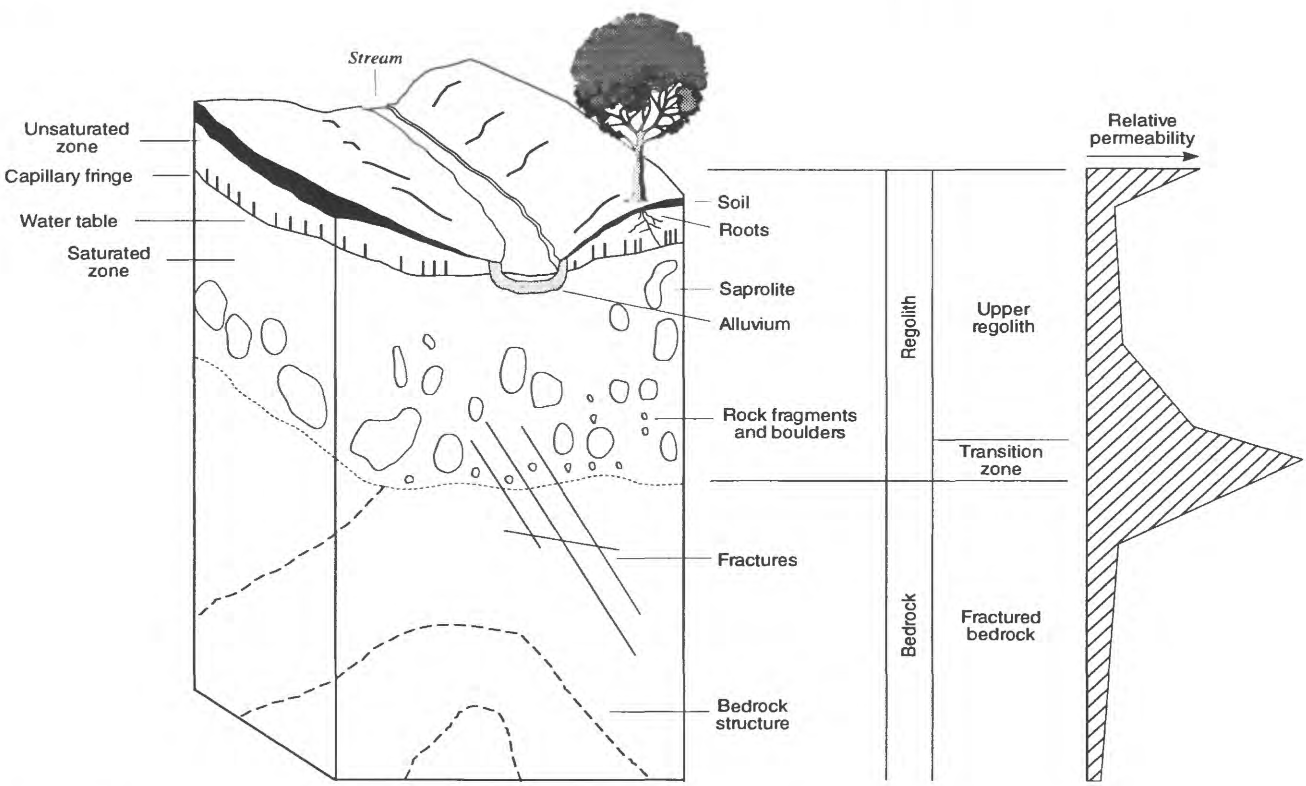

Figure 3. Generalized hydrogeologic conditions in the Piedmont Province (modified from Cardinell and others, 1989 and Nutter and Otton, 1969).

generally ranges from 0.1 to 1 percent (Trainer and Watkins, 1975; Heath, 1984; Cardinell and others, 1989; Harned, 1989). Local variations in porosity are associated with fracture patterns. Hydraulic conductivity in the bedrock zone generally ranges from 1 to 20 ft/d; however, in intensively fractured areas, hydraulic conductivity generally exceeds 20 ft/d (Cardinell and others, 1989). Depth to top of bedrock at the landfills was estimated to range from 0 to 92 ft below land surface. Estimates of depth to bedrock were based on the depth of auger refusal observed during drilling of monitoring wells; however, boulders of resistant rock within the saprolite and pinnacles of bedrock can cause auger refusal. Thus, estimates of depth to bedrock could be less than actual depths.

Water occurs in the unsaturated zone and the saturated zone (Heath, 1980). The unsaturated zone extends from land surface to the top of the saturated zone called the water table and generally ranges from 5 to 50 ft thick at the landfill study sites. Downward movement of water through the unsaturated zone primarily occurs by gravity-driven flow through intergranular spaces and through macropores formed by burrows and roots. Water also moves upward from the saturated zone by capillary action (Heath, 1980). This upward movement occurs in the capillary fringe, which overlies the water table (fig. 3).

Water levels in wells drilled into the saturated zone reflect the level of the water table in the adjacent regolith. The saturated zone within the regolith provides the bulk of water storage in the Piedmont ground-water system (Heath, 1980; Cardinell and others, 1989). "Drainable porosity" in this zone, which is primarily saprolite, ranges from about 20 to 30 percent (Stewart and others, 1964; Nutter and Otton, 1969; Daniel and Sharpless, 1983). The general direction of flow is toward discharge areas, such as perennial streams; however, direction of flow can be locally affected by anisotropic conditions. Although the water table generally is within the regolith, in some areas the unsaturated zone extends into bedrock. This situation most commonly occurs beneath relatively high bluffs bordering major stream valleys where bedrock is close to land surface. This condition occurs at the Harrisburg Road and York Road landfills.

SANITARY LANDFILLS

Sanitary landfills were developed in the 1930's as an alternative to open dumps and are the most commonly used means of solid-waste disposal in North Carolina. Prior to the 1970's, open dumps typically were used for solid-waste disposal. Sanitary landfilling techniques were developed because of environmental problems associated with open dumps, such as air pollution from the burning of refuse, odors, water pollution from runoff and leachate, and potential disease vectors enhanced by providing food and habitat for rodents, insects, and birds (O'Leary and Tansel, 1986). In sanitary landfills, wastes are placed in excavated units called cells, compacted, and covered each day with a layer of soil--generally at least 6 in. thick (Tchobanoglous and others, 1977; O'Leary and Tansel, 1986). Cells generally are designed to have an impermeable bottom and sides to prevent drainage from the cell (Tchobanoglous and others, 1993). When disposal in a cell is completed, a final soil layer, generally at least 2 ft thick, is placed on top of the cell (Tchobanoglous and others, 1977; O'Leary and Tansel, 1986). This soil layer helps to prevent development of surficial cracks upon settlement, contains odors, decreases infiltration, and facilitates growth of vegetation. Cells should be designed so that no wastes are placed within 4 ft of the highest position of the water table (Cardinell and others, 1989).

Federal requirements for municipal solid-waste landfills are listed in subtitle D of the Resource Conservation and Recovery Act, U.S. Environmental Protection Agency (EPA) Criteria for Municipal Solid Waste Landfills, U.S. Code of Regulations Title 40, Section 258, Subparts A through G (U.S. Environmental Protection Agency, 1991). Regulatory requirements for municipal solid-waste landfills established by the State of North Carolina are in North Carolina Solid Waste Management Rules (North Carolina Department of Environment, Health, and Natural Resources, 1994).

Solid Waste

The composition of solid waste varies with climate, season, and demography. On a nationwide basis, solid wastes are composed, by weight, of 45-percent paper; 15-percent food wastes; 11-percent yard and garden wastes; 9-percent metals; 8-percent glass; 4-percent dirt, ashes, and concrete; 3-percent textiles; and 2-percent plastics (Tchobanoglous and others, 1977). Toxic compounds, such as heavy metals and synthetic organic compounds, including pesticides, can be present in domestic wastes. Sources of pesticides in domestic wastes include residues on grass clippings and garden wastes, discarded pesticides, and pesticide containers. Although specific information about the composition of wastes received at the Harrisburg Road and Holbrooks Road landfills was unavailable, paper was the largest component of wastes at these landfills (Stephen P. Kelner, Mecklenburg County Engineering Department, oral commun., 1994). Information about the composition of solid wastes disposed of in the Statesville Road and York Road landfills was unavailable (Keith Carpenter, City of Charlotte Engineering Department, oral commun., 1994).

Solid wastes in landfills undergo physical and chemical degradation. Physical changes are associated with compaction and fragmentation of wastes. Chemical processes, many of which are microbially mediated, cause transformations of solid wastes. Limited information is available regarding microbial composition of solid wastes; however, it is assumed that solid wastes generally have a large and varied microbial population (Pohland, 1976). Glass, wood, rubber, plastic, synthetic textiles, and most metals constitute about 20 percent of solid waste and are inert or degrade very slowly (Tchobanoglous and others, 1993). The remaining 80 percent of solid wastes includes paper, food wastes, lawn and garden debris, and ferrous metal, which are fully or partly degradable (Tchobanoglous and others, 1977). Rates of degradation depend on many factors, including the composition of wastes, degree of compaction, water content, availability of oxygen, temperature, and presence of inhibitory substances. Degradation rates generally increase with increasing temperature and water content (Salvato and others, 1971). However, under extremely wet conditions, such as in landfills where wastes have been placed below the water table or placed in wetlands, decomposition can be very slow because of the rapid development of anaerobic conditions. Wastes in very dry environments also decompose slowly.

Decomposition of solid wastes in sanitary landfills occurs in three stages: the aerobic decomposition stage, the fermentation stage, and the methanogenic stage (Lu, 1985; O'Leary and Tansel, 1986). While exposed to air, solid wastes degrade rapidly. Hydrolytic action of bacteria converts complex organic molecules to smaller ones suitable as food for bacteria. Primary by-products of aerobic decomposition include carbon dioxide, water, sulfate, and ammonia (Baedecker and Back, 1979). In sanitary landfills where wastes are compacted and covered with soil, chemical oxidation and action of aerobic microbes quickly deplete oxygen. As the availability of oxygen decreases, rates of degradation also decrease and the environment within the wastes becomes anaerobic.

As anaerobic processes become dominant, decomposition generally proceeds in two steps. During the first step, facultative bacteria convert large organic molecules to smaller soluble molecules by fermentation. By-products of anaerobic degradation include carbon dioxide and organic acids, which decrease pH and thereby promote dissolution of many inorganic materials. During the second step, methanogenic bacteria convert carbon dioxide to methane. As degradation continues, the availability of oxidizing agents decreases, the landfill environment becomes chemically reducing, and methane production increases. Formation of methane consumes carbon dioxide and hydrogen ions thereby increasing pH.

Decomposition processes do not proceed uniformly throughout a landfill. At any specific time, wastes in various parts of a landfill can be in different stages of decomposition. Rates and types of decomposition processes primarily depend on water content and availability of oxygen. In many landfills, aerobic degradation is completed within several weeks after disposal of the wastes (Tchobanoglous and others, 1977). The progress of anaerobic decomposition is indicated by environmental conditions within the landfill. During early stages of anaerobic degradation, conditions within the landfill are characterized by low pH (4.0-5.0 units) and large chemical-oxygen demand, specific conductance, and metals content (O'Leary and Tansel, 1986). Later stages of anaerobic decomposition are characterized by increased methane production, pH ranging from 7.0 to 8.0, and moderate chemical-oxygen demand and specific conductance (O'Leary and Tansel, 1986).

Leachate

The liquid produced by solid wastes in landfills is commonly referred to as leachate. Little water is released by decomposition of municipal wastes because of the large paper content, which absorbs much of the metabolically produced water (Salvato and others, 1971). As solid wastes decompose, volume decreases. This reduction in volume can cause settling and cracking of cover materials, which increases infiltration of precipitation. Leachate is generated by percolation of water through waste materials (O'Leary and Tansel, 1986). Water can enter wastes by downward percolation or by lateral ground-water flow at sites where wastes have been placed below the water table. The amount of leachate produced depends on precipitation rate, infiltration rate, inflow of ground water, amount and type of refuse, type and thickness of cover material, and topographic setting (Tchobanoglous and others, 1993).

Leachate composition is highly variable within and among sanitary landfills (O'Leary and Tansel, 1986). Factors affecting leachate composition include availability of oxidizing materials within the landfill, waste composition, and degree of infiltration of precipitation (Baedecker and Back, 1979). Influx of oxygen-rich water can alter redox conditions in a landfill. Typical ranges of selected constituents and properties of leachate from municipal landfills are listed in U.S. Environmental Protection Agency (1986). As a landfill ages, concentrations of many constituents in leachate decrease with time (Cameron, 1978). Various chemical reactions including oxidation-reduction, dissolution, precipitation, ion exchange, and sorption are involved in leachate production. The organic components of wastes play a major role in these reactions (Baedecker and Back, 1979). Physical processes also are involved in leachate formation and movement. Density and concentration gradients can be established in leachate. Entrainment of particulate and colloidal materials released by compaction of wastes occurs as water moves through a landfill.

Water percolating through a landfill interacts with solid, liquid, and gaseous components of the wastes (O'Leary and Tansel, 1986). Carbon dioxide, formed as a metabolic by-product of degradation, is easily dissolved in water and causes a decrease in pH. Decreases in pH contribute to dissolution of carbonate species and metals, thereby increasing hardness and dissolved solids content of leachate. Microbially generated organic acids also decrease pH (Baedecker and Back, 1979). Leachate formed during initial aerobic stages of decomposition is primarily derived from liquid squeezed out of the wastes by compaction and is characterized by a large biochemical-oxygen demand, entrainment of particulate matter, high specific conductance, and small concentrations of organic compounds. Leachate formed during the fermentation stage of anaerobic decomposition is characterized by low pH, large organic acid concentration, and high specific conductance.

Leachate formed during the methanogenic stage characteristically has a pH within the range of 6.6 to 7.4, and lower specific conductance and smaller metals content than leachate formed during the fermentation stage (O'Leary and Tansel, 1986). Concentrations of metals generally are largest in leachate formed during the fermentation stage because of the increased dissolution of metals caused by low pH. The high pH and increased reducing potential characteristic of leachate produced during the methanogenic phase decrease solubility of metals and promote formation of insoluble metal sulfides (Borden and Yanoschak, 1989). Also associated with the increase in pH is a decrease in the solvent capacity of leachate which in turn causes precipitation of many inorganic materials and thereby decreases specific conductance.

Because bicarbonate is produced by anaerobic degradation processes and the dissolution of carbon dioxide, the alkalinity of leachate generally is large. Landfill materials such as ash, soil, and rock also can contribute to large bicarbonate concentrations. Under anaerobic conditions, sulfate derived from wastes can be reduced to sulfide, which readily reacts with metals to form insoluble metal sulfides. Chloride is not reactive; variations in concentration are largely the result of dilution. Small concentrations of heavy metals such as cadmium, chromium, copper, mercury, nickel, lead, and zinc commonly occur in leachate from municipal wastes.

Water Quality

Leachate can affect water-quality conditions at sanitary landfills. Various water-quality constituents and properties including specific conductance, chemical-oxygen demand, biochemical-oxygen demand, alkalinity, sulfate, chloride, chromium, iron, lead, manganese, zinc, total organic carbon, and synthetic organic compounds can indicate the presence of leachate in surface water and ground water. With the exception of synthetic organic compounds, these constituents and properties are also natural characteristics of surface water and ground water; thus, their presence does not necessarily indicate effects of leachate. However, possible effects of leachate are indicated if values of several indicator constituents or properties exceed those of background samples. Because synthetic organic compounds do not naturally occur in water, the presence of these compounds in surface or ground water indicates effects of leachate or other human activities.

Because aluminum, chromium, iron, lead, and manganese are naturally present in soils of the North Carolina Piedmont, large concentrations of these elements can occur in water as a result of dissolution caused by chemical action of leachate or because of the presence of suspended soil particles. Screened intervals of most monitoring wells sampled during this study are in unconsolidated material. Small soil particles can pass through well screens or be suspended in surface water, thereby contributing to large concentrations of aluminum, chromium, iron, lead, and manganese in water samples.

Temporal changes in concentrations of indicator constituents and properties can show effects of leachate or changes in leachate quality associated with various stages of waste decomposition. Initial effects of leachate on water quality generally include increases in specific conductance, chemical-oxygen demand, biochemical-oxygen demand, and chloride concentration. Subsequent effects of leachate include increases in alkalinity, iron, manganese, and total organic carbon. Several years after landfill closure, concentrations of most constituents decrease primarily as a result of changes in degradation processes within the landfill (Tchobanoglous and others, 1977; O'Leary and Tansel, 1986). Effects of leachate on water quality are generally smaller at sites distant from the landfill than at sites close to the landfill.

The chemical composition of leachate typically changes along its flow path in the landfill and in the ground-water system (fig. 4). Dilution and dispersion are major factors that contribute to decreased concentrations of various constituents. Chemical reactions, changes in redox potential, and changes in environmental conditions cause increases, decreases, and transformations of various constituents. Ion-exchange reactions of clay result in preferential adsorption of ammonia, calcium, and magnesium, and release of sodium and potassium, thereby causing increases in sodium and potassium concentrations along the flow path. Low pH and low redox potential cause dissolution of most metals. Large amounts of iron and manganese in leachate have been attributed to chemical reduction of iron and manganese oxides in soils rather than to iron and manganese present in wastes (Baedecker and Back, 1979). Complexation of metals with organics and carbonate species can cause precipitation of metals along the flow path (Stumm and Morgan, 1981). Wastes in the landfill can reabsorb some of the leached materials (Cameron, 1978).

Dilution can greatly alter the effects of leachate on surface water. Effects of leachate on surface waters generally are largest during periods of low streamflow. Some chemical changes occur as leachate enters a stream, such as precipitation of metals upon transition from a reducing environment (typical of a landfill) to an oxidizing environment (typical of surface waters). Volatilization of low molecular weight, organic compounds, and ammonia also occurs when leachate enters surface water. Leachate can also affect aesthetic characteristics of surface water; increases in odor and iron staining are commonly associated with inflow of leachate. Leachate with large chemical and biochemical-oxygen demand can contribute to reduced dissolved-oxygen concentration in streams. Leachate has also caused fish kills (Cameron, 1978).

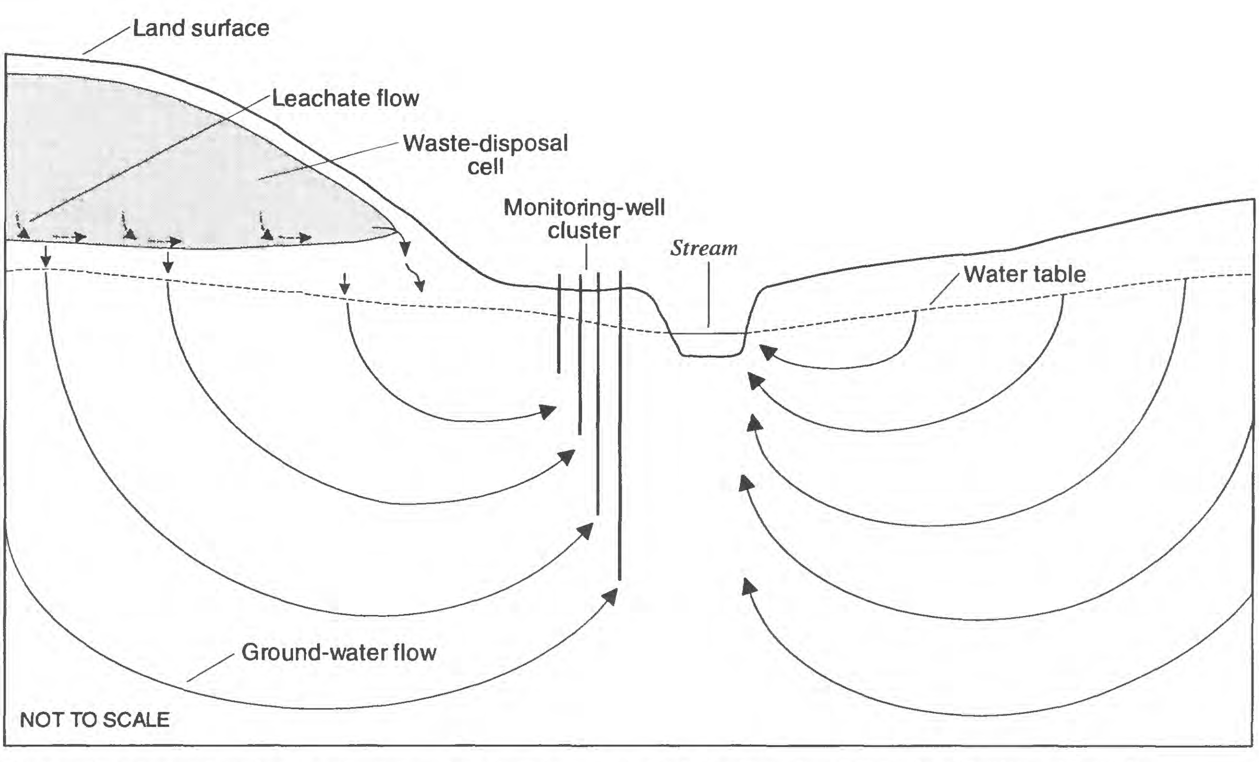

Figure 4. Generalized ground-water flow paths at a typical sanitary landfill in the Piedmont Province.

Mechanical compaction of silt or clay, which typically underlies the Mecklenburg County landfills, contributes to low vertical permeability. Downward percolation is limited, and leachate more readily moves horizontally along the base of the waste-disposal cell (fig. 4). In areas of high precipitation and low permeability, a perched zone of leachate commonly develops, and leachate springs occur. Soils, especially fine-grained soils, have high adsorptive capacity and can remove many contaminants from leachate. Layers of soil placed within waste-disposal cells for daily cover can potentially bind and immobilize many contaminants. Factors that affect the capability of soils to remove contaminants include pH and the loading rate. Attenuation capacity generally is greatest when pH is near neutral and decreases with decreasing pH. At high pH, removal of metals is facilitated by precipitation reactions; however, removal rates are not maintained because soil pores quickly become clogged with metal precipitates (Cameron, 1978). As the loading rate increases, removal capacity generally decreases. Likewise, as velocity of flow increases, less attenuation and dispersion of leachate occurs.

Dispersion generally is greater in materials of high porosity than in materials of low porosity. Porosity of saprolite generally ranges from 20 to 30 percent in comparison to porosity of bedrock, which generally ranges from 0.1 to 1 percent (Heath, 1980). The large adsorptive capacity of clay, a major component of saprolite in the study area, also decreases concentrations of many constituents of leachate. Thus, effects of leachate on ground-water quality generally are less in saprolite than in bedrock. Offsite contamination of ground water by leachate generally is less likely to occur and generally is less severe in landfills where depth to bedrock is large, than in landfills where bedrock is at or near land surface. The thicker the layer of saprolite overlying bedrock, the slower the movement of leachate and the greater the effects of attenuation processes. Although the hydraulic conductivity of bedrock and saprolite are similar, porosity of bedrock is generally much less than that of saprolite (Heath, 1980). Thus, for the same hydraulic gradient, linear ground-water velocities are 20 to 200 times larger in bedrock than in saprolite. Leachate in bedrock can thereby move offsite much more rapidly than leachate in saprolite and is less likely to undergo attenuation processes.

WATER-QUALITY CONDITIONS AT SELECTED LANDFILLS

Water-quality conditions at the Harrisburg Road, Holbrooks Road, McAlpine Creek at Greenway Park, Statesville Road, and York Road landfills are described in this section. The location and description of the physical and hydrologic setting of each landfill is followed by a synopsis of landfill operations and a summary of monitoring activities. Surface- and ground-water quality evaluations include statistical summary tables and graphs of concentrations of selected constituents. Lengthy summary tables that interrupt the flow of text are presented at the end of the report. A concluding section discusses the pertinent water-quality conditions at each landfill.

Harrisburg Road Landfill

The Harrisburg Road landfill is in eastern Mecklenburg County just north of the Charlotte city limit (fig. 1). This landfill occupies about 305 acres and is in the Reedy Creek drainage basin. The Harrisburg Road landfill is the most recently developed of the five landfills described in this report and in 1993 was receiving only demolition wastes. Three small northward-flowing streams originate in this landfill--Wiberly Branch, which drains the eastern part of the landfill, an unnamed stream, which drains the western part of the landfill, and a short unnamed stream, which drains the central part of the landfill (fig. 5). Land-surface elevations range from about 680 ft above sea level along streams in the northern part of the landfill to about 780 ft in the northeastern corner of the landfill and along the southwestern boundary of the landfill. Land northwest of the landfill and along Harrisburg Road, which is parallel to the eastern boundary of the landfill, is primarily residential. Land west and north of the landfill is primarily undeveloped woodland. There are several commercial and industrial establishments and numerous residences located along the southwestern border of the landfill, which roughly parallel Pence Road. A wood preservation plant is adjacent to the southwestern part of the landfill.

The Harrisburg Road landfill is underlain by bedrock consisting of metamorphosed diorite, quartz diorite, and tonalite (Goldsmith and others, 1982). Depth to bedrock is highly variable. Although bedrock is exposed near the northern boundary of the landfill, it has been reached in only a few of the borings. Depth to bedrock reported in driller's logs for wells along the southwestern boundary of the landfill is 90 to 100 ft below land surface (elevation of 680 to 690 ft above sea

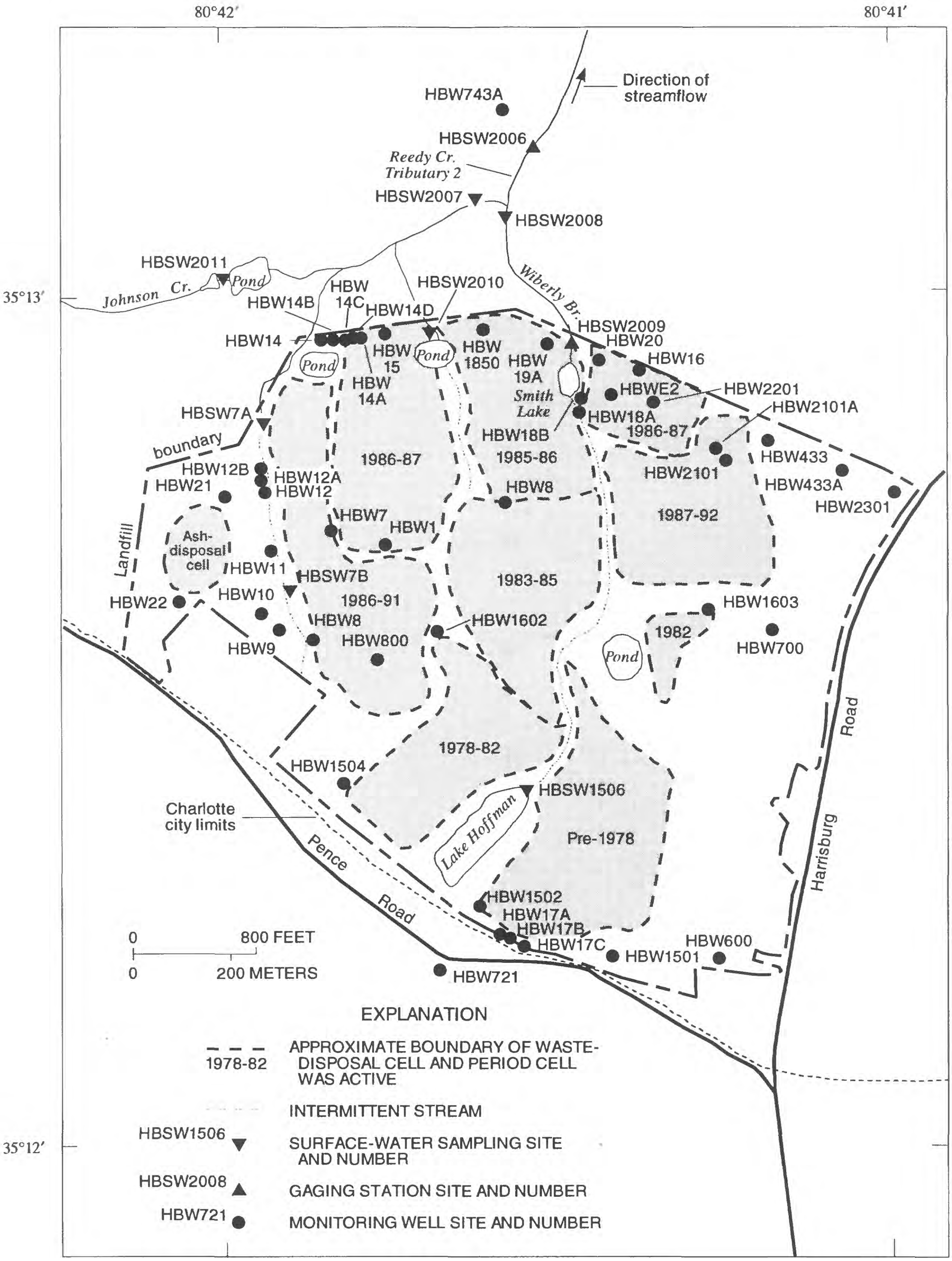

Figure 5. Waste-disposal cells and monitoring sites at the Harrisburg Road landfill (modified from Smith, 1993).

level). Split-spoon and auger samples from the northeastern part of the landfill, near well site HBW2201 (fig. 5), indicated bedrock at a depth of 84 ft below land surface (elevation of 656 ft above sea level) (Cardinell and others, 1989).

The Harrisburg Road landfill began receiving wastes in 1973. Excavation and fill techniques were used for disposal of residential, commercial, and industrial solid wastes, and demolition material. The most recently developed waste-disposal area was used for disposal of ash from Mecklenburg County's waste incinerator. All of the wastes were placed in the unsaturated zone and, except for the cell used for disposal of incinerator ash, all waste-disposal cells were unlined (Smith, 1993).

Landfilling began near the southern border of the landfill near Lake Hoffman and proceeded to the north. On April 1, 1992, Harrisburg Road landfill discontinued acceptance of municipal wastes. In 1993, disposal was limited to demolition materials. A 2-ft thick soil layer was placed over cells upon closure (Cardinell and others, 1989; Smith, 1993). In 1989, a 9-hole golf course was opened in the southeastern part of the landfill.

The USGS began monitoring activities at the Harrisburg Road landfill in 1982. The monitoring network has included as many as 9 surface-water sites and 45 ground-water sites (fig. 5). Several of the monitoring sites were destroyed as a result of landfill operations. Information describing surface-water monitoring sites is listed in table 3. Two of the surface-water sites, HBSW7A and HBSW7B, are on the westernmost unnamed stream. Site HBSW7B is upstream from the ash disposal cell and is about 1,500 ft upstream from site HBSW7A. Site HBSW2010 is on the central unnamed stream, about 500 ft above its confluence with the western tributary to Reedy Creek (fig. 5). Site HBSW2007 is on a tributary to Reedy Creek downstream from the confluence of the westernmost and central streams in the landfill. Site HBSW1506 is at Lake Hoffman near the southern boundary of the landfill. Site HBSW2009 is on Wiberly Branch about 200 ft downstream from Smith Lake and about 0.5 mi downstream from site HBSW1506. Site HBSW2008 is on Wiberly Branch about 0.2 mi north of the landfill, downstream from site HBSW2009 (fig. 5). Site HBSW2011, on Johnson Creek, does not receive drainage from the landfill and was established to obtain bacterial samples representative of background conditions. Site HBSW2006 is on Reedy Creek tributary 2, downstream from the landfill and below the confluence of streams draining the landfill. Sites HBSW2007, HBSW2008, and HBSW2011 were primarily sampled for fecal coliform and fecal streptococcus bacteria.

Continuous records of streamflow have been collected since December 1984 at site HBSW2009 and since April 1988 at site HBSW2006. Continuous records of specific conductance and temperature were collected from December 1984 to November 1990 at site HBSW2009 and from April 1988 to November 1990 at HBSW2006. These data are in USGS annual hydrologic data reports (U.S. Geological Survey, 1985-93).

Table 3. Description of surface-water monitoring sites at the Harrisburg Road landfill

[Location of sites shown in figure 5. USGS, U.S. Geological Survey; P, periodic sample collection; C, continuous discharge; S, continuous specific conductance; T, continuous temperature]

Stream or lake	Mecklenburg County site number	USGS identification number	Date established	Drainage area (square miles)	Record type
Unnamed tributary to Reedy Creek tributary 2	HBSW7A	0212429910	Sept. 1982	0.1	P
Unnamed tributary to Reedy Creek tributary 2	HBSW7B	0212429908	July 1988	.09	P
Lake Hoffman	HBSW1506	0212429935	Aug. 1983	.06	P
Reedy Creek tributary 2	HBSW2006	0212429960	Dec. 1984	1.0	C,P,S,T
Tributary to Reedy Creek tributary 2	HBSW2007	0212429920	Nov. 1982	.44	P
Wiberly Branch	HBSW2008	0212429940	Nov. 1982	.50	P
Wiberly Branch	HBSW2009	0212429930	Oct. 1984	.39	C,P,S,T
Unnamed tributary to Reedy Creek tributary 2	HBSW2010	0212429915	Sept. 1984	.34	P
Unnamed tributary to Reedy Creek tributary 2	HBSW2011	0212429912	Apr. 1989	.18	P

The ground-water quality network included 35 water-quality monitoring wells ranging in depth from 8.5 to 97 ft below land surface and 7 domestic supply wells (Smith, 1993). Three wells (HBW2201A, HBW2201, and HBW2301) were used for water-level monitoring only and were not sampled during this study. Information describing ground-water monitoring wells is listed in table 4. Monitoring wells HBW17A-C, HBW1501, and HBW1502 were installed along the southern boundary of the landfill, upgradient from the southernmost waste-disposal cell (fig. 5). Most of the other monitoring wells are in the northern and western parts of the landfill and are downgradient from waste-disposal cells. Well clusters HBW12, 17, and 18, and wells HBW14B-D were installed during 1987-88. Five wells, which were used for domestic supply before landfill construction, also were used to monitor water quality. These former domestic supply wells include HBW433A, HBW600, and HBW700, in the eastern part of the landfill near Harrisburg Road; well HBW800, in the southwestern part of the landfill, which was used to supply water to a landfill shop; and well HBW433, near the northeastern corner of the landfill, which formerly was used for domestic supply and presently is used to supply water to the landfill office. Two offsite domestic wells were used to monitor water quality--well HBW743A, which is about 0.3 mi north of the landfill, and well HBW721, which is about 0.1 mi south of the landfill (fig. 5).

Periodic water-level measurements were made in all wells except HBW433, HBW600, HBW700, HBW721, HBW743A, and HBW800, which were not accessible for measurement. Based on water-level data, the direction of ground-water flow at the landfill is generally northward toward Reedy Creek tributary 2 or toward streams that drain the landfill (fig. 6). Because the elevation of the water table along Pence Road and Harrisburg Road is higher than in the landfill, it appears that offsite movement of ground water occurs only along the northern and northwestern boundaries of the landfill. Thus, ground water in offsite areas along Pence and Harrisburg Roads should be unaffected by leachate migration from the Harrisburg Road landfill.

Surface-Water Quality

No data representative of background surface-water quality were available for the Harrisburg Road landfill study area. Selected surface-water quality data are summarized by range and median in table 5. Comparisons of water-quality conditions at surface-water monitoring sites are limited because of the different sampling frequencies and time periods during which these sites were sampled. With the exception of pH, iron, and manganese, most constituents in surface-water samples did not exceed Mecklenburg County action levels. The pH of some surface-water samples was less than the 6.5 unit minimum designated acceptable by the Mecklenburg County Engineering Department (tables 2 and 6). Concentrations of iron exceeded the 300 micrograms per liter (μg/L) action level in all samples from surface-water monitoring sites except HBSW1506 (Lake Hoffman). Concentrations of manganese also exceeded the 50 μg/L action level in most surface-water samples.

Few samples were collected at surface-water monitoring sites for analysis of synthetic organic compounds. No samples were collected for analysis of synthetic organic compounds at sites HBSW2007 and HBSW2011, and only total organic halogen concentration was analyzed in samples from sites HBSW7A, HBSW1506, and HBSW2010 (Smith, 1993). Synthetic organic compounds detected in samples from surface-water sites include phenols, the pesticides chlordane, DDT, 2,4-D, and 2,4-DP, and total organic halogens (table 7, p. 84). Concentrations of most synthetic organic compounds were much less than maximum contaminant levels (MCL) (U.S. Environ-mental Protection Agency, 1993). Because of the large number of synthetic organic compounds detected in samples from monitoring sites at this landfill, synthetic organic compounds listed in table 7 have been grouped by chemical class.

Samples from site HBSW2006, which is the most downstream surface-water monitoring site, generally were acceptable based on Mecklenburg County action levels for all constituents except pH, iron, and manganese (table 6). Water quality at site HBSW2006 generally appeared to be less affected by leachate than water quality at other surface-water monitoring sites (table 5), probably as a result of dilution or from oxidation, precipitation, and chemical and biological degradation processes. More than one-fourth of the drainage area of site HBSW2006 is outside of the landfill, whereas the drainage areas for most of the other surface-water sites are entirely or almost entirely within the landfill (fig. 5; table 3).

Samples from site HBSW7B generally had larger chemical-oxygen demand, biochemical-oxygen demand, iron, and manganese concentrations than samples from other surface-water sites (table 5). Arsenic, chromium, and total organic halogens exceeded action levels in two of three samples collected at site HBSW7B (table 6). The maximum total organic halogen concentration in samples from this site was 0.95 milligram per liter (mg/L).

Table 4. Description of ground-water monitoring sites at the Harrisburg Road landfill

[Location of sites shown in figure 5. Well depth, casing depth, and screen openings listed in feet below land surface. USGS, U.S. Geological Survey; PVC, polyvinyl chloride; --, no data; GAL, galvanized steel]

Mecklenburg County site number	USGS identification number	Date installed	Well depth (feet)	Casing			Screen opening		Well use	Owner
				Type	Diameter (inches)	Depth (feet)	From (feet)	To (feet)		
HBWE2	351335080412801	Mar. 1983	29.3	PVC	2	24.3	24.3	29.3	Monitoring	Mecklenburg County
HBW1	351321080414601	Sept. 1982	48.9	PVC	2	38.9	38.9	48.9	Monitoring	Mecklenburg County
HBW7	351322080415001	Sept. 1982	48.3	PVC	2	38.3	38.3	48.3	Monitoring	Mecklenburg County
HBW8	351317080414901	June 1983	23.3	PVC	2	18.3	18.3	23.3	Monitoring	Mecklenburg County
HBW9	351319080415101	May 1983	28.3	PVC	2	18.3	18.3	28.3	Monitoring	Mecklenburg County
HBW10	351320080415501	May 1983	48.9	PVC	2	38.9	38.9	48.9	Monitoring	Mecklenburg County
HBW11	351326080415501	June 1983	23.8	PVC	2	18.8	18.8	23.8	Monitoring	Mecklenburg County
HBW12	351330080415701	May 1983	23.4	PVC	2	18.4	18.4	23.4	Monitoring	Mecklenburg County
HBW12A	351330080415702	Nov. 1987	16.5	PVC	2	11.5	11.5	16.5	Monitoring	Mecklenburg County
HBW12B	351330080415703	Nov. 1987	11.3	PVC	2	6.3	6.3	11.3	Monitoring	Mecklenburg County
HBW14	351337080415001	May 1983	22.4	PVC	2	17.4	17.4	22.4	Monitoring	Mecklenburg County
HBW14A	351337080414801	Aug. 1983	23.5	PVC	2	18.5	18.5	23.5	Monitoring	Mecklenburg County
HBW14B	351337080415003	Nov. 1987	38.3	PVC	2	33.3	33.3	38.3	Monitoring	Mecklenburg County
HBW14C	351337080415004	Nov. 1987	29.9	PVC	2	24.9	24.9	29.9	Monitoring	Mecklenburg County
HBW14D	351337080415005	Nov. 1987	14.9	PVC	2	9.9	9.9	14.9	Monitoring	Mecklenburg County
HBW15	351340080414901	Aug. 1983	38.6	PVC	2	28.6	28.6	38.6	Monitoring	Mecklenburg County
HBW16	351338080411201	Aug. 1983	44.5	PVC	2	34.5	34.5	44.5	Monitoring	Mecklenburg County
HBW17A	351258080412701	Dec. 1987	54.9	PVC	2	49.9	49.9	54.9	Monitoring	Mecklenburg County
HBW17B	351258080412702	Dec. 1987	44.7	PVC	2	39.7	39.7	44.7	Monitoring	Mecklenburg County
HBW17C	351258080412703	Dec. 1987	35.1	PVC	2	30.1	30.1	35.1	Monitoring	Mecklenburg County
HBW18A	351339080413201	May 1988	30.1	PVC	2	25.1	25.1	30.1	Monitoring	Mecklenburg County
HBW18B	351339080413202	May 1988	19.9	PVC	2	14.9	14.9	19.9	Monitoring	Mecklenburg County
HBW19A	351340080413601	May 1988	25.9	PVC	2	20.9	20.9	25.9	Monitoring	Mecklenburg County
HBW20	351342080413401	May 1988	27.6	PVC	2	22.6	22.6	27.6	Monitoring	Mecklenburg County
HBW21	351336080421301	Sept. 1989	29.2	PVC	2	24.2	24.2	29.2	Monitoring	Mecklenburg County
HBW22	351331080421401	Sept. 1989	39.4	PVC	2	34.4	34.4	39.4	Monitoring	Mecklenburg County
HBW433	351330080410801	Unknown	--	--	--	--	--	--	Domestic	Mecklenburg County
HBW433A	351327080410701	Unknown	--	--	--	--	--	--	Domestic	Mecklenburg County
HBW600	351258080412101	Unknown	--	--	--	--	--	--	Domestic	Mecklenburg County
HBW700	351317080411801	Unknown	--	--	--	--	--	--	Domestic	Mecklenburg County
HBW721	351257080414101	Unknown	--	--	--	--	--	--	Domestic	Private
HBW743A	351351080413701	Unknown	--	--	--	--	--	--	Domestic	Private
HBW800	351327080414601	Unknown	--	--	--	--	--	--	Domestic	Mecklenburg County
HBW1501	351258080412401	Aug. 1979	42.4	PVC	4	39.9	39.9	42.4	Monitoring	Mecklenburg County
HBW1502	351259080413001	Aug. 1979	22.4	PVC	4	19.9	19.9	22.4	Monitoring	Mecklenburg County
HBW1504	351307080414601	May 1980	42.7	PVC	4	37.7	37.7	42.7	Monitoring	Mecklenburg County
HBW1602	351317080414101	May 1980	38.0	PVC	4	33.0	33.0	38.0	Monitoring	Mecklenburg County
HBW1603	351319080411701	Aug. 1979	50.9	PVC	4	48.4	48.4	50.9	Monitoring	Mecklenburg County
HBW1754	351334080412901	July 1980	8.5	PVC	2.5	5.5	5.5	8.5	Monitoring	Mecklenburg County
HBW1850	351340080413501	Oct. 1976	97.0	GAL	6.25	88	No screen		Monitoring	Mecklenburg County
HBW2100	351327080413501	Mar. 1983	59.2	PVC	2	49.2	49.2	59.2	Monitoring	Mecklenburg County
HBW2101	351331080411601	Feb. 1983	67.8	PVC	2	57.8	57.8	67.8	Monitoring	Mecklenburg County
HBW2101A	351331080411603	Nov. 1984	57.6	PVC	4	52.6	52.6	57.6	Monitoring	Mecklenburg County
HBW2201	351333080405501	Nov. 1985	52.7	PVC	4	42.7	42.7	52.7	Monitoring	Mecklenburg County
HBW2301	351327080404401	Nov. 1985	55.0	PVC	4	35.0	35.0	55.0	Monitoring	Mecklenburg County

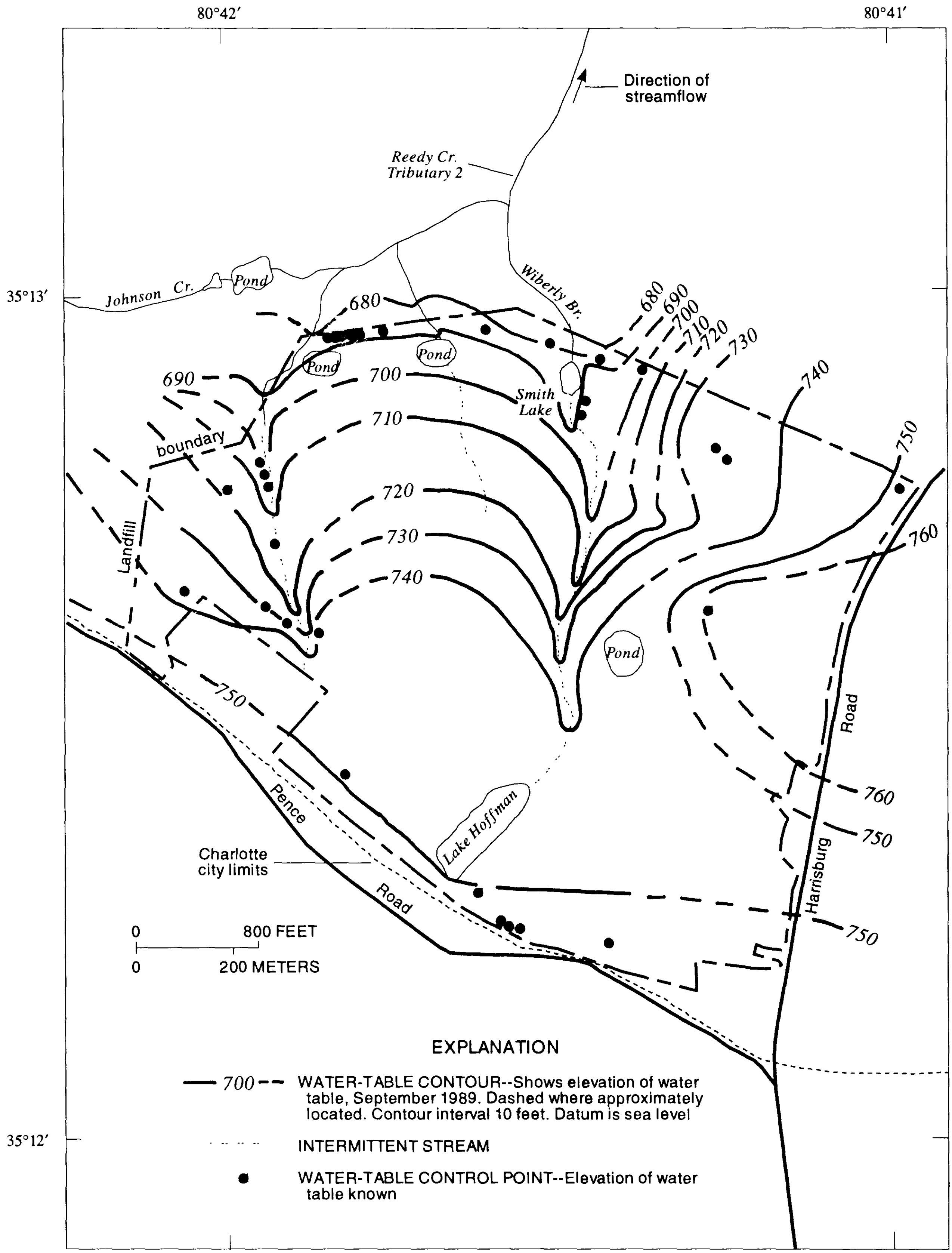

Figure 6. Elevation of the water table at the Harrisburg Road landfill, September 1989.

Table 5.--Summary of selected surface-water quality data for the Harrisburg Road landfill, 1986-92

[--, no data or insufficient data for computation of median; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; <, less than; *, value estimated using a log-probability regression to predict values below detection limits; >, greater than; cols/100 mL, colonies per 100 milliliters; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; µg/L, microgram per liter]

Constituent or property		HBSW7A	HBSW7B	HBSW1506	HBSW2006	HBSW2007	HBSW2008	HBSW2009	HBSW2010	HBSW2011
Specific conductance (µS/cm)	Range	90-128	63-184	110-143	73-168	--	148	85-200	142-190	--
	Median	106	137	126	125	--	--	142	166	--
	Samples	4	6	2	85	0	1	87	2	0
pH, field (standard units)	Range	6.2-7.5	5.9-6.9	7.5-9.1	6.0-8.0	--	7.4	6.1-7.5	6.2-7.2	--
	Median	6.6	6.3	--	7.3	--	--	6.9	6.5	--
	Samples	4	6	2	24	0	1	22	2	0
Dissolved oxygen (mg/L)	Range	6.1-12.2	1.0-7.6	5.5-6.4	6.2-12.6	--	8.2	1.1-11.7	5-10.4	--
	Median	10.4	6.9	6.0	9.2	--	--	8.0	7.7	--
	Samples	3	6	2	20	0	1	20	2	0
Chemical-oxygen demand (mg/L)	Range	<5-10	28-86	6.0-15	<5-100	--	17	bdl-32	<5-19	--
	Median	8	66	10.5	9.5*	--	--	14	--	--
	Samples	4	3	2	22	0	1	21	2	0
Biochemical-oxygen demand (mg/L)	Range	0.2-1.5	6.1 - >12	0.8-1.4	<0.1-14	--	0.5	<0.1-10	0.5-7.9	--
	Median	0.6	12	1.1	1.1*	--	--	1.5*	4.2	--
	Samples	4	3	2	20	0	1	19	2	0
Fecal coliform (cols/100 mL)	Range	82	300-450	--	36-21,000	54-51,000	9-7,000	72-3,000	--	<10-3,500
	Median	--	375	--	800	760	340	475	--	310
	Samples	1	2	0	61	32	34	14	0	38
Fecal streptococcus (cols/100 mL)	Range	--	1,000	--	91-80,000	99-77,000	bdl-57,000	54-6,100	--	10-2,300
	Median	--	--	--	980	670	700	830	--	360
	Samples	0	1	0	56	31	32	14	0	35
Alkalinity, fixed endpoint (mg/L as $CaCO_3$)	Range	31-56	15-59	28-34	38-67	--	--	33-77	26-67	--
	Median	44	51	31	56	--	--	46	46	--
	Samples	4	3	2	11	0	0	10	2	0
Sulfate, (mg/L)	Range	<1.0-3.8	6.9-10	5.0-6.0	2.3-7.8	--	3.8	1.2-9.6	7.4-19	--
	Median	2.0	8.4	5.5	5.0	--	--	6.0	13.2	--
	Samples	4	2	2	13	0	1	12	2	0
Chloride, dissolved (mg/L)	Range	4.4-4.7	5.7-15	7.9-14	3.4-12	--	4.5	3.2-15	8.4-10	--
	Median	4.5	11	11	4.4	--	--	7.8	9.2	--
	Samples	4	3	2	22	0	1	21	2	0
Fluoride, total (mg/L)	Range	<0.20	<0.2	<0.2-0.2	bdl	--	<0.1	bdl	<0.2	--
	Median	<0.20	<0.2	--	--	--	--	--	--	--
	Samples	4	3	2	16	0	1	15	2	0
Aluminum, total (µg/L)	Range	370-8,600	2,100-14,000	260-15,000	210-4,800	--	--	<100-26,000	180-1,100	--
	Median	830	3,700	--	840	--	--	900*	640	--
	Samples	4	3	2	12	0	0	11	2	0
Arsenic, total (µg/L)	Range	10-44	12-450	<1	bdl	--	<25	bdl-73	<1	--
	Median	26	450	--	1.0*	--	--	0.4*	--	--
	Samples	4	3	2	22	0	1	21	2	0
Barium, total (µg/L)	Range	<100-100	<100	<100	<100-300	--	<100	<100-200	<100-100	--
	Median	<100	<100	--	<100	--	--	<100	<100	--
	Samples	4	3	2	22	0	1	21	2	0
Cadmium, total (µg/L)	Range	<1-1	bdl	<1	bdl	--	<5	bdl	<1-1	--
	Median	--	--	--	--	--	--	--	--	--
	Samples	4	3	2	22	0	1	21	2	0
Chromium, total (µg/L)	Range	3-15	30-850	1-2	bdl-63	--	<25	bdl-13	2.0-3.0	--
	Median	5	180	--	2.0*	--	--	2.0*	1.5	--
	Samples	4	3	2	22	0	1	21	2	0
Copper, total (µg/L)	Range	<50-60	70-300	<50-60	bdl-70	--	<50	bdl-130	<[illegible]-130	--
	Median	<50	160	--	5	--	--	3.0	--	--
	Samples	4	3	2	22	0	1	21	2	0
Iron, total (µg/L)	Range	650-2,200	4,600-14,000	230-1,000	470-30,000	--	1,200	890-44,000	990-3,900	--
	Median	1,000	8,100	620	1,500	--	--	3,400	2,400	--
	Samples	4	3	2	22	0	1	21	2	0
Lead, total (µg/L)	Range	2-9	2-46	1-8	bdl-24	--	<5	bdl-21	3.0-5.0	--
	Median	3	3	4.5	2.0*	--	--	3.0*	4.0	--
	Samples	4	3	2	22	0	1	21	2	0
Manganese, total (µg/L)	Range	130-300	290-4,500	20-60	80-840	--	140	100-3,100	1,600-4,300	--
	Median	180	1,400	40	220	--	--	680	3,000	--
	Samples	4	3	2	22	0	1	21	2	0
Mercury, total (µg/L)	Range	<0.20	<0.20-0.20	<0.20	bdl	--	<1.0	bdl-2.3	<0.2-0.2	--
	Median	<0.20	0.20	<0.2	--	--	--	0.03	--	--
	Samples	4	3	2	22	0	1	21	2	0
Zinc, total (µg/L)	Range	<50-120	50-150	<50-150	bdl-280	--	140	bdl-210	100-220	--
	Median	--	100	--	60*	--	--	60	160	--
	Samples	4	3	2	22	0	1	21	2	0
Organic carbon, total (mg/L)	Range	2.0	7.8-27	3.2-4.9	1.1-11	--	1.8	1.5-13	2.7	--
	Median	--	17	4.1	3.1	--	--	3.1	--	--
	Samples	1	2	2	16	0	1	13	1	0

Table 6.--Summary of constituents and properties exceeding or outside of ranges designated by Mecklenburg County action levels in surface-water samples from the Harrisburg Road landfill, 1986-92

[--, no data; mg/L, milligram per liter; >, greater than; µg/L, microgram per liter]

Constituent or property		HBSW7A	HBSW7B	HBSW1506	HBSW2006	HBSW2008	HBSW2009	HBSW2010
pH, field (standard units)	Exceedences	2	4	1	4	0	5	1
	Samples	4	6	2	24	1	22	2
	Minimum	6.2	5.9	--	6.0	--	6.1	6.2
	Maximum	--	--	9.1	--	--	--	--
Chemical-oxygen demand (mg/L)	Exceedences	0	3	0	2	0	4	0
	Samples	4	3	2	22	1	22	2
	Maximum	--	86	--	100	--	32	--
Biochemical-oxygen demand (mg/L)	Exceedences	0	3	0	1	0	2	1
	Samples	4	3	2	20	1	19	2
	Maximum	--	>12	--	14	--	13	7.9
Arsenic, total (µg/L)	Exceedences	0	2	0	0	0	1	0
	Samples	4	3	2	22	1	21	2
	Maximum	--	450	--	--	--	73	--
Chromium, total (µg/L)	Exceedences	0	2	0	1	0	0	0
	Samples	4	3	2	22	1	21	2
	Maximum	--	850	--	63	--	--	--
Iron, total (µg/L)	Exceedences	4	3	1	22	1	21	2
	Samples	4	3	2	22	1	21	2
	Maximum	2,200	14,000	1,000	30,000	1,200	44,000	3,900
Manganese, total (µg/L)	Exceedences	4	3	1	22	1	21	2
	Samples	4	3	2	22	1	21	2
	Maximum	300	4,500	60	840	140	3,100	4,300
Mercury, total (µg/L)	Exceedences	0	0	0	0	0	1	0
	Samples	4	3	2	22	1	21	2
	Maximum	--	--	--	--	--	2.3	--
Organic carbon, total (mg/L)	Exceedences	0	1	0	1	0	1	0
	Samples	1	2	2	16	1	13	1
	Maximum	--	27	--	11	--	13	--
Organic halogens, total (mg/L)	Exceedences	0	2	0	0	0	0	0
	Samples	2	3	2	15	1	15	1
	Maximum	--	0.95	--	--	--	--	--

Samples from site HBSW7A, which is downstream from site HBSW7B, generally had smaller concentrations of arsenic, chromium, and total organic halogens than samples from site HBSW7B (table 5). Observed differences in arsenic, chromium, and total organic halogen concentrations in samples from sites HBSW7A and HBSW7B are possibly related to attenuation processes occurring in the stream, or to the different time periods during which these sites were sampled. Arsenic and chromium naturally occur in some soils of the Piedmont. Soil erosion caused by activities at the landfill could have contributed to arsenic and chromium concentrations observed at these sites. Site HBSW7A was periodically sampled from September 1982 to July 1987, whereas site HBSW7B was periodically sampled from July 1988 to July 1989 (Smith, 1993). The ash-disposal cell west of the stream on which sites HBSW7A and HBSW7B are located was active from September 1989 through 1992. The waste-disposal cell east of this stream was active during 1986-91. Waste disposal in this cell began in the southernmost areas and progressed northward. Thus, sampling at site HBSW7A ceased shortly after nearby waste-disposal activities began.

Large densities of fecal coliform and fecal streptococcus bacteria were present in samples from most surface-water monitoring sites (table 5). No bacteriological samples were collected at sites HBSW1506 and HBSW2010 during 1986-92 (Smith, 1993). Median densities of fecal coliforms, 800 colonies per 100 milliliters (cols/100), and fecal streptococci, 980 cols/100 mL, were largest at site

HBSW2006. Large numbers of bacteria were present in samples from site HBSW2009, the drainage area of which lies entirely within the landfill. However, large densities of bacteria also were present in samples from site HBSW2011, the drainage area of which lies outside the landfill (fig. 5). Median densities of fecal coliforms and fecal streptococci generally were much smaller in ground water than in surface water.

The seasonal Kendall test was used to evaluate temporal trends in selected water-quality constituents at surface-water sites (table 8). Data from sites HBSW7B, HBSW2007, HBSW2008, HBSW2010, and HBSW2011 were inadequate for trend analysis. Data from site HBSW7A indicated a decreasing trend in biochemical-oxygen demand of -0.6 milligram per liter per year (mg/L/yr) during 1982-87. Data from site HBSW1506 indicate a decreasing trend in alkalinity (-6.1 mg/L/yr) during 1983-87. Data indicate increasing trends in specific conductance for sites HBSW2006 and HBSW2009 and an increasing trend in pH for site HBSW2006 during 1984-92. These increasing trends were small in magnitude. Specific conductance increased at an average rate of 3 microsiemens per centimeter per year (μS/cm/yr), and pH increased at an average rate of 0.09 units per year (units/yr) at site HBSW2006. Similarly, specific conductance at site HBSW2009 increased at an average rate of 6 μS/cm/yr. No trends in chemical-oxygen demand, biochemical-oxygen demand, alkalinity, chloride, iron, or manganese were detected for sites HBSW2006 and HBSW2009.

Ground-Water Quality

Water-quality data indicate that none of the monitoring wells were representative of background conditions in the regolith. Water samples from onsite wells along the southern boundary of the landfill, which are upgradient from waste-disposal cells, had larger chemical-oxygen demands and concentrations of synthetic organic compounds than most of the wells downgradient from waste-disposal cells (table 9, p. 87).

Samples from offsite domestic supply wells, HBW721 and HBW743A, appear to be representative of water quality in the bedrock. Median values of specific conductance (53 microsiemens per centimeter [μS/cm]), pH (6.2 units), and alkalinity (18 mg/L) of samples from well HBW721, which is near the southern boundary of the landfill, and median values of specific conductance (134 μS/cm), pH (6.6 units), and alkalinity (60 mg/L) of samples from well HBW743A, which is north of the landfill, are small in comparison to corresponding values for onsite wells (table 9). Concentrations of iron and manganese in samples from wells HBW721 and HBW743A also are small in comparison to corresponding values in samples from onsite wells and probably are typical of natural ground-water quality in bedrock near the Harrisburg Road landfill.

Natural water-quality conditions probably contributed to the low pH of ground-water samples. The pH of most samples was less than the minimum action level of 6.5 units (tables 2 and 10). Iron and manganese exceeded action levels in almost all samples from monitoring wells in the regolith. Exceedences of action levels for chemical-oxygen demand, biochemical-oxygen demand, arsenic, chromium, and total organic carbon were common in samples from some of the onsite monitoring wells (table 10, p. 94). Action levels for arsenic (50 μg/L) and chromium (50 μg/L) were most commonly exceeded in samples from wells HBW12B, HBW14D, HBW18B, and HBW19A. Mercury concentrations exceeded action levels in some samples from wells HBW14B, HBW18A, and HBW22. Total organic halogen concentrations exceeded action levels in some samples from wells HBW17C and HBW1501 (table 10).

Concentrations of inorganic constituents and values of physical and chemical properties indicate that water from well HBW18B has been affected by leachate to a greater extent than water from other wells. Well HBW18B is in the northern part of the landfill and is downgradient from a waste-disposal cell that was active during 1986-87. Samples were collected from this well during 1988-92. Median values of specific conductance (398 μS/cm), chemical-oxygen demand (34 mg/L), alkalinity (229 mg/L), aluminum (59,000 μg/L), copper (1,200 μg/L), iron (77,000 μg/L), and manganese (1,000 μg/L) were larger in samples from well HBW18B than corresponding median values of samples from other monitoring wells, including well HBW18A, which is adjacent to well HBW18B. The larger concentrations of indicator constituents in water from well HBW18B (screened interval 14.9 to 19.9 ft below land surface) than in water from well HBW18A (screened interval 25.1 to 30.1 ft below land surface) indicate leachate has primarily affected shallow ground water in this area. Wells HBW18A and HBW18B are about 200 ft east of Wiberly Branch (fig. 5). The greater permeability of shallow soils than of the deeper saprolite (fig. 3) near well cluster 18 also could have contributed to differences in values of indicator constituents and

Table 8. Summary of seasonal Kendall trend test results for selected surface-water quality data from the Harrisburg Road landfill, 1979-92

[Only results significant at a probability level of 0.10 are shown. p, probability level; *, trend tests were made but trends were not significant; Slope, trend slope expressed in units per year; --, data inadequate for analysis; µS/cm, microsiemens per centimeter; % median, slope expressed as a percentage of the seasonal median; n, number observations; Record, period of record; mg/L, milligram per liter; µg/L, microgram per liter]

Constituent or property		HBSW7A	HBSW1506	HBSW2006	HBSW2009
Specific conductance (µS/cm)	p	*	*	0.074	0.027
	Slope	--	--	3.0	6.0
	% median	--	--	2.4	4.3
	n	18	6	28	117
	Record	1982-87	1983-87	1984-92	1984-92
pH, field (standard units)	p	*	*	0.016	*
	Slope	--	--	0.09	--
	n	16	6	28	--
	Record	1982-87	1983-87	1984-92	1984-92
Chemical-oxygen demand (mg/L)	p	*	--	*	*
	Slope	--	--	--	--
	% median	--	--	--	--
	n	14	5	26	26
	Record	1982-87	1983-87	1984-92	1984-92
Biochemical-oxygen demand (mg/L)	p	0.035	--	*	*
	Slope	-0.6	--	--	--
	% median	-62	--	--	--
	n	14	5	24	24
	Record	1982-87	1983-87	1984-92	1984-92
Alkalinity, total (mg/L as $CaCO_3$)	p	*	0.086	*	*
	Slope	--	-6.1	--	--
	% median	--	-17.8	--	--
	n	16	6	14	13
	Record	1982-87	1983-87	1984-90	1985-90
Chloride, dissolved (mg/L)	p	*	--	*	*
	Slope	--	--	--	--
	% median	--	--	--	--
	n	16	5	26	26
	Record	1982-87	1983-87	1984-92	1984-90
Iron, total (µg/L)	p	*	--	*	*
	Slope	--	--	--	--
	% median	--	--	--	--
	n	16	5	26	26
	Record	1983-87	1983-87	1984-92	1985-93
Manganese, total (µg/L)	p	*	--	*	*
	Slope	--	--	--	--
	% median	--	--	--	--
	n	16	5	28	28
	Record	1983-87	1983-87	1984-92	1985-92

properties in samples from wells HBW18A and HBW18B. It is also possible that little downward movement of leachate occurs in this area of the landfill because of ground-water discharge into Wiberly Branch (fig. 6). The elevation of Wiberly Branch in the vicinity of wells HBW18A and HBW18B is about 680 ft above sea level, whereas the elevation of land surface at wells HBW18A and HBW18B is about 709 ft (table 4). Thus, the elevation of Wiberly Branch is about the same as the elevation of the lower part of the screened interval in well HBW18A.

Median concentrations of aluminum were larger for samples from wells HBW12, HBW12A, and HBW12B than for samples from any other wells except HBW14D and HBW18B (table 9). The shallowest well in cluster 12, HBW12B (11.3 ft), had the largest median aluminum concentration (42,000 μg/L), whereas the deepest well in cluster 12, HBW12 (23.4 ft), had the smallest median aluminum concentration (10,000 μg/L). A similar pattern occurred among the wells in this cluster with respect to iron; well HBW12B had the largest median concentration (18,000 μg/L), and well HBW12 had the smallest median concentration (4,000 μg/L). A similar distribution of aluminum and iron with respect to well depth occurred in samples from cluster 14 (wells HBW14B, HBW14C, and HBW14D) and cluster 18 (wells HBW18A and HBW18B). The relative distribution of aluminum and iron with respect to well depth could be related to natural processes as well as to movement of leachate. Distribution of manganese with respect to well depth did not follow the same pattern as aluminum and iron. Generally, the well of intermediate depth had the largest median manganese concentration. Suspended clay particles could have contributed to the large aluminum, iron, and manganese concentrations observed in ground water.

Samples for analysis of synthetic organic compounds were not collected at all ground-water monitoring sites (Smith, 1993). Samples were collected for pesticide analysis more commonly than for analysis of other classes of synthetic organic compounds. Data indicate the presence of numerous synthetic organic compounds in ground water throughout the landfill (table 11, p. 98); however, most of these compounds were present in very small concentrations. The most commonly detected pesticide was the herbicide 2,4-D. Other pesticides detected in ground-water samples from the Harrisburg Road landfill include aldrin, chlordane, DDT, dieldrin, endosulfan, heptachlor, heptachlor epoxide, lindane, perthane, 2,4-DP, 2,4,5-T, and silvex.

Wastes buried in the landfill are a possible source of pesticides in these water samples. Use of aldrin (U.S. Environmental Protection Agency, 1985; Sine, 1991); chlordane (Kutz and others, 1991, p. 43); DDT (Kutz and others, 1991); dieldrin (Sine, 1991); heptachlor (U.S. Environmental Protection Agency, 1987); and lindane (U.S. Environmental Protection Agency, 1985) has been restricted or discontinued in the United States. Thus, it is unlikely that present day applications of these pesticides at or near the landfill contributed to the presence of these pesticides in ground water. Chlordane was detected in a water sample from offsite well HBW721. Because well HBW721 is upgradient from the landfill, it is unlikely that the landfill is the source of the chlordane. Chlordane is considered to have limited mobility in aqueous systems (Smith and others, 1988) because of its low aqueous solubility, low vapor pressure, and tendency to adsorb to soils or sediment (Lucius and others, 1992). These characteristics indicate a nearby source of chlordane in water from this well. Residues from termite control applications at structures near this well are a possible source of the chlordane detected in water samples from well HBW721.

Synthetic organic compounds other than pesticides were detected in samples from several monitoring wells (table 11). Generally, concentrations of these compounds were less than MCL's (U.S. Environmental Protection Agency, 1993); however, MCL's for some synthetic organic compounds were exceeded in samples from wells HBW17C, HBW18A, HBW21, and HBW1501. The MCL for vinyl chloride (2 μg/L) was exceeded in samples from well HBW17C (maximum concentration 5.9 μg/L). The MCL for 1,2-dichloroethane (5 μg/L) was exceeded in a sample from well HBW1501 (57 μg/L). Samples from wells HBW18A and HBW21 contained 1,1,1-trichloroethane at a concentration of 5 μg/L. A sample from well HBW1501 also contained concentrations of 1,1,2-trichloroethane (6.5 μg/L), trichloroethylene (74 μg/L), tetrachloroethylene (130 μg/L), 1,2-dichloropropane (9.6 μg/L), and benzene (31 μg/L) in excess of MCL's. Most of the synthetic organic compounds which exceeded MCL's are solvents (Verschueren, 1983).

Sources of synthetic organic compounds detected in ground-water samples cannot be directly determined with available data. However, based on ground-water levels (fig. 6) and the well location relative to waste-disposal cells, the likelihood that the landfill is the source of these compounds can be estimated. For example, the 1,1,1-trichloroethane detected at a concentration of 5 µg/L in a sample from well HBW21 does not appear to be derived from landfill wastes because the only waste-disposal area upgradient from well HBW21 is a lined ash-disposal pit (figs. 5 and 6). Because 1,1,1-trichloroethane is removed by heating, it should not be present in incinerator ash.

Synthetic organic compounds detected in samples from HBW18A probably were derived from landfill wastes. Many of the synthetic organic compounds detected in samples from well HBW18A also were detected in samples from adjacent well, HBW18B. The detection of many of the same compounds in water from wells HBW18A and HBW18B suggests a common source of these compounds. Because these wells were sampled at different times, differences between concentrations of synthetic organic compounds in samples from wells HBW18A and HBW18B do not necessarily indicate relative distribution of these compounds with respect to well depth.

The presence of many of the same synthetic organic compounds in samples from wells HBW17C and HBW1501 suggests a common source of these compounds. No data for volatile and semivolatile organic compounds were available for wells HBW17A, HBW17B, HBW600, and HBW1502, which are near wells HBW17C and HBW1501 (Smith, 1993). Wells HBW17C and HBW1501 are upgradient from waste-disposal cells (fig. 5), and the direction of ground-water movement indicated by water-level elevations (fig. 6) indicates that water from waste-disposal cells does not flow toward these wells. However, upgradient movement of compounds less dense than water can occur as a result of density gradients and water-level fluctuations (Mackay and others, 1985). The large total organic halogen concentrations in samples from well HBSW7B possibly were derived from the same source as the synthetic organic compounds detected in samples from wells HBW17C and HBW1501.

Several volatile and semivolatile organic compounds were detected in samples from offsite domestic well HBW743A, about 0.3 mi north of the landfill. Chloroform and 1,1-dichloroethane were detected in all five of the samples collected from this well for analysis of synthetic organic compounds. Tetrachloroethylene, toluene, and phenols also were detected in samples from well HBW743A. Concentrations of synthetic organic compounds in samples from well HBW743A were much less than MCL's. Although the landfill is a possible source of these compounds, water-level elevations (fig. 6) and typical ground-water flow paths (fig. 4) indicate it is more likely that leachate would discharge into Reedy Creek tributary 2 than flow beneath the stream. Thus, it is unlikely that leachate has affected water quality at well HBW743A, which is on the opposite side of Reedy Creek tributary 2 from the landfill.

Samples from several monitoring wells indicated statistically significant trends in ground-water quality (table 12, p. 102). Samples from well HBW7 indicate decreasing trends in specific conductance (-18.9 µS/cm/yr) and alkalinity (-12.6 mg/L/yr) from 1982 to 1986. Well HBW7 is downgradient from two waste-disposal cells that were active from 1978 to 1982 and from 1986 to 1991, respectively. Decreasing trends observed for well HBW7 probably are related to changes in the chemical quality of leachate from the older waste-disposal cell in the southern part of the landfill (fig. 5) and indicate a general improvement in water-quality conditions at this site prior to the time the adjacent waste-disposal cells were activated.

Wells for which data indicated only one water-quality trend include HBW10 (specific conductance increased 2 µS/cm/yr), HBW12A (biochemical-oxygen demand decreased 1.4 mg/L/yr), HBW17C (pH decreased 0.10 units/yr), HBW18B (specific conductance increased 40 µS/cm/yr), HBW20 (manganese decreased 55 micrograms per liter per year [µg/L/yr]), HBW21(pH increased 0.08 units/yr), and HBW721 (biochemical-oxygen demand decreased 0.06 mg/L/yr). The similar increasing trends in specific conductance indicated by samples from adjacent wells HBW18B (40 µS/cm/yr) and HBW18A (42.8 µS/cm/yr) indicate increased effects of leachate since 1988. The large rates of increase in specific conductance for wells HBW18A and HBW18B are consistent with data for other constituents in water samples from these wells that also indicate increased effects of leachate. Causes of trends at sites for which a trend in only one constituent occurred cannot be fully assessed.

Multiple trends were detected for several wells. Samples from well HBW12B indicate increasing trends in pH (0.12 units/yr) and chemical-oxygen demand (1.1 mg/L/yr), and a decreasing trend in manganese concentration (-320 µg/L/yr). The relation of these trends to changes in leachate quality at the landfill is uncertain. Although the decreasing trend in manganese concentration indicates a decrease in the effect of leachate, the increasing trend in chemical-oxygen demand indicates an increase in the effect of leachate. Well HBW12B is in the northwestern part of the landfill, adjacent to the western stream. Because ground water at the Harrisburg Road landfill discharges to streams (fig. 6), ground water at well HBW12B could have been affected by leachate from more than one waste-disposal cell.

Samples from well HBW22 indicated an increasing trend in specific conductance (5 μS/cm/yr) and a decreasing trend in manganese concentration (-10 μg/L/yr). Like well HBW12B, samples from well HBW22 indicated changes in water quality inconsistent with typical changes in leachate quality. Unlike well HBW12B, well HBW22 is in a part of the landfill that should be relatively unaffected by the landfill (fig. 5). Also, the magnitude of trends observed for this well were small and could reflect changes in analytical techniques.

Samples from well HBW1603, which is in the east-central part of the landfill, indicate increasing trends in specific conductance (25 μS/cm/yr) and alkalinity (10.8 mg/L/yr). These trends indicate that the effects of leachate at well HBW1603 increased during 1982-88. Other statistically significant trends include increases in specific conductance (1.0 μS/cm/yr) and pH (0.11 units/yr) for the offsite domestic well HBW743A during 1983-92. Causes of trends detected in samples from well HBW743A cannot be determined.

Changes in Water-Level Fluctuations in Response to Landfilling

Three wells were installed at the Harrisburg Road landfill to monitor changes in ground-water levels caused by landfill activities. Wells HBW2101A and HBW2201 were installed in proposed waste-disposal cells. Casings of these wells were extended as wastes were placed in these cells. Well HBW2301 was installed in the northeastern corner of the landfill, in an area undisturbed by landfill activities. The hydrographs for wells HBW2101A and HBW2201 reflect the effects of landfill activities on ground-water levels in waste-disposal areas (fig. 7). The hydrograph for HBW2301 reflects ground-water level conditions in an undisturbed part of the landfill.

Well HBW2101A was constructed at the perimeter of a proposed landfill cell on November 1, 1984, and collection of hourly water-level records began on the same date. This well was drilled in saprolite derived from metamorphosed quartz diorite, and was installed to a depth of 32.2 ft below the original land surface. As landfill operations progressed, the elevation of land surface at well HBW2101A increased by approximately 25 ft, thereby increasing well depth and depth to water surface with respect to land-surface elevation. This increase in land-surface elevation did not result in significant changes in the elevation of the water table. However, changes in the responsiveness of the water table to infiltration of precipitation were evident. As shown in figure 7, the ground-water level at well HBW2101A was more responsive to recharge from precipitation events during the well's initial period of operation than during later periods. Although land-surface elevation increased by approximately 25 ft as wastes were placed in the disposal cell, there was little change in ground-water levels or responsiveness to recharge until after mid-1988.

During initial development of the waste-disposal cell adjacent to well HBW2101A, native soils were excavated east of well HBW2101A. When excavation for the adjacent cell was completed, land-surface elevation at well HBW2101A remained unchanged. However, approximately 15 ft east of well HBW2101A, there was a 25 to 35 ft vertical drop from land surface to the bottom of the newly excavated landfill cell. As a result of the excavation, the rate of ground-water recharge was much faster than when natural soil layers were in place.

Rapid response to precipitation can be seen in the hydrograph for well HBW2101A beginning in July or August of 1988 (fig. 7). A rapid increase in water-level elevation occurred in early 1989 in response to the large-scale removal of overlying soils. By October of 1989, after several layers of waste and soil had been deposited in the cell, responsiveness to precipitation decreased and fluctuations in ground-water levels became much more gradual. After completion of the part of the waste-disposal cell near well HBW2101A, water-level fluctuations became seasonally cyclic, exhibiting smoothly undulating seasonal patterns in the hydrograph (fig. 7).

Well HBW2201 was installed at the edge of a proposed landfill cell. This well was constructed on November 26, 1985, and collection of hourly water-level records began on December 18, 1985. Well HBW2201 was originally drilled to a depth of 32 ft below land surface in saprolite derived from metamorphosed quartz diorite.

As landfill operations continued, the waste-disposal cell was enlarged and eventually surrounded well HBW2201. As the waste-disposal cell was developed, land-surface elevation at the well increased by approximately 20 ft, thereby increasing the well depth and depth to water surface with respect to land surface. This increase in land-surface elevation did not cause significant changes in water-table elevation;

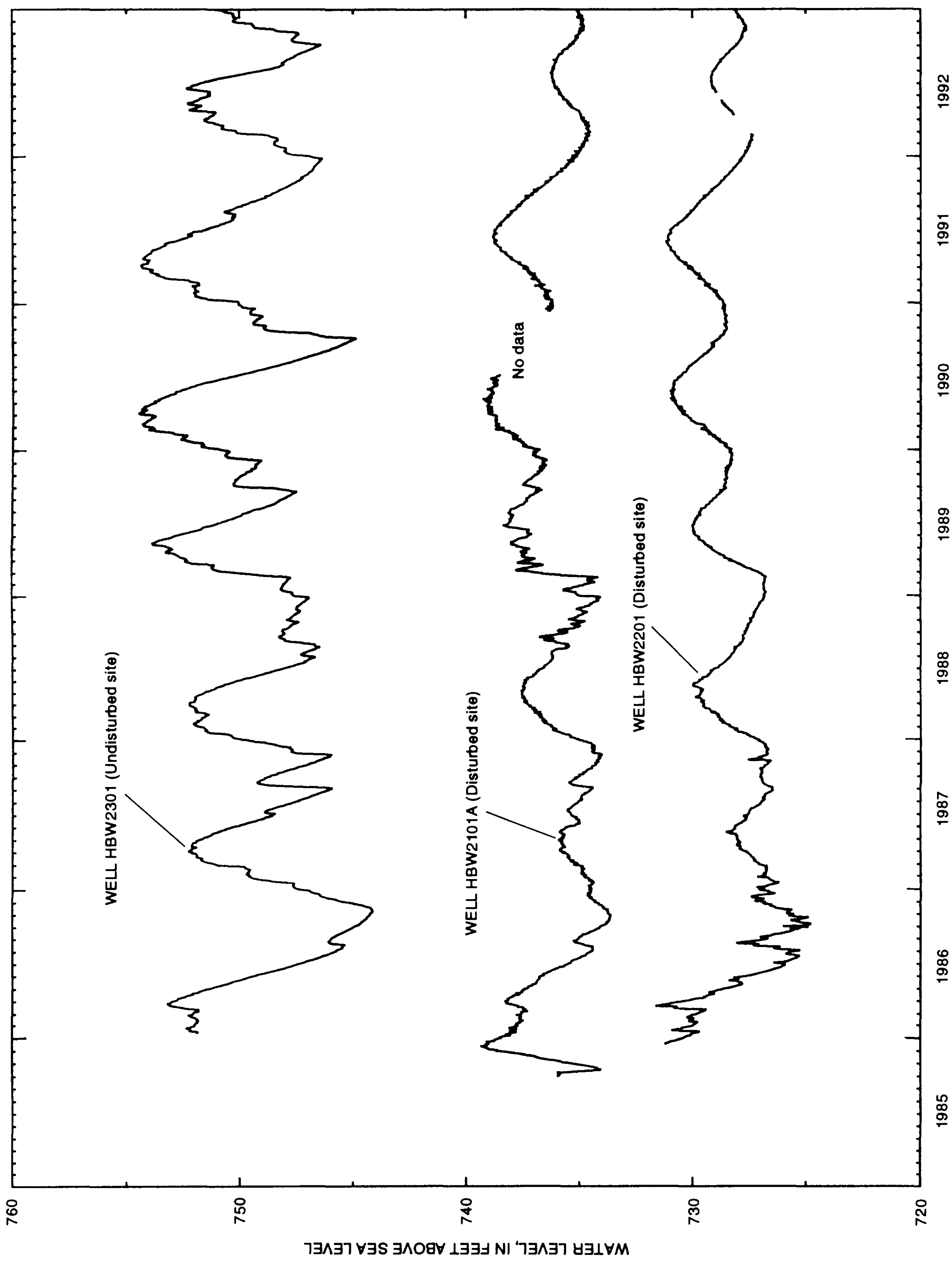

Figure 7. Hydrographs for monitoring wells HBW2301, HBW2101A, and HBW2201 at the Harrisburg Road landfill, 1985-92.

however, the responsiveness of the water table to infiltration of precipitation decreased. As shown in figure 7, ground-water level fluctuations at well HBW2201 responded to changes in thickness of the overlying soil materials. Prior to landfilling activities near well HBW2201, infiltration of precipitation produced rapid, distinct rises in ground-water levels. Beginning in early 1987 and continuing through mid-1988, the hydrograph shows a period of transition. During this transition period, landfill activities progressed, and ground-water levels became less responsive to precipitation. As landfill activities continued and land-surface elevation increased, the infiltration rates of precipitation decreased and ground-water fluctuations became much more subdued and gradual. As the waste-disposal cells near well HBW2201 were completed, ground-water level fluctuations continued to be gradual and cyclic, exhibiting smoothly undulating seasonal changes.

Well HBW2301 was installed in an undisturbed area in the northeastern corner of the Harrisburg Road landfill (fig. 5) on November 27, 1985, and collection of water-level records began on January 14, 1986. The well was drilled to a depth of 55 ft below land surface in saprolite derived from metamorphosed quartz diorite. Land-surface elevation at well HBW2301 has not changed. The water-level hydrograph for well HBW2301 shows fluctuations of ground-water levels in an area unaffected by landfill activities. Soils in the vicinity of well HBW2301 have not been disturbed by activities at the landfill. The water-level hydrograph for well HBW2301 indicates a very responsive water table (fig. 7). Infiltration of precipitation through undisturbed soil produces fairly rapid changes in ground-water levels. The seasonal variations at this site are greater than those from either of the other two water-level monitoring wells at the Harrisburg Road landfill. The range in water levels in well HBW2301 during 1986-92 was approximately 10 ft, whereas the ranges in water levels in wells HBW2101A and HBW2201 were 6 and 7 ft, respectively. Well HBW2301 serves as a background site representative of natural conditions for comparison with nearby wells.

Conclusions

The Harrisburg Road landfill has not had a large effect on surface-water quality downstream from the landfill as indicated by water-quality data for site HBSW2006 on Reedy Creek tributary 2. Except for pH and iron, most constituents and properties of samples from site HBSW2006 were acceptable based on Mecklenburg County action levels. Low pH and large iron concentrations probably are natural characteristics of surface water in this part of Mecklenburg County. Although the effects of leachate on water quality are evident in streams originating in the landfill, dilution and various attenuation processes such as adsorption and biodegradation appear to have contributed to improvement of the surface-water quality by the time water reaches Reedy Creek tributary 2 (site HBSW2006). Because much of the waste-disposal activity at the Harrisburg Road landfill is recent and the rates of leachate movement through saprolite are slow, the maximum effects of leachate at site HBSW2006 possibly will not occur for several years.

Few synthetic organic compounds were detected in samples collected at surface-water monitoring sites. The most commonly detected types of synthetic organic compounds were total organic halogens and pesticides, concentrations of which generally were less than action levels and MCL's. However, the action level for total organic halogens was exceeded in samples from site HBSW7B. Landfill wastes do not appear to be the source of the large total organic halogen concentrations in samples from site HBSW7B. The source and identity of the compounds contributing to the large total organic halogen concentrations detected in samples from site HBSW7B are not known.

Trends in surface-water quality were detected for several monitoring sites. However, because of the numerous waste-disposal activities that occurred at various times during the study period, causes of most surface-water quality trends could not be determined.

Except for pH, iron, and manganese, constituents and properties of samples from most monitoring wells generally were acceptable based on Mecklenburg County action levels. Concentrations of arsenic and chromium in samples from the northwestern part of the landfill commonly exceeded Mecklenburg County action levels. Water-quality data indicate that well HBW18B in the north-central part of the landfill was the well most affected by leachate during 1986-92. Chemical-oxygen demand, biochemical-oxygen demand, arsenic, chromium, copper, iron, manganese, and total organic carbon concentrations in samples from well HBW18B commonly exceeded Mecklenburg County action levels.

Synthetic organic compounds were detected in samples from wells throughout the landfill. Small concentrations of several pesticides, including chlordane, DDT, 2,4-D, 2,4-DP, and 2,4,5-T, were detected in samples from several wells. Concentrations of pesticides in ground-water samples were much less than MCL's. Concentrations of several compounds, particularly chlorinated organic compounds, exceeded MCL's in samples from wells HBW17C, HBW18A, HBW21, and HBW1501. Several chlorinated organic compounds also were consistently detected at small concentrations in samples from well HBW743A, an offsite domestic well. Sources of these compounds are not known. However, based on well locations and ground-water flow paths, landfill wastes are a probable source of these compounds in ground water at HBW18A. Landfill wastes do not appear to be the source of synthetic organic compounds in ground water from wells HBW17C, HBW21, HBW1501, and HBW743A. Because of the proximity of well HBW17C to well HBW1501, it is likely that synthetic organic compounds in ground water at these sites are derived from a common source.

Trends in ground-water quality differ in magnitude and direction. Because of the various waste-disposal activities and the different time periods during which waste-disposal cells were active, evaluation of trends in ground-water quality is difficult. Data from well HBW7 indicate decreasing trends in specific conductance and alkalinity and indicate that effects of leachate decreased at this site from 1982 to 1986. However, because sampling at this site was discontinued in 1986, effects of two waste-disposal cells that were established adjacent to this well in 1986 are not known. Increasing trends in specific conductance and alkalinity for well HBW1603 generally indicate increased effects of leachate. The increasing trends in specific conductance for wells HBW18A and HBW18B indicate that effects of leachate have increased at these wells since 1988. An increasing trend in specific conductance for well HBW14D also indicates that effects of leachate have increased in the vicinity of this well; however, water-quality trends for most of the wells do not clearly indicate increasing or decreasing effects of leachate.

Water levels were continuously monitored at three wells. Changes in water-level fluctuations associated with waste-disposal operations occurred in the two wells, which were in waste-disposal cells. Although the land-surface elevations at these wells increased as waste disposal proceeded, there were no significant changes in water-level elevations. However, hydrographs for these wells indicate that responsiveness of the water table to precipitation decreased as disposal of wastes near these sites continued.

Holbrooks Road Landfill

The Holbrooks Road landfill in north-central Mecklenburg County is about 5 mi north of the Charlotte city limit (fig. 1). The landfill covers about 65 acres and lies within the Clarke Creek Basin (fig. 8). An intermittent stream that flows into the South Prong of Clarke Creek bisects the landfill. A natural gas pipeline is buried beneath this stream. Surface drainage in the southeastern part of the landfill flows eastward into a tributary of the South Prong of Clarke Creek. Land-surface elevations at the landfill range from about 660 ft above sea level along the northeastern boundary adjacent to the South Prong of Clarke Creek, to nearly 780 ft in the southern part of the landfill. Elevation of land surface at Holbrooks Road, which forms the southwestern boundary of the landfill, is about 750 ft above sea level. Several residences are located south and west of the landfill; however, the area surrounding the landfill is primarily woodland.

Limited information regarding depth to bedrock was available for this site. No bedrock outcrops were observed in the vicinity of the Holbrooks Road landfill. According to the driller's log for well HRW3, which was constructed as a supply well for the landfill office, bedrock occurs at a depth of 55 ft (elevation of 685 ft above sea level at this site). This area is underlain by metamorphosed quartz diorite, diorite, and tonalite (Goldsmith and others, 1982). Saprolite in some parts of the Holbrooks Road study area contains granular quartz in a tan clay and silt matrix and probably was derived from porphyritic quartz diorite or granite (Cardinell and others, 1989). This type of saprolite differs from the fine-grained reddish silt and clay saprolite that occurs throughout most of Mecklenburg County, and because of its coarser texture, it probably has a greater hydraulic conductivity than the more common type of saprolite.

The Holbrooks Road sanitary landfill opened in 1968 and closed in 1986. Municipal wastes were deposited in two unlined waste-disposal cells, one on each side of the intermittent stream (fig. 8). The western cell is the older disposal area and was used for waste disposal during 1968-81. The eastern cell was used for waste disposal during 1981-86. Both waste-disposal cells are above the water table. Excavation and fill techniques were used for disposal of wastes at this site. A final cover of sandy-clay loam was placed over each landfill cell. The western part of this site has been converted to a recreational area for flying model aircraft.

The USGS began monitoring water quality at the Holbrooks Road landfill in February 1983 (Smith, 1993). The monitoring network included two surface-water sites and six ground-water sites. Information about these sites is listed in tables 13 and 14. Surface-water sites are on the South Prong of Clarke Creek: site HRSW1 is downstream from the landfill and site HRSW2 is upstream from the landfill (fig. 8). The landfill represents about 6 percent of the drainage area upstream from surface-water monitoring site HRSW1 and about 32 percent of the drainage area between sites HRSW2 and HRSW1 (table 13). Ground-water sites

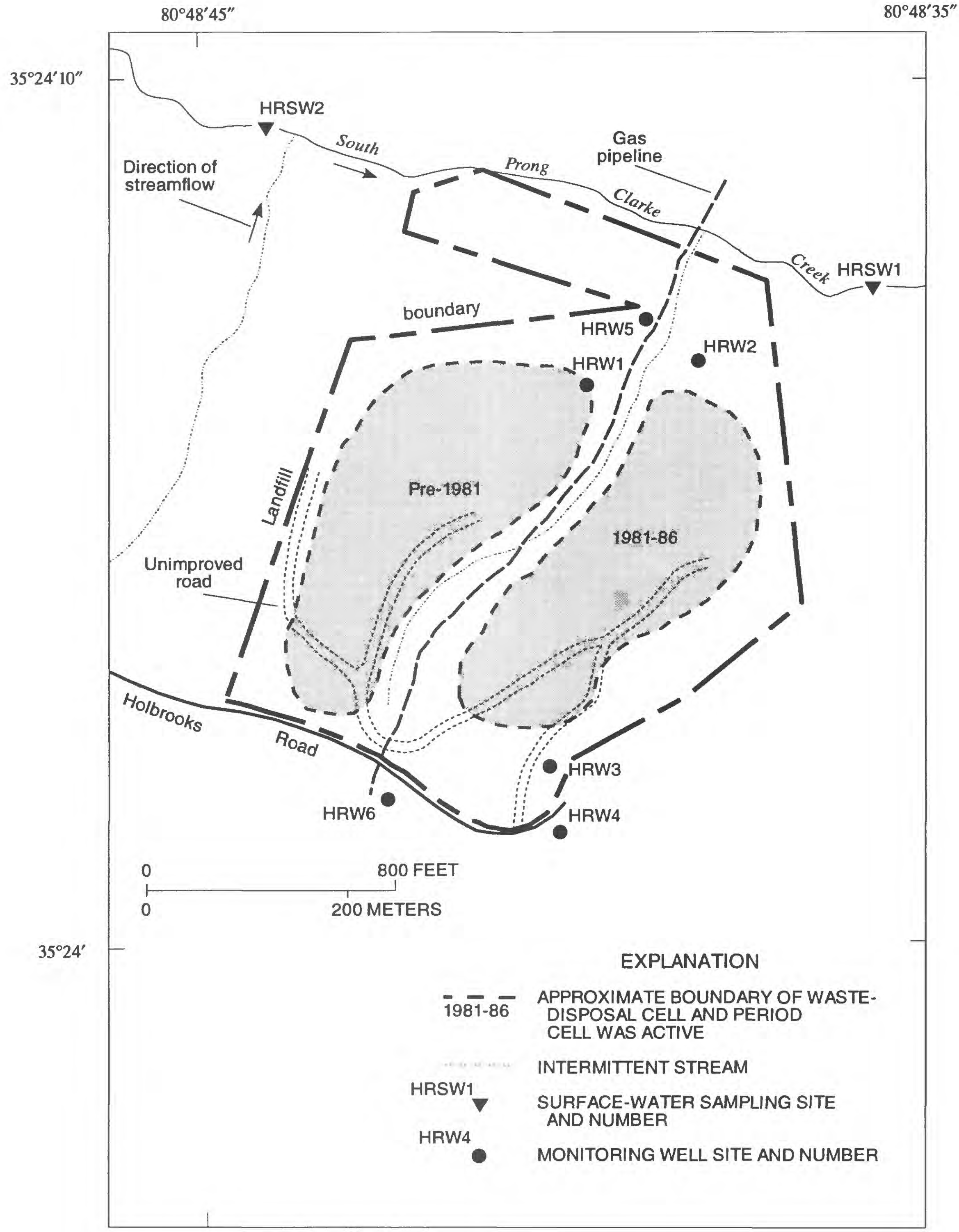

Figure 8. Waste-disposal cells and monitoring sites at the Holbrooks Road landfill (modified from Smith, 1993).

include monitoring wells HRW1, HRW2, and HRW5, which are in the northeastern part of the study area downgradient from the waste-disposal cells; well HRW3, which was formerly used as a supply well for the landfill office and is within the landfill boundary; and domestic supply wells HRW4 and HRW6, which are south of the landfill along Holbrooks Road (fig. 8). Monitoring wells HRW1, HRW2, and HRW5 are shallow, with depths ranging from 11.3 to 14.4 ft, and are representative of hydrologic conditions in the regolith (table 14). Domestic supply wells HRW3 and HRW6 are deep, with depths of 371 ft and 125 ft, respectively, and are representative of hydrologic conditions in the bedrock (table 14). The depth of well HRW4 is unknown.

Table 13. Description of surface-water monitoring sites at the Holbrooks Road landfill

[Location of sites shown in figure 8. USGS, U.S. Geological Survey; P, periodic sample collection]

Stream	Mecklenburg County site number	USGS identification number	Date established	Drainage area (square miles)	Record type
South Prong of Clarke Creek	HRSW1	0212404995	Feb. 1983	1.85	P
South Prong of Clarke Creek	HRSW2	0212404990	Feb. 1983	1.52	P

Periodic water-level measurements were made in wells HRW1, HRW2, and HRW5. Wells HRW3, HRW4, and HRW6 were not accessible for water-level measurement. Construction of a water-table elevation map for this site was not feasible because water-level data were primarily limited to a small area at the base of the disposal cells. Ground-water flow is generally toward the South Prong of Clarke Creek; however, because wastes in the southern part of the landfill were placed in an area topographically higher than surrounding areas, leachate could have moved in several directions.

Surface-Water Quality

Comparison of water-quality data for sites HRSW1 and HRSW2 indicates the Holbrooks Road landfill had little effect on the chemical quality of the South Prong of Clarke Creek during 1987 to 1992. Median values of specific conductance, alkalinity, chemical-oxygen demand, biochemical-oxygen demand, sulfate, chloride, and iron are similar at these sites (table 15). However, median concentrations of manganese and zinc were slightly larger for site HRSW1, which is downstream from the landfill, than for site HRSW2, which is upstream from the landfill. Because these metals occur naturally in soils of the North Carolina Piedmont, soil erosion in the drainage area between sites HRSW2 and HRSW1 could have contributed to the downstream increase in these constituents.

Densities of fecal coliform and fecal streptococcus bacteria generally were much larger in water samples from site HRSW2 than in samples from site HRSW1. Bacterial densities were much smaller in ground-water samples than in surface-water samples, which also indicates the landfill is not a major source of bacteria in the South Prong of Clarke Creek.

Surface-water samples generally were acceptable based on Mecklenburg County action levels (tables 2 and 16). However, the pH of most samples was less than the 6.5 minimum acceptable level. Iron and manganese concentrations exceeded Mecklenburg County action levels in all surface-water samples (table 16). Few surface-water samples were collected for analysis of synthetic organic compounds (table 17). Total organic halogen concentrations exceeded detection levels in two of five samples from site HRSW2. No other synthetic organic compounds were detected in surface-water samples.

Table 14. Description of ground-water monitoring sites at the Holbrooks Road landfill

[Location of sites shown in figure 8. Well depth, casing depth, and screen openings listed in feet below land surface. USGS, U.S. Geological Survey; PVC, polyvinyl chloride; GAL, galvanized steel; --, no data]

Mecklenburg County site number	USGS identification number	Date installed	Well depth (feet)	Casing			Screen opening		Well use	Owner
				Type	Diameter (inches)	Depth (feet)	From (feet)	To (feet)		
HRW1	352415080485601	Jan. 1983	11.3	PVC	2	6.3	6.3	11.3	Monitoring	Mecklenburg County
HRW2	352415080484901	Sept. 1983	14.4	PVC	2	9.4	9.4	14.4	Monitoring	Mecklenburg County
HRW3	352404080485401	Oct. 1981	371	GAL	6.25	58	No screen		Domestic	Mecklenburg County
HRW4	352402080485201	Jan. 1983	--	--	--	--	--	--	Domestic	Private
HRW5	352418080485101	Mar. 1983	11.8	PVC	2	6.8	6.8	11.8	Monitoring	Mecklenburg County
HRW6	352403080490001	? 1946	125	--	--	--	--	--	Domestic	Private

Table 15. Summary of selected surface- and ground-water quality data for the Holbrooks Road landfill, 1986-92

[μS/cm, microsiemens per centimeter; --, no data or insufficient data for computation of median; mg/L, milligram per liter; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; *, value calculated using a log-probability regression to estimate values below detection limits; <, less than; >, greater than; cols/100 mL, colonies per 100 milliliters; μg/L, microgram per liter]

Constituent or property		Surface-water sites		Ground-water sites					
		HRSW1	HRSW2	HRW1	HRW2	HRW3	HRW4	HRW5	HRW6
Specific conductance (μS/cm)	Range	101-215	97-220	1,030-1,700	150-410	420-438	130-230	420-595	101-172
	Median	173	159	1,340	317	429	172	478	160
	Samples	13	12	12	14	2	14	14	13
pH, field (standard units)	Range	6.1-7.5	6.3-7.6	5.9-6.8	5.4-6.6	6.9-7.1	5.7-6.6	5.9-7.4	5.6-6.8
	Median	6.6	6.6	6.4	5.9	--	6.2	6.2	6.0
	Samples	13	12	12	14	2	14	14	13
Dissolved oxygen (mg/L)	Range	7.6-12.0	7.2-12.1	--	--	--	--	--	--
	Median	10.4	8.6	--	--	--	--	--	--
	Samples	11	11	0	0	0	0	0	0
Chemical-oxygen demand (mg/L)	Range	bdl-22	bdl-20	7-280	bdl-21	--	bdl	bdl-21	bdl
	Median	6*	6*	84	<5	--	--	10*	<5
	Samples	10	9	6	10	0	4	10	4
Biochemical-oxygen demand (mg/L)	Range	0.5-3.0	0.5-2.1	1.2-18	bdl-3.1	0.8	0.1-1.7	0.8-4.0	0.2-2.0
	Median	0.8	0.7	3.6	1.4*	--	0.4	1.0	0.4
	Samples	10	9	6	10	1	12	10	10
Fecal coliform (cols/100 mL)	Range	bdl->60,000	160-3,400	<10-180	<100	--	bdl	9	bdl
	Median	380	1,220	--	--	--	<10	--	<10
	Samples	6	4	2	1	0	4	1	5
Fecal streptococcus (cols/100 mL)	Range	80-890	130-1,100	40	--	--	<10-18	130	bdl
	Median	170	900	--	--	--	--	--	<10
	Samples	5	3	1	0	0	2	1	3
Alkalinity, fixed endpoint (mg/L as $CaCO_3$)	Range	33-85	33-74	485-653	54-243	177	54-77	95-233	48-66
	Median	50	52	545	94	--	68	112	53
	Samples	8	7	5	8	1	10	9	8
Sulfate (mg/L)	Range	7.5-14	8.4-15	5.8-28	bdl-7.0	18	6.5-24	10-15	1.0-5.9
	Median	9.7	9.6	7.8	4.3*	--	19	13	3.0
	Samples	7	6	3	7	1	8	7	7
Chloride, dissolved (mg/L)	Range	6.5-12	6.7-12	120-200	7.2-15	10	2.3-19	59-78	5.3-7.6
	Median	8.8	8.3	145	9.0	--	6.2	70	6.6
	Samples	10	9	6	10	1	12	10	10
Fluoride, total (mg/L)	Range	bdl	bdl	bdl-0.2	bdl	--	bdl	bdl	bdl
	Median	<0.2	<0.2	<0.2	<0.1	--	<0.2	<0.1	<0.1
	Samples	9	8	3	3	0	4	3	3
Aluminum, total (μg/L)	Range	200-5,100	<100-6,200	100-240,000	340-4,700	--	<100-950	420-24,000	<100-140
	Median	990	400	120,000	580	--	190	2,700	140
	Samples	8	7	2	4	0	4	3	3
Arsenic, total (μg/L)	Range	bdl	bdl	bdl	bdl	--	bdl	bdl	bdl
	Median	<2	<2	<2	<5	--	<1	<2	<2
	Samples	10	9	4	6	0	7	5	5
Barium, total (μg/L)	Range	<100-300	<100	300-1,600	<100-900	--	<100-300	<100-600	<100
	Median	<100	<100	600	<100	--	<100	<100	<100
	Samples	10	9	4	6	0	7	5	5
Cadmium, total (μg/L)	Range	bdl	bdl	bdl	bdl	--	bdl	bdl	bdl
	Median	<1	<1	<2	<2	--	<1	<1	<1
	Samples	10	9	4	6	0	7	5	5
Chromium, total (μg/L)	Range	bdl-6	bdl-6	6-270	3-24	--	bdl	bdl	bdl
	Median	2*	2*	68	4	--	2	<10	<2
	Samples	10	9	4	6	0	7	5	5
Copper, total (μg/L)	Range	bdl-70	bdl	bdl-220	bdl-80	--	bdl-60	bdl-70	220-330
	Median	<50	<50	<100	<50	--	<50	<50	290
	Samples	10	9	4	6	0	7	5	5
Iron, total (μg/L)	Range	560-5,500	550-5,800	37,000-520,000	490-17,000	--	210-820	480-24,000	bdl-160
	Median	1,200	1,300	140,000	700	--	340	5,700	50
	Samples	10	9	4	6	0	7	5	5
Lead, total (μg/L)	Range	bdl-6.0	bdl-9	3-240	bdl-7	--	bdl-10	bdl-30	bdl-9
	Median	2*	3*	66	<5	--	<1	8	<5
	Samples	10	9	4	6	0	7	5	5
Manganese, total (μg/L)	Range	120-290	90-190	11,000-19,000	90-570	--	bdl-20	260-1,400	bdl-30
	Median	180	150	16,000	380	--	20	420	<20
	Samples	10	9	4	6	0	7	5	5
Mercury, total (μg/L)	Range	bdl	bdl	bdl	bdl	--	bdl	bdl	bdl
	Median	<0.2	<0.2	<5	<0.3	--	<0.2	<0.2	<0.2
	Samples	10	9	4	6	0	7	5	5
Zinc, total (μg/L)	Range	bdl-140	bdl-220	50-530	bdl-210	--	60-730	20-200	bdl-220
	Median	65*	50*	85	110*	--	600	100	50
	Samples	10	9	4	6	0	7	5	5
Organic carbon, total (mg/L)	Range	2.2-4.6	1.7-4.2	19-99	3.3-13.2	--	0.5-1.5	2.5-24	0.1-0.9
	Median	2.8	2.3	35	5.0	--	0.9	8.8	0.2
	Samples	5	5	5	6	0	7	4	5

Table 16. Summary of constituents and properties exceeding or outside of ranges designated by Mecklenburg County action levels in surface- and ground-water samples from the Holbrooks Road landfill, 1986-92

[µS/cm, microsiemens per centimeter; --, no data; mg/L, milligram per liter; µg/L, microgram per liter]

Constituent or property		Surface-water sites		Ground-water sites					
		HRSW1	HRSW2	HRW1	HRW2	HRW3	HRW4	HRW5	HRW6
Specific	Exceedences	0	0	12	0	0	0	0	0
conductance	Samples	13	12	12	14	2	14	14	14
(µS/cm)	Maximum	--	--	1,700	--	--	--	--	--
pH, field	Exceedences	6	4	7	13	0	11	10	11
(standard	Samples	13	12	12	14	2	14	14	13
units)	Minimum	6.1	6.3	5.9	5.4	--	5.7	5.9	5.5
	Maximum	--	--	--	--	--	--	--	--
Chemical-	Exceedences	0	0	5	0	--	0	0	0
oxygen demand	Samples	10	9	6	10	0	4	10	4
(mg/L)	Maximum	--	--	280	--	--	--	--	--
Biochemical-	Exceedences	0	0	3	0	0	0	0	0
oxygen demand	Samples	10	9	6	10	1	12	10	10
(mg/L)	Maximum	--	--	18	--	--	--	--	--
Barium,	Exceedences	0	0	2	0	--	0	0	0
total	Samples	10	9	4	6	0	7	5	5
(µg/L)	Maximum	--	--	1,600	--	--	--	--	--
Chromium,	Exceedences	0	0	2	0	--	0	0	0
total	Samples	10	9	4	6	0	7	5	5
(µg/L)	Maximum	--	--	270	--	--	--	--	--
Iron,	Exceedences	10	9	4	6	--	4	5	0
total	Samples	10	9	4	6	0	7	5	5
(µg/L)	Maximum	5,500	5,800	520,000	17,000	--	820	24,000	--
Lead,	Exceedences	0	0	2	0	--	0	0	0
total	Samples	10	9	4	6	0	7	5	5
(µg/L)	Maximum	--	--	240	--	--	--	--	--
Manganese,	Exceedences	10	9	4	6	--	0	5	0
total	Samples	10	9	4	6	0	5	5	5
(µg/L)	Maximum	290	190	19,000	570	--	--	1,400	--
Mercury,	Exceedences	0	0	1	0	--	0	0	0
total	Samples	10	9	4	6	0	7	5	5
(µg/L)	Maximum	--	--	1.1	--	--	--	--	--
Organic	Exceedences	0	0	5	1	--	0	2	0
carbon, total	Samples	5	5	5	6	0	7	4	5
(mg/L)	Maximum	--	--	99	13	--	--	24	--
Organic	Exceedences	0	0	1	3	--	0	0	0
halogens, total	Samples	6	5	6	6	0	6	5	6
(mg/L)	Maximum	--	--	0.29	0.59	--	--	--	--

Table 17. Summary of synthetic organic compounds detected in surface- and ground-water samples from the Holbrooks Road landfill, 1986-92

[mg/L, milligram per liter; Max. detected, maximum concentration detected; --, not detected; µg/L, microgram per liter]

Compound		Surface-water sites		Ground-water sites					
		HRSW1	HRSW2	HRW1	HRW2	HRW3	HRW4	HRW5	HRW6
Total organic	Samples	6	5	6	6	0	6	5	6
halogens	Detections	0	2	6	6	--	2	4	2
(mg/L)	Max. detected	--	0.02	0.29	0.59	--	0.03	0.03	0.02
2,4-D,	Samples	1	1	1	1	0	1	2	1
total	Detections	0	0	0	0	--	0	1	0
(µg/L)	Max. detected	--	--	--	--	--	--	0.01	--
2,4,5-T,	Samples	1	1	1	1	0	1	2	1
total	Detections	0	0	0	0	--	0	1	0
(µg/L)	Max. detected	--	--	--	--	--	--	0.01	--
Dichlorodi-	Samples	0	0	0	0	0	1	0	1
fluoromethane,	Detections	--	--	--	--	--	0	--	1
total (µg/L)	Max. detected	--	--	--	--	--	--	--	0.90
Trichloro-	Samples	0	0	0	0	1	1	0	1
fluoromethane,	Detections	--	--	--	--	0	1	--	1
total (µg/L)	Max. detected	--	--	--	--	--	3.6	--	5.8

The seasonal Kendall test was used to detect trends in water quality at sites HRSW1 and HRSW2. Statistically significant decreasing trends in biochemical-oxygen demand were detected for both surface-water sites. Trends were of similar magnitude, -0.07 mg/L/yr for site HRSW1, and -0.10 mg/L/yr for site HRSW2 (table 18). These trends in biochemical-oxygen demand are possibly related to changes in wastewater-treatment practices at a sewage-disposal plant upstream from site HRSW2. Data for site HRSW2, which is upstream from the landfill, indicated a decreasing trend in manganese concentration (-5 mg/L/yr). Thus, trend analysis of data for sites HRSW1 and HRSW2 does not indicate changes in surface-water quality related to the Holbrooks Road landfill.

Ground-Water Quality

Ground-water quality showed large areal and temporal differences in concentrations of many constituents. Concentrations of constituents considered indicative of leachate generally were larger in water from wells near waste-disposal cells than in water from wells farther away from waste-disposal cells. Samples from well HRW1, which is the well closest to the waste disposal cells, had larger median values of specific conductance, alkalinity, and concentrations of chemical-oxygen demand, biochemical-oxygen demand, chloride, aluminum, barium, chromium, iron, lead, manganese, and total organic carbon than samples from any of the other wells (table 15). The specific conductance and concentrations of iron, manganese, and total organic carbon in all samples from HRW1 exceeded Mecklenburg County action levels (tables 2 and 16). The pH, chemical-oxygen demand, biochemical-oxygen demand, and concentrations of lead, mercury, and total organic halogens in samples from well HRW1 commonly exceeded Mecklenburg County action levels (table 16). Well HRW1 is adjacent to and downgradient from the northeastern edge of the western waste-disposal cell (fig. 8). Because of this location, ground water at well HRW1 is affected by leachate and is indicative of the chemical quality of leachate leaving the western waste-disposal cell.

Samples from well HRW5, which is about 250 ft downgradient from well HRW1 (fig. 8), generally had larger concentrations of alkalinity, chloride, aluminum, iron, and manganese than samples from any of the wells except HRW1 (table 15). Dilution, adsorption, and biodegradation probably contribute to decreases in concentration of many constituents in ground water as distance from waste-disposal cells increases. Because chloride in ground water typically does not undergo chemical reactions or transformations, ratios of peak chloride concentrations can provide a minimum estimate of dilution rate. The peak chloride concentration in samples from well HRW1was 290 mg/L in 1983, and the peak chloride concentration in samples from well HRW5 was 78 mg/L in 1986 (Smith, 1993). The ratio of these chloride concentrations indicates at least a 4-fold dilution occurred as ground water flowed 250 ft from well HRW1 to well HRW5.

Concentrations of alkalinity, sulfate, aluminum, iron, manganese, and zinc also were smaller in samples from well HRW5 than in samples from well HRW1 (Smith, 1993) and indicate attenuation resulting from adsorptive processes and precipitation reactions. Similar decreases in concentrations of many constituents probably have occurred as ground water flows away from the waste-disposal cells. Thus, effects of leachate probably are greatly decreased by the time the leachate has moved through the regolith and discharged into the South Prong of Clarke Creek.

Water-quality data for well HRW2, which is about 100 ft downgradient from the eastern waste-disposal cell, generally indicate smaller effects of leachate than data for wells HRW1 or HRW5 (Smith, 1993). Median concentrations of chemical-oxygen demand, chloride, iron, manganese, and total organic carbon for well HRW2 are smaller than for wells HRW1 and HRW5 (table 15), which suggests that a smaller volume of leachate, or less concentrated leachate, has been produced in the eastern waste-disposal cell. Another possible explanation for these differences in ground-water quality is that ground-water flow patterns are such that much of the leachate from the eastern cell does not flow past well HRW2.

Water-quality data collected during 1986-92 for wells HRW3, HRW4, and HRW6 generally do not indicate effects of leachate (table 15). Except for pH values below 6.5, analytical results for samples from these wells were acceptable based on Mecklenburg County action levels (tables 2 and 16). Because wells HRW3, HRW4, and HRW6 were used for water supply, plumbing materials could have contributed to the small amounts of copper, lead, and zinc in samples from these wells. Synthetic organic compounds detected in samples from wells HRW4 and HRW6 indicate possible migration of leachate from the landfill. Trichlorofluoromethane was detected in samples from wells HRW4 and HRW6, and dichlorodifluoromethane was detected in samples from well HRW6 (table 17). Possible sources of these volatile organic compounds include refrigerants and aerosol propellants in landfill wastes. Health advisories recommend that the lifetime intake of

Table 18. Summary of seasonal Kendall trend test results for selected water-quality data from the Holbrooks Road landfill, 1982-92

[Only results significant at a probability level of 0.10 are shown. p, probability level; *, trend tests were made but trends were not significant; <0.001, probability level less than 0.001; Slope, trend slope expressed in units per year; --, data inadequate for analysis; µS/cm, microsiemen per centimeter; % median, slope expressed as a percentage of the seasonal median; n, number of observations; Record, period of record; mg/L, milligram per liter; µg/L, microgram per liter]

Constituent or property		Surface-water sites		Ground-water sites					
		HRSW1	HRSW2	HRW1	HRW2	HRW3	HRW4	HRW5	HRW6
Specific conductance (µS/cm)	p	*	*	0.001	<0.001	0.010	0.043	0.002	0.018
	Slope	--	--	-78	28	38	-4.3	21	2.8
	% median	--	--	-5.7	12.7	9.4	-2.4	4.6	1.8
	n	26	26	29	25	19	28	30	26
	Record	1983-92	1983-92	1983-92	1983-92	1983-86	1983-92	1982-92	1983-92
pH, field (standard units)	p	*	*	*	0.042	*	*	*	*
	Slope	--	--	--	-0.09	--	--	--	--
	n	26	25	26	24	18	28	28	27
	Record	1983-92	1983-92	1983-92	1983-92	1983-86	1983-92	1982-92	1983-92
Chemical-oxygen demand (mg/L)	p	*	*	--	*	0.027	--	--	--
	Slope	--	--	--	--	-4.2	--	--	--
	% median	--	--	--	--	--	--	--	--
	n	21	20	16	20	11	13	20	12
	Record	1983-90	1983-92	1983-92	1983-92	1983-86	1983-92	1983-92	1983-92
Biochemical-oxygen demand (mg/L)	p	0.062	0.014	*	*	*	0.082	*	0.045
	Slope	-0.07	-0.10	--	--	--	-0.05	--	-0.09
	% median	-6.1	-10	--	--	--	-6.1	--	-16.4
	n	21	20	15	20	12	24	20	21
	Record	1983-92	1983-92	1983-92	1983-92	1983-86	1983-92	1983-92	1983-92
Alkalinity, total (mg/L as $CaCO_3$)	p	*	*	*	0.020	0.071	0.020	0.073	0.020
	Slope	--	--	--	19	20	-4.0	6.7	1.3
	% median	--	--	--	25.9	11.1	-5.5	6.4	2.6
	n	21	20	16	17	14	20	21	19
	Record	1983-90	1983-90	1983-90	1983-90	1983-86	1983-90	1983-90	1983-90
Sulfate (mg/L)	p	*	*	*	*	*	0.081	*	*
	Slope	--	--	--	--	--	1.4	--	--
	% median	--	--	--	--	--	11.2	--	--
	n	18	17	13	16	13	20	18	23
	Record	1983-91	1983-91	1983-91	1983-91	1983-86	1983-91	1983-91	1983-92
Chloride, dissolved (mg/L)	p	*	*	0.004	*	*	*	0.052	*
	Slope	--	--	-14	--	--	--	2.6	--
	% median	--	--	-7.5	--	--	--	4.2	--
	n	22	21	15	20	13	25	22	19
	Record	1983-92	1983-92	1983-92	1983-92	1983-86	1983-92	1983-92	1983-91
Iron, total (µg/L)	p	*	*	*	*	--	*	*	*
	Slope	--	--	--	--	--	--	--	--
	% median	--	--	--	--	--	--	--	--
	n	20	19	7	7	2	10	8	8
	Record	1983-92	1983-92	1983-92	1983-92	1983	1983-92	1983-92	1983-92
Manganese, total (µg/L)	p	*	0.040	0.024	*	--	--	*	*
	Slope	--	-5	-2,800	--	--	--	--	--
	% median	--	-3.6	-15.7	--	--	--	--	--
	n	20	19	7	7	2	10	8	8
	Record	1983-92	1983-92	1983-92	1988-92	1983	1983-92	1983-92	1983-92

dichlorofluoromethane should not exceed 1,000 µg/L/day (U.S. Environmental Protection Agency, 1993), which is more than 1,000 times larger than the concentration detected in water from well HRW6. Migration of these compounds into bedrock could have been enhanced by pumpage.

Statistically significant trends in specific conductance, pH, chemical-oxygen demand, biochemical-oxygen demand, sulfate, chloride, alkalinity, and manganese were detected for wells at the Holbrooks Road landfill (table 18). Water-quality data collected from 1983 through 1992 at well HRW1 showed decreasing trends in specific conductance (-78 µS/cm/yr), chloride (-14 mg/L/yr), and manganese (-2,800 µg/L/yr). These trends indicate that specific conductance and concentrations of chloride and manganese in leachate from the older, western waste-disposal cell have decreased since 1983. Data collected at well HRW5 show increasing trends in specific conductance (21 µS/cm/yr), alkalinity (6.7 mg/L/yr), and chloride (2.6 mg/L/yr) (table 18). The different directions of trends for wells HRW1 and HRW5 probably reflect the rate of leachate movement and changes in leachate quality along the ground-water flow path.

The time interval between occurrences of peak chloride concentrations in ground water at wells HRW1 and HRW5 indicates the time required for movement of leachate through saprolite. Data indicate that the chloride concentration of ground water at well HRW5 peaked in 1986 (Smith, 1993). Assuming the peak concentration of chloride in ground water at well HRW1 occurred in April 1983, at least 3 years elapsed before the peak concentration of chloride occurred in ground water from well HRW5. Based on the elapsed time between chloride concentration peaks, ground-water movement between wells HRW1 and HRW5 apparently was about 250 ft during that 3-year period. This corresponds to a ground-water velocity of less than 0.22 ft/d, assuming that well HRW5 is directly downgradient from well HRW1 and that ground water flows in a straight line between the wells. This velocity is in agreement with ground-water velocities reported by Stewart and others (1964) ranging from 0.04 to 1.06 ft/d for saprolite derived from parent material similar to that at the Holbrooks Road landfill.

The seasonal Kendall test indicated overall increasing trends in specific conductance and alkalinity, and a decreasing trend in pH during the period of record for well HRW2 (table 18), which is located downgradient from the eastern, more recent, waste-disposal cell (fig. 8). Trends detected for well HRW2 indicate the effects of leachate on ground water at this site have increased since 1983. However, trends in specific conductance, chloride, and sulfate for well HRW2 were non-monotonic and appear to be related to closure of the eastern waste-disposal cell. As shown in figure 9, specific conductance of samples from well HRW2 generally decreased from 1983 through 1986, when the eastern waste-disposal cell was closed. Specific conductance increased from 1987 until early 1991 and began to decrease in 1992. Concentrations of chloride and sulfate followed a similar pattern with minimum concentrations generally occurring in 1986 (Smith, 1993). Placement of the final soil layer on the eastern disposal cell in 1986 possibly decreased infiltration of precipitation into the wastes, thereby decreasing leachate production and contributing to the low specific conductance and concentrations of chloride and sulfate in samples collected from well HRW2 during 1986. Changes in water quality that occurred after 1986 probably indicate aging of wastes in the eastern waste-disposal cell.

Trends also were detected for the water-supply wells HRW3, HRW4, and HRW6 (table 18). Sampling of well HRW3 ceased in 1986 when the landfill office was closed and the pump was removed. However, increasing trends in specific conductance (38 µS/cm/yr) and alkalinity (20 mg/L/yr), and a decreasing trend in chemical-oxygen demand (-4.2 mg/L/yr) were detected for this well from 1983 to 1986. These trends indicate well HRW3 has been affected by leachate.

Decreasing trends in specific conductance (-4.3 µS/cm/yr), biochemical-oxygen demand (-0.05 mg/L/yr), and alkalinity (-4.0 mg/L/yr), and an increasing trend in sulfate concentration (1.4 mg/L/yr) were detected for well HRW4. Increasing trends in specific conductance (2.8 µS/cm/yr) and alkalinity (1.3 mg/L/yr), and a decreasing trend in biochemical-oxygen demand (-0.09 mg/L/yr) were detected for well HRW6. Trends detected for wells HRW4 and HRW6 indicate changes in ground-water quality were possibly caused by offsite movement of leachate. The magnitude of these trends, however, was small.

Direction of ground-water movement in this area, south of the landfill, is not known. The detection of chlorofluorocarbons in water from wells HRW4 and HRW6 could indicate southward migration of leachate. However, concentrations of many constituents typical of leachate, such as heavy metals, chemical-oxygen demand, and synthetic organic compounds in samples from wells HRW4 and HRW6 are small. The small values of these properties and constituents indicate a high degree of attenuation. Processes involved in attenuation probably include adsorption, dilution, and degradation. The possible effects of leachate observed in water-quality samples from HRW4 and HRW6

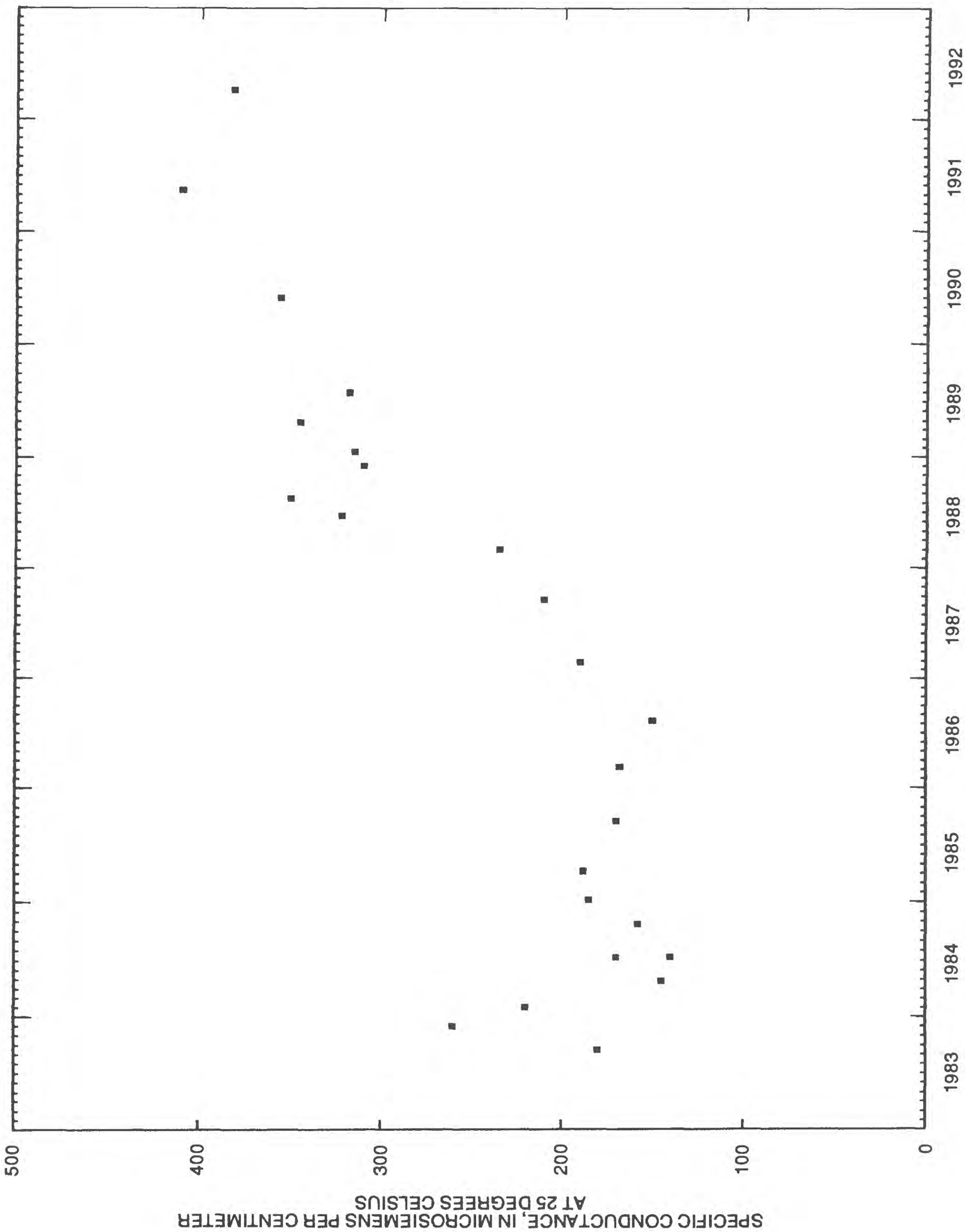

Figure 9. Specific conductance of water samples from the Holbrooks Road landfill monitoring well HRW2, 1983-92.

are primarily associated with changes in concentrations of conservative constituents such as chloride, alkalinity, and sulfate. Trends in biochemical-oxygen demand at wells HRW4 and HRW6 could also be related to changes in the condition of residential septic systems.

Conclusions

The Holbrooks Road landfill has had little effect on the chemical quality of the South Prong of Clarke Creek. Surface-water samples collected at sites upstream and downstream from the landfill contained similar concentrations of most constituents. However, concentrations of manganese and zinc generally were slightly larger downstream from the landfill than upstream. Based on the time interval between occurrence of peak chloride concentrations at wells HRW1 and HRW5, the rate of leachate movement has been very slow. It is possible that concentrations of leachate in ground water along the South Prong of Clarke Creek had not peaked by 1992.

Leachate from the Holbrooks Road landfill apparently has affected water quality in the regolith and the bedrock onsite and offsite. Analytical results for samples from all monitoring wells indicate possible effects of the landfill on water quality. The quality of water from monitoring well HRW1, located at the toe of the oldest waste-disposal cell, generally improved from 1983 to 1992. However, trend analysis indicates the quality of water at monitoring wells HRW2 and HRW5 has been increasingly degraded by leachate since 1983. Trends in water-quality data from domestic supply wells indicate possible effects of offsite leachate migration. However, the magnitude of trends detected for supply wells is much less than the magnitude of trends detected for monitoring wells, which indicates that the supply wells have been much less affected by leachate than the monitoring wells. Effects of leachate on water quality at monitoring wells are expected to be large in comparison to effects at supply wells because the monitoring wells are much closer to the waste-disposal cells and are much shallower than the supply wells, and therefore, there is less opportunity for attenuation processes to occur. Peak concentrations of chloride and chemical-oxygen demand were about 4 and 10 times smaller in water samples from HRW5 than in water samples from HRW1. These decreases in concentration at increased distance from the waste-disposal cell, reflect dilution, dispersion, and various attenuation processes occurring in saprolite and indicate that effects of leachate diminish with distance from the leachate source.

Direction and rates of ground-water movement are not well defined at this site, particularly in the southern part of the landfill. Based on the 3-year time interval between occurrence of peak chloride concentrations at wells HRW1 and HRW5, the rate of lateral ground-water movement in the 250 ft between these sites appears to be very slow, less than 0.22 ft/d. No information was available regarding vertical rates of ground-water movement. However, the presence of chlorofluorocarbons, which are volatile compounds, in bedrock wells indicates considerable vertical movement of ground water, which could have been induced by pumpage.

McAlpine Creek at Greenway Park Landfill

The McAlpine Creek at Greenway Park Landfill is in southeastern Mecklenburg County and lies entirely within the city limits of Charlotte (fig. 1). The landfill occupies about 28 acres in the McAlpine Creek Basin. The CSX railroad is south of the landfill, Monroe Road is to the west, and McAlpine Creek is on the east side (fig. 10). Land north and northwest of the landfill is primarily woodland, whereas land southwest and west of the landfill is primarily commercial. A recreation area is east of the landfill. The nearest residences are south of the landfill, on the opposite side of McAlpine Creek.

Surface water at this site generally flows to the south and southeast into McAlpine Creek. Topographic relief is about 50 ft, ranging from an elevation of 630 ft above sea level along the northern edge of the landfill to about 580 ft at McAlpine Creek along the southeastern edge of the landfill. The area is underlain by metavolcanic basement rock ranging in composition from mafic to felsic (Goldsmith and others, 1982). Limited information was available regarding depth to bedrock in the vicinity of the landfill. Driller's logs for monitoring wells along the eastern boundary of the landfill and adjacent to McAlpine Creek reported depth of auger refusal at 29 ft. Logs for test holes in the northern part of the landfill indicated depths to bedrock greater than 50 ft. Thus, data indicate the thickness of the regolith at this landfill ranges from about 29 ft to more than 50 ft.

The McAlpine Creek at Greenway Park landfill opened in 1968 and closed in 1972. This site was operated by Mecklenburg County as a sanitary landfill. A maximum of 150-200 tons of municipal refuse per day was deposited in unlined waste-disposal cells at this site (David Morton, Mecklenburg County Engineering Department, oral commun., 1993). A rock-lined drainway was constructed between the central and southernmost waste-disposal cells. The landfill has been converted to a recreational area administered by Mecklenburg County Parks and Recreation Department.

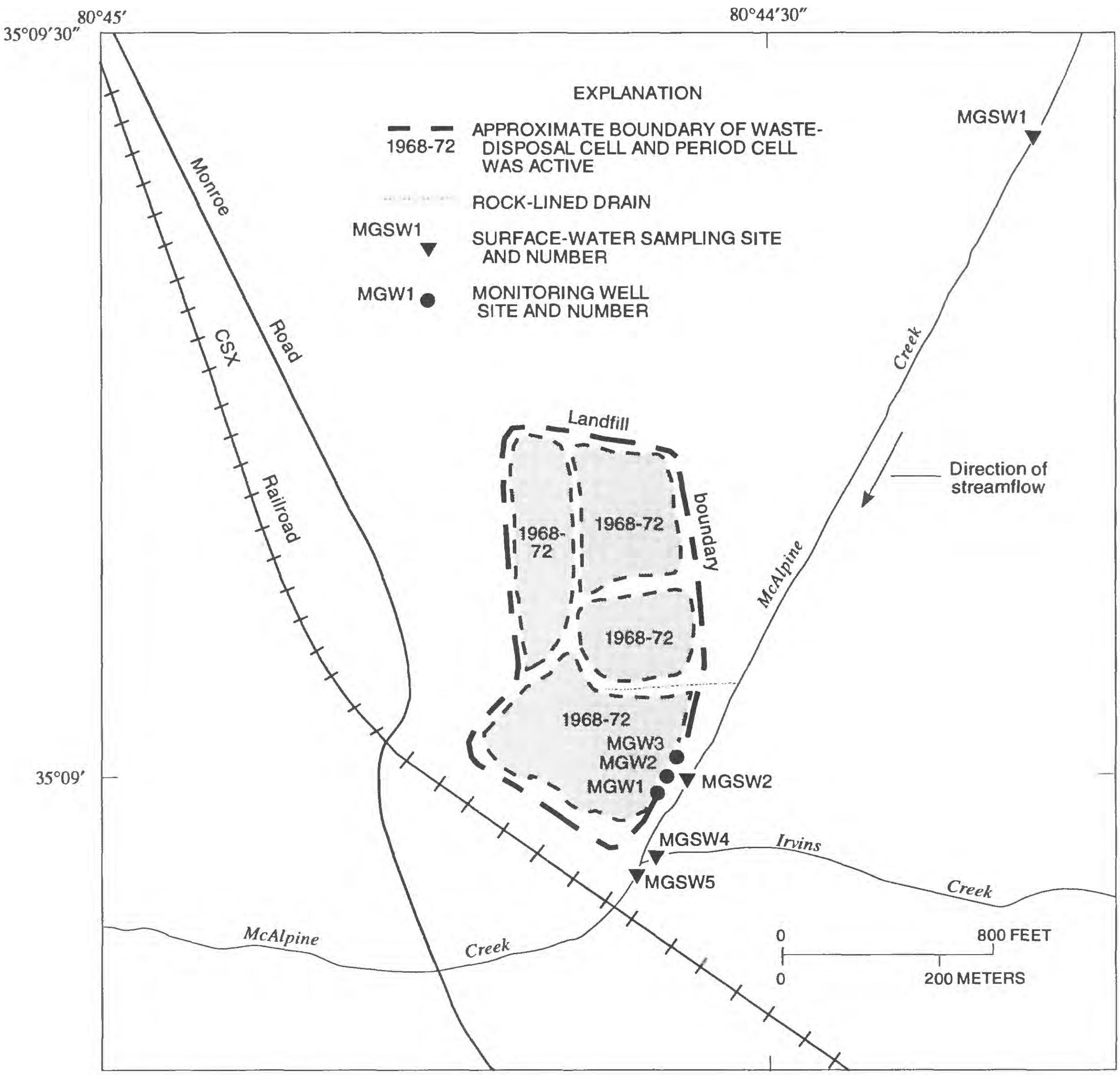

Figure 10. Waste-disposal cells and monitoring sites at the McAlpine Creek at Greenway Park landfill (modified from Smith, 1993).

The USGS began a water-quality monitoring program at this landfill in June 1987. The monitoring network included four surface-water sites and three ground-water sites (fig. 10). Information about these sites is listed in tables 19 and 20. Three of the surface-water sites are on McAlpine Creek: site MGSW1, upstream from the landfill; site MGSW2, adjacent to the landfill and to the monitoring wells; and site MGSW5, downstream from the landfill and below the confluence of McAlpine Creek and Irvins Creek. The fourth surface-water site, MGSW4, is on Irvins Creek about 50 ft above the mouth of the creek. The ground-water sites consist of a cluster of three wells, MGW1, MGW2, and MGW3, each with screened intervals at different depths (fig. 2), located at the eastern boundary of the landfill on the west bank of McAlpine Creek (fig. 10).

Limited water-level data were available for this site. Test holes drilled to a depth of 50 ft in the northern part of the landfill reportedly were dry. Water levels in the three monitoring wells, which are at the eastern edge of the landfill, ranged from about 9.5 to 15 ft below land surface from 1987 to 1992.

Surface-Water Quality

Comparison of water-quality data for sites MGSW1 and MGSW2 generally indicated little effect of the landfill on the chemical quality of McAlpine Creek. Median values of water-quality data for these sites are similar (table 21); however, chemical-oxygen demand, aluminum, iron, and manganese concentrations in samples collected during September 1987 were much larger at site MGSW2 than at site MGSW1 (Smith, 1993). Unlike the other samples, these samples were collected during low flow and probably reflect a large proportion of flow derived from inflow of ground water and leachate. Samples collected during conditions other than low streamflow are affected by surface runoff and generally do not show effects of ground-water seepage. However, because the September 1987 samples were collected 2 weeks apart, changes in streamflow or human activities during that time interval could have contributed to observed differences in water quality.

The surface-water site MGSW5 is downstream from the confluence with Irvins Creek (fig. 10); therefore, comparison of water quality at site MGSW5 with site MGSW2 must take into account changes caused by inflow from the Irvins Creek drainage. Manganese and iron concentrations generally were larger in water samples from site MGSW5 than from sites MGSW4 or MGSW2 and possibly indicate inflow of leachate from the landfill. The landfill occupies less than 1 percent of the drainage area of sites MGSW2 and MGSW5 (table 20) and, because of dilution, effects of leachate should be small except during low flow.

Levels of most constituents and properties of surface-water samples were acceptable based on action levels designated by Mecklenburg County (tables 2 and 22). However, pH and concentrations of iron and manganese of some samples exceeded Mecklenburg County action limits (table 22). Total organic halogens and the herbicides 2, 4-D and 2,4-DP were the only synthetic organic compounds detected in surface-water samples (table 23). The herbicides were detected in samples from all surface-water monitoring sites, including site MGSW1, which is upstream from the landfill (Smith, 1993). Concentrations of these herbicides were small; the maximum detected concentrations of 2,4-D was 0.07 µg/L, which is 1,000 times less than the MCL of 70 µg/L set by the U.S. Environmental Protection Agency (1993) for drinking water. Data were insufficient to calculate trends in water quality at any of the monitoring sites.

Large numbers of fecal indicator bacteria (fecal coliform and fecal streptococcus) were present in surface-water samples. Fecal coliform densities ranged from 72 to 12,000 cols/100 mL, and fecal streptococcus densities ranged from 63 to 6,900 cols/100 mL (table 21). Bacterial densities were largest in samples from site MGSW5 and smallest in samples from site MGSW4 (Smith, 1993). Effluent from a sewage-treatment plant near site MGSW1 could have contributed to the large numbers of bacteria in McAlpine Creek. Sewage disposal upstream from the landfill also could have contributed to observed exceedences of the pH standard in water samples from McAlpine Creek. Densities of fecal indicator bacteria were much smaller in ground-water samples than in surface-water samples.

Ground-Water Quality

Ground-water samples appear to be affected by leachate from the landfill as indicated by large chemical-oxygen demand (maximum 110 mg/L) and total organic carbon concentration (maximum 23 mg/L). Specific conductance, chemical-oxygen demand, and concentrations of iron, manganese, and total organic carbon exceeded Mecklenburg County action levels, and the pH was less than the minimum acceptable level in samples from all wells (tables 2 and 22). Action levels for barium and chromium also were exceeded in water samples from well MGW3. The chemical quality of water from the well cluster varied with respect to well depth as illustrated by the

Table 19. Description of surface-water monitoring sites at the McAlpine Creek at Greenway Park landfill

[Location of sites shown in figure 10. USGS, U.S. Geological Survey; P, periodic sample collection]

Stream	Mecklenburg County site number	USGS identification number	Date established	Drainage area (square miles)	Record type
McAlpine Creek	MGSW1	0214652600	June 1987	17.5	P
McAlpine Creek	MGSW2	0214652625	June 1987	17.6	P
Irvins Creek	MGSW4	0214658200	June 1987	14.4	P
McAlpine Creek	MGSW5	0214658250	June 1987	32.1	P

Table 20. Description of ground-water monitoring sites at the McAlpine Creek at Greenway Park landfill

[Location of sites shown in figure 10. Well depth, casing depth, and screen openings listed in feet below land surface. USGS, U.S. Geological Survey; PVC, polyvinyl chloride]

				Casing			Screen opening			
Mecklenburg County site number	USGS identification number	Date installed	Well depth (feet)	Type	Diameter (inches)	Depth (feet)	From (feet)	To (feet)	Well use	Owner
MGW1	350904080443301	May 1987	29.2	PVC	2	24.2	24.2	29.2	Monitoring	Mecklenburg County
MGW2	350904080443302	May 1987	23.6	PVC	2	18.6	18.6	23.6	Monitoring	Mecklenburg County
MGW3	350904080443303	May 1987	18.6	PVC	2	13.6	13.6	18.6	Monitoring	Mecklenburg County

Table 21. Summary of selected surface- and ground-water quality data for the McAlpine Creek at Greenway Park landfill, 1987-92

[µS/cm, microsiemens per centimeter; --, no data or insufficient data for computation of median; mg/L, milligram per liter; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; <, less than; cols/100 mL, colonies per 100 milliliters; µg/L, microgram per liter]

Constituent or property		Surface-water sites				Ground-water sites		
		MGSW1	MGSW2	MGSW4	MGSW5	MGW1	MGW2	MGW3
Specific conductance (µS/cm)	Range	127-192	125-192	118-200	110-199	270-1,660	810-1,010	960-1,290
	Median	158	155	152	161	1,130	900	1,100
	Samples	8	9	9	12	12	11	11
pH, field (standard units)	Range	6.8-8.8	6.9-8.8	6.3-8.6	6.5-8.7	6.2-6.8	6.2-6.9	6.4-6.8
	Median	7.9	7.8	7.8	7.4	6.5	6.5	6.6
	Samples	7	7	7	10	11	10	10
Dissolved oxygen (mg/L)	Range	7.9-12.9	8.7-12.8	8.2-14.3	7.7-12	--	--	--
	Median	10.5	10.4	10.4	9.2	--	--	--
	Samples	6	6	6	8	0	0	0
Chemical-oxygen demand (mg/L)	Range	9-14	9-22	bdl-19	9-19	30-110	19-76	29-72
	Median	12	10	11	17	39	48	50
	Samples	3	3	3	5	5	2	2
Biochemical-oxygen demand (mg/L)	Range	0.6-2.0	0.9-2.4	0.8-1.3	0.3-2.9	1.3-8.2	1.0-2.0	2.8-4.5
	Median	0.7	1.4	0.9	1.5	5.1	1.5	3.6
	Samples	3	3	3	5	5	2	2
Fecal coliform (cols/100 mL)	Range	290-3,100	200-2,700	72-2,400	300-12,000	bdl-20	<10-81	<10
	Median	1,700	1,450	1,200	1,400	<10	--	<10
	Samples	2	2	2	4	3	2	2
Fecal streptococcus (cols/100 mL)	Range	300-390	360	63-460	270-6,900	bdl	9-18	<10
	Median	345	360	262	680	--	14	<10
	Samples	2	2	2	3	2	2	2
Alkalinity, fixed endpoint (mg/L as $CaCO_3$)	Range	48-61	39-64	51-62	36-79	466-515	440-476	630-659
	Median	54.5	51.5	56	54	490	458	644
	Samples	2	2	2	4	4	2	2
Sulfate (mg/L)	Range	5.8-8.3	5.7-5.8	6.2-6.3	4.6-7.8	2.9-8.0	0.5	<0.1
	Median	7.0	5.8	6.2	6.7	6.3	--	--
	Samples	2	2	2	3	3	1	1
Chloride, dissolved (mg/L)	Range	5.5-6.2	5.1-6.5	5.5-6.4	4.9-9.7	92-130	28-29	28-32
	Median	6.0	6.2	6.3	6.8	120	28	30
	Samples	3	3	3	5	5	2	2
Fluoride, total (mg/L)	Range	bdl	bdl	bdl	bdl	bdl	0.3	0.1
	Median	--	--	--	<0.2	--	--	--
	Samples	2	2	2	4	2	1	1
Aluminum, total (µg/L)	Range	2,600	30,000	2,000	260-9,100	1,100-1,800	--	--
	Median	--	--	--	9,000	1,400	--	--
	Samples	1	1	1	3	2	0	0
Arsenic, total (µg/L)	Range	bdl	bdl	bdl	bdl	bdl	bdl	bdl
	Median	3	<1	<2	<2	<3	--	--
	Samples	3	3	3	5	4	2	2
Barium, total (µg/L)	Range	<100	<100	<100	<100	<100-200	<100-200	900-1,000
	Median	<100	<100	<100	<100	150	--	950
	Samples	3	3	3	5	4	2	2
Cadmium, total (µg/L)	Range	bdl	bdl	bdl	bdl	bdl	bdl	bdl
	Median	<1	<1	<1	<1	<2	--	--
	Samples	3	3	3	5	4	2	2
Chromium, total (µg/L)	Range	bdl	bdl	bdl	bdl	8-31	bdl-28	2-60
	Median	<10	<10	<10	5	17	--	31
	Samples	3	3	3	5	4	2	2
Copper, total (µg/L)	Range	bdl	bdl	bdl	bdl	bdl	bdl	bdl
	Median	<50	<50	<50	<50	<50	--	--
	Samples	3	3	3	5	4	2	2
Iron, total (µg/L)	Range	880-2,600	880-8,200	850-2,300	620-7,100	4,900-11,000	7,400-20,000	83,000-110,000
	Median	940	950	1,600	870	8,600	13,500	96,500
	Samples	3	3	3	5	4	2	2
Lead, total (µg/L)	Range	bdl-5	bdl-6	bdl-5	bdl-6	bdl-18	<5-12	2-18
	Median	<5	<5	<5	3	<5	--	10
	Samples	3	3	3	5	4	2	2
Manganese, total (µg/L)	Range	70-80	70-320	90-140	110-6,700	9,600-10,000	12,000	12,000
	Median	70	90	130	190	10,000	12,000	--
	Samples	3	3	3	5	4	2	1
Mercury, total (µg/L)	Range	bdl	bdl	bdl	bdl	bdl	bdl	bdl
	Median	<0.2	<0.2	<0.2	<0.2	<0.2	--	--
	Samples	3	3	3	5	4	2	2
Zinc, total (µg/L)	Range	bdl	bdl	bdl-60	bdl-110	<10-70	bdl	<10-100
	Median	<50	<50	<50	<50	60	--	--
	Samples	3	3	3	5	4	2	2
Organic carbon, total (mg/L)	Range	3.9-4.5	3.8-4.5	2.9-5.7	3.4-7.9	13-23	7.2-11	14
	Median	4.2	4.2	4.3	4.5	14	9.1	14
	Samples	2	2	2	3	4	2	2

Table 22. Summary of constituents and properties exceeding or outside of ranges designated by Mecklenburg County action levels in surface- and ground-water samples from the McAlpine Creek at Greenway Park landfill, 1987-92

[μS/cm, microsiemens per centimeter; --, no data; mg/L, milligram per liter; μg/L, microgram per liter]

Constituent or property		Surface-water sites				Ground-water sites		
		MGSW1	MGSW2	MGSW4	MGSW5	MGW1	MGW2	MGW3
Specific conductance (μS/cm)	Exceedences	0	0	0	0	8	2	10
	Samples	8	9	9	12	12	11	11
	Maximum	--	--	--	--	1,660	1,010	1,290
pH, field (standard units)	Exceedences	1	1	2	1	6	5	4
	Samples	7	7	7	10	11	10	10
	Minimum	--	--	6.3	--	6.2	6.2	6.4
	Maximum	8.8	8.8	8.6	8.7	--	--	--
Chemical-oxygen demand (mg/L)	Exceedences	0	0	0	0	5	1	2
	Samples	3	3	3	5	5	2	2
	Maximum	--	--	--	--	110	76	72
Biochemical-oxygen demand (mg/L)	Exceedences	0	0	0	0	3	0	0
	Samples	3	3	3	5	5	2	2
	Maximum	--	--	--	--	8.2	--	--
Barium, total (μg/L)	Exceedences	0	0	0	0	0	0	1
	Samples	3	3	3	5	4	2	2
	Maximum	--	--	--	--	--	--	1,000
Chromium, total (μg/L)	Exceedences	0	0	0	0	0	0	1
	Samples	3	3	3	5	4	2	2
	Maximum	--	--	--	--	--	--	60
Iron, total (μg/L)	Exceedences	3	3	3	5	4	2	2
	Samples	3	3	3	5	4	2	2
	Maximum	2,600	8,200	2,300	7,100	11,000	20,000	110,000
Manganese, total (μg/L)	Exceedences	3	3	3	5	4	2	1
	Samples	3	3	3	5	4	2	2
	Maximum	80	320	140	6,700	10,000	12,000	12,000
Organic carbon, total (mg/L)	Exceedences	0	0	0	0	4	1	2
	Samples	2	2	2	3	4	2	2
	Maximum	--	--	--	--	23	11	14

Table 23. Summary of synthetic organic compounds detected in surface- and ground-water samples from the McAlpine Creek at Greenway Park landfill, 1987-92

[mg/L, milligram per liter; Max. detected, maximum concentration detected; --, not detected; μg/L, microgram per liter]

Compound		Surface-water sites				Ground-water sites		
		MGSW1	MGSW2	MGSW4	MGSW5	MGW1	MGW2	MGW3
Total organic halogens (mg/L)	Samples	2	2	2	2	2	2	2
	Detections	1	1	1	0	2	1	2
	Max. detected	0.02	0.01	0.02	--	0.04	0.02	0.03
2,4-D, total (μg/L)	Samples	1	2	1	1	3	1	1
	Detections	1	2	1	1	0	0	0
	Max. detected	0.07	0.07	0.02	0.05	--	--	--
2,4-DP, total (μg/L)	Samples	1	1	1	1	3	1	1
	Detections	1	1	0	1	0	0	0
	Max. detected	0.03	0.03	--	0.02	--	--	--

samples collected on May 16, 1991 (fig. 11). Specific conductance and chloride concentration were largest in samples from MGW1, the deepest well (29.2 ft below land surface). MGW3, the shallowest well (18.6 ft below land surface), yielded water with a barium concentration of 1,000 µg/L compared to 200 µg/L in samples from wells MGW2 and MGW1. The concentration of iron in water from well MGW3 also was much larger than water from the other wells. Biochemical-oxygen demand was largest in samples from well MGW3 and smallest in samples from well MGW1, whereas chemical-oxygen demand was largest in samples from well MGW2, the well of intermediate depth (fig. 11). Differences in water quality with depth probably are related to differences in permeability, availability of oxygen, and subsequent variation in types and rates of degradation processes with respect to depth.

Action levels designated by Mecklenburg County (table 2) for specific conductance, pH, chemical-oxygen demand, biochemical-oxygen demand, barium, chromium, iron, manganese, and total organic carbon were exceeded by some ground-water samples (table 22). The only synthetic organic compound detected in ground-water samples was the total organic halogen class of compounds.

Conclusions

The chemical quality of surface-water samples was considerably different from that of ground-water samples. The pH of surface water exceeded that of ground water with median pH ranging from 7.4 to 7.9 for surface-water sites in comparison to median pH ranging from 6.5 to 6.6 units for ground-water sites. Values for most other water-quality constituents and properties were larger in ground water than in surface water: median chemical-oxygen demand ranged from 10 to 17 mg/L for surface-water sites and from 39 to 50 mg/L for ground-water sites; median alkalinity ranged from 51.5 to 56 mg/L for surface-water sites and from 458 to 644 mg/L for ground-water sites. Concentrations of iron and manganese generally were more than 10 times greater in ground water than in surface water. Because of the differences in chemical quality between surface water and ground water, changes in surface-water quality could occur where there is significant ground-water discharge to McAlpine Creek, particularly during low streamflow when effects of dilution are minimal.

Data are insufficient to assess the effects of the McAlpine Creek at Greenway Park landfill on surface- and ground-water quality. Limited surface-water quality data were collected during low streamflow conditions. Samples collected during low streamflow indicate leachate from the landfill possibly has affected the quality of McAlpine Creek.

Data from the three monitoring wells indicate considerable variability in water quality with depth. Insufficient ground-water data are available to determine the areal and vertical extent of leachate migration in and near the landfill.

Statesville Road Landfill

The Statesville Road landfill occupies about 140 acres in central Mecklenburg County and lies within the northern Charlotte city limit (fig. 1). The landfill is entirely within the Irwin Creek Basin. Surface water in most of the landfill drains directly into Irwin Creek, which flows southwestward through the middle of the landfill (fig. 12). Surface water along the southeastern boundary of the landfill drains southward into an unnamed tributary of Irwin Creek. Land surfaces slope steeply toward Irwin Creek, with an average slope of about 20 percent. Maximum topographic relief is almost 100 ft. Land north and east of the landfill is primarily wooded with some residences. Land south and southeast of the landfill is primarily urban and industrial. Residential and commercial areas are near the western boundary of the landfill.

Limited information regarding depth to bedrock was available for this site. No bedrock outcrops were observed in the vicinity of the Statesville Road landfill. During a study by Law Engineering Testing Company (1980), partially weathered rock or dense silty sand, possibly indicative of nearness to bedrock, was observed in several borings at elevations ranging from 668 to 675 ft above sea level, which is about the elevation of the Irwin Creek streambed.

The Statesville Road landfill opened in 1940 and closed in 1970 (Smith, 1993). This is the oldest of the five landfills discussed in this report. Waste disposal at this site pre-dates implementation of most regulations and design specifications for modern sanitary landfills. Landfilling operations began in the southwestern part of the landfill and progressed to the east and north. Various types of wastes were disposed at this site. Chemical wastes reportedly were placed in the southwestern part of the landfill during the 1940's (Law Engineering Testing Company, 1980). Demolition materials also were disposed at the site, primarily in the southeastern part of the landfill. The volume of wastes disposed at this landfill is unknown. Average thickness of refuse reportedly is 30 ft; however, 62 ft of refuse was penetrated in a boring by

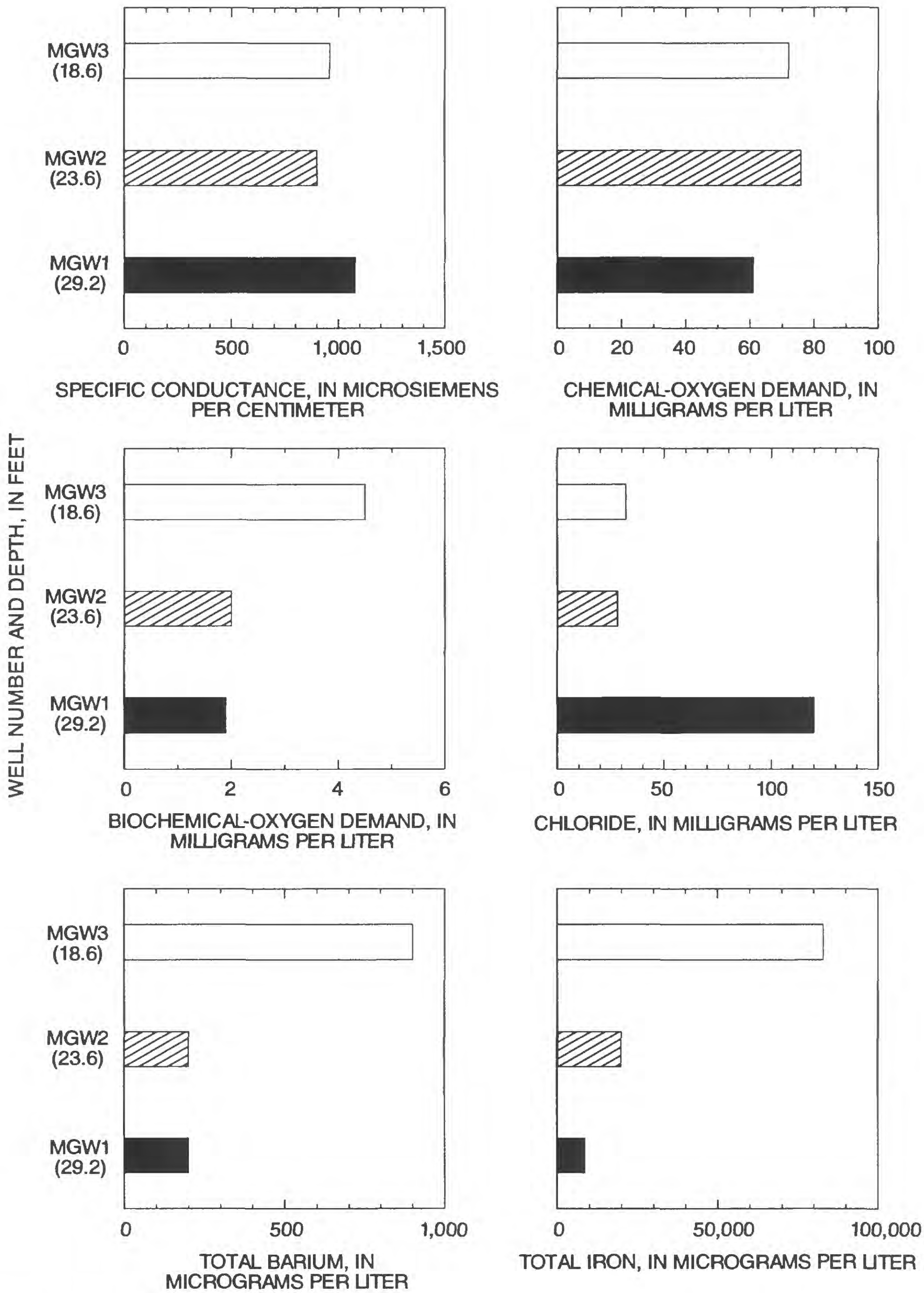

Figure 11. Values of selected constituents and properties of ground-water samples from adjacent monitoring wells MGW1, MGW2, and MGW3, McAlpine Creek at Greenway Park landfill, May 16, 1991.

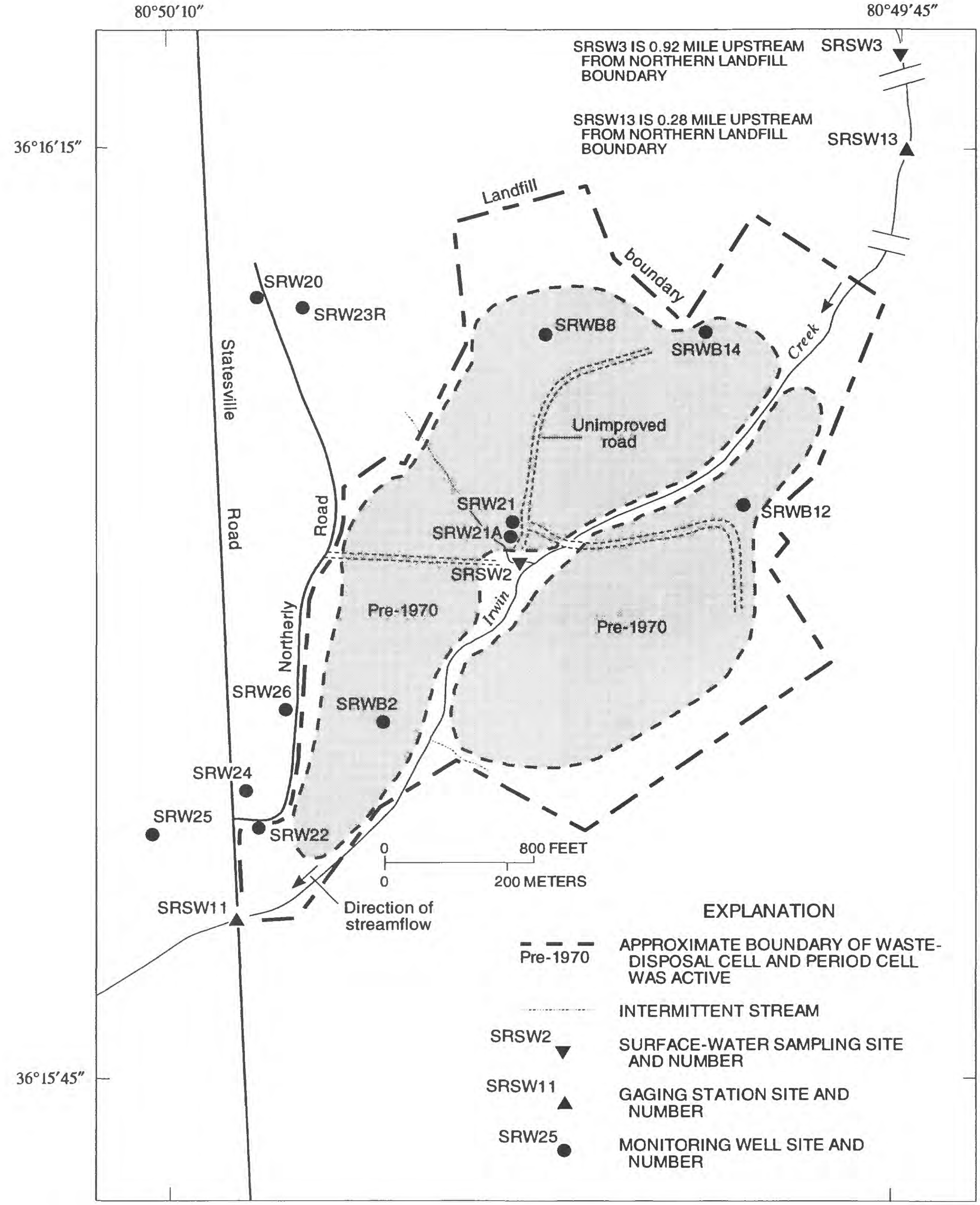

Figure 12. Waste-disposal cells and monitoring sites at the Statesville Road landfill (modified from Smith, 1993).

Law Engineering Testing Company (1980). Refuse in much of the landfill was placed in the saturated zone (Cardinell and others, 1989). During the 30-year period of operation, refuse also was placed along the Irwin Creek flood plain in mounds 70 to 80 ft high (Smith, 1993). Refuse was not compacted, although the volume of waste materials was periodically reduced by open burning. No daily soil cover was applied during landfilling operations (Smith, 1993). After closure of the landfill, refuse was covered with a soil layer of undetermined thickness. In 1992, much of the southern part of the landfill was vegetated. An auto salvage yard was established in the northwestern part of the landfill in 1980 and removed from the site in 1992.

The USGS began monitoring surface-water quality at this landfill in 1979. In 1983, monitoring activities were expanded to include collection of ground-water quality and water-level data. The expanded monitoring network included 4 surface-water sites and 12 ground-water sites (fig. 12). Information about surface-water monitoring sites is listed in table 24. Three of the surface-water sites are on Irwin Creek: SRSW3 and SRSW13 are upstream from the landfill, and SRSW11 is downstream from the landfill. The landfill occupies about 16 percent of the drainage area between sites SRSW13 and SRSW11 (table 24). Site SRSW2 is on a tributary of Irwin Creek, which drains a 0.18-square-mile (mi^2) area, about half of which is within landfill boundaries. Continuous records of streamflow were obtained at site SRSW11 from 1981 to 1992, and at site SRSW13 from 1989 to 1992. Daily records of specific conductance and temperature were obtained at site SRSW11 from 1982 to 1990, and at site SRSW13 from 1989 to 1990. Streamflow, specific conductance, and temperature records for sites SRSW11 and SRSW13 are in the USGS annual hydrologic data reports (U.S. Geological Survey, 1982-93).

Wells ranging in depth from 15.6 to 54.1 ft were used to monitor ground-water quality in the vicinity of the landfill (table 25). Monitoring wells SRW20, SRW22, SRW24, SRW25, and SRW26 were installed west and southwest of the landfill to detect potential offsite migration of leachate. Well SRW23R, a domestic supply well about 0.15 mi west of the landfill, was sampled from 1983 until it was abandoned in 1987. Two adjacent monitoring wells, SRW21 and SRW21A, are located along the Irwin Creek flood plain near the center of the landfill. Borings SRWB2, SRWB8, SRWB12, and SRWB14, were installed in refuse disposal areas in 1980 by Law Engineering Testing Company. Water samples from these borings were analyzed to characterize chemical quality of leachate within the landfill.

Water-level data from a network of borings and pits (Law Engineering Testing Company, 1980) were used to construct a water-table elevation map (fig. 13). Periodic water-level measurements were made in all wells except well SRW23R, which was not accessible for measurement. Based on these water-level measurements, the direction of ground-water flow at the landfill is primarily toward Irwin Creek and to the southwest. Water levels indicate ground water is discharged to streams within the landfill. Thus, Irwin Creek downstream from the landfill is the offsite surface-water body potentially most affected by movement of leachate from the landfill. Ground water adjacent to Irwin Creek near the landfill also is likely to be affected by leachate from the landfill.

Surface-Water Quality

Site SRSW2, on the tributary to Irwin Creek near the center of the landfill, appears to be the surface-water site most affected by leachate. Concentrations of inorganic constituents generally were much larger in samples from site SRSW2 than in samples from other surface-water sites. Median concentrations of iron (4,500 µg/L) and manganese (2,900 µg/L) for site SRSW2 during 1986-92 were 15 times, and nearly 60 times, larger than action levels for iron and manganese, respectively (table 26). Chemical-oxygen demand, biochemical-oxygen demand, and nitrate in samples from site SRSW2 generally exceeded action levels (table 27). The large chemical- and biochemical-oxygen demands of water from site SRSW2 have contributed to the small dissolved-oxygen concentrations in this stream.

Median values of specific conductance, chemical-oxygen demand, biochemical-oxygen demand, alkalinity, chloride, iron, lead, manganese, and zinc were larger for site SRSW11, which is downstream from the landfill, than median values for sites SRSW3 and SRSW13, which are upstream from the landfill (table 26). The increase in concentrations of these constituents downstream from the landfill probably is related to seepage of leachate into Irwin Creek. However, action levels for iron and manganese commonly were exceeded in samples from upstream surface-water sites, SRSW3 and SRSW13 (table 27). Thus, geologic conditions and land-use activities not related to waste disposal at the Statesville Road landfill have contributed to exceedences of action levels in water samples from Irwin Creek.

Table 24. Description of surface-water monitoring sites at the Statesville Road landfill

[Location of sites shown in figure 12. USGS, U.S. Geological Survey; P, periodic sample collection; C, continuous discharge; S, continuous specific conductance; T, continuous temperature]

Stream	Mecklenburg County site number	USGS identification number	Date established	Drainage area (square miles)	Record type
Tributary to Irwin Creek	SRSW2	0214620810	Aug. 1979	0.18	P
Irwin Creek	SRSW3	0214620750	Oct. 1979	3.41	P
Irwin Creek	SRSW11	02146211	Apr. 1980	5.97	C,P,S,T
Irwin Creek	SRSW13	0214620760	Mar. 1988	4.40	C,P,S,T

Table 25. Description of ground-water monitoring sites at the Statesville Road landfill

[Location of sites shown in figure 12. Well depth, casing depth, and screen openings listed in feet below land surface. USGS, U.S. Geological Survey; PVC, polyvinyl chloride; --, no data]

Mecklenburg County site number	USGS identification number	Date installed	Well depth (feet)	Casing			Screen opening		Well use	Owner
				Type	Diameter (inches)	Depth (feet)	From (feet)	To (feet)		
SRWB2	351553080500701	May 1980	42.5	PVC	2	--	--	--	Monitoring	City of Charlotte
SRWB8	351614080495501	June 1980	25.0	PVC	2	--	--	--	Monitoring	City of Charlotte
SRWB12	351606080494101	June 1980	29.0	PVC	2	--	--	--	Monitoring	City of Charlotte
SRWB14	351555080495101	Unknown	--	--	--	--	--	--	Monitoring	City of Charlotte
SRW20	351615080501301	Feb. 1983	54.1	PVC	2	44.1	44.1	54.1	Monitoring	City of Charlotte
SRW21	351603080495801	Feb. 1983	24.2	PVC	2	14.2	14.2	24.2	Monitoring	City of Charlotte
SRW21A	351605080495801	Sept. 1988	15.6	PVC	2	10.6	10.6	15.6	Monitoring	City of Charlotte
SRW22	351547080501401	Feb. 1983	32.5	PVC	2	22.5	22.5	32.5	Monitoring	City of Charlotte
SRW23R	351614080501401	Unknown	--	--	--	--	--	--	Domestic	Private
SRW24	351548080501401	Sept. 1988	20.2	PVC	2	15.2	15.2	20.2	Monitoring	Private
SRW25	351547080521801	Sept. 1988	19.6	PVC	2	14.6	14.6	19.6	Monitoring	Private
SRW26	351551080501301	Sept. 1988	32.0	PVC	2	27.0	27.0	32.0	Monitoring	Private

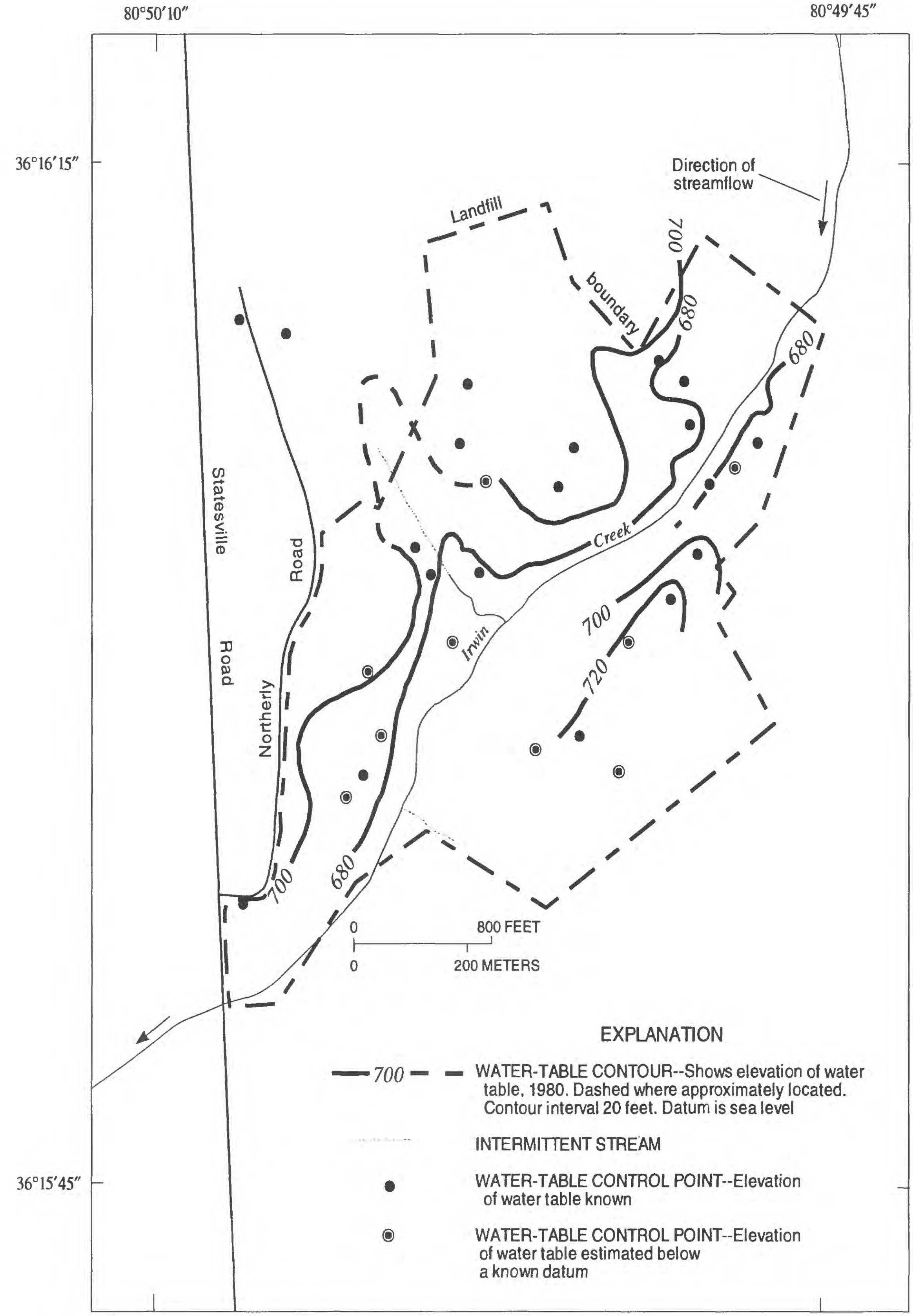

Figure 13. Elevation of the water table at the Statesville Road landfill, 1980 (Cardinell and others, 1989).

Table 26. Summary of selected surface-water quality data for the Statesville Road landfill, 1986-92

[μS/cm, microsiemens per centimeter; mg/L, milligram per liter; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; *, value estimated using a log-probability regression to predict values below detection limit; --, no data or insufficient data for computation of median; cols/100 mL, colonies per 100 milliliters; <, less than; μg/L, microgram per liter]

Constituent or property		SRSW2	SRSW3	SRSW11	SRSW13
Specific conductance (μS/cm)	Range	995-2,690	123-185	112-1,060	102-185
	Median	1,230	139	388	151
	Samples	16	15	98	45
pH, field (standard units)	Range	6.1-7.6	6.1-7.6	6.1-7.8	6.2-7.8
	Median	7.1	6.7	6.9	7.0
	Samples	16	15	23	15
Dissolved oxygen (mg/L)	Range	2.0-10.2	5.8-13.9	5.2-13.8	7.1-16.8
	Median	5.8	9.1	10.2	9.8
	Samples	16	15	22	14
Chemical-oxygen demand (mg/L)	Range	20-47	bdl-9	bdl-24	bdl-12
	Median	26	6*	14	5
	Samples	9	9	20	11
Biochemical-oxygen demand (mg/L)	Range	1.3-22	0.3-1.4	0.7-5.2	bdl-2.8
	Median	6.3	0.8	2.6	0.8*
	Samples	9	9	20	11
Fecal coliform (cols/100 mL)	Range	--	--	610-1,500	210
	Median	--	--	1,060	--
	Samples	0	0	2	1
Fecal streptococcus (cols/100 mL)	Range	--	--	180-370	940
	Median	--	--	275	--
	Samples	0	0	2	1
Alkalinity, fixed endpoint (mg/L as $CaCO_3$)	Range	190-413	34-75	62-253	43-74
	Median	285	56	116	62
	Samples	10	10	15	6
Sulfate (mg/L)	Range	48-320	4.8-15	7.5-31	5.4-9.8
	Median	165	7.6*	17	7.8
	Samples	6	6	11	3
Chloride, dissolved (mg/L)	Range	100-210	4.0-8.0	15-160	4.5-6.7
	Median	150	5.5	42	5.4
	Samples	9	9	20	11
Fluoride, total (mg/L)	Range	bdl	bdl	bdl	bdl
	Median	<0.2	<0.2	<0.2	<0.2
	Samples	8	8	18	9
Aluminum, total (μg/L)	Range	bdl-6,200	210-950	120-1,300	280-1,000
	Median	240	360	420	500
	Samples	7	7	14	5
Arsenic, total (μg/L)	Range	bdl-5	bdl	bdl-4	bdl
	Median	3	<2	0.6*	<2
	Samples	9	9	20	11
Barium, total (μg/L)	Range	<100-1,500	<100-300	<100-500	<100-300
	Median	200	<100	<100	<100
	Samples	9	9	20	11
Cadmium, total (μg/L)	Range	bdl	bdl	bdl	bdl
	Median	<1	<2	<1	<2
	Samples	9	9	20	11
Chromium, total (μg/L)	Range	bdl-31	bdl	bdl-10	bdl
	Median	4*	2	2*	<10
	Samples	9	9	20	11
Copper, total (μg/L)	Range	bdl	bdl	bdl-50	bdl
	Median	<50	<50	14*	<50
	Samples	9	9	20	11
Iron, total (μg/L)	Range	2,100-38,000	460-2,000	530-2,200	260-1,300
	Median	4,500	920	1,200	470
	Samples	9	9	20	11
Lead, total (μg/L)	Range	bdl-6	bdl-5	bdl-23	bdl-6
	Median	2*	2*	3*	2*
	Samples	9	9	20	11
Manganese, total (μg/L)	Range	1,700-6,500	80-290	260-1,500	30-210
	Median	2,900	110	540	50
	Samples	9	9	20	11
Mercury, total (μg/L)	Range	bdl	bdl	bdl	bdl
	Median	<0.2	<0.2	<0.2	<0.2
	Samples	9	9	20	11
Zinc, total (μg/L)	Range	bdl-160	bdl-740	bdl-200	bdl-180
	Median	60*	50*	70*	27*
	Samples	9	9	20	11
Organic carbon, total (mg/L)	Range	9.0-19	2.0-3.2	3.8-13	1.8-3.6
	Median	14	2.4	4.7	2.4
	Samples	3	5	11	11

Table 27. Summary of constituents and properties exceeding or outside of ranges designated by Mecklenburg County action levels in surface- and ground-water samples from the Statesville Road landfill, 1986-92

[µS/cm, microsiemens per centimeter; --, no data; mg/L, milligram per liter; >, greater than; µg/L, microgram per liter]

Constituent or property		Surface-water sites				Ground-water sites							
		SRSW2	SRSW3	SRSW11	SRSW13	SRW20	SRW21	SRW21A	SRW22	SRW23R	SRW24	SRW25	SRW26
Specific conductance (µS/cm)	Exceedences	14	0	2	0	0	17	8	0	0	0	0	0
	Samples	16	15	98	45	17	17	8	15	5	8	8	9
	Maximum	2,690	--	1,030	--	--	2,700	3,000	--	--	--	--	--
pH, field (standard units)	Exceedences	1	4	3	5	15	13	8	10	4	8	8	9
	Samples	16	15	23	15	17	17	8	15	5	8	8	9
	Minimum	6.1	6.1	6.1	6.2	6.0	6.2	6.2	6.0	6.1	5.4	5.9	5.9
	Maximum	--	--	--	--	--	--	--	--	8.9	--	--	--
Chemical-oxygen demand (mg/L)	Exceedences	6	0	0	0	0	10	6	0	--	1	1	3
	Samples	9	9	20	11	11	10	6	10	0	6	6	6
	Maximum	47	--	--	--	--	110	480	--	--	43	41	49
Biochemical-oxygen demand (mg/L)	Exceedences	6	0	1	0	1	1	2	2	0	1	2	1
	Samples	9	9	20	11	11	10	6	10	4	6	6	6
	Maximum	>22	--	5.2	--	10	>12	>9.0	6.3	--	>5.8	5.2	9.3
Sulfate (mg/L)	Exceedences	1	0	0	0	0	0	0	0	0	0	0	0
	Samples	6	6	11	8	6	6	4	7	4	5	5	6
	Maximum	320	--	--	--	--	--	--	--	--	--	--	--
Chloride, dissolved (mg/L)	Exceedences	0	0	0	0	0	6	5	0	0	0	0	0
	Samples	9	9	20	11	11	10	5	9	4	6	6	6
	Maximum	--	--	--	--	--	350	510	--	--	--	--	--
Nitrate as N (mg/L)	Exceedences	2	0	0	0	0	0	0	0	0	0	0	0
	Samples	3	3	10	8	5	5	4	7	4	4	5	5
	Maximum	22	--	--	--	--	--	--	--	--	--	--	--
Barium, total (µg/L)	Exceedences	1	0	0	0	0	1	2	0	--	1	1	1
	Samples	9	9	20	11	7	6	6	7	0	6	6	6
	Maximum	1,500	--	--	--	--	4,200	5,000	--	--	1,000	1,000	1,400
Chromium, total (µg/L)	Exceedences	0	0	0	0	3	0	0	0	--	0	1	0
	Samples	9	9	20	11	7	6	6	7	0	6	6	6
	Maximum	--	--	--	--	220	--	--	--	--	--	92	--
Iron, total (µg/L)	Exceedences	9	9	20	9	7	6	6	6	--	5	6	5
	Samples	9	9	20	11	7	6	6	7	0	6	6	6
	Maximum	38,000	2,000	2,200	1,300	84,000	6,400	32,000	810	--	8,700	35,000	7,400
Manganese, total (µg/L)	Exceedences	9	9	20	8	7	6	6	6	--	4	5	6
	Samples	9	9	20	11	7	6	6	7	0	6	6	6
	Maximum	6,500	290	1,600	210	1,800	4,200	39,000	330	--	310	310	1,800
Mercury, total (µg/L)	Exceedences	0	0	0	0	0	0	1	0	--	0	0	0
	Samples	9	9	20	11	7	6	6	7	0	6	6	6
	Maximum	--	--	--	--	--	--	2.0	--	--	--	--	--
Organic carbon, total (mg/L)	Exceedences	2	0	1	0	1	6	2	0	--	0	0	1
	Samples	9	5	11	11	8	6	2	6	0	6	4	5
	Maximum	19	--	13	--	24	39	48	--	--	--	--	16

The herbicides 2,4-D and 2,4-DP were detected in Irwin Creek upstream from the landfill at sites SRSW3 and SRSW13 and downstream from the landfill at site SRSW11 (table 28). These herbicides were not detected in samples from site SRSW2. Because these compounds were detected upstream from the landfill and were not detected in samples from site SRSW2 or from wells in the landfill, the occurrence of these compounds in Irwin Creek apparently is unrelated to the landfill. Except for the total organic halogen group, the only other synthetic organic compounds detected in surface-water samples were chloroform and 1,4-dichlorobenzene which were detected downstream from the landfill at site SRSW11. Samples from site SRSW2 and from onsite wells were not analyzed for chloroform or 1,4-dichlorobenzene; however, samples from offsite wells were analyzed for 1,4-dichlorobenzene, but it was not detected. Thus, data are insufficient to determine if the landfill was a source of these compounds.

The seasonal Kendall test was used to evaluate temporal trends in selected surface-water quality data. As noted in table 29, some water-quality data for sites SRSW11 and SRSW13 were adjusted for streamflow using streamflow data from site SRSW11. Streamflow data were not available for site SRSW2. Statistically significant increasing trends in specific conductance (28.6 µS/cm/yr), alkalinity (13.5 mg/L/yr), iron (510 µg/L/yr), and manganese (300 µg/L/yr) were detected for site SRSW2. Statistically significant decreasing trends in biochemical-oxygen demand were detected for sites upstream from the landfill during 1979-92 for site SRSW3 (-0.1 mg/L/yr) and during 1988-92 for site SRSW13 (-0.5 mg/L/yr). Decreasing trends in specific conductance (-5.5 µS/cm/yr) and iron concentration (-130 µg/L/yr) also were detected for site SRSW13 from 1988 to 1992. Trends observed for sites SRSW3 and SRSW13 probably indicate effects of human activities or land-use changes upstream from the Statesville Road landfill.

Data from site SRSW11, which is downstream from the landfill, indicate decreasing trends in specific conductance (-6.9 µS/cm/yr), chemical-oxygen demand (-1.0 mg/L/yr), biochemical-oxygen demand (-0.2 mg/L/yr), chloride (-1.1 mg/L/yr), ammonia (-0.4 mg/L/yr), and iron (-56 µg/L/yr), and increasing trends in pH (0.04 units/yr) and alkalinity (4.1 mg/L/yr). These trends, typical of changes in water quality associated with transition to advanced stages of solid-waste decomposition, indicate water quality at site SRSW11 generally improved from 1980 to 1992. However, trends detected for site SRSW11 can be related to factors other than changes in leachate quality. The landfill occupies only 16 percent of the drainage area of site SRSW11 (table 24). Similar trends in specific conductance, biochemical-oxygen demand, and iron also were detected upstream from the landfill at site SRSW13 (table 29). Thus, some of the trends detected for site SRSW11 probably are associated with changes in water quality upstream from the landfill.

Trends observed for site SRSW11 were not consistent with those for site SRSW2, even though the tributary on which site SRSW2 is located flows into Irwins Creek upstream from site SRSW11. Specific conductance and iron concentrations indicate increasing trends at site SRSW2 and decreasing trends at site SRSW11 during similar time periods (table 29). Because more than half the drainage area of site SRSW2 lies outside the landfill, increasing trends in specific conductance and iron at this site could be related to changes in offsite land use. In addition to the landfill, known land uses in the drainage area of site SRSW2 during the time period used for trend analysis included a salvage yard, residential and commercial areas, and an interstate highway interchange. Erosion of the soil layer covering refuse and settling of refuse could have contributed to increased infiltration or increased surficial seepage of leachate, thereby altering water-quality characteristics at site SRSW2. The chemical quality of water at site SRSW2 generally was similar to that of nearby well SRW21. Concentrations of most constituents were larger in samples from well SRW21 than in samples from site SRSW2 (Smith, 1993). However, median concentrations of iron and sulfate were larger in samples from site SRSW2 than in samples from well SRW21 (tables 27 and 30, respectively). Because wastes at this landfill were placed below the water table, degradation rates probably are very slow as a result of limited oxygen availability.

Ground-Water Quality

Data indicated that none of the water samples from the monitoring wells represented background water-quality conditions. Chemical-oxygen demand was larger than expected for natural ground water in samples from all wells except well SRW25. However, concentrations of sulfate, arsenic, barium, chromium, copper, and total organic carbon in samples from well SRW25 generally were larger than concentrations in samples from other monitoring wells, which indicates

Table 28. Summary of synthetic organic compounds detected in surface- and ground-water samples from the Statesville Road landfill, 1986-92

[Detections, number of samples in which the compound was detected; --, not detected; mg/L, milligram per liter; Max. detected, maximum concentration detected; µg/L, microgram per liter]

Compound		Surface-water sites				Ground-water sites							
		SRSW2	SRSW3	SRSW11	SRSW13	SRW20	SRW21	SRW21A	SRW22	SRW23R	SRW24	SRW25	SRW26
Total organic halogens (mg/L)	Samples	2	2	6	6	3	2	2	2	0	2	2	2
	Detections	0	0	2	2	1	2	2	0	--	0	2	0
	Max. detected	--	--	0.02	0.02	0.01	0.03	0.04	--	--	--	0.02	--
DDT, total (µg/L)	Samples	3	2	8	4	4	4	1	3	0	1	1	2
	Detections	0	0	0	0	0	0	0	1	--	0	0	0
	Max. detected	--	--	--	--	--	--	--	0.04	--	--	--	--
2,4-D, total (µg/L)	Samples	3	2	8	4	4	4	1	3	1	1	1	2
	Detections	0	1	4	1	1	0	0	0	0	0	0	0
	Max. detected	--	0.02	0.34	0.03	0.04	--	--	--	--	--	--	--
2,4-DP, total (µg/L)	Samples	3	2	8	4	4	4	1	3	1	1	1	2
	Detections	0	1	2	1	0	0	0	0	0	0	0	0
	Max. detected	--	0.03	0.02	0.04	--	--	--	--	--	--	--	--
Chloroform, total (µg/L)	Samples	0	0	2	0	0	0	0	0	1	0	1	0
	Detections	--	--	1	--	--	--	--	--	0	--	0	--
	Max. detected	--	--	0.3	--	--	--	--	--	--	--	--	--
Trichloro-fluoro-methane, total (µg/L)	Samples	0	0	2	0	0	0	0	0	1	0	1	0
	Detections	--	--	0	--	--	--	--	--	1	--	0	--
	Max. detected	--	--	--	--	--	--	--	--	1.4	--	--	--
trans-1,2-Dichloro-ethylene, total (µg/L)	Samples	0	0	2	0	0	0	0	0	1	0	1	0
	Detections	--	--	0	--	--	--	--	--	1	--	0	--
	Max. detected	--	--	--	--	--	--	--	--	0.2	--	--	--
Trichloro-ethylene, total (µg/L)	Samples	0	0	2	0	0	0	0	0	1	0	1	0
	Detections	--	--	0	--	--	--	--	--	1	--	0	--
	Max. detected	--	--	--	--	--	--	--	--	0.2	--	--	--
1,4-Dichloro-benzene, total (µg/L)	Samples	0	2	4	1	1	0	0	1	1	2	2	0
	Detections	--	0	2	0	0	--	--	0	0	0	0	--
	Max. detected	--	--	0.40	--	--	--	--	--	--	--	--	--
Toluene, total (µg/L)	Samples	0	0	2	0	0	0	0	0	1	0	1	0
	Detections	--	--	0	--	--	--	--	--	1	--	0	--
	Max. detected	--	--	--	--	--	--	--	--	0.5	--	--	--
Ethyl-benzene, total (µg/L)	Samples	0	0	2	0	0	0	0	0	1	0	1	0
	Detections	--	--	0	--	--	--	--	--	1	--	0	--
	Max. detected	--	--	--	--	--	--	--	--	0.3	--	--	--
Bis(2-ethyl-hexyl) phthalate, total (µg/L)	Samples	0	2	2	1	1	0	0	1	0	2	1	0
	Detections	--	0	0	0	0	--	--	0	--	1	1	--
	Max. detected	--	--	--	--	--	--	--	--	--	5.0	9.0	--

Table 29. Summary of seasonal Kendall trend test results for selected water-quality data from the Statesville Road landfill, 1979-92

[Only results significant at a probability level of 0.10 are shown. p, probability level; *, trend tests were made but trends were not significant; <0.001, probability level less than 0.001; Slope, trend slope expressed in units per year; --, data inadequate for analysis; µS/cm, microsiemens per centimeter; % median, slope expressed as a percentage of the seasonal median; n, number of observations; Record, period of record; mg/L, milligram per liter; µg/L, microgram per liter]

Constituent		Surface-water sites				Ground-water sites						
		SRSW2	SRSW3	SRSW11	SRSW13	SRW20	SRW21	SRW22	SRW23R	SRW24	SRW25	SRW26
Specific conductance ($\mu S/cm$)	p	0.077	*	0.015[a]	0.078[a]	0.047	0.032	<0.001	0.088	0.054	*	*
	Slope	28.6	--	-6.9	-5.5	-3.0	-88.6	-86	5.8	44	--	--
	% median	2.9	--	-1.8	-3.5	-1.1	-3.9	-9.5	4.5	22	--	--
	n	34	35	195	45	27	30	26	14	8	8	9
	Record	1979-92	1979-92	1980-92	1988-92	1984-92	1983-92	1983-91	1983-87	1989-92	1989-92	1989-92
pH, field (standard units)	p	*	*	0.065[a]	*	*	0.028	*	*	--	0.089	*
	Slope	--	--	0.04	--	--	0.03	--	--	--	0.07	--
	n	33	31	44	15	27	30	26	14	8	8	9
	Record	1979-92	1979-92	1980-92	1988-92	1984-92	1983-92	1983-92	1983-87	1989-92	1989-92	1989-92
Chemical-oxygen demand (mg/L)	p	*	*	<0.001[a]	--	*	0.016	<0.001	--	--	--	--
	Slope	--	--	-1.0	--	--	-5.0	-4.1	--	--	--	--
	% median	--	--	-5.9	--	--	-5.1	-26.9	--	--	--	--
	n	23	23	40	11	19	20	20	4	6	6	6
	Record	1979-92	1979-92	1980-92	1988-92	1984-92	1983-92	1983-92	1983-84	1989-92	1989-92	1989-92
Biochemical-oxygen demand (mg/L)	p	*	0.031	<0.001[a]	0.051[a]	*	*	*	*	--	--	--
	Slope	--	-0.1	-0.2	-0.5	--	--	--	--	--	--	--
	% median	--	-7.3	-6.6	-5.6	--	--	--	--	--	--	--
	n	23	23	40	11	19	21	20	12	5	6	6
	Record	1979-92	1979-92	1980-92	1988-92	1984-92	1983-92	1983-92	1983-87	1989-92	1989-92	1989-92
Alkalinity, total (mg/L as $CaCO_3$)	p	0.036	*	0.007[a]	--	*	0.003	0.026	*	--	--	--
	Slope	13.5	--	4.1	--	--	33	-12.8	--	--	--	--
	% median	6.1	--	4.1	--	--	4.8	-4.6	--	--	--	--
	n	26	25	36	6	20	24	21	13	5	4	4
	Record	1979-90	1979-90	1980-90	1988-90	1984-90	1983-90	1983-90	1983-87	1989-90	1989-90	1989-90
Chloride, dissolved (mg/L)	p	*	*	0.052[a]	*	*	*	0.016	0.024	0.089	--	--
	Slope	--	--	-1.1	--	--	--	-11	0.7	5.5	--	--
	% median	--	--	-2.5	--	--	--	-10.2	9.0	14.1	--	--
	n	23	23	39	11	19	21	19	12	6	6	6
	Record	1979-92	1979-92	1980-92	1988-92	1984-92	1983-92	1983-92	1983-87	1989-92	1989-92	1989-92
Ammonia (mg/L as N)	p	--	--	0.066[a]	--	--	--	--	--	--	--	--
	Slope	--	--	-0.4	--	--	--	--	--	--	--	--
	% median	--	--	-38	--	--	--	--	--	--	--	--
	n	7	7	11	5	3	3	2	0	3	3	3
	Record	1986-90	1986-90	1986-90	1988-90	1989-90	1989-90	1990-91	--	1989-90	1989-90	1989-90
Iron, total ($\mu g/L$)	p	0.091	*	0.004[a]	0.055	--	--	--	--	--	--	--
	Slope	510	--	-56	-130	--	--	--	--	--	--	--
	% median	11.7	--	-4.8	-26	--	--	--	--	--	--	--
	n	20	20	39	11	7	7	8	0	6	6	6
	Record	1981-92	1981-92	1980-92	1988-92	1988-92	1983-92	1983-92	--	1989-92	1989-92	1989-92
Manganese, total ($\mu g/L$)	p	0.010	*	*	*	--	--	--	--	--	--	--
	Slope	300	--	--	--	--	--	--	--	--	--	--
	% median	14.9	--	--	--	--	--	--	--	--	--	--
	n	20	20	38	11	7	7	9	0	6	6	6
	Record	1981-92	1981-92	1980-92	1988-90	1988-92	1983-92	1983-92	--	1989-92	1989-92	1989-92

[a]Data adjusted for streamflow.

Table 30. Summary of selected ground-water quality data for the Statesville Road landfill, 1986-92

[µS/cm, microsiemens per centimeter; --, no data or insufficient data for computation of median; mg/L, milligram per liter; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; *, value calculated using a log-probability regression to estimate values below detection limits; cols/100 mL, colonies per 100 milliliters; <, less than; µg/L, microgram per liter]

Constituent or property		SRW20	SRW21	SRW21A	SRW22	SRW23R	SRW24	SRW25	SRW26
Specific	Range	222-300	1,690-2,600	2,000-3,000	420-998	105-135	142-272	240-324	440-600
conductance	Median	275	2,250	2,720	790	130	185	297	510
(µS/cm)	Samples	17	17	8	15	5	8	8	9
pH, field	Range	6.0-6.8	6.2-7.4	6.2-6.4	6.0-6.9	6.1-8.9	5.4-6.1	5.9-6.2	5.9-6.3
(standard	Median	6.3	6.4	6.4	6.3	6.5	5.6	6.1	6.1
units)	Samples	17	17	8	15	5	8	8	9
Dissolved	Range	--	--	--	--	--	--	--	--
oxygen	Median	--	--	--	--	--	--	--	--
(mg/L)	Samples	0	0	0	0	0	0	0	0
Chemical-	Range	bdl-17	64-110	120-480	bdl-24	--	bdl-43	bdl-41	9-49
oxygen demand	Median	8*	94	125	17*	--	9.5*	10	24
(mg/L)	Samples	11	10	6	10	0	6	6	6
Biochemical-	Range	0.2-10	0.9-12	0.9-9.0	0.3-6.3	0.1-1.1	0.2-5.8	bdl-5.2	1.0-9.3
oxygen demand	Median	1.5	4.1	3.3	1.4	0.8	1.5	1.0	2.4
(mg/L)	Samples	11	10	6	10	4	6	6	6
Fecal coliform	Range	--	--	--	--	--	--	--	--
(cols/100 mL)	Median	--	--	--	--	--	--	--	--
	Samples	0	0	0	0	0	0	0	0
Fecal	Range	--	--	--	--	--	--	--	--
streptococcus	Median	--	--	--	--	--	--	--	--
(cols/100 mL)	Samples	0	0	0	0	0	0	0	0
Alkalinity, fixed	Range	69-90	646-876	774-859	112-302	23-44	25-36	96-118	117-213
endpoint	Median	82	771	792	276	43	33	107	198
(mg/L as $CaCO_3$)	Samples	10	11	4	10	5	5	4	4
Sulfate	Range	19-25	3.3-8.5	5.4-18	17-30	bdl-2.3	bdl	36-44	3.8-4.4
(mg/L)	Median	22	4.6	6.6	27	1.5	--	40	4.1
	Samples	6	6	3	5	4	2	2	2
Chloride,	Range	12-23	1-350	340-510	26-120	8.1-9.9	27-46	2.1-7.0	46-63
dissolved	Median	17	270	420	71	8.8	39	3.1	48
(mg/L)	Samples	11	10	5	9	4	6	6	6
Fluoride,	Range	bdl	bdl	bdl	bdl	<0.2	bdl	bdl	bdl
total	Median	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
(mg/L)	Samples	5	4	3	3	4	4	4	6
Aluminum,	Range	1,400-15,000	730-3,500	bdl-30,000	300-1,200	--	1,600-19,000	1,000-40,000	360-6,500
total	Median	2,000	1,600	1,700	720	--	8,000	10,000	1,600
(µg/L)	Samples	4	4	4	5	0	4	4	4
Arsenic,	Range	bdl	bdl-12	bdl-37	bdl	--	bdl	bdl-33	bdl
total	Median	<10	10*	10	<2	--	<2	<2	<2
(µg/L)	Samples	7	6	6	7	0	6	6	6
Barium,	Range	<100-600	200-4,200	<100-5,000	<100-900	--	<100-1,000	<100-1,000	100-1,400
total	Median	200	350	600	150*	--	<100	150*	200
(µg/L)	Samples	7	6	6	7	0	6	6	6
Cadmium,	Range	bdl	bdl	bdl	bdl	--	bdl	bdl	bdl
total	Median	<2	<2	<2	<2	--	<2	<2	<2
(µg/L)	Samples	7	6	6	7	0	6	6	6
Chromium,	Range	9-220	bdl	bdl	bdl-14	--	bdl-12	bdl-92	bdl
total	Median	34	<2	10*	5*	--	8*	8*	6*
(µg/L)	Samples	9	6	6	7	0	6	6	6
Copper,	Range	bdl-110	bdl-50	bdl-90	bdl	--	bdl	bdl-70	bdl
total	Median	<50	<50	<50	<50	--	<50	<50*	<50
(µg/L)	Samples	7	6	6	7	0	6	6	6
Iron,	Range	1,900-84,000	680-6,400	1,000-32,000	190-810	--	90-8,700	1,700-35,000	220-7,400
total	Median	4,800	3,600	2,000	550	--	2,400	15,000	920
(µg/L)	Samples	7	6	6	7	0	6	6	6
Lead,	Range	bdl-12	bdl	bdl-7	bdl-11	--	bdl-10	bdl-6	bdl-13
total	Median	4*	2	3	3*	--	5*	<5	5
(µg/L)	Samples	7	6	6	7	0	6	6	6
Manganese,	Range	50-1,700	3,600-4,200	22,000-39,000	40-330	--	20-310	40-310	250-1,800
total	Median	100	3,800	28,000	100	--	75	140	420
(µg/L)	Samples	7	6	6	7	0	6	6	6
Mercury,	Range	bdl	bdl	bdl-2.0	bdl	--	bdl	bdl	bdl
total	Median	<0.2	<0.2	<1.0	<0.2	--	<0.2	<0.2	<0.2
(µg/L)	Samples	7	6	6	7	0	6	6	6
Zinc,	Range	bdl-230	10-130	bdl-470	bdl-200	--	bdl-110	bdl-250	bdl-220
total	Median	70*	60	130*	60*	--	80*	90	50*
(µg/L)	Samples	7	6	6	7	0	6	6	6
Organic	Range	1.3-24	9.0-39	27-48	3.5-8.9	--	0.8-6.0	1.9-8.5	5.6-16
carbon,	Median	5.4	32	38	5.6	--	1.8	4.3	6.7
total (mg/L)	Samples	8	6	2	6	0	6	4	5

well SRW25 is not representative of background conditions. Concentrations of inorganic constituents generally were larger in samples from wells SRW21 and SRW21A, which are located near the center of the landfill, than in samples from other wells (table 30). However, well SRW25, which is offsite, was the well with the largest median concentration of iron (15,000 µg/L). Mecklenburg County action levels were more commonly exceeded in samples from wells SRW21 and SRW21A than from other wells (table 27). The pH of most ground-water samples was less than the minimum action level of 6.5 units and possibly represents natural conditions in this area. In samples from wells SRW21, SRW21A, and SRW26, chemical-oxygen demand, barium, and total organic carbon, which generally are considered indicators of leachate, equalled or exceeded action levels (table 27).

Concentrations of chromium exceeded action levels in some samples from the offsite wells SRW20 and SRW25 (table 27). Water samples collected during 1980-81 from borings SRWB8, SRWB12, and SRWB14, which were drilled into refuse, also contained large concentrations of chromium (maximum concentration 480 µg/L) (Cardinell and others, 1989; Smith, 1993). However, because chromium concentrations generally were smaller in samples from onsite wells SRW21 and SRW21A than in samples from offsite wells SRW20 and SRW25, it appears that chromium in samples from wells SRW20 and SRW25 was not derived from the landfill. Naturally occurring chromium, present in soil of the North Carolina Piedmont, could have been the primary source of chromium in water from these wells (Shacklette and Boerngen, 1984).

Total organic halogens were detected in ground-water samples from wells SRW20, SRW21, SRW21A, and SRW25 at concentrations ranging from 0.01 to 0.04 mg/L (table 28). Other synthetic organic compounds detected in ground water included the insecticide DDT (well SRW22) and bis(2-ethylhexyl) phthalate (wells SRW24 and SRW25). DDT, an insecticide no longer used in the United States (Kutz and others, 1991), was detected only in one sample at a concentration of 0.04 µg/L. The concentration of bis(2-ethylhexyl) phthalate exceeded the MCL of 6 µg/L in a water sample from well SRW25 (9 µg/L). However, this compound is a common laboratory contaminant, and determination of its presence in ground water requires additional quality-assurance data. Laboratory contamination and plastics are potential sources of phthalates.

Water samples from domestic supply well SRW23R contained the volatile organic compounds, trichlorofluoromethane, *trans*-1,2-dichloroethylene, trichlorethylene, toluene, and ethylbenzene (table 28). No MCL has been established for trichlorofluoromethane, which has been commonly used as a refrigerant and an aerosol propellant. Concentrations of *trans*-1,2-dichloroethylene, trichlorethylene, toluene, and ethylbenzene detected in ground-water samples were less than MCL's established by the U.S. Environmental Protection Agency (1993). These compounds are characteristic of various solvents and gasoline, the source of which cannot be determined with available data. Water from well SRW25 also was analyzed for volatile organic compounds; however, none were detected (Smith, 1993).

Water-quality data from onsite wells SRW22 and SRW21 generally are consistent with aging processes of landfill wastes and indicate improvement in ground-water quality. Data from well SRW22 indicated decreasing trends in specific conductance (-86 µS/cm/yr), chemical-oxygen demand (-4.1 mg/L/yr), alkalinity (-12.8 mg/L/yr), and chloride (-11 mg/L/yr), consistent with long-term changes in leachate quality resulting from aging of landfill wastes. Data from well SRW21, which is near the center of the landfill (fig. 12), indicated increasing trends in pH (0.03 units/yr) and alkalinity (33 mg/L/yr), and decreasing trends in specific conductance (-88.6 µS/cm/yr) and chemical-oxygen demand (-5.0 mg/L) (table 28). Trends in chloride concentration of samples from well SRW21 were non-monotonic as shown in figure 14. Chloride concentrations in samples from well SRW21 generally decreased from 1983 until mid-1986 when the concentration greatly increased. The concentration of chloride in a sample collected on June 23, 1986, was 1.0 mg/L, whereas the concentration in a sample collected on August 18, 1986, was 350 mg/L (fig. 14). Since August 18, 1986, chloride concentrations have decreased by more than 50 percent, with a concentration of 170 mg/L measured in a sample collected on April 8, 1992 (Smith, 1993). A possible cause of this abrupt and sustained increase in chloride concentration could be the release of a large pocket of leachate caused by settling of overburden or refuse. Chloride concentrations in samples from well SRW21A, which was drilled adjacent to well SRW21, were larger than concentrations in samples from well SRW21 (table 30). Well SRW21A was drilled in 1988 and is about 4 ft shallower than well SRW21 (table 25).

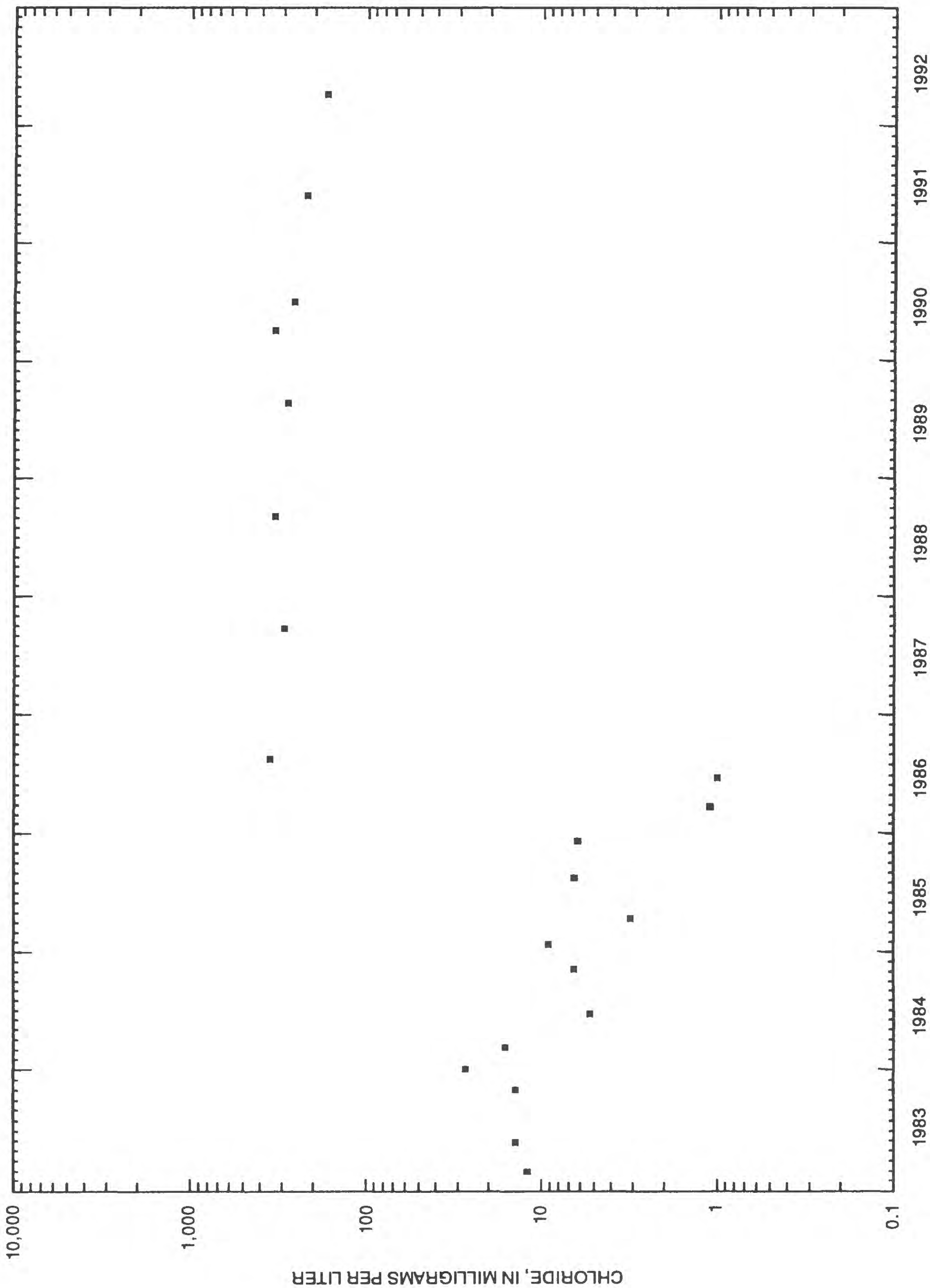

Figure 14. Chloride concentrations in water samples from the Statesville Road landfill monitoring well SRW21, 1983-92.

Data do not indicate concomitant increases in other constituents from June to August 1986. Insufficient data were available to assess trends in water quality at well SRW21A. With the exception of chloride concentra-tions in samples from well SRW21, trends detected for onsite wells indicate a general improvement in the chemical quality of leachate.

Water-quality trends for onsite wells generally showed decreasing trends in specific conductance and chloride, whereas offsite wells generally showed increasing trends in these constituents (table 29). Data from domestic supply well SRW23R indicated small increases in specific conductance (5.8 μS/cm/yr) and chloride concentration (0.7 mg/L/yr) from 1983 to 1987 (Smith, 1993). Data from well SRW24 also indicated increasing trends in specific conductance (44 μS/cm/yr) and chloride concentration (5.5 mg/L/yr) from 1989 to 1992 (Smith, 1993). An increasing trend in pH (0.07 units/yr) was detected for well SRW25. No trends in specific conductance or pH were detected for well SRW26, and data were inadequate for computation of trends in other water-quality constituents and properties. A small decreasing trend in specific conductance (-3.0 μS/cm/yr) was detected for well SRW20 during 1984-92 (Smith, 1993). Data are inadequate to determine whether leachate from the landfill or other land-use changes or human activities in the area are the cause of trends observed for offsite wells SRW23R, SRW24, and SRW25.

Conclusions

Comparison of specific conductance and concentrations of chemical-oxygen demand, biochemical-oxygen demand, chloride, sulfate, iron, manganese, and total organic carbon in samples from surface-water sites upstream and downstream from the landfill indicates that the Statesville Road landfill has affected water quality in Irwin Creek. However, based on decreasing trends in specific conductance, chemical-oxygen demand, biochemical-oxygen demand, chloride, ammonia, and iron and an increasing trend in pH for site SRSW11, water quality in Irwin Creek downstream from the landfill has improved since 1980. Water-quality trends detected for site SRSW2 are inconsistent with those for site SRSW11. Data for site SRSW2, which drains the northwestern half of the landfill, show increasing trends in specific conductance and iron concentration. However, data for site SRSW11, which is located on Irwin Creek downstream from the landfill, indicate decreasing trends in specific conductance and iron concentration.

Concentrations of most constituents were larger in samples from onsite wells than from offsite wells or surface-water sites. Trends detected for offsite wells could be related to offsite land-use characteristics or to the landfill. Because wastes at this site were placed in the saturated zone, there is potential for migration of leachate into bedrock aquifers. Information about water-quality conditions in bedrock is needed to determine if such migration has occurred.

York Road Landfill

The York Road landfill occupies about 375 acres in southwestern Mecklenburg County and is within Charlotte city limits (fig. 1). This is the largest of the five landfills described in this report. Surface drainage is generally southwestward by way of two unnamed tributaries to Sugar Creek (fig. 15). A north-south trending ridge that roughly bisects the landfill is the drainage divide for the two tributaries. Flow in the southern tributary is perennial, whereas flow in the northern tributary is intermittent. Land-surface elevations range from about 692 ft above sea level at boring YRWB12, in the northeastern corner of the landfill, to less than 580 ft along Sugar Creek near the southern boundary of the landfill. Land use near the landfill is varied: land southeast of the landfill is primarily residential, land north and northwest of the landfill is primarily urban and industrial, and land southwest of the landfill is primarily undeveloped and wooded.

Bedrock underlying the landfill includes locally porphyritic metamorphosed quartz diorite, diorite, and tonalite (Goldsmith and others, 1982). Cardinell and others (1989) reported bedrock samples collected in the central part of the landfill, near wells YRWA and YRWB, showed a high degree of chemical weathering and that saprolite samples consisted primarily of silty clay, sandy clay, and silty sand. Samples collected near the depth of auger refusal were described as partially weathered bedrock, micaceous sand, or micaceous, sandy, clayey silt (Cardinell and others, 1989). Depth to bedrock ranges from about 17 ft below land surface (Law Engineering Testing Company, 1983) to about 63 ft below land surface at well YRWA (Cardinell and others, 1989). Depth to bedrock generally is less in the eastern and northeastern parts of the landfill than in the southern and western parts.

York Road landfill was operated as a municipal landfill from 1968 to 1986. Residential, commercial, and industrial wastes were disposed of using a combination of excavation-and-fill and ramp-disposal

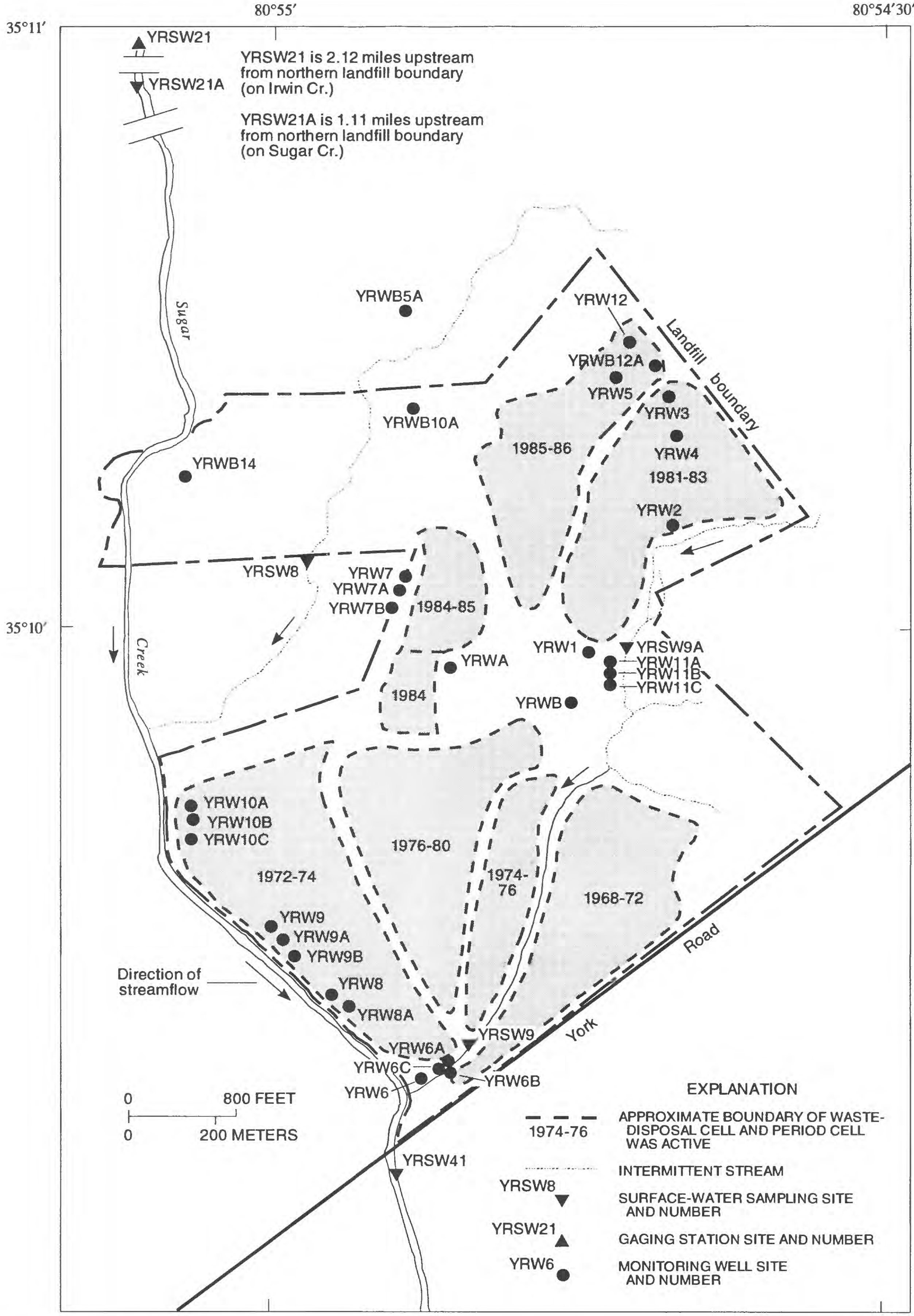

Figure 15. Waste-disposal cells and monitoring sites at the York Road landfill (modified from Smith, 1993).

methods (Cardinell and others, 1989). During 1971-86, an average of 1,200 tons of refuse per day was accepted (Smith, 1993). Landfilling operations began in the southern part of the site and progressed northward (fig. 15). Eight waste-disposal cells were constructed during operation of this landfill. Waste-disposal cells are above the water table and are unlined (Smith, 1993). A 6-in. soil cover was applied daily to refuse (Cardinell and others, 1989). Upon closure, a final 2-ft thick soil layer was placed over waste-disposal cells (Smith, 1993). The landfill is currently used as a recreational area and includes softball fields, tennis courts, and an 18-hole golf course.

The USGS began monitoring surface-water quality at York Road landfill in 1979 and ground-water quality in 1981. From 1981 to 1986, monitoring efforts primarily involved assessment of water-quality conditions in the northern half of the landfill. The monitoring network was expanded in 1986 and 1988 to include ground-water sites in the southern and western parts of the landfill. As part of the expansion, a series of well clusters, closely spaced wells with screened intervals at different depths, were installed (fig. 2). The expanded monitoring network included 6 surface-water sites and 30 ground-water sites. Approximate locations of these sites are shown in figure 15, and information about these sites is listed in tables 31 and 32.

Surface-water-monitoring sites YRSW21 on Sugar Creek and YRSW21A on Irwin Creek are about 2.1 and 1.1 mi upstream from the northern boundary of the landfill, respectively (fig. 15). Site YRSW8 is on an unnamed tributary to Sugar Creek in the northern part of the landfill. Sites YRSW9A and YRSW9 are on an unnamed tributary to Sugar Creek in the southern part of the landfill (fig. 15). Site YRSW9A is about 0.7 mi upstream from site YRSW9. Site YRSW41 is on Sugar Creek just below the southernmost tip of the landfill. York Road landfill occupies about 18 percent of Sugar Creek's drainage area between sites YRSW21A and YRSW41 (table 31). Continuous records of streamflow have been collected at site YRSW21 since water-quality monitoring at the landfill began, and have been published in USGS annual hydrologic data reports (U.S. Geological Survey, 1979-93).

Wells ranging in depth from 9.3 to 333 ft below land surface were used to monitor ground-water quality in the vicinity of the York Road landfill (table 32). The chemical quality of water from well YRWA (333 ft depth) is representative of ground-water conditions in bedrock, whereas water from the other wells is representative of conditions in regolith. Well clusters 6, 8, 9, and 10 were installed along the southwestern boundary of the landfill near Sugar Creek and downgradient from the older waste-disposal cells in the southern half of the landfill (fig. 15). Well cluster 11 was installed along the southern tributary to Sugar Creek, adjacent to site YRSW9A. Well cluster was installed in an upland area near the center of the landfill and downgradient from the central waste-disposal cells, which were active from 1984 to 1985 (fig. 15). Wells YRWA, YRW1, YRW2, and YRW3 are in the central and northern parts of the landfill, in or adjacent to waste-disposal cells which were active during 1981-86. Water-level recorders were installed to measure ground-water fluctuations at well YRWB, which is in an upland area in the central part of the landfill, and at well YRW6, which is in a valley at the mouth of the southern tributary near Sugar Creek (fig. 15).

Periodic water-level measurements were made in all wells. Water-level data from a network of borings (Law Engineering Testing Company, 1983) and from monitoring wells were used to construct a water-table elevation map (fig. 16). The direction of ground-water movement is primarily to the southwest with ground water discharging into the two tributaries and Sugar Creek. Thus, Sugar Creek and ground water adjacent to Sugar Creek downstream from the landfill are at the greatest risk of contamination from offsite migration of leachate. Water levels ranged from less than 1 ft below land surface at wells YRW11A and YRW9B, which are adjacent to streams, to more than 95 ft below land surface at well YRWA, which is in an upland area. The water table is within the regolith at most of the wells; however, along ridges, the water table is within bedrock. At well YRWA, bedrock is 68 ft below land surface (Cardinell and others, 1989), and water levels ranged from about 73 to 95.5 ft below land surface during this study. Similar situations exist north of the landfill where the upper part of the bedrock is in the unsaturated zone (Law Engineering Testing Company, 1983).

Table 31. Description of surface-water monitoring sites at the York Road landfill

[Location of sites shown in figure 15. USGS, U.S. Geological Survey; P, periodic sample collection; C, continuous discharge]

Stream	Mecklenburg County site number	USGS identification number	Date established	Drainage area (square miles)	Record type
Unnamed tributary to Sugar Creek	YRSW8	0214632330	Aug. 1979	0.37	P
Unnamed tributary to Sugar Creek	YRSW9	0214632340	Apr. 1980	1.02	P
Unnamed tributary to Sugar Creek	YRSW9A	0214632335	Oct. 1981	.87	P
Irwin Creek	YRSW21	02146300	Aug. 1969	30.7	C, P
Sugar Creek	YRSW21A	0214632322	Oct. 1981	38.0	P
Sugar Creek	YRSW41	0214632815	Apr. 1980	41.2	P

Table 32. Description of ground-water monitoring sites at the York Road landfill

[Location of sites shown in figure 15. Well depth, casing depth, and screen openings listed in feet below land surface. USGS, U.S. Geological Survey; PVC, polyvinyl chloride; --, no data]

Mecklenburg County site number	USGS identification number	Date installed	Well depth (feet)	Casing			Screen opening		Well use	Owner
				Type	Diameter (inches)	Depth (feet)	From (feet)	To (feet)		
YRWA	351026080544301	July 1970	333	Steel	6.25	45.0	No screen		Monitoring	City of Charlotte
YRW1	351028080543001	Nov. 1980	26.7	PVC	2	16.7	16.7	26.7	Monitoring	City of Charlotte
YRW2	351036080542301	Dec. 1980	16.8	PVC	2	6.8	6.8	16.8	Monitoring	City of Charlotte
YRW3	351046080542301	Nov. 1980	32.7	PVC	2	22.7	22.7	32.7	Monitoring	City of Charlotte
YRW4	351042080542501	Unknown	35.7	Iron	1.25	--	--	--	Domestic	City of Charlotte
YRW5	351047080542701	Unknown	--	--	--	--	--	--	Domestic	City of Charlotte
YRW6	351003080544201	Nov. 1984	24.5	PVC	4	19.5	19.5	24.5	Monitoring	City of Charlotte
YRW6A	351003080544202	June 1986	27.9	PVC	2	17.9	17.9	27.9	Monitoring	City of Charlotte
YRW6B	351003080544203	June 1986	18.3	PVC	2	8.3	8.3	18.3	Monitoring	City of Charlotte
YRW6C	351003080544204	June 1986	13.0	PVC	2	8.0	8.0	13.0	Monitoring	City of Charlotte
YRW7	351034080544701	Mar. 1988	23.1	PVC	2	18.1	18.1	23.1	Monitoring	City of Charlotte
YRW7A	351034080544702	Mar. 1988	17.0	PVC	2	12.0	12.0	17.0	Monitoring	City of Charlotte
YRW7B	351034080544703	Mar. 1988	28.4	PVC	2	23.4	23.4	28.4	Monitoring	City of Charlotte
YRW8	351003080545101	Mar. 1988	15.5	PVC	2	10.5	10.5	15.5	Monitoring	City of Charlotte
YRW8A	351003080545102	Mar. 1988	22.8	PVC	2	17.8	17.8	22.8	Monitoring	City of Charlotte
YRW9	351008080545901	Apr. 1988	22.0	PVC	2	17.0	17.0	22.0	Monitoring	City of Charlotte
YRW9A	351008080545902	Apr. 1988	26.5	PVC	2	21.5	21.5	26.5	Monitoring	City of Charlotte
YRW9B	351008080545903	Apr. 1988	15.8	PVC	2	10.8	10.8	15.8	Monitoring	City of Charlotte
YRW10A	351020080542601	Apr. 1988	22.3	PVC	2	17.3	17.3	22.3	Monitoring	City of Charlotte
YRW10B	351020080542602	Apr. 1988	20.0	PVC	2	15.0	15.0	20.0	Monitoring	City of Charlotte
YRW10C	351020080542603	Apr. 1988	16.5	PVC	2	11.5	11.5	16.5	Monitoring	City of Charlotte
YRW11A	351029080542801	Apr. 1988	14.8	PVC	2	9.8	9.8	14.8	Monitoring	City of Charlotte
YRW11B	351029080542802	Apr. 1988	19.8	PVC	2	14.8	14.8	19.8	Monitoring	City of Charlotte
YRW11C	351029080542803	Apr. 1988	9.3	PVC	2	4.3	4.3	9.3	Monitoring	City of Charlotte
YRWB	351023080542703	Sept. 1984	25.5	PVC	4	20.5	20.5	25.5	Monitoring	City of Charlotte
YRWB5A	351050080544901	Oct. 1982	32.0	PVC	2	22.0	22.0	32.0	Monitoring	City of Charlotte
YRWB10A	351046080544801	Nov. 1982	27.0	PVC	2	17.0	17.0	27.0	Monitoring	City of Charlotte
YRWB12	351052080543001	Oct. 1982	48.5	PVC	2	38.5	38.5	48.5	Monitoring	City of Charlotte
YRWB12A	351052080543002	Oct. 1982	40.5	PVC	2	30.5	30.5	40.5	Monitoring	City of Charlotte
YRWB14	351036080550501	Oct. 1982	49.5	PVC	2	39.5	39.5	49.5	Monitoring	City of Charlotte

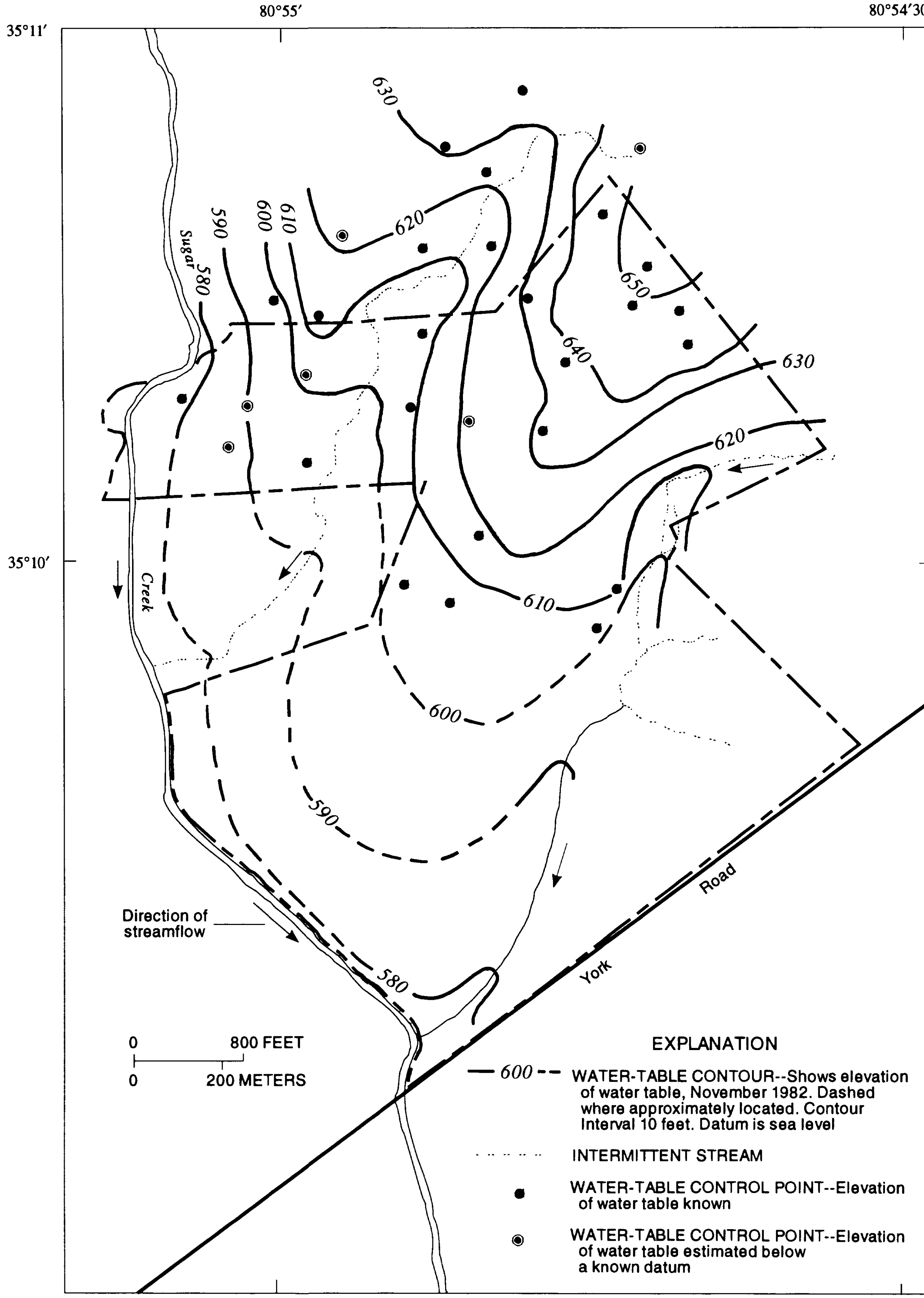

Figure 16. Elevation of the water table at the York Road landfill, November 1982 (modified from Cardinell and others, 1989).

Surface-Water Quality

Water samples from the tributaries generally indicated greater effects of leachate than samples from Sugar Creek. Water samples from the tributary which drains the northwestern part of the landfill (site YRSW8) generally were less affected by leachate than water samples from sites YRSW9 and YRSW9A, which are on the tributary that drains the southeastern part of the landfill. The median specific conductance for site YRSW8 was 145 μS/cm compared to median specific conductance of 240 μS/cm for site YRSW9A and 345 μS/cm for site YRSW9 (table 33). Median values for alkalinity, chloride, and manganese were more than two times larger for sites YRSW9 and YRSW9A than for site YRSW8 (table 33). Much of the drainage area of site YRSW8 is outside the landfill. Site YRSW9 is about 0.7 mi downstream from site YRSW9A and receives drainage from the oldest part of the landfill (fig. 15). Specific conductance and concentrations of constituents indicative of leachate generally were larger in samples from the downstream site, YRSW9, than in samples from the upstream site, YRSW9A (Smith, 1993). Median values for chemical-oxygen demand, biochemical-oxygen demand, and chloride were 2.4, 2.2, and 4 times larger for sites YRSW9 than YRSW9A (table 33). Median concentrations of iron and manganese also were larger for site YRSW9 (3,600 μg/L and 1,100 μg/L, respectively) than for site YRSW9A (1,400 μg/L and 750 μg/L, respectively) (table 33).

Differences in the effects of leachate on water quality in the tributaries are also indicated by the number of exceedences of Mecklenburg County action levels (table 34). The pH of surface-water samples from sites YRSW8, YRSW9, and YRSW9A commonly was less than the designated range of 6.5 to 8.5 units (tables 2 and 34). Action levels for iron and manganese were exceeded in all samples from these tributaries. No other constituents in water samples from sites YRSW8 and YRSW9A exceeded action levels; however, action levels for specific conductance, biochemical-oxygen demand, chloride, and total organic halogens were exceeded in samples from site YRSW9 (table 34).

Few samples were collected from the tributary sites for analysis of synthetic organic compounds (Smith, 1993). Pesticides and total organic halogens were the only groups of synthetic organic compounds for which samples were collected at all tributaries (table 35). The herbicides 2,4-D and 2,4-DP were detected in samples from all tributary sites. The maximum detected herbicide concentration was 0.30 μg/L of 2,4-D at site YRSW9A (table 35), which is more than 200 times less than the MCL of 70 μg/L (U.S. Environmental Protection Agency, 1993) for this compound. Herbicide applications upstream from the landfill or associated with recreational areas of the landfill are possible sources of these compounds. Total organic halogens were detected in almost all samples from sites YRSW8, YRSW9, and YRSW9A (table 35). No synthetic organic compounds were detected in samples collected at site YRSW9A in November 1992 even though several synthetic organic compounds were detected in samples collected from nearby wells (YRW11A, YRW11B, and YRW11C) the same day (Smith, 1993).

Comparison of surface-water samples from sites YRSW21 and YRSW21A (upstream from the landfill) with samples from site YRSW41 (downstream from the landfill) indicate little effect of the landfill on the chemical quality of Sugar Creek. Limited data are available for site YRSW21, which is located about 1 mi upstream from site YRSW21A. Median concentrations of most constituents are similar for sites YRSW21A and YRSW41 (table 33). However, median concentrations of iron (1,200 μg/L) and manganese (280 μg/L) for site YRSW41 are somewhat larger than median concentrations of iron (990 μg/L) and manganese (200 μg/L) at site YRSW21A, and possibly indicate effects of the landfill (table 33). However, results of paired T-tests indicated the differences in iron and manganese concentrations were not statistically significant ($p=0.10$). Thus, effects of the landfill on water quality of Sugar Creek are not apparent.

The chemical quality of water from Sugar Creek (sites YRSW21A and YRSW41) differed from that of the tributaries (sites YRSW8, YRSW9, and YRSW9A). Median values of specific conductance, pH, chemical-oxygen demand, biochemical-oxygen demand, sulfate, fluoride, arsenic, lead, zinc, and total organic carbon generally were larger for the Sugar Creek sites than for the tributaries (table 33). However, median concentrations of iron and manganese were 3 to 4 times larger for sites YRSW8 and YRSW9 than for sites YRSW21A and YRSW41. Exceedences of action levels for iron and manganese in samples from sites on Sugar Creek were similar to those for sites on the tributaries (table 34). Concentrations of iron and manganese exceeded action levels in almost all samples from Sugar Creek (sites YRSW21,

Table 33. Summary of selected surface-water quality data for the York Road landfill, 1986-92

[µS/cm, microsiemens per centimeter; mg/L, milligram per liter; <, less than; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; --, no data or insufficient data for computation of median; *, value calculated using a log-probability regression to estimate values below detection limits; cols/100 mL, colonies per 100 milliliters; µg/L, microgram per liter]

Constituent or property		YRSW8	YRSW9	YRSW9A	YRSW21	YRSW21A	YRSW41
Specific	Range	99-250	210-1,730	91-340	286-360	260-750	260-550
conductance	Median	145	345	240	294	463	420
(µS/cm)	Samples	13	17	15	3	16	19
pH, field	Range	6.1-6.9	5.8-7.5	6.3-7.6	7.1-7.7	6.5-7.5	6.3-7.4
(standard	Median	6.4	6.8	6.6	7.2	7.0	7.1
units)	Samples	13	17	15	3	16	19
Dissolved	Range	4.1-10.4	0.9-12.2	3.3-10.4	7.6-11.3	5.7-11.0	5.3-10.4
oxygen	Median	7.4	9.0	7.9	7.9	9.3	7.8
(mg/L)	Samples	12	16	14	3	15	18
Chemical-	Range	<5-19	<5-100	bdl-21	<5	23-60	bdl-52
oxygen demand	Median	9.0	17	7	--	32	30*
(mg/L)	Samples	7	10	8	1	10	12
Biochemical-	Range	0.7-2.8	1.3-10	0.3-1.7	2.6	1.3-19	1.7-18
oxygen	Median	0.9	1.8	0.8	--	7.0	8.3
demand (mg/L)	Samples	7	10	8	1	10	12
Fecal	Range	10	--	63,000	--	260	420-3,700
coliform	Median	--	--	--	--	--	1,400
(cols/100 mL)	Samples	1	0	1	0	1	3
Fecal	Range	9	--	<10	--	<10	45-1,100
streptococcus	Median	--	--	--	--	--	570
(cols/100 mL)	Samples	1	0	1	0	1	2
Alkalinity,	Range	23-67	75-361	23-121	69-98	33-131	39-121
field (mg/L	Median	46	98	80	85	81	72
as $CaCO_3$)	Samples	8	13	8	3	12	15
Sulfate	Range	3.5-13	9.3-16	3.8-12	20	22-32	20-44
(mg/L)	Median	6.8	9.8	5.3	--	28	26
	Samples	5	9	4	1	7	8
Chloride,	Range	4.2-19	1.3-440	0.5-11	23	19-110	19-73
dissolved	Median	6.2	36	9	--	38	34
(mg/L)	Samples	7	10	8	1	10	12
Fluoride,	Range	<0.2-0.3	bdl-0.2	bdl	0.3	0.3-1.0	0.3-1.1
total	Median	<0.2	<0.2	<0.2	--	0.6	0.6
(mg/L)	Samples	6	9	7	1	9	11
Aluminum,	Range	570-2,100	160-1,500	<100-1,700	220	230-5,100	<100-1,500
total	Median	1,400	550	260	--	700	790*
(µg/L)	Samples	6	9	5	1	9	11
Arsenic,	Range	<1-5	bdl-5	bdl	3	bdl-5.0	bdl-7
total	Median	<2	<1	<2	--	2.5*	3*
(µg/L)	Samples	7	10	8	1	10	12
Barium,	Range	<100-400	<100-900	<100-500	<100	<100-500	<100-500
total	Median	<100	<100	<100	--	<100	<100
(µg/L)	Samples	7	10	8	1	10	12
Cadmium,	Range	bdl	bdl	bdl	1	bdl	bdl-7
total	Median	<1	<1	<2	--	<2	<1
(µg/L)	Samples	7	10	8	1	10	12
Chromium,	Range	bdl-18	bdl-14	bdl-25	19	bdl-21	bdl-24
total	Median	3*	2*	4*	--	6*	5.5*
(µg/L)	Samples	7	10	8	1	10	12
Copper,	Range	bdl	bdl-60	bdl	<50	bdl-60	<50-60
total	Median	<50	<50	<50	--	<50	<50
(µg/L)	Samples	7	10	8	1	10	12
Iron,	Range	1,700-5,700	2,600-80,000	1,300-3,500	870	660-9,100	610-1,700
total	Median	3,700	3,600	1,400	--	990	1,200
(µg/L)	Samples	7	10	8	1	10	12
Lead,	Range	bdl-8	2-36	2-6	3	2-38	bdl-69
total	Median	2*	3	2.4*	--	12	13*
(µg/L)	Samples	7	10	8	1	10	12
Manganese,	Range	110-1,000	550-11,000	360-1,600	250	80-470	120-570
total	Median	390	1,100	750	--	200	280
(µg/L)	Samples	7	10	8	1	10	12
Mercury,	Range	bdl	<0.10-0.40	bdl	<0.20	bdl-1.5	bdl-2.1
total	Median	bdl	<0.20	<0.20	--	<0.20	bdl
(µg/L)	Samples	7	10	8	1	10	12
Zinc,	Range	20-110	bdl-160	bdl-100	70	70-340	40-510
total	Median	80	65*	<50	--	180	140
(µg/L)	Samples	7	10	8	1	10	12
Organic	Range	3.1-4.9	2.1-7.0	1.8-4.9	--	7.9-15	6.8-15
carbon, total	Median	4.8	4.9	2.8	--	11	11
(mg/L)	Samples	3	4	4	0	4	5

Table 34. Summary of constituents and properties exceeding or outside of ranges designated by Mecklenburg County action levels in surface-water samples from the York Road landfill 1986-92

[µS/cm, microsiemens per centimeter; --, no data; mg/L, milligram per liter; µg/L, microgram per liter]

Constituent or property		YRSW8	YRSW9	YRSW9A	YRSW21	YRSW21A	YRSW41
Specific	Exceedences	0	1	0	0	0	0
conductance	Samples	13	17	15	3	16	19
(µS/cm)	Maximum	--	1,720	--	--	--	--
pH,	Exceedences	7	6	6	0	3	2
field	Samples	13	17	15	1	16	19
(standard	Minimum	6.1	5.8	6.3	--	6.5	6.3
units)	Maximum	--	--	--	--	--	--
Chemical-	Exceedences	0	3	0	0	7	9
oxygen demand	Samples	7	10	8	1	10	12
(mg/L)	Maximum	--	100	--	--	60	52
Biochemical-	Exceedences	0	2	0	0	6	7
oxygen demand	Samples	7	10	8	1	10	12
(mg/L)	Maximum	--	10	--	--	19	18
Chloride,	Exceedences	0	1	0	0	0	0
dissolved	Samples	7	10	8	1	10	12
(mg/L)	Maximum	--	440	--	--	--	--
Nitrate as N,	Exceedences	0	0	0	0	1	1
total	Samples	5	8	7	1	8	10
(mg/L)	Maximum	--	--	--	--	16	14
Cadmium,	Exceedences	0	0	0	0	0	1
total	Samples	7	10	8	1	10	12
(µg/L)	Maximum	--	--	--	--	--	7
Iron,	Exceedences	7	10	8	1	10	12
total	Samples	7	10	8	1	10	12
(µg/L)	Maximum	5,700	80,000	3,500	870	9,100	1,700
Lead,	Exceedences	0	0	0	0	0	1
total	Samples	7	10	8	1	10	12
(µg/L)	Maximum	--	--	--	--	--	69
Manganese,	Exceedences	7	10	8	1	9	12
total	Samples	7	10	8	1	10	12
(µg/L)	Maximum	1,000	11,000	1,600	250	470	570
Mercury,	Exceedences	0	0	0	0	1	1
total	Samples	7	10	8	1	10	12
(µg/L)	Maximum	--	--	--	--	1.5	2.1
Organic	Exceedences	0	0	0	--	2	3
carbon, total	Samples	3	4	4	0	4	5
(mg/L)	Maximum	--	--	--	--	15	15
Organic	Exceedences	0	1	0	--	2	3
halogens,	Samples	5	5	7	0	5	6
total (mg/L)	Maximum	--	0.11	--	--	0.17	0.12

Table 35. Summary of synthetic organic compounds detected in surface-water samples from the York Road landfill, 1986-92

[mg/L, milligram per liter; Max. detected, maximum concentration detected; µg/L, microgram per liter; --, not detected]

Total organic halogens (mg/L)		YRSW8	YRSW9	YRSW9A	YRSW21A	YRSW41
	Samples	5	5	7	5	6
	Detections	4	5	5	5	6
	Max. detected	0.03	0.11	0.02	0.17	0.12

Pesticides (µg/L)		YRSW8	YRSW9	YRSW9A	YRSW21A	YRSW41
Perthane,	Samples	1	2	2	4	4
total	Detections	0	0	0	0	0
	Max. detected	--	--	--	--	--
2,4-D,	Samples	1	2	2	4	4
total	Detections	1	1	1	4	4
	Max. detected	0.03	0.02	0.30	12	0.11
2,4-DP,	Samples	1	2	2	4	4
total	Detections	1	1	1	1	1
	Max. detected	0.12	0.04	0.01	0.02	0.03
2,4,5-T,	Samples	1	2	2	4	4
total	Detections	0	0	0	0	1
	Max. detected	--	--	--	--	0.01

Halogenated aliphatic compounds (µg/L)		YRSW9A	YRSW21A	YRSW41
Methyl	Samples	2	2	2
chloride,	Detections	0	0	0
total	Max. detected	--	--	--
Chlorodibromo-	Samples	2	2	2
methane,	Detections	0	1	1
total	Max. detected	--	0.2	0.2

Table 35. Summary of synthetic organic compounds detected in surface-water samples from the York Road landfill, 1986-92--Continued

[mg/L, milligram per liter; Max. detected, maximum concentration detected; µg/L, microgram per liter; --, not detected]

Halogenated aliphatic compounds (µg/L)--Continued		YRSW9A	YRSW21A	YRSW41
Dichlorobromo-methane, total	Samples	2	2	2
	Detections	0	1	1
	Max. detected	--	0.5	0.4
Methylene chloride, total	Samples	2	2	2
	Detections	0	1	0
	Max. detected	--	0.2	--
Chloroform, total	Samples	2	2	2
	Detections	0	2	2
	Max. detected	--	1.0	0.8
Dichlorodifluoro-methane, total	Samples	0	2	2
	Detections	--	0	0
	Max. detected	--	--	--
Trichlorofluoro-methane, total	Samples	0	2	2
	Detections	--	0	0
	Max. detected	--	--	--
Vinyl chloride, total	Samples	2	2	2
	Detections	0	0	0
	Max. detected	--	--	--
Chloroethane, total	Samples	2	2	2
	Detections	0	0	0
	Max. detected	--	--	--
1,1-Dichloro-ethane, total	Samples	2	2	2
	Detections	0	0	0
	Max. detected	--	--	--
1,2-Dichloro-ethane, total	Samples	2	2	3
	Detections	0	1	1
	Max. detected	--	0.8	0.3
1,1,1-Trichloro-ethane, total	Samples	2	2	2
	Detections	0	0	0
	Max. detected	--	--	--
1,1,2,2-Tetra-chloroethane, total	Samples	2	2	2
	Detections	0	0	0
	Max. detected	--	--	--
trans-1,2-Dichloroethylene, total	Samples	0	2	2
	Detections	--	1	1
	Max. detected	--	0.2	0.2
1,1-Dichloro-ethylene, total	Samples	2	2	2
	Detections	0	0	0
	Max. detected	--	--	--
1,2-Dichloro-ethylene, total	Samples	2	0	0
	Detections	0	--	--
	Max. detected	--	--	--
Trichloro-ethylene, total	Samples	2	2	2
	Detections	0	1	1
	Max. detected	--	0.3	0.2
Tetrachloro-ethylene, total	Samples	2	2	2
	Detections	0	2	2
	Max. detected	--	1.0	0.9

Aromatic compounds (µg/L)		YRSW9A	YRSW21A	YRSW41
Benzene, total	Samples	2	2	2
	Detections	0	0	0
	Max. detected	--	--	--
Toluene, total	Samples	2	2	2
	Detections	0	1	1
	Max. detected	--	1.4	0.9

Ketones and phthalates (µg/L)		YRSW9	YRSW9A	YRSW21A	YRSW41
Methyl-isobutyl ketone, total	Samples	0	2	2	2
	Detections	--	0	0	0
	Max. detected	--	--	--	--
Bis(2-ethylhexyl) phthalate, total	Samples	1	3	2	3
	Detections	0	0	0	0
	Max. detected	--	--	--	--
Diethyl-phthalate, total	Samples	1	3	2	3
	Detections	0	0	0	0
	Max. detected	--	--	--	--
Dibutyl phthalate, total	Samples	1	3	2	3
	Detections	0	0	0	0
	Max. detected	--	--	--	--

YRSW21A, and YRSW41). Chemical-oxygen demand, biochemical-oxygen demand, total organic carbon, and total organic halogen concentrations in samples from Sugar Creek commonly exceeded action levels. Action levels for nitrate, cadmium, lead, and mercury also were exceeded in some samples from Sugar Creek during 1986-92 (table 34).

Many more synthetic organic compounds were detected in water samples from Sugar Creek than from tributaries in the landfill (table 35). In addition to total organic halogens and the herbicides 2,4-D and 2,4-DP, which also were detected in water samples from the tributaries, trihalomethanes and various volatile and semivolatile organic compounds were detected in samples from Sugar Creek (table 35). Concentrations of synthetic organic compounds generally were detected at concentrations at least several times less than the MCL. Similarities in the frequency of detection and in the concentrations at which synthetic organic compounds were detected in water samples from Sugar Creek, upstream and downstream from the landfill, indicate the landfill is not a significant source of these compounds.

The seasonal Kendall test was used to evaluate trends in water quality at surface-water sites. As noted in table 36, concentrations of some constituents were adjusted for streamflow for trend analysis of data from sites YRSW21A and YRSW41. Data from other sites were not adjusted for streamflow.

Water-table elevations (fig. 16) indicate that the tributary on which site YRSW8 is located receives drainage from the northernmost waste-disposal cell, which was active during 1985-86. Water-quality data from site YRSW8 indicate an increasing trend in specific conductance (7 μS/cm/yr) and a decreasing trend in biochemical-oxygen demand (-0.1 mg/L/yr) during 1979-91. Data from site YRSW8 indicate no distinct trend in specific conductance before 1985; however, specific conductance at this site generally increased after 1985 (Smith, 1993). The increase in specific conductance that occurred at site YRSW8 after 1985 probably was the result of increased inflow of leachate. Changes in land use upstream from the landfill could have contributed to the decreasing trend in biochemical-oxygen demand detected for site YRSW8.

Data collected from 1981 to 1992 at site YRSW9A (Smith, 1993) indicate increasing trends in specific conductance (7 μS/cm/yr) and chloride (0.42 mg/L/yr). However, water-quality data from site YRSW9, which is about one-half mile downstream from site YRSW9A, indicate a decreasing trend in biochemical-oxygen demand (-0.25 mg/L/yr). No statistically significant trends in specific conductance and chloride concentrations were detected (table 36). Water quality at site YRSW9 is affected by leachate from the older, southern waste-disposal cells as well as from the more recently constructed northern waste-disposal cells (figs. 15 and 16).

Statistically significant decreasing trends in chemical-oxygen demand and ammonia concentration were detected for sites YRSW21A and YRSW41 (table 36). The average rate of change in chemical-oxygen demand was -2.1 mg/L/yr for site YRSW21A from 1981 to 1991 and -4.0 mg/L/yr for site YRSW41 from 1980 to 1991. The average rate of change in ammonia concentration was -1.2 mg/L/yr for site YRSW21A from 1986 to 1991 and -0.75 mg/L/yr for site YRSW41 from 1981 to 1990. Because trends in chemical-oxygen demand and ammonia were similar for sites upstream and downstream from the landfill, these changes appear to be caused by upstream changes in land use and are probably unrelated to the landfill. An increasing trend in iron concentration was detected for site YRSW41 (74 μg/L/yr); however, no corresponding trend was detected for site YRSW21A (table 36). Iron is considered an indicator of leachate (Baedecker and Back, 1979; Cardinell and others, 1989), and large concentrations of iron were present in samples from sites YRSW8 and YRSW9, which are on tributaries to Sugar Creek (Smith, 1993). Increased inflow of iron from the tributaries and from ground-water seepage into Sugar Creek may have contributed to the increasing trend in iron concentration detected for site YRSW41.

Ground-Water Quality

The chemical quality of ground water at the York Road landfill varied with respect to location, well depth, and time. No offsite wells were sampled during 1986-92. However, water samples collected in 1984 from boring YRWB5A, which is north of the landfill, and borings YRWB10A and YRWB14, which are along the northern and western boundaries of the landfill, probably are representative of background water-quality conditions. Values of selected constituents and properties of samples from borings YRWB5A, YRWB10A, and YRWB14 ranged from <50 to 88 μS/cm for specific conductance; <5 mg/L for chemical-oxygen demand; 23 to 56 mg/L for alkalinity; 2.5 to 5.6 mg/L for chloride; and 1.2 to 2.5 mg/L for total organic carbon (Cardinell and others, 1989; Smith, 1993). No data for iron and manganese were available for the samples from these borings.

Table 36. Summary of seasonal Kendall trend test results for selected surface-water quality data from the York Road landfill, 1979-92

[Only results significant at a probability level of 0.10 are shown. p, probability level; *, trend tests were made but trends were not significant; Slope, trend slope expressed in units per year; --, data inadequate for analysis; μS/cm, microsiemens per centimeter; % median, slope expressed as a percentage of the seasonal median; n, number of observations; Record, period of record; mg/L, milligram per liter; μg/L, microgram per liter]

Constituent or property		YRSW8	YRSW9	YRSW9A	YRSW21A	YRSW41
Specific conductance (μS/cm)	p	0.005	*	0.004	*	*
	Slope	7	--	7	--	--
	% median	5.6	--	3.5	--	--
	n	27	35	29	33	38
	Record	1979-91	1979-91	1981-92	1981-93	1980-91
pH, field (standard units)	p	*	0.086	*	*	*
	Slope	--	0.06	--	--	--
	% median					
	n	26	34	28	32	38
	Record	1971-91	1979-91	1981-92	1982-91	1980-91
Chemical-oxygen demand (mg/L)	p	*	*	*	0.044[a]	0.008[a]
	Slope	--	--	--	-2.1	-4.0
	% median	--	--	--	-5.8	-12.1
	n	20	27	20	24	29
	Record	1979-91	1979-91	1981-92	1981-91	1980-91
Biochemical-oxygen demand (mg/L)	p	0.018	0.097	*	*	*
	Slope	-0.1	-0.25	--	--	--
	% median	-5.0	-8.2	--	--	--
	n	20	27	20	24	29
	Record	1979-91	1979-92	1981-92	1981-91	1980-91
Alkalinity, total (mg/L as $CaCO_3$)	p	*	*	*	*	*
	Slope	--	--	--	--	--
	% median	--	--	--	--	--
	n	20	29	23	28	35
	Record	1979-90	1979-90	1981-92	1981-90	1980-90
Sulfate (mg/L)	p	*	*	*	*	*
	Slope	--	--	--	--	--
	% median	--	--	--	--	--
	n	17	21	15	18	20
	Record	1983-91	1983-91	1983-92	1983-91	1983-91
Chloride, dissolved (mg/L)	p	*	*	0.035	*	*
	Slope	--	--	0.42	--	--
	% median	--	--	6.0	--	--
	n	20	26	21	24	29
	Record	1979-91	1979-91	1981-92	1981-91	1980-91
Ammonia (mg/L as N)	p	--	--	--	0.055[a]	0.077[a]
	Slope	--	--	--	-1.2	-0.75
	% median	--	--	--	-26.7	-50
	n	6	9	5	9	13
	Record	1986-90	1986-90	1986-91	1986-91	1981-90
Iron, total (μg/L)	p	*	*	*	*	0.050[a]
	Slope	--	--	--	--	74
	% median	--	--	--	--	7.5
	n	17	24	20	23	28
	Record	1983-91	1981-91	1981-92	1981-91	1980-91
Manganese, total (μg/L)	p	*	*	*	*	*
	Slope	--	--	--	--	--
	% median	--	--	--	--	--
	n	17	24	20	23	28
	Record	1983-91	1981-91	1981-92	1981-91	1980-91

[a]Data adjusted for streamflow.

Specific conductance, chemical-oxygen demand, alkalinity, and total organic carbon generally were much larger in samples collected from onsite monitoring wells during 1986-92 than the background values (table 37, p. 105). Specific conductance, chemical-oxygen demand, alkalinity, chloride, and total organic carbon in water samples collected from onsite monitoring wells during 1986-92 ranged from 45 to 3,000 µS/cm for specific conductance; <5 to 2,700 mg/L for chemical-oxygen demand; 20 to 1,470 mg/L for alkalinity; 0.8 to 320 mg/L for chloride; and from 0.2 to 92 mg/L for total organic carbon (table 37). Values for these constituents and properties in water from well YRWA, which taps bedrock and is the deepest monitoring well at 333 ft below land surface, were similar to background levels.

Water samples from well YRW1, at the toe of the northeastern waste-disposal cell (fig. 15), generally had larger values for indicator constituents and properties than samples from other wells (table 37). As a result, well YRW1 appears to be the well most affected by leachate. Median values for samples from well YRW1 include 1,400 µS/cm for specific conductance; 180 mg/L for chemical-oxygen demand; 743 mg/L for alkalinity; and 53 mg/L for total organic carbon. Well YRW10A, on the bank of Sugar Creek near the mouth of the northern tributary (fig. 15), had the largest median concentration of chloride, 220 mg/L. Well YRW10C, adjacent to well YRW10A, had the largest median concentration of iron, 120,000 µg/L. Well YRW11A, which is downgradient from the northeastern disposal cell, had the largest median concentration of manganese 8,300 µg/L (table 37). The concentration of iron in all ground-water samples exceeded the Mecklenburg County action level of 300 µg/L (tables 2 and 38). The concentration of manganese in nearly all ground-water samples exceeded the action level of 50 µg/L. The pH of ground-water samples generally was less than the 6.5 to 8.5 range designated as acceptable by the Mecklenburg County Engineering Department (tables 2 and 38). Total organic carbon and chemical-oxygen demand commonly exceeded action levels in samples from wells YRW6B, YRW6C, YRW8, YRW9B, YRW10A, YRW10B, and YRW10C, which are in the southwestern part of the landfill near Sugar Creek. The concentration of total organic halogens commonly exceeded action levels in samples from wells YRWA, YRW1, YRW6C, YRW7, YRW11A, YRW11B, and YRW11C, which, except for well YRW6C, are in the central part of the landfill (table 38).

Ground-water quality of samples from the well clusters showed large differences with respect to well depth (Smith, 1993). Wells in stream valleys, especially the shallowest well in each cluster, showed greater variability in water quality than wells in upland parts of the landfill. For example, in well cluster 6, which is near the mouth of the eastern tributary to Sugar Creek, variation in the specific conductance of water from the shallowest well, YRW6C, was about 10 times greater than variation in the specific conductance of water from the deepest well, YRWB (fig. 17). Less variation in specific conductance occurred in samples from wells in cluster 7, which is in an upland area, than in samples from wells in cluster 6 (fig. 17). Specific conductance in water from the shallowest well in cluster 7, YRW7A (17.0 ft deep), ranged from 100 to 160 µS/cm compared to 96 to 185 µS/cm for the deepest well, YRW7B (28.4 ft deep).

Comparison of water-level hydrographs from recording well YRW6, which is in a stream valley near Sugar Creek in the southern part of the landfill, and well YRWB, which is in an upland area in the central part of the landfill, shows differences in water-level response to precipitation as illustrated for 1988-89 by figure 17. Water levels in well YRWB show less fluctuation than in well YRW6 (fig. 17). Water-levels in well YRW6 ranged from 0.93 to 8.49 ft below land surface (elevation 578-585 ft above sea level) during 1986-92, whereas water levels in well YRWB ranged from 13.40 to 16.49 ft below land surface (elevation 596-599 ft above sea level) during 1984-91.

During high streamflow, water from Sugar Creek can recharge alluvial deposits (fig. 3). Differences between recharge characteristics of alluvial soils at sites along Sugar Creek and of soils at upland sites probably contributed to the variations in water quality observed for these sites. Infiltration of precipitation or surface water during high flow would dilute ground water thereby decreasing concentrations of most constituents. This is consistent with data for well cluster 6 where specific conductance generally decreased as water levels rose (fig. 17; Smith, 1993).

Data for the well clusters indicated no consistent patterns in water quality with respect to depth (Smith, 1993). The median values of chemical-oxygen demand and alkalinity for well clusters 6, 8, and 9 generally were smallest in the deepest well and largest in the shallowest well; whereas, the median values of chemical-oxygen demand and alkalinity were smallest in the shallowest well (table 37). Median iron concentrations generally were larger for the shallowest

Table 38. Summary of constituents and properties exceeding or outside of ranges designated by Mecklenburg County action levels in ground-water samples from the York Road landfill, 1986-92

[µS/cm, microsiemens per centimeter; --, no data; mg/L, milligram per liter; >, greater than; µg/L, microgram per liter]

Constituent or property		YRWA	YRW1	YRW2	YRW3	YRW6	YRW6A	YRW6B	YRW6C	YRW7	YRW7A	YRW7B	YRW8
Specific conductance (µS/cm)	Exceedences	0	10	0	0	0	0	6	7	0	0	0	0
	Samples	4	11	8	8	2	21	18	18	11	11	14	17
	Maximum	--	3,000	--	--	--	--	1,130	1,350	--	--	--	--
pH, field (standard units)	Exceedences	4	6	7	7	2	15	13	9	11	9	12	12
	Samples	4	11	8	7	2	20	17	16	11	9	13	12
	Minimum	6.0	5.9	5.6	5.0	6.2	5.9	6.1	5.5	5.5	5.5	5.6	5.6
	Maximum	--	--	--	--	--	--	--	--	--	--	--	--
Chemical-oxygen demand (mg/L)	Exceedences	0	4	0	0	0	0	5	6	1	0	0	4
	Samples	3	5	5	5	2	8	8	8	5	4	9	7
	Maximum	--	2,700	--	--	--	--	48	99	41	--	--	61
Biochemical-oxygen demand (mg/L)	Exceedences	0	4	0	1	0	1	2	3	2	0	2	2
	Samples	3	5	5	5	2	10	8	10	5	4	9	7
	Maximum	--	>510	--	17	--	8.1	13	>7.2	8.3	--	6.3	6.6
Chloride, dissolved (mg/L)	Exceedences	0	0	0	0	0	0	0	0	0	0	0	0
	Samples	3	5	6	5	2	8	8	8	5	4	9	7
	Maximum	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic, total (µg/L)	Exceedences	0	0	0	0	--	0	0	0	0	0	0	4
	Samples	1	1	1	1	0	5	6	5	5	5	9	7
	Maximum	--	--	--	--	--	--	--	--	--	--	--	240
Barium, total (µg/L)	Exceedences	0	0	0	0	--	1	0	1	1	1	0	0
	Samples	1	1	1	1	0	5	6	5	5	5	9	7
	Maximum	--	--	--	--	--	1,400	--	2,000	1,400	1,500	--	--
Chromium, total (µg/L)	Exceedences	0	0	1	0	--	0	1	1	1	1	0	3
	Samples	1	1	1	1	0	5	6	5	5	5	9	7
	Maximum	--	--	410	--	--	--	73	130	70	120	--	250
Iron, total (µg/L)	Exceedences	1	1	1	1	--	5	6	5	5	5	9	7
	Samples	1	1	1	1	0	5	6	5	5	5	9	7
	Maximum	5,100	150,000	25,000	8,500	--	82,000	81,000	86,000	72,000	230,000	11,000	200,000
Lead, total (µg/L)	Exceedences	1	0	1	0	--	0	0	1	0	2	0	2
	Samples	1	1	1	1	0	5	6	5	5	5	9	7
	Maximum	84	--	84	--	--	--	--	66	--	97	--	81
Manganese, total (µg/L)	Exceedences	1	1	1	1	--	5	6	5	5	5	8	7
	Samples	1	1	1	1	0	5	6	5	5	5	9	7
	Maximum	290	35,000	1,800	2,300	--	1,300	4,600	2,200	500	1,800	150	1,900
Mercury, total (µg/L)	Exceedences	0	0	0	0	--	0	0	0	0	0	0	1
	Samples	1	1	1	1	0	5	6	5	5	5	9	7
	Maximum	--	--	--	--	--	--	--	--	--	--	--	1.5
Organic carbon, total (mg/L)	Exceedences	0	4	0	1	--	2	6	7	0	0	0	4
	Samples	2	4	3	2	0	10	8	7	3	3	4	5
	Maximum	--	80	--	23	--	20	17	21	--	--	--	26
Organic halogens, total (mg/L)	Exceedences	1	2	0	0	--	0	1	3	2	0	1	0
	Samples	3	2	3	2	0	8	7	6	5	5	5	5
	Maximum	0.32	0.64	--	--	--	--	0.24	0.33	0.11	--	0.13	--

Table 38. Summary of constituents and properties exceeding or outside of ranges designated by Mecklenburg County action levels in ground-water samples from the York Road landfill, 1986-92--Continued

[µS/cm, microsiemens per centimeter; --, no data; mg/L, milligram per liter; >, greater than; µg/L, microgram per liter]

Constituent or property		YRW8A	YRW9	YRW9A	YRW9B	YRW10A	YRW10B	YRW10C	YRW11A	YRW11B	YRW11C	YRWB12
Specific conductance (µS/cm)	Exceedences	0	0	0	0	7	3	0	0	0	0	0
	Samples	12	9	10	11	13	12	11	11	14	10	3
	Maximum	--	--	--	--	1,540	1,020	--	--	--	--	--
pH, field (standard units)	Exceedences	7	8	5	9	12	5	11	10	12	10	3
	Samples	11	10	11	11	13	11	11	10	13	10	3
	Maximum	6.0	6.2	6.1	5.8	6.0	6.2	6.0	5.7	5.2	5.3	5.9
		--	--	--	--	--	--	--	--	--	--	--
Chemical-oxygen demand (mg/L)	Exceedences	0	0	0	6	8	5	6	2	2	1	0
	Samples	6	5	6	7	8	5	6	5	8	4	2
	Maximum	--	--	--	50	140	80	100	53	29	37	--
Biochemical-oxygen demand (mg/L)	Exceedences	1	1	2	1	6	3	6	3	1	0	0
	Samples	6	5	6	7	8	5	6	5	8	4	2
	Maximum	11	12	9.2	5.9	>20	16	20	15	6.7	--	--
Chloride, dissolved (mg/L)	Exceedences	0	0	0	0	3	0	0	0	0	0	0
	Samples	6	5	6	7	8	5	6	5	8	5	2
	Maximum	--	--	--	--	320	--	--	--	--	--	--
Arsenic, total (µg/L)	Exceedences	1	0	0	1	0	0	0	0	0	0	0
	Samples	6	5	6	7	8	5	6	5	8	4	1
	Maximum	72	--	--	170	--	--	--	--	--	--	--
Barium, total (µg/L)	Exceedences	1	1	0	1	2	1	1	1	1	1	0
	Samples	6	5	6	7	8	5	6	5	8	5	1
	Maximum	2,000	1,400	--	3,200	4,300	3,000	5,600	1,000	1,500	1,200	--
Chromium, total (µg/L)	Exceedences	3	1	1	2	1	0	2	0	0	2	0
	Samples	6	5	6	7	8	5	6	5	8	5	1
	Maximum	440	86	90	1,400	68	--	64	--	--	120	--
Iron, total (µg/L)	Exceedences	6	5	6	7	8	5	6	5	8	5	1
	Samples	6	5	6	7	8	5	6	5	8	5	1
	Maximum	190,000	39,000	52,000	340,000	100,000	120,000	190,000	85,000	23,000	209,000	3,100
Lead, total (µg/L)	Exceedences	1	0	0	1	0	0	0	0	0	1	0
	Samples	6	5	6	7	8	5	6	5	8	5	1
	Maximum	150	--	--	87	--	--	--	--	--	110	--
Manganese, total (µg/L)	Exceedences	5	5	6	7	8	5	6	5	8	5	1
	Samples	6	5	6	7	8	5	6	5	8	5	1
	Maximum	11,000	840	620	22,000	5,900	6,400	7,400	12,000	15,000	14,000	320
Mercury, total (µg/L)	Exceedences	0	0	0	2	0	0	0	0	0	0	0
	Samples	6	5	6	7	8	5	4	5	8	5	1
	Maximum	--	--	--	2.6	--	--	--	--	--	--	--
Organic carbon, total (mg/L)	Exceedences	1	0	0	2	6	5	3	0	0	1	0
	Samples	3	3	4	6	6	5	3	3	6	3	2
	Maximum	20	--	--	92	28	67	47	--	--	10	--
Organic halogens, total (mg/L)	Exceedences	0	0	0	1	1	0	0	2	3	2	0
	Samples	5	5	5	5	6	4	6	5	5	5	2
	Maximum	--	--	--	0.10	0.10	--	--	0.29	0.33	0.16	--

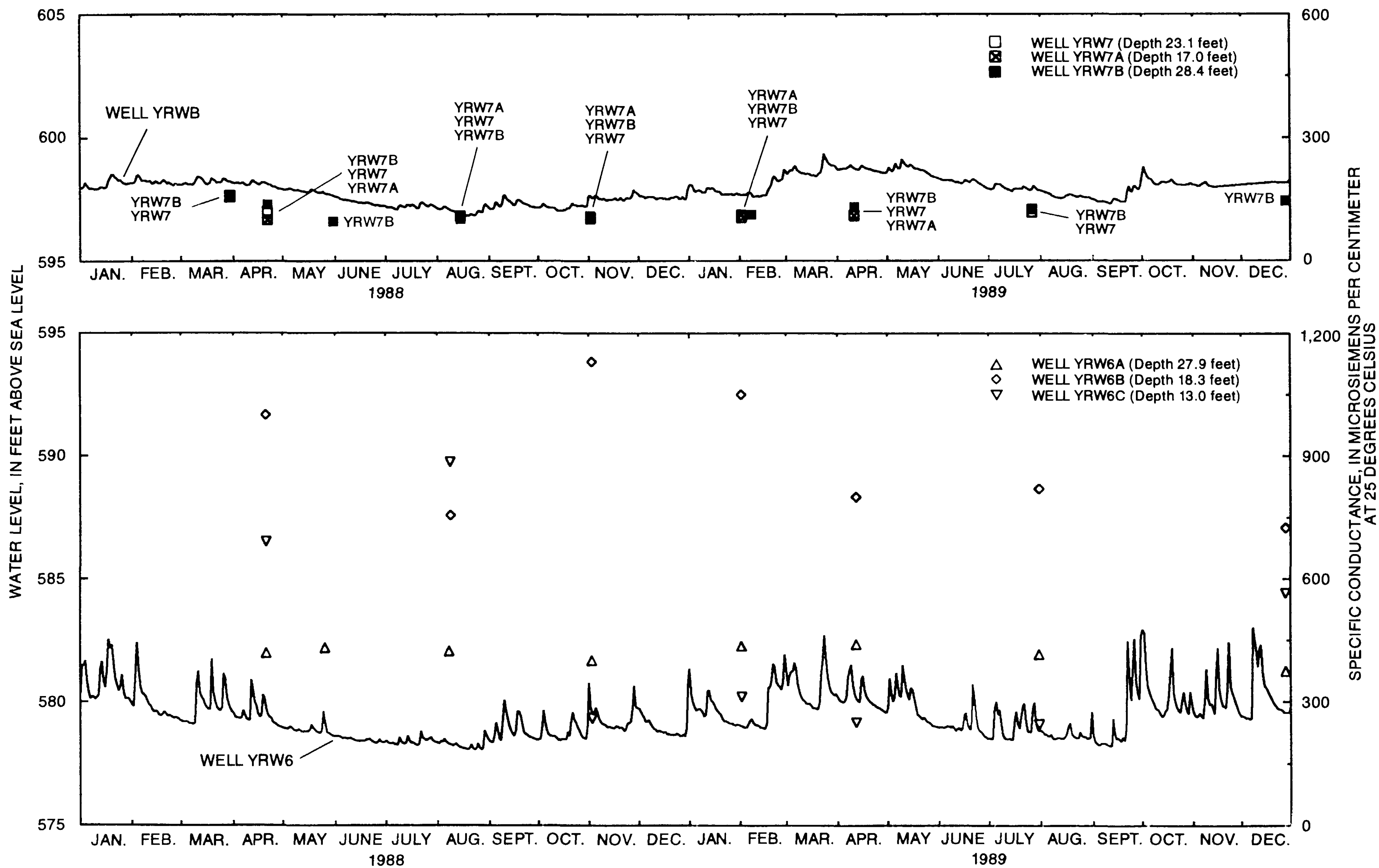

Figure 17. Mean daily water-level elevations for monitoring wells YRWB and YRW6, and specific conductance of water samples from York Road well clusters 6 and 7, 1988-89.

and intermediate depth wells than for the deepest well in well clusters near Sugar Creek (clusters 6, 8, 9, and 10). For well clusters 7 and 11, median concentrations of iron and manganese were largest for the shallowest well in cluster 7 and the well of intermediate depth in cluster 11 (table 38). These variations in water quality with respect to well depth are possibly related to the elevation of the leachate source and to depth-related differences in flow path (fig. 4), microbial activity, and redox conditions in the regolith. Among wells near Sugar Creek, the effects of leachate appear to be largest at well clusters 6 and 10, which are at the mouth of the tributaries. The water-table map (fig. 16) indicates ground water discharges into the tributaries. Thus, movement of leachate from waste-disposal cells toward the tributaries and Sugar Creek has probably contributed to the large concentrations of indicator constituents observed in well clusters 6 and 10.

The relative effects of leachate on ground water indicated by inorganic constituents were similar to those indicated by the distribution of synthetic organic compounds (tables 37 and 39, p. 105 and 109, respectively). Concentrations of methylene chloride, 1,2-dichloroethylene, trichloroethylene, tetrachloroethylene, vinyl chloride, and bis(2-ethylhexyl) phthalate in samples from several wells exceeded MCL's. Total organic halogen concentrations also exceeded the Mecklenburg County action level of 0.1 mg/L in samples from many wells (table 38). Of the wells adjacent to streams (fig. 15), samples from wells in clusters 6 and 10 generally contained the largest amounts of synthetic organic compounds (table 39). More synthetic organic compounds were detected in water samples from wells in clusters 11, 7, and 10 than in samples from other monitoring wells (table 39). Concentrations of synthetic organic compounds at these clusters differed with respect to well depth. Differences in concentrations of selected synthetic organic compounds with respect to well depth are shown for well clusters 7 and 11 in figures 18 and 19. The concentration of methylene chloride in one sample from well YRW10C, 22 μg/L, exceeded the MCL of 5 μg/L (Smith, 1993). Other compounds detected in water samples from well cluster 10 included chloroethane, 1,1-dichloroethane, benzene, toluene, and bis(2-ethylhexyl) phthalate, none of which exceeded MCL's (table 39).

Samples from wells in clusters 7 and 11 generally contained the largest amounts of synthetic organic compounds (table 39). Data for well cluster 7 indicated the largest concentrations of synthetic organic compounds were in samples from the intermediate depth well, YRW7 (fig. 18). Methylene chloride and tetrachloroethylene were detected in samples from well cluster 7 at concentrations above the MCL of 5 μg/L established for these compounds (U.S. Environmental Protection Agency, 1993). Samples from well cluster 11 showed a different pattern of distribution with respect to depth than cluster 7 (figs. 18 and 19). Concentrations of most synthetic organic compounds detected in samples from well cluster 11 were largest in the deepest well, YRW11B (Smith, 1993). Concentrations of vinyl chloride, 1,2-dichloroethylene, and trichloroethylene exceeded MCL's in samples from cluster 11. The presence of larger concentrations of these compounds in water from deeper wells than in water from shallower wells could indicate either more rapid degradation in shallower zones or differences in flow paths (fig. 4).

Methyl isobutyl ketone was detected in several water samples (Smith, 1993); however, this compound also was detected in field blanks, which indicates its presence probably is related to accidental laboratory or field contamination rather than to its presence in ground water at this landfill. No samples for analysis of synthetic organic compounds were collected from surface-water sites on the tributaries to Sugar Creek (Smith, 1993). Thus, the presence of the synthetic organic compounds detected in water from well clusters 7 and 11 in the tributaries is unknown.

Temporal trends in selected water-quality constituents and properties were detected for several ground-water monitoring sites (table 40). Because of the recent installation (1988) of well clusters 7, 8, 9, 10, and 11, data generally were insufficient for trend analysis of most constituents. The large effects of dilution from infiltration of precipitation and the large variability in water-quality conditions at well clusters along Sugar Creek (clusters 8, 9, and 10) masked trends for these sites, especially in the shallow wells where effects of dilution were large. No trends were detected for well YRWA, which taps bedrock.

Trends detected for wells YRW1, YRW2, and YRW3, which are adjacent to the northeastern waste-disposal cell (active from 1981 to 1983), differ in direction and magnitude (table 40). Increasing trends were detected for wells YRW1 and YRW3 in contrast to decreasing trends for well YRW2. Differences in

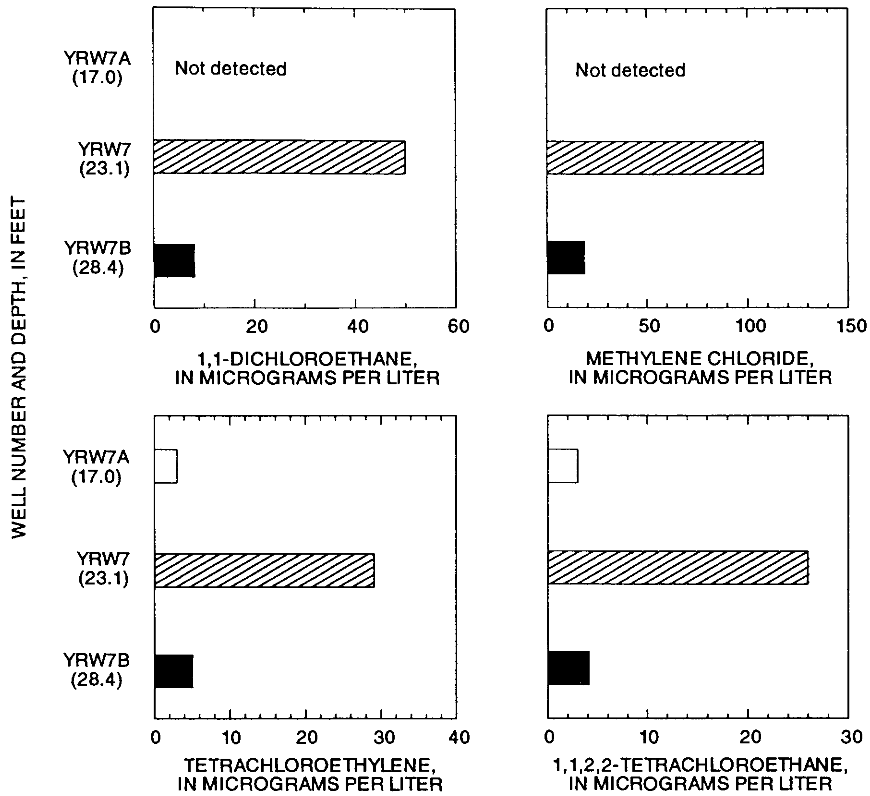

Figure 18. Concentrations of selected synthetic organic compounds in water samples from the York Road landfill monitoring wells YRW7, YRW7A, and YRW7B, November 10, 1992.

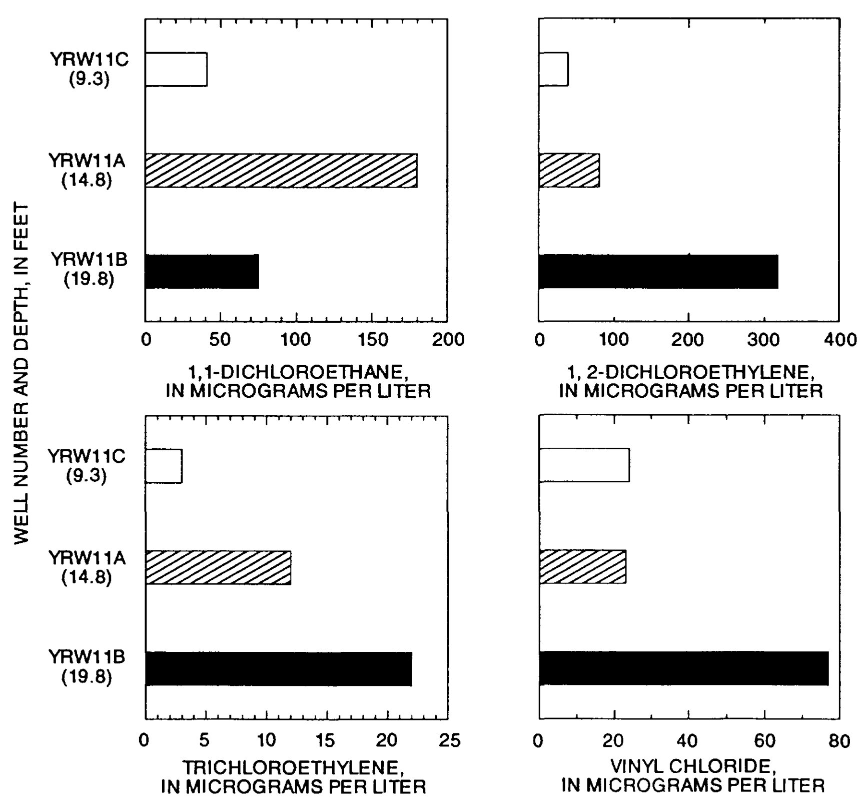

Figure 19. Concentrations of selected synthetic organic compounds in water samples from the York Road landfill monitoring wells YRW11A, YRW11B, and YRW11C, November 9, 1992.

Table 40. Summary of seasonal Kendall trend test results for selected ground-water quality data from the York Road landfill, 1979-92

[Only results significant at a probability level of 0.10 are shown. p, probability level; <0.001, probability level less than 0.001; *, trend tests were made but trends were not significant; Slope, trend slope expressed in units per year; --, data inadequate for analysis; µS/cm, microsiemens per centimeter; % median, slope expressed as a percentage of the seasonal median; n, number of observations; Record, period of record; mg/L, milligram per liter; µg/L, microgram per liter]

Constituent or property		YRW1	YRW2	YRW3	YRW6A	YRW6B	YRW6C	YRW7	YRW7A	YRW7B	YRW8	YRW8A
Specific conductance (µS/cm)	p	<0.001	*	<0.001	*	0.056	0.003	0.080	*	0.024	*	*
	Slope	210	--	13	--	-78	-190	25	--	23	--	--
	% median	96	--	8.2	--	-9.5	-33.7	18.3	--	16.2	--	--
	n	32	29	28	21	18	18	11	11	13	13	12
	Record	1981-88	1981-92	1981-88	1986-92	1986-92	1986-92	1988-92	1988-92	1988-92	1988-92	1988-92
pH, field (standard units)	p	*	*	*	*	*	*	*	*	*	*	*
	Slope	--	--	--	--	--	--	--	--	--	--	--
	n	31	27	26	20	17	16	11	9	13	12	11
	Record	1981-88	1981-92	1981-88	1986-92	1986-92	1986-91	1988-92	1988-92	1988-92	1988-92	1988-92
Chemical-oxygen demand (mg/L)	p	*	0.044	*	*	*	*	--	--	--	--	--
	Slope	--	-1.6	--	--	--	--	--	--	--	--	--
	% median	--	-20.1	--	--	--	--	--	--	--	--	--
	n	24	24	25	8	8	8	5	4	9	7	5
	Record	1981-88	1981-92	1981-88	1986-92	1986-92	1986-92	1988-92	1988-92	1988-92	1988-92	1988-92
Biochemical-oxygen demand (mg/L)	p	*	0.052	*	0.076	0.042	*	--	--	*	--	--
	Slope	--	-0.3	--	-0.34	-0.7	--	--	--	--	--	--
	% median	--	-9.4	--	-37.7	-21.4	--	--	--	--	--	--
	n	24	23	25	10	8	10	5	4	9	7	6
	Record	1981-88	1981-92	1981-88	1986-92	1986-92	1986-92	1988-92	1988-92	1988-92	1988-92	1988-92
Alkalinity, total (mg/L as CaCO3)	p	<0.001	*	0.056	*	0.074	0.029	--	--	*	--	--
	Slope	116	--	5.9	--	-15	-60	--	--	--	--	--
	% median	122	--	10.4	--	-5.1	-21.4	--	--	--	--	--
	n	31	26	26	13	12	12	3	3	9	6	5
	Record	1981-88	1981-87	1981-88	1986-92	1986-92	1986-92	1988-90	1988-90	1988-92	1988-92	1988-92
Sulfate (mg/L)	p	*	*	*	0.057	*	0.074	--	--	--	--	--
	Slope	--	--	--	2.5	--	0.8	--	--	--	--	--
	% median	--	--	--	34.7	--	14.3	--	--	--	--	--
	n	16	15	16	9	9	10	5	4	9	7	6
	Record	1983-88	1983-92	1983-88	1986-92	1986-92	1986-92	1988-92	1988-92	1988-92	1988-92	1988-92
Chloride, dissolved (mg/L)	p	0.014	0.078	*	0.057	*	0.038	--	--	--	--	--
	Slope	4.8	-0.3	--	2.7	--	-21	--	--	--	--	--
	% median	99	-5.9	--	7.8	--	-34.4	--	--	--	--	--
	n	24	23	24	8	9	8	5	4	9	6	6
	Record	1981-88	1981-87	1981-88	1986-92	1986-92	1986-92	1988-92	1988-92	1988-92	1988-92	1988-92
Iron, total (µg/L)	p	--	--	--	--	--	--	--	--	--	--	--
	Slope	--	--	--	--	--	--	--	--	--	--	--
	% median	--	--	--	--	--	--	--	--	--	--	--
	n	10	8	7	5	6	5	5	5	9	7	6
	Record	1981-88	1981-92	1981-88	1988-92	1988-92	1989-92	1988-92	1988-92	1988-92	1988-92	1988-92
Manganese, total (µg/L)	p	--	--	--	--	0.089	--	--	--	--	--	--
	Slope	--	--	--	--	-440	--	--	--	--	--	--
	% median	--	--	--	--	-12.8	--	--	--	--	--	--
	n	10	9	7	5	7	5	5	5	9	7	6
	Record	1981-88	1981-92	1981-88	1988-92	1988-92	1989-92	1989-92	1988-92	1988-92	1988-92	1988-92

Table 40. Summary of seasonal Kendall trend test results for selected ground-water quality data from the York Road landfill, 1979-92--Continued

[Only results significant at a probability level of 0.10 are shown. p, probability level; <0.001, probability level less than 0.001; *, trend tests were made but trends were not significant; Slope, trend slope expressed in units per year; --, data inadequate for analysis; µS/cm, microsiemens per centimeter; % median, slope expressed as a percentage of the seasonal median; n, number of observations; Record, period of record; mg/L, milligram per liter; µg/L, microgram per liter]

Constituent or property		YRW9	YRW9A	YRW9B	YRW10A	YRW10B	YRW10C	YRW11A	YRW11B	YRW11C
Specific conductance (µS/cm)	p	*	*	*	0.052	*	0.014	0.088	*	*
	Slope	--	--	--	129	--	-35	56	--	--
	% median	--	--	--	13.2	--	-10.6	20.6	--	--
	n	9	10	11	13	12	11	11	14	10
	Record	1988-92	1988-92	1988-92	1988-92	1988-92	1988-92	1988-92	1988-92	1988-92
pH, field (standard units)	p	*	*	*	*	*	*	*	*	*
	Slope	--	--	--	--	--	--	--	--	--
	n	9	10	11	13	11	11	10	13	10
	Record	1988-92	1988-92	1988-92	1988-92	1988-92	1988-92	1988-92	1988-92	1988-92
Chemical-oxygen demand (mg/L)	p	--	--	--	--	--	--	--	--	--
	Slope	--	--	--	--	--	--	--	--	--
	% median	--	--	--	--	--	--	--	--	--
	n	5	6	7	8	5	6	5	8	4
	Record	1988-92	1988-92	1988-92	1988-92	1988-91	1983-92	1988-92	1988-92	1988-92
Biochemical-oxygen demand (mg/L)	p	--	--	--	--	--	--	--	--	--
	Slope	--	--	--	--	--	--	--	--	--
	% median	--	--	--	--	--	--	--	--	--
	n	5	6	7	8	5	6	5	8	4
	Record	1988-92	1988-92	1988-92	1988-92	1988-92	1988-92	1988-92	1988-92	1988-92
Alkalinity, total (mg/L as $CaCO_3$)	p	--	--	--	--	--	--	--	0.065	--
	Slope	--	--	--	--	--	--	--	-26	--
	% median	--	--	--	--	--	--	--	-22.6	--
	n	4	5	7	6	6	5	4	9	4
	Record	1988-92	1988-92	1988-92	1988-92	1988-90	1988-92	1988-92	1988-92	1988-92
Sulfate (mg/L)	p	--	--	*	*	--	--	--	--	--
	Slope	--	--	--	--	--	--	--	--	--
	% median	--	--	--	--	--	--	--	--	--
	n	5	7	8	8	7	5	5	7	4
	Record	1988-92	1988-92	1988-92	1988-92	1988-90	1988-92	1988-92	1988-92	1988-92
Chloride, dissolved (mg/L)	p	--	--	--	0.054	--	--	--	--	--
	Slope	--	--	--	45	--	--	--	--	--
	% median	--	--	--	22	--	--	--	--	--
	n	5	6	7	8	5	6	4	8	4
	Record	1988-92	1988-92	1988-92	1988-92	1988-91	1988-92	1988-92	1988-92	1988-92
Iron, total (µg/L)	p	--	--	--	--	--	--	--	--	--
	Slope	--	--	--	--	--	--	--	--	--
	% median	--	--	--	--	--	--	--	--	--
	n	5	6	7	8	5	6	5	8	5
	Record	1988-92	1988-92	1988-92	1988-92	1988-91	1988-92	1988-92	1988-92	1988-92
Manganese, total (µg/L)	p	--	--	--	--	--	--	--	0.023	--
	Slope	--	--	--	--	--	--	--	-1,370	--
	% median	--	--	--	--	--	--	--	-22.6	--
	n	5	6	7	8	5	6	5	8	5
	Record	1988-92	1988-92	1988-92	1988-92	1988-91	1988-92	1988-92	1988-92	1988-92

trends appear to be primarily related to depth of the screened interval and to the time period for which trends were computed. Large increasing trends in specific conductance (210 µS/cm/yr), alkalinity (116 mg/L/yr), and chloride (4.8 mg/L/yr) were detected for well YRW1 during 1981-88. Specific conductance, alkalinity, and chloride in water from well YRW1 began to increase in 1985 (Smith, 1993), about 2 years after closure of the adjacent waste-disposal cell. Well YRW1 is near the southern end of the northeastern waste-disposal cell (fig. 15) and has a screened interval from 16.7 to 26.7 ft below land surface (table 32). Data for well YRW3 also indicate increasing trends in specific conductance (13 µS/cm/yr) and alkalinity (5.9 mg/L/yr) during 1981-88 (Smith, 1993). However, the trends were smaller in magnitude than trends detected for well YRW1, and the increase in specific conductance and alkalinity began in early 1984 rather than 1985. Well YRW3 is near the northern side of the waste-disposal cell (fig. 15) and has a screened interval from 22.7 to 32.7 ft below land surface (table 32). The increasing trends detected for wells YRW1 and YRW3 indicate increased effects of leachate during 1981-88.

Decreasing trends in chemical-oxygen demand (-1.6 mg/L/yr), biochemical-oxygen demand (-0.3 mg/L/yr), and chloride concentration (-0.3 mg/L/yr) for well YRW2 generally indicate the effects of leachate decreased at this site during 1981-92. Well YRW2 is adjacent to the southeastern side of the northeastern waste-disposal cell (fig. 15), and the depth of the screened interval (6.8 to 16.8 ft below land surface) is shallower than the screened intervals at wells YRW1 and YRW3 (table 32). The apparent decrease in the effects of leachate in ground water at well YRW2, in contrast to the increased effects at wells YRW1 and YRW3, possibly indicates differences in rates of ground-water movement and differences in flow paths with respect to depth (fig. 4). Shallow ground water, such as that represented by samples from well YRW2, could have been affected by leachate before deeper ground water, such as that in wells YRW1 and YRW3, was affected. Also, the effects of leachate on shallow ground water could decrease sooner than those in deeper zones because rates of circulation generally are greater in shallow zones than in deep zones (fig. 4) or because degradation rates are more rapid (Mackay and others, 1985). Another factor that could have contributed to the differences in trends among these wells is that most trends for well YRW2 were calculated for a longer time interval than were trends for wells YRW1 and YRW3.

Trends observed for monitoring wells YRW6A, YRW6B, and YRW6C also differ in magnitude and direction with respect to well depth (table 40). These wells are located near the mouth of the southernmost tributary (fig. 15). Trends detected for well YRW6A, the deepest well in cluster 6, include a decreasing trend in biochemical-oxygen demand (-0.34 mg/L/yr) and increasing trends in chloride (2.7 mg/L/yr) and sulfate (2.5 mg/L/yr). Trends detected for well YRW6B, the well of intermediate depth, include decreasing trends in specific conductance (-78 µS/cm/yr), biochemical-oxygen demand (-0.7 mg/L/yr), alkalinity (-15 mg/L/yr), and manganese (-440 µg/L/yr). Trends detected for well YRW6C, the shallowest well, include decreasing trends in specific conductance (-190 µS/cm/yr), alkalinity (-60 mg/L/yr), and chloride (-21 mg/L/yr), and an increasing trend in sulfate (0.8 mg/L/yr). Although trend analysis indicates the effects of leachate at wells YRW6B and YRW6C generally decreased from 1988 to 1992, the increasing trend in chloride in samples from the deepest well in this cluster indicates the effects of leachate increased from 1988 to 1992. These trends could reflect differences in the degree of circulation in the shallow regolith with respect to depth above the transition zone (fig. 3). Circulation generally decreases as depth increases, thus effects of leachate can be longer lasting in deeper zones of the regolith than in shallower zones (fig. 4). Biological and chemical degradation processes typically have a greater effect in shallower zones than in deeper zones because of greater availability of oxygen and nutrients.

Trends detected for other wells include increases in specific conductance for wells YRW7 (25 µS/cm/yr) and YRW7B (23 µS/cm/yr). No trends were detected for well YRW7A, the shallowest well in this cluster. No trends were detected for well clusters 8 and 9. Trends detected at well cluster 10 include increases in specific conductance (129 µS/cm/yr) and chloride (45 mg/L/yr) for well YRW10A, the deepest well in cluster 10 (table 40). These trends indicate increasing effects of leachate at well YRW10A. No trends were detected for well YRW10B, the well of intermediate depth. However, a decreasing trend in specific conductance (-85 µS/cm/yr) was detected for well YRW10C, the shallowest well in the cluster. Like the trends observed for other wells, trends for well cluster

10 also appear to be related to well depth. Samples from well cluster 10 indicate the effects of leachate on deeper ground water increased while the effects of leachate on shallower ground water decreased from 1988 to 1992 (Smith, 1993). Trends detected at well cluster 11 include decreases in alkalinity (-26 mg/L/yr) and manganese (-1,370 µg/L/yr) for well YRW11B, the deepest well in the cluster, and an increasing trend in specific conductance (56 µS/cm/yr) for well YRW11A, the well of intermediate depth (table 40). No trends were observed for well YRW11C, the shallowest well in cluster 11.

Thus, trend analysis indicates that temporal changes in effects of leachate on ground-water quality differ with respect to well depth. Effects of leachate in the regolith generally appear and dissipate more quickly in shallow ground water than in deep ground water.

Conclusions

The York Road landfill generally has had a larger effect on the water quality of the two tributaries that drain the landfill than on the water quality of Sugar Creek. Water samples from the tributaries contained large concentrations of iron and manganese. On the southern tributary to Sugar Creek, the effects of leachate were greater in water samples from the downstream site (YRSW9) than in samples from the upstream site (YRSW9A). Trends detected for the tributary sites generally showed increasing effects of leachate; however, trends in biochemical-oxygen demand decreased for the tributary sites.

Concentrations and trends for surface-water samples collected at sites on Sugar Creek upstream and downstream from the landfill generally were similar for most constituents, including synthetic organic compounds. However, median concentrations of iron and manganese were larger for the downstream site (YRSW41) than for the upstream site (YRSW21A). Leachate is a possible cause of elevated iron and manganese concentrations in water samples from the downstream site. An increasing trend in iron concentration (74 µg/L/yr) was detected for site YRSW41, which is downstream from the landfill, whereas no corresponding trend was detected for site YRSW21A, which is upstream from the landfill. Iron concentrations exceeded the Mecklenburg County action level of 300 µg/L in all samples from Sugar Creek.

Water-quality data for monitoring wells indicate the effects of leachate vary with respect to location, well depth, and time. Water from wells in clusters 6 and 10 generally appears to be more affected by leachate than water from other wells near Sugar Creek. Water samples from monitoring wells commonly exceeded action levels for iron, manganese, and chemical-oxygen demand. Numerous synthetic organic compounds, particularly chlorinated aliphatic compounds, were detected in ground-water samples, especially from well clusters 7 and 11 where concentrations of several of these compounds exceeded MCL's.

Ground-water quality varied with depth. No consistent pattern of variation was observed. Trend analysis indicated improvement in the quality of shallow ground water, but indicated effects of leachate in deeper ground water had increased. Possible causes of observed differences in water quality with depth include differences in permeability, circulation rates, recharge patterns, and chemical and biological properties in the regolith.

SUMMARY OF CONCLUSIONS

During 1986-92, effects of landfills on surface- and ground-water quality were studied at the Harrisburg Road, Holbrooks Road, McAlpine Creek at Greenway Park, Statesville Road, and York Road landfills in Mecklenburg County, North Carolina. Landfill leachate has affected the quality of surface and ground water in and near most of these landfills. However, effects of leachate differ with respect to characteristics of the sampling site, proximity of the sampling site to waste-disposal cells, and age and design of the landfill.

Surface-water quality generally was less affected by leachate than ground-water quality. Water from small streams originating within the landfills generally showed greater effects of leachate than streams with larger drainage areas. Leachate has had little effect on water quality in the South Prong of Clarke Creek, McAlpine Creek, and Sugar Creek, which are adjacent to the Holbrooks Road, McAlpine

Creek at Greenway Park, and York Road landfills, respectively. However, during low streamflow conditions, concentrations of iron and manganese were larger in samples from sites downstream from the landfills than in samples from sites upstream from the landfills. In contrast to large streams at other landfills, the water quality of Irwin Creek was significantly affected by the Statesville Road landfill. The Statesville Road landfill is the oldest of the landfills investigated and was active before implementation of modern design standards and regulations.

Ground water showed large differences in chemical quality with respect to well depth; however, no consistent patterns were observed with respect to well depth. Concentrations of constituents and properties considered to be indicators of leachate differed greatly among samples from wells in a given cluster. Concentrations of constituents in samples from some well clusters were largest in the deepest well, whereas concentrations in samples from other clusters were largest in the shallowest well. Differences in water-quality samples from well clusters appear to be related to the ground-water flow path.

Effects of leachate on ground-water quality generally were largest in samples from wells adjacent to and downgradient from waste-disposal cells. Effects of leachate generally decreased with increasing distance from waste-disposal cells. Water-quality characteristics and concentrations of constituents possibly indicative of leachate, such as biochemical-oxygen demand, chemical-oxygen demand, alkalinity, chloride, manganese, and total organic carbon, generally decreased with increasing distance from waste-disposal cells. Various physical, chemical, and biological processes, such as dilution, adsorption, precipitation, and degradation, contributed to decreases in these constituents. At the Harrisburg Road and Holbrooks Road landfill study areas, effects of leachate generally were much smaller in samples from offsite wells than in samples from onsite wells. No offsite wells were sampled at the York Road landfill study area during 1986-92.

Effects of leachate on water quality also showed changes with time. Temporal trends in water quality indicate effects of leachate on surface and ground water in the vicinity of several of the landfills generally decreased during the study period. Trend analysis indicates water quality of Irwin Creek downstream from the Statesville Road landfill improved during 1980-92. Statistically significant decreasing trends in specific conductance, chemical-oxygen demand, biochemical-oxygen demand, chloride, ammonia, and iron were detected for Irwin Creek, downstream from the Statesville Road landfill. Decreasing trends in constituents and properties indicative of leachate were common for monitoring wells at the Holbrooks Road and Statesville Road landfills. Water-quality data for the Harrisburg Road and York Road landfills indicate that effects of leachate decreased in some parts of these landfills; however, effects of leachate appear to have increased in other parts of these landfills. Data for the McAlpine Creek at Greenway Park landfill were insufficient for trend analysis.

Concentrations of iron and manganese in ground water and surface water in nearly all samples from monitoring sites exceeded action levels established by the Mecklenburg County Department of Engineering. However, iron and manganese occur naturally in soils of Mecklenburg County, and large concentrations of these elements in water possibly were caused by suspended soil particles in water samples. The pH of many water samples, especially ground-water samples from the Harrisburg Road, Statesville Road, and York Road landfills, was less than the acceptable range of 6.5 to 8.5 units established by the Mecklenburg County Engineering Department. Concentrations of synthetic organic compounds generally were less than MCL's and health advisories established by the U.S. Environmental Protection Agency. The herbicides 2,4-D and 2,4-DP were the synthetic organic compounds most commonly detected in water samples from the landfills. Concentrations of several chlorinated organic compounds exceeded MCL's in water samples from several wells at the Harrisburg Road and York Road landfills. Landfill wastes appear to be the source of the chlorinated organic compounds in ground water at the York Road landfill; however, the source of the chlorinated organic compounds in ground water at the Harrisburg Road landfill is unknown.

REFERENCES CITED

Baedecker, M.J., and Back, William, 1979, Hydrogeological processes and chemical reactions at a landfill: Ground Water, v. 17, no. 5, p. 429-437.

Borden, R.C., and Yanoschak, T.M., 1989, North Carolina sanitary landfills: Leachate generation, management, and water quality inputs: Water Resources Research Institute of the University of North Carolina, report no. 243, 53 p.

Butler, J.R., 1971, Structure of the Charlotte belt and adjacent belts in York County, South Carolina: South Carolina State Development Board, Division of Geology, Geologic Notes, v. 15, p. 49-62.

Cameron, R.D., 1978, The effects of solid waste landfill leachate on receiving waters: American Water Works Association Journal, v. 70, no. 3, p. 173-176.

Cardinell, A.P., Barnes, C.R., Eddins, W.H., and Coble, R.W., 1989, Hydrologic environments and water-quality characteristics at four landfills in Mecklenburg County North Carolina, 1980-86: U.S. Geological Survey Water-Resources Investigations Report 89-4035, 79 p.

Daniel, C.C., III, and Sharpless, N.B., 1983, Ground-water supply potential and procedures for well-site selection, upper Cape Fear River Basin (North Carolina): North Carolina Department of Natural Resources and Community Development, 73 p.

Daniels, R.B., Kleiss, H.J., Boul, S.W., Byrd, H.J., and Phillips, J.A., 1984, Soil systems in North Carolina: North Carolina Agricultural Research Service, North Carolina State University Bulletin 467, 77 p.

Delta Environmental Consultants, Inc., 1993, Environmental assessment report, Phase I York Road Landfill Charlotte, North Carolina, vols. 1 and 2, Delta Project No. 50-91-014.

Eddins, W.H., and Crawford, J.K., 1984, Reconnaissance of water-quality characteristics of streams in the City of Charlotte and Mecklenburg County: U.S. Geological Survey Water-Resources Investigations Report 84-4308, 105 p.

Farrar, S.S., 1985, Tectonic evolution of the easternmost Piedmont, North Carolina: Geological Society of America Bulletin, v. 96, p. 362-380.

Gilbert, N.J., Brown, H.S., and Schaeffer, M.F., 1982, Structure and geologic history of a part of the Charlotte Belt, South Carolina Piedmont: Southeastern Geology, v. 23, no. 3, p. 129-145.

Goldsmith, R., Milton, D.J., and Horton, J.W., Jr., 1982, Preliminary geologic map of the Charlotte 1° x 2° quadrangle, North Carolina and South Carolina: U.S. Geological Survey Open-File Report 81-56, 1 sheet.

Hack, J.T., 1982, Physiographic dimensions and differential uplift in the Piedmont and Blue Ridge: U.S. Geological Survey Professional Paper 1265, 49 p.

Harned, D.A., 1989, The hydrogeologic framework and a reconnaissance of ground-water quality in the Piedmont Province of North Carolina; with a design for future study: U.S. Geological Survey Water-Resources Investigations Report 88-4130, 55 p.

Harned, D.A., and Daniel, C.C., III, 1989, The transition zone between bedrock and regolith: Conduit for contamination? *in* C.C. Daniel, III, White, R.K., and Stone, P.A., eds., Ground water in the Piedmont, Proceedings of a conference on ground water in the Piedmont of the southeastern United States, Clemson University, p. 336-348.

Heath, R.C., 1980, Basic elements of ground-water hydrology with reference to conditions in North Carolina: U.S. Geological Survey Water-Resources Investigations Report 80-44, 86 p.

___ 1984, Ground-water regions of the United States: U.S. Geological Survey Water-Supply Paper 2242, 78 p.

Henningson, Durham, and Richardson Consultants, 1982, Preliminary site investigation Harrisburg Road Landfill, Mecklenburg County, North Carolina: Henningson, Durham, and Richardson Consultants report.

Hirsch, R.M., Slack, J.R., and Smith, R.A., 1982, Techniques of trend analysis for monthly water quality data: Water Resources Research, v. 18, no. 1, p. 107-121.

Kutz, F.W., Wood, P.H., and Bottimore, D.P., 1991, Organochlorine pesticides and polychlorinated biphenyls in human adipose tissue, *in* Reviews of environmental contamination and toxicology, v. 120, p. 42-47.

Law Engineering Testing Company, 1980, Report of subsurface exploration and engineering evaluation Statesville Avenue landfill, Statesville Avenue at Northerly Road, Charlotte, North Carolina: Law Engineering Testing Company, job no. CH 4442, 50 p.

___ 1983, Report of geotechnical exploration and geohydrological evaluation York Road landfill expansion, Charlotte, North Carolina: Law Engineering Testing Company, job no. CH 4762, 108 p.

LeGrand, H.E., 1967, Ground water of the Piedmont and Blue Ridge Provinces in the southeastern states: U.S. Geological Survey Circular 538, 11 p.

Lu, J.C.S., 1985, Eichenberger, B., and Stearns, R.J., 1985, Leachate from municipal landfills--production and management: Park Ridge, N.J., Noyes Data Corp., 454 p.

Lucius, J.E., Olhoeft, G.R., Hill, P.L., and Duke, S.K., 1992, Properties and hazards of 108 selected substances (1992 ed.): U.S. Geological Survey Open-File Report 92-527, 554 p.

Mackay, D.M., Roberts, P.V., and Cherry, J.A., 1985, Transport of organic contaminants in groundwater: Environmental Science and Technology, v. 19, no. 5, p. 384-392.

National Oceanic and Atmospheric Administration, 1990, Climatological data, annual summary, North Carolina: Asheville, N.C., National Climatic Data Center, v. 95, no. 13.

North Carolina Department of Environment, Health, and Natural Resources, 1994, North Carolina Solid Waste Management Rules: Raleigh, Division of Solid Waste Management, North Carolina Administrative Code Title 15A, Chapter 13, Subchapter 13B (15A NCAC 13B), as amended through January 4, 1994, 198 p.

North Carolina Department of Natural Resources and Community Development, 1985, Geologic map of North Carolina, 1 sheet, scale 1:500,000.

Nutter, L.J., and Otton, E.G., 1969, Ground-water occurrences in the Maryland Piedmont: Maryland Geological Survey Report of Investigations, no. 10, 56 p.

O'Leary, Phil, and Tansel, Berrin, 1986, Land disposal of solid wastes: Protection Health and Environment: Waste Age, March 1986, p. 68-71.

Pavish, M.J., 1985, Appalachian Piedmont morphogenesis, *in* Morisawa, M., and Hacki, J.T., eds., Tectonic geomorphology: Boston, Mass., Allen and Unwin, 299 p.

Pohland, F.G., 1976, Impact of sanitary landfills: An overview of environmental factors and control alternatives: American Paper Institute Report, 82 p.

Ragland, P.C., Hatcher, R.D., Jr., and Whittington, D., 1983, Juxtaposed Mesozoic diabase dike sets from the Carolinas: A preliminary assessment: Geology, v. 11, p. 394-399.

Russell, G.S., Russell, C.W., and Farrar, S.S., 1985, Alleghanian deformation and metamorphism in the eastern North Carolina Piedmont: Geological Society of America Bulletin, v. 96, p. 381-387.

Salvato, J.A., Wilkie, W.G., and Mead, B.E., 1971, Sanitary landfill leaching prevention and control: Journal of the Water Pollution Control Federation v. 43, no. 10, p. 2084-2100.

Schertz, T.L., and Hirsch, R.M., 1985, Trend analysis of weekly acid-rain data--1978-83: U.S. Geological Survey Water-Resources Investigations Report 85-4211, 64 p.

Shacklette, H.T., and Boerngen, J.C., 1984, Element concentrations in soils and other surficial materials of the conterminous United States: U.S. Geological Survey Professional Paper 1270, 105 p.

Sine, Charlotte, 1991, Farm chemicals handbook '91 section C: Willoughby, Ohio, Meister Publishing Co., p. 462.

Smith, D.G., 1993, Surface- and ground-water quality data at selected landfill sites in Mecklenburg County, North Carolina, 1979-92: U.S. Geological Survey Open-File Report 93-437, p. 540.

Smith, J.A., Witkowski, P.J., and Fusillo, T.V., 1988, Manmade organic compounds in the surface waters of the United States--A review of current understanding: U.S. Geological Survey Circular 1007, 92 p.

Stewart, J.W., 1962, Water-yielding potential of weathered crystalline rocks at the Georgia Nuclear Laboratory, *in* Geological Survey research 1962, short papers in geology, hydrology, and topography, articles 1-59: U.S. Geological Survey Professional Paper 450-B, p. 106-107.

Stewart, J.W., Callahan, J.T., Carter, R.F., and others, 1964, Geologic and hydrologic investigation at the site of the Georgia Nuclear Laboratory, Dawson, Ga.: U.S. Geological Survey Bulletin 1133-F, p. 91.

Stumm, Werner, and Morgan, J.J., 1981, Aquatic chemistry: An introduction emphasizing chemical equilibria in natural waters, (2d ed.): New York, John Wiley, p. 323-381.

Tchobanoglous, George, Theisen, Hilary, and Eliassen, P., 1977, Solid wastes--Engineering principles and management issues: New York, McGraw-Hill, Inc., 621 p.

Tchobanoglous, George, Theisen, Hilary, and Vigil, Samuel, 1993, Integrated solid waste management--Engineering principles and management issues: New York, McGraw-Hill, Inc., p. 361-450.

Timme, P.J., 1994, National Water Quality Laboratory 1994 Services Catalog: U.S. Geological Survey Open-File Report 94-304, p. 17.

Trainer, F.W., and Watkins, F.A., 1975, Geohydrologic reconnaissance of the Upper Potomac River Basin: U.S. Geological Survey Water-Supply Paper 2035, 68 p.

U.S. Department of Agriculture, 1980, Soil survey of Mecklenburg County, North Carolina: Soil Conservation Service, 97 p.

U.S. Department of Commerce, Bureau of the Census, 1980: 1980 Census of Population and Housing Public Law 94-171.

___ 1990: 1990 Census of Population and Housing Public Law 94-171.

U.S. Environmental Protection Agency, 1985, Suspended, cancelled, and restricted pesticides, third revision, Washington, D.C., Office of Pesticides and Toxic Substances.

___ 1986, Subtitle D study phase I report: Washington, D.C., Office of Solid Waste and Emergency Response, EPA Report 530-SW-86-054, 38 p.

___ 1987, Environmental News press release, August 11, 1987: Washington, D.C., Office of Public Affairs (A-107), 37 p.

___ 1991, Subtitle D Resource Conservation and Recovery Act, EPA criteria for municipal solid waste landfills, U.S. Code of Regulations, Title 40, Section 258, subparts A, B, C, D, E, F, and G, p. 161:1901-1929.

___ 1993, Drinking water regulations and health advisories: Washington, D.C., Office of Water publication, 11 p.

U.S. Geological Survey, 1979-93 (annual), Water-resources data, North Carolina: U.S. Geological Survey Water-Data Reports.

Verschueren, Karel, 1983, Handbook of environmental data on organic chemicals (2d ed.): New York, Van Nostrand Reinhold Co. Publishers, 1,310 p.

Ward, J.R., and Harr, C.A., eds., 1990, Methods for collection and processing of surface-water and bed-material samples for physical and chemical analyses: U.S. Geological Survey Open-File Report 90-140, 71 p.

Wehr, Frederick, and Grove, Lynn, III, 1985, Stratigraphy and tectonics of the Virginia-North Carolina Blue Ridge: Evolution of a late Proterozoic-early Paleozoic hinge zone, Geological Society of America Bulletin, v. 96, p. 285-295.

Table 7. Summary of synthetic organic compounds detected in surface-water samples from the Harrisburg Road landfill, 1986-92

[mg/L, milligram per liter; Max. detected, maximum concentration detected; --, not detected; µg/L, microgram per liter]

Total organic halogens (mg/L)	HBSW7A	HBSW7B	HBSW1506	HBSW2006	HBSW2008	HBSW2009	HBSW2010
Samples	2	3	2	15	1	15	1
Detections	2	2	1	9	0	8	1
Max. detected	0.03	0.95	0.04	0.03	--	0.03	0.04

Pesticides (µg/L)		HBSW7B	HBSW2006	HBSW2008	HBSW2009
Aldrin, total	Samples	1	14	1	12
	Detections	0	0	0	0
	Max. detected	--	--	--	--
Chlordane, total	Samples	1	14	1	12
	Detections	1	0	0	6
	Max. detected	0.1	--	--	0.1
DDT, total	Samples	1	14	1	12
	Detections	0	0	0	0
	Max. detected	--	--	--	--
Dieldrin, total	Samples	1	14	1	12
	Detections	0	0	0	0
	Max. detected	--	--	--	--
Endosulfan, total	Samples	1	14	1	12
	Detections	0	0	0	0
	Max. detected	--	--	--	--
Heptachlor, total	Samples	1	14	1	12
	Detections	0	0	0	0
	Max. detected	--	--	--	--
Heptachlor epoxide, total	Samples	1	14	1	12
	Detections	0	0	0	0
	Max. detected	--	--	--	--
Lindane, total	Samples	1	14	1	12
	Detections	0	0	0	0
	Max. detected	--	--	--	--
Perthane, total	Samples	1	14	1	12
	Detections	0	0	0	0
	Max. detected	--	--	--	--
2,4-D, total	Samples	1	14	1	12
	Detections	0	7	0	0
	Max. detected	--	0.02	--	--
2,4-DP, total	Samples	1	14	1	12
	Detections	0	6	0	10
	Max. detected	--	0.05	--	0.14
2,4,5-T, total	Samples	1	14	1	12
	Detections	0	0	0	0
	Max. detected	--	--	--	--
Silvex, total	Samples	1	2	1	12
	Detections	0	0	0	0
	Max. detected	--	--	--	--

Halogenated aliphatic compounds (µg/L)		HBSW7B	HBSW2006	HBSW2009
Methyl chloride, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--

Table 7. Summary of synthetic organic compounds detected in surface-water samples from the Harrisburg Road landfill study area, 1986-92--Continued

[mg/L, milligram per liter; Max. detected, maximum concentration detected; --, not detected; µg/L, microgram per liter]

Halogenated aliphatic compounds (µg/L) (Continued)		HBSW7B	HBSW2006	HBSW2009
Methylene chloride, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--
Chloroform, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--
Trichloro-fluoromethane, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--
Dichlorodi-fluoromethane, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--
Vinyl chloride, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--
Chloroethane, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--
1,1-Dichloro-ethane, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--
1,2-Dichloro-ethane, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--
1,1,1-Trichloro-ethane, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--
1,1,2-Trichloro-ethane, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--
1,1,2,2-Tetrachloro-ethane, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--
cis-1,2-Dichloro-ethylene, total	Samples	1	2	12
	Detections	0	0	0
	Max. detected	--	--	--
trans-1,2-Dichloro-ethylene, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--
1,1-Dichloro-ethylene, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--
Trichloro-ethylene, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--
Tetrachloro-ethylene, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--
1,2-Dichloro-propane, total	Samples	1	2	4
	Detections	0	0	0
	Max. detected	--	--	--

Table 7. Summary of synthetic organic compounds detected in surface-water samples from the Harrisburg Road landfill study area, 1986-92--Continued

[mg/L, milligram per liter; Max. detected, maximum concentration detected; --, not detected; µg/L, microgram per liter]

Aromatic and halogenated aromatic compounds (µg/L)		HBSW7B	HBSW2006	HBSW2008	HBSW2009
Benzene, total	Samples	1	2	0	4
	Detections	0	0	--	0
	Max. detected	--	--	--	--
Chlorobenzene, total	Samples	1	2	0	4
	Detections	0	0	--	0
	Max. detected	--	--	--	--
1,4-Dichlorobenzene, total	Samples	1	3	1	5
	Detections	0	0	0	0
	Max. detected	--	--	--	--
1,3-Dichlorobenzene, total	Samples	1	3	1	5
	Detections	0	0	0	0
	Max. detected	--	--	--	--
Toluene, total	Samples	1	2	0	4
	Detections	0	0	--	0
	Max. detected	--	--	--	--
p-Isopropyltoluene, total	Samples	0	0	0	0
	Detections	--	--	--	--
	Max. detected	--	--	--	--
Ethylbenzene, total	Samples	1	2	0	4
	Detections	0	0	--	0
	Max. detected	--	--	--	--
Isopropylbenzene, total	Samples	0	0	0	0
	Detections	--	--	--	--
	Max. detected	--	--	--	--
Pseudocumene, total	Samples	0	0	0	0
	Detections	--	--	--	--
	Max. detected	--	--	--	--
sec-Butylbenzene, total	Samples	0	0	0	0
	Detections	--	--	--	--
	Max. detected	--	--	--	--
Xylene, total	Samples	1	2	0	4
	Detections	0	0	--	0
	Max. detected	--	--	--	--
Phenols, ketones, and phthalates (µg/L)		**HBSW7B**	**HBSW2006**	**HBSW2008**	**HBSW2009**
Phenols, total	Samples	1	0	0	0
	Detections	1	--	--	--
	Max. detected	19	--	--	--
2-Hexanone, total	Samples	0	0	0	0
	Detections	--	--	--	--
	Max. detected	--	--	--	--
Bis(2-ethylhexyl) phthalate, total	Samples	0	3	1	5
	Detections	--	0	0	0
	Max. detected	--	--	--	--
Di-*n*-butyl phthalate, total	Samples	0	3	0	5
	Detections	--	0	--	0
	Max. detected	--	--	--	--
N-Butylbenzyl phthalate, total	Samples	0	3	0	5
	Detections	--	0	--	0
	Max. detected	--	--	--	--

Table 9. Summary of selected ground-water quality data for the Harrisburg Road landfill, 1986-92

[--, no data or insufficient data for computation of median; µS/cm, microsiemens per centimeter; <, less than; mg/L, milligram per liter; cols/100 mL, colonies per 100 milliliters; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; µg/L, microgram per liter; *, value calculated using a log-probability regression to estimate values below detection limits]

Constituent or property		HBWE2	HBW1	HBW8	HBW10	HBW11	HBW12	HBW12A	HBW12B
Specific	Range	61	38	80-84	45-53	63	68-187	104-130	126-263
conductance	Median	--	--	82	50	--	107	118	204
(µS/cm)	Samples	1	1	2	6	1	15	10	19
pH,	Range	5.8	5.4	6.0-6.1	4.6-5.1	5.9	5.8-6.5	5.7-6.4	5.8-6.7
field	Median	--	--	--	5.0	--	6.2	6.1	6.1
(standard units)	Samples	1	1	2	6	1	15	11	19
Chemical-	Range	<5	<5	<5	<5-9	--	<5-21	<5-15	<5-31
oxygen	Median	--	--	--	7	--	8	<5	8
demand (mg/L)	Samples	1	1	1	4	0	11	7	16
Biochemical-	Range	1.3	2.6	0.6	0.9-4.9	--	0.8-7.8	<0.1-6.0	0.7-6.9
oxygen	Median	--	--	--	2.0	--	2.4	2.5	2.0
demand (mg/L)	Samples	1	1	1	4	0	11	7	15
Fecal	Range	--	--	--	--	--	bdl	bdl	bdl
coliform	Median	--	--	--	--	--	--	--	--
(cols/100 mL)	Samples	0	0	0	0	0	2	3	13
Fecal	Range	--	--	--	--	--	<10	<10	bdl-140
streptococcus	Median	--	--	--	--	--	--	--	--
(cols/100 mL)	Samples	0	0	0	0	0	1	2	10
Alkalinity, fixed	Range	26	7	38	2-10	--	46-53	46-56	75-89
endpoint	Median	--	--	--	7	--	49	50	82
(mg/L as $CaCO_3$)	Samples	1	1	1	5	0	10	6	7
Sulfate	Range	1.0	5.8	<1.0	<1.0-1.0	--	bdl-4.9	<1.0-5.6	5.7-35
(mg/L)	Median	--	--	--	<1.0	--	1.6	1.8	8.1
	Samples	1	1	1	4	0	8	3	8
Chloride,	Range	1.8	3.2	2.0	2.3-3.3	--	1.6-3.5	1.8-5.3	1.1-8.2
dissolved	Median	--	--	--	2.7	--	2.6	3.9	6.8
(mg/L)	Samples	1	1	1	4	0	11	7	16
Fluoride,	Range	--	--	<0.2	<0.2	--	bdl	bdl	bdl-0.2
total	Median	--	--	--	<0.2	--	<0.1	<0.2	<0.2
(mg/L)	Samples	0	0	1	4	0	3	4	8
Aluminum,	Range	--	--	--	--	--	1,200-100,000	2,800-45,000	1,400-110,000
total	Median	--	--	--	--	--	10,000	21,000	42,000
(µg/L)	Samples	0	0	0	0	0	5	5	6
Arsenic,	Range	--	--	--	--	--	bdl-36	bdl-37	bdl-120
total	Median	--	--	--	--	--	5*	5*	<2
(µg/L)	Samples	0	0	0	0	0	7	7	15
Barium,	Range	--	--	--	--	--	<100-900	<100-100	<100-2,100
total	Median	--	--	--	--	--	<100	<100	<100
(µg/L)	Samples	0	0	0	0	0	7	7	15
Cadmium,	Range	--	--	--	--	--	bdl	bdl	bdl-5
total	Median	--	--	--	--	--	--	--	<2
(µg/L)	Samples	0	0	0	0	0	7	7	15
Chromium,	Range	--	--	--	--	--	bdl-150	bdl-44	bdl-200
total	Median	--	--	--	--	--	8*	13	10
(µg/L)	Samples	0	0	0	0	0	7	7	15
Copper,	Range	--	--	--	--	--	bdl-600	bdl-140	bdl-550
total	Median	--	--	--	--	--	<50	<50	80*
(µg/L)	Samples	0	0	0	0	0	7	7	15
Iron,	Range	--	--	--	--	--	1,500-180,000	3,900-48,000	390-150,000
total	Median	--	--	--	--	--	4,000	8,100	18,000
(µg/L)	Samples	0	0	0	0	0	7	7	15
Lead,	Range	--	--	--	--	--	5.0-29	5.0-30	bdl-150
total	Median	--	--	--	--	--	11	13	3*
(µg/L)	Samples	0	0	0	0	0	7	7	15

Table 9. Summary of selected ground-water quality data for the Harrisburg Road landfill, 1986-92--Continued

[--, no data or insufficient data for computation of median; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; <, less than; cols/100 mL, colonies per 100 milliliters; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; µg/L, microgram per liter; *, value calculated using a log-probability regression to estimate values below detection limits]

Constituent or property (Continued)		HBWE2	HBW1	HBW8	HBW10	HBW11	HBW12	HBW12A	HBW12B
Manganese,	Range	--	--	--	--	--	bdl-1,400	220-1,200	40-4,000
total	Median	--	--	--	--	--	100*	620	410
(µg/L)	Samples	0	0	0	0	0	7	7	15
Mercury,	Range	--	--	--	--	--	bdl	bdl	bdl
total	Median	--	--	--	--	--	--	--	--
(µg/L)	Samples	0	0	0	0	0	7	7	15
Zinc,	Range	--	--	--	--	--	<10-210	<10-200	<10-290
total	Median	--	--	--	--	--	120	100	100
(µg/L)	Samples	0	0	0	0	0	7	7	15
Organic carbon,	Range	--	--	--	5.5	--	0.5-5.5	0.7-4.0	0.8-8.7
total	Median	--	--	--	--	--	2.5	2.8	3.0
(mg/L)	Samples	0	0	0	1	0	5	4	14

Constituent or property		HBW14	HBW14A	HBW14B	HBW14C	HBW14D	HBW15	HBW16	HBW17A
Specific	Range	61-140	185-192	67-175	71-185	106-195	98-115	37-53	bdl-34
conductance	Median	104	188	110	108	158	102	44	26
(µS/cm)	Samples	14	5	11	11	18	14	13	11
pH,	Range	5.9-6.5	6.3-6.5	5.8-6.5	5.7-6.8	5.6-7.1	5.9-6.4	5.1-6.0	4.8-6.1
field	Median	6.3	6.4	6.3	6.3	6.4	6.0	5.6	5.3
(standard units)	Samples	15	5	11	11	19	14	13	12
Chemical-	Range	<5-19	<5-9	bdl	<5-47	<5-71	<5-16	<5-15	<5-46
oxygen	Median	<5	<5	<5	13	11	<5	<5	13
demand (mg/L)	Samples	9	4	7	6	16	7	7	7
Biochemical-	Range	0.3-2.9	0.5-2.0	0.1-5.1	0.3-5.1	0.6-8.7	0.5-5.9	0.1-4.2	1.6-20
oxygen	Median	1.1	0.9	2.1	1.0	1.6	1.3	1.1	3.9
demand (mg/L)	Samples	9	4	7	6	15	7	7	7
Fecal	Range	bdl	--	<10-21	bdl	bdl-350	--	--	<10-35
coliform	Median	--	--	--	--	<10	--	--	--
(cols/100 mL)	Samples	2	0	2	2	14	0	0	2
Fecal	Range	<10	--	<10	<10	bdl	--	--	10.0
streptococcus	Median	--	--	--	--	--	--	--	--
(cols/100 mL)	Samples	1	0	1	1	12	0	0	1
Alkalinity,	Range	43-59	82-85	44-54	49-59	64-79	43-49	12-18	3-10
fixed endpoint	Median	49	82	48	51	66	48	15	7.0
(mg/L as $CaCO_3$)	Samples	9	5	6	5	7	13	12	7
Sulfate	Range	3.4-6.2	1.0-3.8	3.9-6.8	3.5-6.2	1.0-11	<1.0-4.2	bdl	<1.0-4.8
(mg/L)	Median	4.0	2.0	5.3	4.4	5.1	<1.0	<1.0	<1.0
	Samples	6	4	4	3	10	7	7	4
Chloride,	Range	bdl-3.4	2.3-3.2	<2.0-3.1	1.3-3.4	2.1-11	1.8-2.4	2.1-5.8	1.8-2.7
dissolved	Median	2.6*	2.8	2.6	2.4	8.0	1.8	2.7	2.5
(mg/L)	Samples	9	4	7	6	16	7	7	7
Fluoride,	Range	<0.2-0.2	bdl	bdl-0.2	<0.2-0.2	0.2-0.5	--	--	bdl
total	Median	0.2	<0.2	<0.2	0.2	0.4	--	--	--
(mg/L)	Samples	3	4	3	3	8	0	0	3
Aluminum,	Range	130-940	--	<100-970	460-3,000	5,100-160,000	--	--	140-390
total	Median	460	--	660	1,000	26,000	--	--	250
(µg/L)	Samples	4	0	5	4	6	0	0	5
Arsenic,	Range	bdl	--	bdl	bdl	bdl-55	--	--	bdl
total	Median	--	--	--	--	1*	--	--	--
(µg/L)	Samples	6	0	7	6	15	0	0	7

Table 9. Summary of selected ground-water quality data for the Harrisburg Road landfill, 1986-92--Continued

[--, no data or insufficient data for computation of median; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; <, less than; cols/100 mL, colonies per 100 milliliters; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; µg/L, microgram per liter; *, value calculated using a log-probability regression to estimate values below detection limits]

Constituent or property (Continued)		HBW14	HBW14A	HBW14B	HBW14C	HBW14D	HBW15	HBW16	HBW17A
Barium,	Range	<100-400	--	<100-200	<100-300	<100-700	--	--	<100-300
total	Median	<100	--	<100	<100	<100	--	--	<100
(µg/L)	Samples	6	0	7	6	15	0	0	7
Cadmium,	Range	bdl	--	bdl	bdl-10	bdl	--	--	bdl
total	Median	--	--	--	--	--	--	--	--
(µg/L)	Samples	6	0	7	6	15	0	0	7
Chromium,	Range	bdl	--	bdl-19	bdl	4-180	--	--	bdl-17
total	Median	--	--	6*	--	39	--	--	8*
(µg/L)	Samples	6	0	7	6	15	0	0	7
Copper,	Range	<50	--	bdl-60	<50-80	9-430	--	--	bdl
total	Median	<50	--	<50	50	130	--	--	<50
(µg/L)	Samples	6	0	7	6	15	0	0	7
Iron,	Range	1,300-8,200	--	400-3,200	3,000-9,600	2,200-110,000	--	--	70-880
total	Median	3,400	--	1,700	5,600	20,000	--	--	220
(µg/L)	Samples	6	0	7	6	15	0	0	7
Lead,	Range	bdl-14	--	bdl-21	bdl-23	2-44	--	--	bdl-8.0
total	Median	--	--	<5	3.2*	9	--	--	6
(µg/L)	Samples	6	0	7	6	15	0	0	7
Manganese,	Range	80-200	--	130-280	240-510	90-350	--	--	20-90
total	Median	150	--	200	260	160	--	--	60
(µg/L)	Samples	6	0	7	6	15	0	0	7
Mercury,	Range	bdl	--	bdl-4.7	bdl	bdl-0.3	--	--	bdl
total	Median	--	--	0.20	--	0.1*	--	--	--
(µg/L)	Samples	6	0	7	6	15	0	0	7
Zinc,	Range	bdl-70	--	bdl-180	bdl-110	<10-250	--	--	bdl-130
total	Median	--	--	<50	60	70	--	--	<50
(µg/L)	Samples	6	0	7	6	15	0	0	7
Organic carbon,	Range	0.8-4.7	--	0.9-7.1	4.1-8.7	0.2-10	--	--	2.6-14
total	Median	2.5	--	2.2	6.2	3.2	--	--	3.2
(mg/L)	Samples	4	0	4	4	14	0	0	4

Constituent or property		HBW17B	HBW17C	HBW18A	HBW18B	HBW19A	HBW20	HBW21	HBW22
Specific	Range	bdl-80	bdl-138	131-327	301-612	170-340	56-158	78-124	57-107
conductance	Median	36	59	210	398	243	87	108	80
(µS/cm)	Samples	12	20	19	14	8	11	14	14
pH,	Range	5.1-5.9	4.6-5.7	6.1-6.9	5.8-6.4	6.2-7.2	6.1-6.7	5.8-6.4	5.4-6.2
field	Median	5.4	5.2	6.4	6.1	6.4	6.5	6.3	5.8
(standard units)	Samples	12	20	19	14	8	11	15	14
Chemical-	Range	<5-33	<5-56	<5-50	21-45	7	<5-11	<5-30	<5-68
oxygen demand	Median	12	10*	10	34	--	<5	8	17
(mg/L)	Samples	6	16	16	4	1	7	15	14
Biochemical-	Range	0.7-9.1	0.5-11	0.3-8.1	bdl	4.4	0.9-4.4	0.9-7.5	0.6-16
oxygen	Median	3.0	4.3	1.7	--	--	1.7	2.3	1.5
demand (mg/L)	Samples	6	15	15	5	1	7	14	13
Fecal	Range	<10	bdl-160	bdl-1,000	bdl	bdl	bdl	bdl-480	<2-250
coliform	Median	--	<10	<10	<10	--	--	<10	<10
(cols/100 mL)	Samples	2	14	11	6	4	4	14	13
Fecal	Range	<10	<10-700	bdl-2,400	<10	bdl-67	<10	bdl-200	bdl-160
streptococcus	Median	--	<10	<10	<10	9	<10	<10	<10
(cols/100 mL)	Samples	1	12	10	5	3	3	13	12

Table 9. Summary of selected ground-water quality data for the Harrisburg Road landfill, 1986-92--Continued

[--, no data or insufficient data for computation of median; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; <, less than; cols/100 mL, colonies per 100 milliliters; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; µg/L, microgram per liter; *, value calculated using a log-probability regression to estimate values below detection limits]

Constituent or property (Continued)		HBW17B	HBW17C	HBW18A	HBW18B	HBW19A	HBW20	HBW21	HBW22
Alkalinity,	Range	7-10	10-15	74-136	194-331	112-156	41-44	46-72	20-26
fixed endpoint	Median	7.5	12	89	229	134	43	53	23
(mg/L as $CaCO_3$)	Samples	5	7	9	6	5	4	5	5
Sulfate	Range	2.1-10	1.8-30	bdl-3.0	--	--	0.4-3.8	0.9-1.4	bdl
(mg/L)	Median	9.8	4.4	1.9*	--	--	3.0	1.2	--
	Samples	3	10	8	0	0	3	5	5
Chloride,	Range	<2.0-3.1	3.5-5.3	2.6-9.0	2.3-26	2.0	bdl-3.6	2.5-5.8	9.6-12
dissolved	Median	2.6	4.0	5.5	11	--	2.0	3.3	11
(mg/L)	Samples	6	16	16	5	1	7	15	14
Fluoride,	Range	bdl	bdl	bdl	bdl	0.3	bdl	bdl	bdl
total	Median	--	<0.1	<0.1	<0.1	--	<0.2	<0.1	<0.1
(mg/L)	Samples	3	8	8	5	1	4	10	6
Aluminum,	Range	300-3,100	240-22,000	790-16,000	5,800-130,000	230,000	1,300-45,000	1,500-28,000	660-39,000
total	Median	1,600	2,400	4,800	59,000	--	8,400	7,500	2,900
(µg/L)	Samples	4	6	7	3	1	5	5	5
Arsenic,	Range	bdl-26	bdl	bdl-17	<25-220	110	bdl	bdl	bdl-31
total	Median	--	--	1.0*	41	--	--	--	<2
(µg/L)	Samples	6	15	16	5	1	7	15	14
Barium,	Range	<100-300	<100-500	<100-300	<100-500	600	<100-100	<100-200	<100-600
total	Median	<100	<100	<100	300	--	<100	<100	<100
(µg/L)	Samples	6	15	16	5	1	7	15	14
Cadmium,	Range	bdl	bdl	bdl	bdl	<2	bdl	bdl	bdl
total	Median	--	--	--	<2	--	--	--	--
(µg/L)	Samples	6	15	16	5	1	7	15	14
Chromium,	Range	bdl-14	bdl-29	bdl-46	<25-160	240	bdl-33	bdl-50	bdl-330
total	Median	11*	9	10*	49	--	9*	13*	22*
(µg/L)	Samples	6	15	16	5	1	7	15	14
Copper,	Range	bdl-<50	<50-70	bdl-150	320-2,500	780	bdl-70	bdl-200	bdl-100
total	Median	<50	3*	23	1,200	--	<50	60	8*
(µg/L)	Samples	6	15	16	5	1	7	15	14
Iron,	Range	300-2,900	240-13,000	600-12,000	21,000-170,000	290,000	1,500-35,000	770-61,000	230-47,000
total	Median	1,600	830	1,800	77,000	--	13,000	8,000	1,600
(µg/L)	Samples	6	15	16	5	1	7	15	14
Lead,	Range	bdl-16	<1-26	bdl-32	<2-19	41	<2-34	bdl-15	<1-18
total	Median	4*	2	4	7	--	7	3	2*
(µg/L)	Samples	6	15	16	5	1	7	15	14
Manganese,	Range	50-680	110-680	40-740	590-1,500	4,800	30-250	30-400	<10-470
total	Median	110	350	220	1,000	--	160	100	55
(µg/L)	Samples	6	15	16	5	1	7	15	14
Mercury,	Range	bdl-1.0	bdl	bdl-8.6	bdl	<0.20	bdl	bdl	<0.1-2.1
total	Median	0.30	--	0.20	--	--	<0.20	--	<0.20
(µg/L)	Samples	6	15	16	5	1	7	15	14
Zinc,	Range	<50-110	<10-3,000	<10-210	120-350	630	<10-190	bdl-220	<10-180
total	Median	bdl	60	40	290	--	140	50*	40
(µg/L)	Samples	6	15	16	5	1	7	15	14
Organic carbon,	Range	0.7-51	1.5-13	0.5-8.3	7.4-44	1.1-11	0.6-2.3	1.5-9.5	1.1-17
total	Median	1.8	3.6	4.3	18	4.9	0.9	2.4	5.3
(mg/L)	Samples	4	15	14	8	3	5	14	13

Constituent or property		HBW433	HBW600	HBW700	HBW721	HBW743A	HBW800	HBW1501	HBSW1502
Specific	Range	78-97	95-108	80-97	38-70	101-150	90-100	40-62	57
conductance	Median	88	95	86	53	134	92	54	--
(µS/cm)	Samples	13	3	4	9	20	5	3	1

Table 9. Summary of selected ground-water quality data for the Harrisburg Road landfill, 1986-92--Continued

[--, no data or insufficient data for computation of median; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; <, less than; cols/100 mL, colonies per 100 milliliters; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; µg/L, microgram per liter; *, value calculated using a log-probability regression to estimate values below detection limits]

Constituent or property (Continued)		HBW433	HBW600	HBW700	HBW721	HBW743A	HBW800	HB W1501	HBSW1502
pH,	Range	5.6-7.3	6.4-6.7	6.2-6.8	5.9-6.5	5.6-7.4	6.2-7.3	4.7-5.1	5.8
field	Median	6.5	6.6	6.6	6.2	6.6	6.9	5.1	--
(standard units)	Samples	14	3	4	10	23	5	3	1
Chemical-	Range	bdl	--	--	bdl	bdl	<5	19	--
oxygen	Median	<5	--	--	<5	<5	--	--	--
demand (mg/L)	Samples	7	0	0	4	15	1	1	0
Biochemical-	Range	<0.1-1.6	<0.1-0.4	0.1-0.5	<0.1-1.4	<0.1-1.3	0.1-2.0	--	--
oxygen	Median	0.2	0.4	0.1	0.2*	0.2*	0.3	--	--
demand (mg/L)	Samples	13	2	3	8	16	5	0	0
Fecal	Range	bdl-9	--	--	bdl	bdl	--	<2	--
coliform	Median	<2	--	--	--	--	--	--	--
(cols/100 mL)	Samples	7	0	0	4	15	0	1	0
Fecal	Range	bdl-20	--	--	<2	bdl	--	--	--
streptococcus	Median	<5	--	--	--	--	--	--	--
(cols/100 mL)	Samples	4	0	0	2	12	0	0	0
Alkalinity, fixed	Range	36-43	44-51	34-41	12-21	51-64	33-43	--	--
endpoint (mg/L	Median	41	48	38	18	60	39	--	--
as $CaCO_3$)	Samples	10	2	3	7	10	5	0	0
Sulfate	Range	bdl-4.4	<1.0	<1.0-1.0	bdl-1.0	bdl	<1-1.3	<1.0	--
(mg/L)	Median	1.0	--	<1.0	<1.0	<1.0	1.0	--	--
	Samples	9	2	3	5	12	5	1	0
Chloride,	Range	bdl-2.8	0.8-2.5	1.8-5.0	bdl-4.0	3.8-7.7	1.5-2.7	4.3	--
dissolved	Median	2.1	1.6	3.0	1.7*	5.7	1.8	--	--
(mg/L)	Samples	13	2	3	8	19	5	1	0
Fluoride,	Range	bdl	--	--	bdl	bdl	--	--	--
total	Median	--	--	--	--	--	--	--	--
(mg/L)	Samples	4	0	0	3	7	0	0	0
Aluminum,	Range	<100-580	--	--	<100-150	<100-460	--	--	--
total	Median	<100	--	--	100*	<100	--	--	--
(µg/L)	Samples	6	0	0	4	7	0	0	0
Arsenic,	Range	bdl	--	--	bdl	bdl	--	<1	--
total	Median	--	--	--	<1	<2	--	--	--
(µg/L)	Samples	9	0	0	6	17	0	1	0
Barium,	Range	<100-100	--	--	<100	<100	--	<100	--
total	Median	<100	--	--	<100	<100	--	--	--
(µg/L)	Samples	9	0	0	6	17	0	1	0
Cadmium,	Range	bdl	--	--	bdl	bdl	--	<1	--
total	Median	<1	--	--	--	<1	--	--	--
(µg/L)	Samples	9	0	0	6	17	0	1	0
Chromium,	Range	bdl	--	--	bdl	bdl-5.0	--	5.0	--
total	Median	--	--	--	--	1*	--	--	--
(µg/L)	Samples	9	0	0	6	17	0	1	0
Copper,	Range	bdl	--	--	<50-100	bdl-50	--	8.0	--
total	Median	<50	--	--	62	27	--	--	--
(µg/L)	Samples	9	0	0	6	17	0	1	0
Iron,	Range	<50-390	--	--	<50-160	<10-1,400	--	2,300	--
total	Median	110	--	--	60	40	--	--	--
(µg/L)	Samples	9	0	0	6	17	0	1	0
Lead,	Range	bdl-33	--	--	<2-33	bdl-31	--	4.0	--
total	Median	4*	--	--	--	1*	--	--	--
(µg/L)	Samples	9	0	0	6	17	0	1	0
Manganese,	Range	<10-800	--	--	<10-40	<10-80	--	640	--
total	Median	<20	--	--	<20*	7*	--	--	--
(µg/L)	Samples	9	0	0	6	17	0	1	0

Table 9. Summary of selected ground-water quality data for the Harrisburg Road landfill, 1986-92--Continued

[--, no data or insufficient data for computation of median; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; <, less than; cols/100 mL, colonies per 100 milliliters; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; µg/L, microgram per liter; *, value calculated using a log-probability regression to estimate values below detection limits]

Constituent or property (Continued)		HBW433	HBW600	HBW700	HBW721	HBW743A	HBW800	HBW1501	HBSW1502
Mercury,	Range	bdl	--	--	bdl	bdl	--	0.5	--
total	Median	<0.20	--	--	<0.20	--	--	--	--
(µg/L)	Samples	9	0	0	6	17	0	1	0
Zinc,	Range	380-1,400	--	--	<50-630	70-830	--	100	--
total	Median	1,000	--	--	--	140	--	--	--
(µg/L)	Samples	9	0	0	6	17	0	1	0
Organic carbon,	Range	<0.1-0.4	--	0.3	<0.1-0.2	<0.1-0.6	--	6.5	--
total	Median	--	--	--	<0.1	0.1*	--	--	--
(mg/L)	Samples	6	0	1	5	15	0	1	0

Constituent or property		HBW1504	HBW1602	HBW1603	HBW1850	HBW2101
Specific conductance (µS/cm)	Range	27-84	175-185	154	122-215	20-22
	Median	36	180	--	179	21
	Samples	8	2	1	18	4
pH, field (standard units)	Range	5.0-6.0	5.9	5.5	5.6-6.9	4.6-5.2
	Median	5.4	--	--	6.4	5.1
	Samples	8	2	1	18	4
Chemical-oxygen demand (mg/L)	Range	<5-6	12	--	bdl	<5
	Median	<5	--	--	<5	<5
	Samples	7	1	0	15	3
Biochemical-oxygen demand (mg/L)	Range	0.2-9.8	7.6	--	0.1-2.3	0.8-3.4
	Median	1.3	--	--	1.0	2.2
	Samples	7	1	0	14	3
Fecal coliform (cols/100 mL)	Range	--	--	--	<10-18	--
	Median	--	--	--	<10	--
	Samples	0	0	0	3	0
Fecal streptococcus (cols/100 mL)	Range	--	--	--	<10-99	--
	Median	--	--	--	10	--
	Samples	0	0	0	3	0
Alkalinity, fixed end-point (mg/L as $CaCO_3$)	Range	2.0-8.0	72-77	--	59-108	2-5
	Median	3.0	74	--	84	2
	Samples	7	2	0	11	3
Sulfate (mg/L)	Range	<1.0-2.5	1.0	--	<1.0-4.8	1.0-3.0
	Median	1.2	--	--	1.0*	1.8
	Samples	7	1	0	11	3
Chloride, dissolved (mg/L)	Range	2.3-4.7	3.4	--	2.3-5.0	2.6-3.8
	Median	2.8	--	--	2.9	2.9
	Samples	7	1	0	15	3
Fluoride, total (mg/L)	Range	--	--	--	bdl	--
	Median	--	--	--	--	--
	Samples	0	0	0	4	0

Table 9. Summary of selected ground-water quality data for the Harrisburg Road landfill, 1986-92 --Continued

[--, no data or insufficient data for computation of median; µS/cm, microsiemens per centimeter; mg/L, milligram per liter; <, less than; cols/100 mL, colonies per 100 milliliters; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; µg/L, microgram per liter; *, value calculated using a log-probability regression to estimate values below detection limits]

Constituent or property (Continued)		HBW1504	HBW1602	HBW1603	HBW1850	HBW2101
Aluminum,	Range	--	--	--	<100-580	--
total	Median	--	--	--	190	--
(µg/L)	Samples	0	0	0	6	0
Arsenic,	Range	--	--	--	bdl	--
total	Median	--	--	--	--	--
(µg/L)	Samples	0	0	0	8	0
Barium,	Range	--	--	--	<100-100	--
total	Median	--	--	--	<100	--
(µg/L)	Samples	0	0	0	8	0
Cadmium,	Range	--	--	--	bdl	--
total	Median	--	--	--	--	--
(µg/L)	Samples	0	0	0	8	0
Chromium,	Range	--	--	--	bdl-26	--
total	Median	--	--	--	5.4*	--
(µg/L)	Samples	0	0	0	8	0
Copper,	Range	--	--	--	bdl-50	--
total	Median	--	--	--	<50	--
(µg/L)	Samples	0	0	0	8	0
Iron,	Range	--	--	--	<10-1,200	--
total	Median	--	--	--	390	--
(µg/L)	Samples	0	0	0	8	0
Lead,	Range	--	--	--	<5-44	--
total	Median	--	--	--	8	--
(µg/L)	Samples	0	0	0	8	0
Manganese,	Range	--	--	--	<10-70	--
total	Median	--	--	--	60	--
(µg/L)	Samples	0	0	0	8	0
Mercury,	Range	--	--	--	bdl	--
total	Median	--	--	--	<0.20	--
(µg/L)	Samples	0	0	0	8	0
Zinc,	Range	--	--	--	1,000-21,000	--
total	Median	--	--	--	14,000	--
(µg/L)	Samples	0	0	0	8	0
Organic	Range	2.5-3.2	8.1	--	0.1-3.9	2.3-8.3
carbon, total	Median	2.8	--	--	1.2	5.3
(mg/L)	Samples	2	1	0	8	2

Table 10. Summary of constituents and properties exceeding or outside of ranges designated by Mecklenburg County action levels in ground-water samples from the Harrisburg Road landfill, 1986-92

[--, no data; mg/L, milligram per liter; µg/L, microgram per liter; >, greater than]

Constituent or property		HBWE2	HBW1	HBW8	HBW10	HBW11	HBW12	HBW12A	HBW12B	HBW14
pH,	Exceedences	1	1	2	6	1	12	11	16	14
field	Samples	1	1	2	6	1	15	11	19	15
(standard	Minimum	5.8	5.4	6.0	4.6	5.9	5.8	5.7	5.8	5.9
units)	Maximum	--	--	--	--	--	--	--	--	--
Chemical-oxygen	Exceedences	0	0	0	0	--	0	0	1	0
demand	Samples	1	1	1	4	0	11	7	16	9
(mg/L)	Maximum	--	--	--	--	--	--	--	31	--
Biochemical-oxygen	Exceedences	0	--	0	0	--	2	1	3	0
demand	Samples	1	0	1	4	0	11	7	15	9
(mg/L)	Maximum	--	--	--	--	--	7.8	6.0	6.9	--
Arsenic,	Exceedences	--	--	--	--	--	0	0	2	0
total	Samples	0	0	0	0	0	7	7	15	6
(µg/L)	Maximum	--	--	--	--	--	--	--	120	--
Barium,	Exceedences	--	--	--	--	--	0	0	1	0
total	Samples	0	0	0	0	0	7	7	15	6
(µg/L)	Maximum	--	--	--	--	--	--	--	2,100	--
Cadmium,	Exceedences	--	--	--	--	--	0	0	0	0
total	Samples	0	0	0	0	0	7	7	15	6
(µg/L)	Maximum	--	--	--	--	--	--	--	--	--
Chromium,	Exceedences	--	--	--	--	--	1	0	2	0
total	Samples	0	0	0	0	0	7	7	15	6
(µg/L)	Maximum	--	--	--	--	--	150	--	200	--
Copper,	Exceedences	--	--	--	--	--	0	0	0	0
total	Samples	0	0	0	0	0	7	7	15	6
(µg/L)	Maximum	--	--	--	--	--	--	--	--	--
Iron,	Exceedences	--	--	--	--	--	7	7	15	6
total	Samples	0	0	0	0	0	7	7	15	6
(µg/L)	Maximum	--	--	--	--	--	180,000	48,000	150,000	8,200
Lead,	Exceedences	--	--	--	--	--	0	0	1	0
total	Samples	0	0	0	0	0	7	7	15	6
(µg/L)	Maximum	--	--	--	--	--	--	--	150	--
Manganese,	Exceedences	--	--	--	--	--	5	7	14	6
total	Samples	0	0	0	0	0	7	7	15	6
(µg/L)	Maximum	--	--	--	--	--	1,400	1,200	4,000	200
Mercury,	Exceedences	--	--	--	--	--	0	0	0	0
total	Samples	0	0	0	0	0	7	7	15	6
(µg/L)	Maximum	--	--	--	--	--	--	--	--	--
Zinc,	Exceedences	--	--	--	--	--	0	0	0	0
total	Samples	0	0	0	0	0	7	7	15	6
(µg/L)	Maximum	--	--	--	--	--	--	--	--	--
Organic	Exceedences	--	--	--	0	--	0	0	0	0
carbon, total	Samples	0	0	0	1	0	5	4	14	4
(mg/L)	Maximum	--	--	--	--	--	--	--	--	--
Organic halogens,	Exceedences	0	--	--	0	--	0	0	0	0
total	Samples	1	0	0	2	0	7	5	13	6
(mg/L)	Maximum	--	--	--	--	--	--	--	--	--

Table 10. Summary of constituents and properties exceeding or outside of ranges designated by Mecklenburg County action levels in ground-water samples from the Harrisburg Road landfill, 1986-92--Continued

[--, no data; mg/L, milligram per liter; µg/L, microgram per liter; >, greater than]

Constituent or property		HBW14A	HBW14B	HBW14C	HBW14D	HBW15	HBW16	HBW17A	HBW17B	HBW17C	HBW18A
pH, field (standard units)	Exceedences	5	11	10	15	14	13	12	12	20	12
	Samples	5	11	11	19	14	13	12	12	20	19
	Minimum	6.3	5.8	5.7	5.6	5.9	5.2	4.8	5.1	4.6	6.1
	Maximum		--	--	--	--	--	--	--	--	--
Chemical-oxygen demand (mg/L)	Exceedences	0	0	1	3	0	0	2	2	3	3
	Samples	4	7	6	16	7	7	7	6	16	16
	Maximum	--	--	47	71	--	--	46	33	56	50
Biochemical-oxygen demand (mg/L)	Exceedences	0	1	1	2	1	0	3	2	7	4
	Samples	4	7	6	15	7	7	7	6	15	15
	Maximum	--	5.1	5.1	8.7	5.9	--	20	9.1	11	8.1
Arsenic, total (µg/L)	Exceedences	--	0	0	1	--	--	0	0	0	0
	Samples	0	7	6	15	0	0	7	6	15	16
	Maximum	--	--	--	55	--	--	--	--	--	--
Barium, total (µg/L)	Exceedences	--	0	0	0	--	--	0	0	0	0
	Samples	0	7	6	15	0	0	7	6	15	16
	Maximum	--	--	--	--	--	--	--	--	--	--
Cadmium, total (µg/L)	Exceedences	--	0	1	0	--	--	0	0	0	0
	Samples	0	7	6	15	0	0	7	6	15	16
	Maximum	--	--	10	--	--	--	--	--	--	--
Chromium, total (µg/L)	Exceedences	--	0	0	5	--	--	0	0	0	0
	Samples	0	7	6	15	0	0	7	6	15	16
	Maximum	--	--	--	180	--	--	--	--	--	--
Copper, total (µg/L)	Exceedences	--	0	0	0	--	--	0	0	0	0
	Samples	0	7	6	15	0	0	7	6	15	16
	Maximum	--	--	--	--	--	--	--	--	--	--
Iron, total (µg/L)	Exceedences	--	7	6	15	--	--	2	6	13	16
	Samples	0	7	6	15	0	0	7	6	15	16
	Maximum	--	3,200	9,600	110,000	--	--	880	2,900	13,000	12,000
Lead, total (µg/L)	Exceedences	--	0	0	0	--	--	0	0	0	0
	Samples	0	7	6	15	0	0	7	6	15	16
	Maximum	--	--	--	--	--	--	--	--	--	--
Manganese, total (µg/L)	Exceedences	--	7	6	15	--	--	6	5	15	15
	Samples	0	7	6	15	0	0	7	6	15	16
	Maximum	--	280	510	350	--	--	90	680	680	740
Mercury, total (µg/L)	Exceedences	--	1	0	0	--	--	0	0	0	2
	Samples	0	7	6	15	0	0	7	6	15	16
	Maximum	--	4.7	--	--	--	--	--	--	--	8.6
Zinc, total (µg/L)	Exceedences	--	0	0	0	--	--	0	0	0	0
	Samples	0	7	6	15	0	0	7	6	15	16
	Maximum	--	--	--	--	--	--	--	--	--	--
Organic carbon, total (mg/L)	Exceedences	--	0	0	1	--	--	1	1	2	0
	Samples	0	4	4	14	0	0	4	4	15	14
	Maximum	--	--	--	10	--	--	14	51	13	--
Organic halogens, total (mg/L)	Exceedences	--	0	0	0	--	--	0	0	2	0
	Samples	0	6	5	13	0	0	6	6	14	14
	Maximum	--	--	--	--	--	--	--	--	0.13	--

Table 10. Summary of constituents and properties exceeding or outside of ranges designated by Mecklenburg County action levels in ground-water samples from the Harrisburg Road landfill, 1986-92--Continued

[--, no data; mg/L, milligram per liter; µg/L, microgram per liter; >, greater than]

Constituent or property		HBW18B	HBW19A	HBW20	HBW21	HBW22	HBW433	HBW600	HBW700	HBW721
pH, field (standard units)	Exceedences	14	5	5	15	15	7	1	1	8
	Samples	14	8	11	15	15	14	3	4	10
	Minimum	5.8	6.2	6.1	5.8	5.4	5.6	6.4	6.2	5.9
	Maximum	--	--	--	--	--	--	--	--	--
Chemical-oxygen demand (mg/L)	Exceedences	2	0	0	1	3	0	--	--	0
	Samples	4	1	7	15	15	7	0	0	4
	Maximum	45	--	--	30	68	--	--	--	--
Biochemical-oxygen demand (mg/L)	Exceedences	1	0	0	3	3	0	0	0	0
	Samples	5	1	7	14	14	13	2	3	8
	Maximum	13	--	--	7.5	>16	--	--	--	--
Arsenic, total (µg/L)	Exceedences	2	1	0	0	0	0	--	--	0
	Samples	5	1	7	15	15	9	0	0	6
	Maximum	220	110	--	--	--	--	--	--	--
Barium, total (µg/L)	Exceedences	0	0	0	0	0	0	--	--	0
	Samples	5	1	7	15	15	9	0	0	6
	Maximum	--	--	--	--	--	--	--	--	--
Cadmium, total (µg/L)	Exceedences	0	0	0	0	0	0	--	--	0
	Samples	5	1	7	15	15	9	0	0	6
	Maximum	--	--	--	--	--	--	--	--	--
Chromium, total (µg/L)	Exceedences	2	1	0	1	1	0	--	--	0
	Samples	5	1	7	15	15	9	0	0	6
	Maximum	160	240	--	50	330	--	--	--	--
Copper, total (µg/L)	Exceedences	3	0	0	0	0	0	--	--	0
	Samples	5	1	7	15	15	9	0	0	6
	Maximum	2,500	--	--	--	--	--	--	--	--
Iron, total (µg/L)	Exceedences	5	1	7	15	12	1	--	--	0
	Samples	5	1	7	15	15	9	0	0	6
	Maximum	170,000	290,000	35,000	61,000	47,000	390	--	--	--
Lead, total (µg/L)	Exceedences	0	0	0	0	0	0	--	--	0
	Samples	5	1	7	15	15	9	0	0	6
	Maximum	--	--	--	--	--	--	--	--	--
Manganese, total (µg/L)	Exceedences	5	1	6	13	10	2	--	--	0
	Samples	5	1	7	15	15	9	0	0	6
	Maximum	1,500	4,800	250	400	470	800	--	--	--
Mercury, total (µg/L)	Exceedences	0	0	0	0	1	0	--	--	0
	Samples	5	1	7	15	15	9	0	0	6
	Maximum	--	--	--	--	2.1	--	--	--	--
Zinc, total (µg/L)	Exceedences	0	0	0	0	0	0	--	--	0
	Samples	5	1	7	15	15	9	0	0	6
	Maximum	--	--	--	--	--	--	--	--	--
Organic carbon, total (mg/L)	Exceedences	5	1	0	0	3	0	--	0	0
	Samples	8	3	5	14	14	6	0	1	5
	Maximum	44	11	--	--	20	--	--	--	--
Organic halogens, total (mg/L)	Exceedences	0	0	0	0	0	0	0	0	0
	Samples	7	3	6	11	10	8	2	2	9
	Maximum	--	--	--	--	--	--	--	--	--

Table 10. Summary of constituents and properties exceeding or outside of ranges designated by Mecklenburg County action levels in ground-water samples from the Harrisburg Road landfill, 1986-92--Continued

[--, no data; mg/L, milligram per liter; µg/L, microgram per liter; >, greater than]

Constituent or property		HBW743A	HBW800	HBW1501	HBW1502	HBW1504	HBW1602	HBW1603	HBW1850	HBW2101
pH, field (standard units)	Exceedences	11	2	3	1	8	2	1	15	4
	Samples	23	5	3	1	8	2	1	18	4
	Minimum	5.6	6.2	4.7	5.8	5.0	5.9	5.5	5.6	4.6
	Maximum	--	--	--	--	--	--	--	--	--
Chemical-oxygen demand (mg/L)	Exceedences	0	0	0	--	0	0	--	0	0
	Samples	15	1	1	0	7	1	0	15	3
	Maximum	--	--	--	--	--	--	--	--	--
Biochemical-oxygen demand (mg/L)	Exceedences	0	0	--	--	1	1	--	0	0
	Samples	16	5	0	0	7	1	0	14	3
	Maximum	--	--	--	--	9.8	7.6	--	--	--
Arsenic, total (µg/L)	Exceedences	0	--	0	--	--	--	--	0	--
	Samples	17	0	1	0	0	0	0	8	0
	Maximum	--	--	--	--	--	--	--	--	--
Barium, total (µg/L)	Exceedences	0	--	0	--	--	--	--	0	--
	Samples	17	0	1	0	0	0	0	8	0
	Maximum	--	--	--	--	--	--	--	--	--
Cadmium, total (µg/L)	Exceedences	0	--	0	--	--	--	--	0	--
	Samples	17	0	1	0	0	0	0	8	0
	Maximum	--	--	--	--	--	--	--	--	--
Chromium, total (µg/L)	Exceedences	0	--	0	--	--	--	--	0	--
	Samples	17	0	1	0	0	0	0	8	0
	Maximum	--	--	--	--	--	--	--	--	--
Copper, total (µg/L)	Exceedences	0	--	0	--	--	--	--	0	--
	Samples	17	0	1	0	0	0	0	8	0
	Maximum	--	--	--	--	--	--	--	--	--
Iron, total (µg/L)	Exceedences	2	--	1	--	--	--	--	5	--
	Samples	17	0	1	0	0	0	0	8	0
	Maximum	1,400	--	2,300	--	--	--	--	1,200	--
Lead, total (µg/L)	Exceedences	0	--	0	--	--	--	--	0	--
	Samples	17	0	1	0	0	0	0	8	0
	Maximum	--	--	--	--	--	--	--	--	--
Manganese, total (µg/L)	Exceedences	2	--	1	--	--	--	--	5	--
	Samples	17	0	1	0	0	0	0	8	0
	Maximum	80	--	640	--	--	--	--	70	--
Mercury, total (µg/L)	Exceedences	0	--	0	--	--	--	--	0	--
	Samples	17	0	1	0	0	0	0	8	0
	Maximum	--	--	--	--	--	--	--	--	--
Zinc, total (µg/L)	Exceedences	0	--	0	--	--	--	--	5	--
	Samples	17	0	1	0	0	0	0	8	0
	Maximum	--	--	--	--	--	--	--	21,000	--
Organic carbon, total (mg/L)	Exceedences	0	--	0	--	0	0	--	0	0
	Samples	15	0	1	0	2	1	0	8	2
	Maximum	--	--	--	--	--	--	--	--	--
Organic halogens, total (mg/L)	Exceedences	0	0	1	--	0	0	--	0	0
	Samples	18	2	1	0	2	1	0	6	3
	Maximum	--	--	0.45	--	--	--	--	--	--

Table 11. Summary of synthetic organic compounds detected in ground-water samples from the Harrisburg Road landfill, 1986-92

[mg/L, milligram per liter; Max. detected, maximum concentration detected; --, not detected; µg/L, microgram per liter]

Total organic halogens (mg/L)	HBWE2	HBW10	HBW12	HBW12A	HBW12B	HBW14	HBW14B	HBW14C	HBW14D	HBW17A	HBW17B
Samples	1	2	7	5	13	6	6	5	13	6	6
Detections	1	2	1	0	1	0	0	0	2	0	2
Max. detected	0.01	0.01	0.01	--	0.02	--	--	--	0.01	--	0.06

	HBW17C	HBW18A	HBW18B	HBW19A	HBW20	HBW21	HBW22	HBW433	HBW600	HBW700	HBW721
Samples	14	4	7	3	3	11	11	8	2	2	9
Detections	8	6	5	1	1	1	8	1	0	0	1
Max. detected	0.13	0.04	0.07	0.02	0.04	0.02	0.03	0.02	--	--	0.05

	HBW743A	HBW800	HBW1501	HBW1504	HBW1602	HBW1850	HBW2101
Samples	18	2	1	2	1	6	3
Detections	1	0	1	0	1	0	1
Max. detected	0.01	--	0.45	--	0.02	--	0.05

Pesticides (µg/L)		HBW12B	HBW14	HBW14A	HBW14D	HBW15	HBW16	HBW17A	HBW17C	HBW18A	HBW18B
Aldrin,	Samples	12	3	4	12	7	7	1	11	9	4
total	Detections	0	0	0	0	0	1	0	0	0	0
	Max. detected	--	--	--	--	--	0.03	--	--	--	--
Chlordane,	Samples	12	3	4	12	7	7	1	11	9	4
total	Detections	0	0	0	0	0	0	0	1	0	0
	Max. detected	--	--	--	--	--	--	--	0.1	--	--
DDT,	Samples	12	3	4	12	7	7	1	11	9	4
total	Detections	0	3	0	0	0	1	0	0	0	0
	Max. detected	--	0.07	--	--	--	0.04	--	--	--	--
Dieldrin,	Samples	12	3	4	12	7	7	1	11	9	4
total	Detections	0	0	0	0	0	0	0	1	0	0
	Max. detected	--	--	--	--	--	--	--	0.10	--	--
Endosulfan,	Samples	12	3	4	12	7	7	1	11	9	4
total	Detections	0	0	0	0	0	1	0	0	0	0
	Max. detected	--	--	--	--	--	0.04	--	--	--	--
Heptachlor,	Samples	12	3	4	12	7	7	1	11	9	4
total	Detections	0	0	0	0	0	0	0	1	0	0
	Max. detected	--	--	--	--	--	--	--	0.02	--	--
Heptachlor	Samples	12	3	4	12	7	7	1	11	9	4
epoxide,	Detections	0	0	0	0	0	0	0	0	0	0
total	Max. detected	--	--	--	--	--	--	--	--	--	--
Lindane,	Samples	12	3	4	12	7	7	1	11	9	4
total	Detections	0	0	0	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--	--	--	--
Perthane,	Samples	12	3	4	12	7	7	1	11	9	4
total	Detections	0	0	0	0	0	1	0	0	0	0
	Max. detected	--	--	--	--	--	0.40	--	--	--	--
2,4-D,	Samples	12	3	4	11	7	7	1	12	9	4
total	Detections	1	0	4	1	6	6	0	0	1	3
	Max. detected	0.01	--	1	0.03	1.80	1.20	--	--	0.01	0.07
2,4-DP,	Samples	12	3	4	11	7	7	1	12	9	4
total	Detections	0	0	0	0	0	0	0	0	1	1
	Max. detected	--	--	--	--	--	--	--	--	0.04	0.04
2,4,5-T,	Samples	12	3	4	11	7	7	1	12	9	4
total	Detections	0	2	4	0	5	5	0	0	1	0
	Max. detected	--	0.02	0.02	--	0.05	0.03	--	0.01	0.01	--
Silvex,	Samples	12	3	4	11	7	7	1	12	9	4
total	Detections	0	1	0	0	0	0	0	0	0	0
	Max. detected	--	0.02	--	--	--	--	--	--	--	--

Pesticides (µg/L) (Continued)		HBW19A	HBW20	HBW21	HBW22	HBW433	HBW721	HBW743A	HBW1501	HBW1850
Aldrin,	Samples	1	1	14	14	1	1	12	1	10
total	Detections	0	0	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--	--	--
Chlordane,	Samples	1	1	14	14	1	1	12	1	10
total	Detections	0	0	1	11	0	1	0	0	0
	Max. detected	--	--	0.2	0.6	--	1.0	--	--	--
DDT,	Samples	1	1	14	14	1	1	12	1	10
total	Detections	0	0	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--	--	--
Dieldrin,	Samples	1	1	14	14	1	1	12	1	10
total	Detections	0	0	2	11	0	0	0	0	0
	Max. detected	--	--	0.10	0.10	--	--	--	--	--

Table 11. Summary of synthetic organic compounds detected in ground-water samples from the Harrisburg Road landfill, 1986-92--Continued

[mg/L, milligram per liter; Max. detected, maximum concentration detected; --, not detected; µg/L, microgram per liter]

Pesticides (µg/L) (Continued)		HBW19A	HBW20	HBW21	HBW22	HBW433	HBW721	HBW743A	HBW1501	HBW1850
Endosulfan, total	Samples	1	1	14	14	1	1	12	1	10
	Detections	0	0	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--	--	--
Heptachlor, total	Samples	1	1	14	14	1	1	12	1	10
	Detections	0	0	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--	--	--
Heptachlor epoxide, total	Samples	1	1	14	14	1	1	12	1	10
	Detections	0	0	2	5	0	0	0	0	0
	Max. detected	--	--	0.01	0.01	--	--	--	--	--
Lindane, total	Samples	1	1	14	14	1	1	12	1	10
	Detections	0	0	0	1	0	0	0	0	0
	Max. detected	--	--	--	0.01	--	--	--	--	--
Perthane, total	Samples	1	1	14	14	1	1	12	1	10
	Detections	0	0	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--	--	--
2,4-D, total	Samples	1	1	15	15	1	1	11	1	10
	Detections	0	1	2	3	0	0	0	1	10
	Max. detected	--	0.01	0.46	2.4	--	--	--	0.22	18
2,4-DP, total	Samples	1	1	15	15	1	1	11	1	10
	Detections	0	0	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--	--	--
2,4,5-T, total	Samples	1	1	15	15	1	1	11	1	10
	Detections	0	1	1	3	0	0	0	1	9
	Max. detected	--	0.01	0.32	1.0	--	--	--	0.09	3.5
Silvex, total	Samples	1	1	15	15	1	1	11	1	10
	Detections	0	0	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--	--	--

Halogenated aliphatic compounds (µg/L)		HBW14D	HBW17C	HBW18A	HBW18B	HBW21	HBW22	HBW721	HBW743A	HBW1501
Methyl chloride, total	Samples	2	4	5	4	6	4	0	5	1
	Detections	0	0	1	0	0	0	--	0	0
	Max. detected	--	--	60	--	--	--	--	--	--
Methylene chloride, total	Samples	2	4	5	4	6	4	1	5	1
	Detections	0	4	5	4	0	0	0	0	1
	Max. detected	--	11	10	8.4	--	--	--	--	22
Chloroform, total	Samples	2	4	5	4	6	4	1	5	1
	Detections	0	4	0	0	0	0	0	5	1
	Max. detected	--	0.40	--	--	--	--	--	0.3	0.3
Trichlorofluoromethane, total	Samples	2	4	4	4	5	4	1	5	1
	Detections	0	0	0	0	0	0	0	0	1
	Max. detected	--	--	--	--	--	--	--	--	1.5
Dichlorodifluoromethane, total	Samples	2	4	4	4	5	4	1	5	1
	Detections	0	4	3	4	0	0	0	0	1
	Max. detected	--	4.3	2.2	15	--	--	--	--	12
Vinyl chloride, total	Samples	2	4	5	4	6	4	1	5	1
	Detections	0	4	0	3	0	0	0	0	1
	Max. detected	--	5.9	--	1.6	--	--	--	--	3.0
Chloroethane, total	Samples	2	4	5	4	6	4	1	5	1
	Detections	0	4	4	3	0	0	0	0	1
	Max. detected	--	1.5	1.1	5.4	--	--	--	--	3.4
1,1-Dichloroethane, total	Samples	2	4	5	4	6	4	1	5	1
	Detections	0	4	4	4	0	0	0	5	1
	Max. detected	--	17	0.60	4.0	--	--	--	0.5	44
1,2-Dichloroethane, total	Samples	2	4	5	4	6	4	1	5	1
	Detections	0	0	0	0	0	0	0	0	1
	Max. detected	--	--	--	--	--	--	--	--	57
1,1,1-Trichloroethane, total	Samples	2	4	5	4	6	4	1	5	1
	Detections	0	0	4	4	1	0	0	0	0
	Max. detected	--	--	5.0	0.80	5.0	--	--	--	--
1,1,2-Trichloroethane, total	Samples	2	4	5	4	6	4	1	5	1
	Detections	0	0	0	0	0	0	0	0	1
	Max. detected	--	--	--	--	--	--	--	--	6.5
1,1,2,2-Tetrachloroethane, total	Samples	2	4	5	4	6	4	1	5	1
	Detections	0	0	1	0	0	0	0	0	0
	Max. detected	--	--	5.0	--	--	--	--	--	--

Table 11. Summary of synthetic organic compounds detected in ground-water samples from the Harrisburg Road landfill, 1986-92--Continued

[mg/L, milligram per liter; Max. detected, maximum concentration detected; --, not detected; µg/L, microgram per liter]

Halogenated aliphatic compounds (µg/L) (Continued)		HBW14D	HBW17C	HBW18A	HBW18B	HBW21	HBW22	HBW721	HBW743A	HBW1501
cis-1,2-Dichloro-ethylene, total	Samples	2	1	0	0	0	0	0	0	0
	Detections	0	1	--	--	--	--	--	--	--
	Max. detected	--	6.2	--	--	--	--	--	--	--
trans-1,2-Dichloro-ethylene, total	Samples	2	4	4	4	5	7	1	5	1
	Detections	0	4	2	4	0	0	0	0	1
	Max. detected	--	4.9	0.70	3.2	--	--	--	--	93
1,1-Dichloro-ethylene, total	Samples	2	4	0	4	6	4	1	5	1
	Detections	0	4	--	0	0	0	0	0	1
	Max. detected	--	0.70	--	--	--	--	--	--	1.0
Trichloro-ethylene, total	Samples	2	4	5	4	6	4	1	5	1
	Detections	0	4	2	4	0	0	0	0	1
	Max. detected	--	33	0.40	2.2	--	--	--	--	74
Tetrachloro-ethylene, total	Samples	2	4	5	4	6	4	1	5	1
	Detections	0	4	4	4	0	0	0	1	1
	Max. detected	--	110	0.50	2.8	--	--	--	0.20	130
1,2-Dichloro-propane, total	Samples	2	4	5	4	6	4	1	5	1
	Detections	0	0	0	0	0	0	0	0	1
	Max. detected	--	--	--	--	--	--	--	--	9.6

Aromatic and halogenated aromatic compounds (µg/L)		HBW10	HBW12	HBW14D	HBW17C	HBW18A	HBW18B	HBW21
Benzene, total	Samples	0	0	2	4	5	4	6
	Detections	--	--	0	4	0	4	0
	Max. detected	--	--	--	4.7	--	1.7	--
Chlorobenzene, total	Samples	0	0	2	4	5	4	6
	Detections	--	--	0	0	0	1	0
	Max. detected	--	--	--	--	--	2.7	--
1,4-Dichloro-benzene, total	Samples	1	1	2	4	6	4	6
	Detections	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--
1,3-Dichloro-benzene, total	Samples	1	1	2	4	6	4	6
	Detections	0	0	0	0	1	0	0
	Max. detected	--	--	--	--	1.8	--	--
Toluene, total	Samples	0	0	2	4	5	4	6
	Detections	--	--	0	0	1	0	1
	Max. detected	--	--	--	--	0.20	--	5.0
p-Isopropyl-toluene, total	Samples	0	0	0	1	0	0	0
	Detections	--	--	--	1	--	--	--
	Max. detected	--	--	--	0.5	--	--	--
Ethylbenzene, total	Samples	0	0	2	4	5	4	6
	Detections	--	--	0	3	0	0	0
	Max. detected	--	--	--	0.30	--	--	--
Isopropyl-benzene, total	Samples	0	0	0	1	0	0	0
	Detections	--	--	--	1	--	--	--
	Max. detected	--	--	--	1.1	--	--	--
Pseudo-cumene, total	Samples	0	0	0	1	0	0	0
	Detections	--	--	--	1	--	--	--
	Max. detected	--	--	--	1.0	--	--	--
sec-Butyl-benzene, total	Samples	0	0	0	1	0	0	0
	Detections	--	--	--	1	--	--	--
	Max. detected	--	--	--	0.20	--	--	--
Xylene, total	Samples	0	0	2	1	5	4	6
	Detections	--	--	0	1	0	0	0
	Max. detected	--	--	--	8.5	--	--	--

Aromatic and halogenated aromatic compounds (µg/L) (Continued)		HBW22	HBW433	HBW721	HBW743A	HBW1501	HBW1850
Benzene, total	Samples	4	0	1	5	1	0
	Detections	0	--	0	0	1	--
	Max. detected	--	--	--	--	31	--
Chloro-benzene, total	Samples	4	0	1	5	1	0
	Detections	0	--	0	0	1	--
	Max. detected	--	--	--	--	0.3	--
1,4-Dichloro-benzene, total	Samples	7	1	1	7	1	3
	Detections	0	0	0	0	1	0
	Max. detected	--	--	--	--	6.6	--

Table 11. Summary of synthetic organic compounds detected in ground-water samples from the Harrisburg Road landfill, 1986-92--Continued

[mg/L, milligram per liter; Max. detected, maximum concentration detected; --, not detected; µg/L, microgram per liter]

Aromatic and halogenated aromatic compounds (µg/L) (Continued)		HBW22	HBW433	HBW721	HBW743A	HBW1501	HBW1850
1,3-Dichloro-benzene, total	Samples	7	1	1	7	1	3
	Detections	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--
Toluene, total	Samples	4	0	1	5	1	0
	Detections	0	--	0	2	1	--
	Max. detected	--	--	--	2.1	0.9	--
p-Isopropyl-toluene, total	Samples	0	0	0	0	0	0
	Detections	--	--	--	--	--	--
	Max. detected	--	--	--	--	--	--
Ethyl-benzene, total	Samples	4	0	1	5	1	0
	Detections	0	--	0	0	1	--
	Max. detected	--	--	--	--	0.6	--
Isopropyl-benzene, total	Samples	0	0	0	0	0	0
	Detections	--	--	--	--	--	--
	Max. detected	--	--	--	--	--	--
Pseudo-cumene, total	Samples	0	0	0	0	0	0
	Detections	--	--	--	--	--	--
	Max. detected	--	--	--	--	--	--
sec-Butyl-benzene, total	Samples	0	0	0	0	0	0
	Detections	--	--	--	--	--	--
	Max. detected	--	--	--	--	--	--
Xylene, total	Samples	4	0	1	0	1	0
	Detections	0	--	0	5	1	--
	Max. detected	--	--	--	--	22	--

Phenols, ketones, and phthalates (µg/L)		HBW10	HBW12	HBW14D	HBW17C	HBW18A	HBW18B
Phenols, total	Samples	0	0	0	0	0	0
	Detections	--	--	--	--	--	--
	Max. detected	--	--	--	--	--	--
2-Hexanone, total	Samples	0	0	0	0	1	0
	Detections	--	--	--	--	1	--
	Max. detected	--	--	--	--	50	--
Bis(2-ethylhexyl) phthalate, total	Samples	1	1	2	3	5	2
	Detections	1	1	0	0	1	0
	Max. detected	19	6	--	--	12	--
Di-*n*-butyl phthalate, total	Samples	1	1	2	3	5	2
	Detections	0	0	0	0	0	1
	Max. detected	--	--	--	--	--	5.0
N-Butylbenzyl phthalate, total	Samples	1	1	2	3	5	2
	Detections	1	0	0	0	0	0
	Max. detected	8	--	--	--	--	--

Phenols, ketones, and phthalates (µg/L) (Continued)		HBW21	HBW22	HBW433	HBW743A	HBW1850
Phenols, total	Samples	0	0	0	1	0
	Detections	--	--	--	1	--
	Max. detected	--	--	--	23	--
2-Hexanone, total	Samples	1	0	0	0	0
	Detections	1	--	--	--	--
	Max. detected	100	--	--	--	--
Bis(2-ethyl-hexyl) phthalate, total	Samples	6	7	1	4	3
	Detections	1	2	0	0	0
	Max. detected	6.0	17	--	--	--
Di-*n*-butyl phthalate, total	Samples	6	7	1	4	3
	Detections	0	0	0	0	0
	Max. detected	--	--	--	--	--
N-Butylbenzyl phthalate, total	Samples	6	7	1	4	3
	Detections	0	0	0	0	0
	Max. detected	--	--	--	--	--

Table 12. Summary of seasonal Kendall trend test results for selected ground-water quality data from the Harrisburg Road landfill, 1979-92

[Only results significant at a probability level of 0.10 are shown. p, probability level; --, data inadequate for analysis; *, trend tests were made but trends were not significant; Slope, trend slope expressed in units per year; µS/cm, microsiemens per centimeter; % median, slope expressed as a percentage of the seasonal median; n, number observations; Record, period of record; mg/L, milligram per liter; µg/L, microgram per liter; <0.001, probability level less than 0.001]

Constituent or property		HBW1	HBW7	HBW10	HBW12	HBW12A	HBW12B	HBW14	HBW14A	HBW14B	HBW14C
Specific conductance (µS/cm)	p	--	0.043	0.035	*	*	*	*	*	*	*
	Slope	--	-18.9	2.0	--	--	--	--	--	--	--
	% median	--	-12.0	4.1	--	--	--	--	--	--	--
	n	14	13	20	23	11	21	20	17	11	11
	Record	1982-86	1982-86	1983-88	1983-92	1988-92	1988-92	1983-92	1983-86	1988-92	1988-92
pH, field (standard units)	p	*	--	*	*	*	0.056	*	0.081	*	*
	Slope	--	--	--	--	--	0.12	--	-0.18	--	--
	n	13	11	20	23	11	21	20	17	11	11
	Record	1983-86	1983-85	1983-88	1983-92	1988-92	1988-92	1983-92	1983-86	1988-92	1988-92
Chemical-oxygen demand (mg/L)	p	--	--	--	*	--	0.040	*	--	--	*
	Slope	--	--	--	--	--	1.1	--	--	--	--
	% median	--	--	--	--	--	12.4	--	--	--	--
	n	9	9	14	18	7	18	12	14	7	6
	Record	1982-86	1982-85	1983-87	1983-92	1988-92	1988-92	1983-92	1983-86	1988-92	1988-92
Biochemical-oxygen demand (mg/L)	p	--	--	*	*	0.086	*	0.014	0.029	*	*
	Slope	--	--	--	--	-1.4	--	-0.4	-0.50	--	--
	% median	--	--	--	--	-57.4	--	-31.7	-33.3	--	--
	n	9	9	14	18	7	17	12	14	7	6
	Record	1982-86	1983-85	1983-87	1983-92	1988-92	1988-92	1983-92	1983-86	1988-92	1988-92
Alkalinity, total (mg/L as $CaCO_3$)	p	*	0.022	*	*	--	--	*	0.081	--	--
	Slope	--	-12.6	--	--	--	--	--	-6.0	--	--
	% median	--	-18.2	--	--	--	--	--	-6.2	--	--
	n	13	11	18	18	7	7	13	17	6	5
	Record	1982-86	1982-86	1983-87	1983-90	1988-91	1988-90	1983-90	1983-86	1988-90	1988-90
Chloride, dissolved (mg/L)	p	*	*	*	*	--	*	*	0.081	*	*
	Slope	--	--	--	--	--	--	--	-0.6	--	--
	% median	--	--	--	--	--	--	--	-18.3	--	--
	n	11	11	14	18	7	18	12	15	7	6
	Record	1982-86	1982-86	1983-87	1983-92	1988-92	1988-92	1983-92	1983-86	1988-92	1988-92
Iron, total (µg/L)	p	--	--	--	--	--	*	0.089	--	0.086	*
	Slope	--	--	--	--	--	--	-1,800	--	-590	--
	% median	--	--	--	--	--	--	-53.8	--	-38.2	--
	n	9	4	1	8	7	17	6	0	7	6
	Record	1982-84	1982-84	1983	1983-92	1988-92	1988-92	1988-92	--	1988-92	1988-92
Manganese, total (µg/L)	p	--	--	--	--	--	0.059	*	--	*	*
	Slope	--	--	--	--	--	-320	--	--	--	--
	% median	--	--	--	--	--	-74.4	--	--	--	--
	n	9	4	1	8	7	17	6	0	7	6
	Record	1982-84	1982-84	1983	1983-92	1988-92	1988-92	1988-92	--	1988-92	1988-92

Table 12. Summary of seasonal Kendall trend test results for selected ground-water quality data from the Harrisburg Road landfill, 1979-92--Continued

[Only results significant at a probability level of 0.10 are shown. p, probability level; --, data inadequate for analysis; *, trend tests were made but trends were not significant; Slope, trend slope expressed in units per year; µS/cm, microsiemens per centimeter; % median, slope expressed as a percentage of the seasonal median; n, number observations; Record, period of record; mg/L, milligram per liter; µg/L, microgram per liter; <0.001, probability level less than 0.0001]

Constituent or property		HBW14D	HBW15	HBW16	HBW17A	HBW17B	HBW17C	HBW18A	HBW18B	HBW20	HBW21
Specific conductance (µS/cm)	p	0.006	0.045	*	*	*	*	<0.001	0.025	*	*
	Slope	13	-3.5	--	--	--	--	42.8	40	--	--
	% median	8.2	-3.3	--	--	--	--	18	9.4	--	--
	n	21	27	24	12	12	22	20	15	11	18
	Record	1988-92	1983-88	1983-88	1988-92	1988-92	1988-92	1988-92	1988-92	1988-92	1988-93
pH, field (standard units)	p	0.056	0.012	*	*	*	0.029	*	*	*	0.029
	Slope	0.08	-0.08	--	--	--	-0.10	--	--	--	0.08
	n	21	26	23	12	12	22	19	15	11	18
	Record	1988-93	1983-88	1983-88	1988-92	1988-92	1988-92	1988-92	1988-92	1988-92	1988-93
Chemical-oxygen demand (mg/L)	p	*	*	*	--	--	*	*	--	*	*
	Slope	--	--	--	--	--	--	--	--	--	--
	% median	--	--	--	--	--	--	--	--	--	--
	n	18	17	17	7	6	18	17	5	7	18
	Record	1988-93	1983-87	1983-87	1988-92	1988-92	1988-92	1988-93	1989-92	1988-92	1989-92
Biochemical-oxygen demand (mg/L)	p	*	*	*	--	--	*	*	--	*	*
	Slope	--	--	--	--	--	--	--	--	--	--
	% median	--	--	--	--	--	--	--	--	--	--
	n	17	17	17	7	6	17	16	6	7	18
	Record	1988-93	1983-87	1983-87	1988-92	1988-92	1988-92	1988-92	1989-92	1988-92	1989-92
Alkalinity, total (mg/L as $CaCO_3$)	p	--	0.015	*	--	--	--	--	--	--	--
	Slope	--	-6.2	--	--	--	--	--	--	--	--
	% median	--	-12.2	--	--	--	--	--	--	--	--
	n	7	26	22	7	5	7	9	6	5	5
	Record	1988-90	1983-87	1983-87	1988-90	1988-90	1988-90	1988-90	1988-90	1988-90	1989-90
Chloride, dissolved (mg/L)	p	0.025	*	*	--	--	*	0.008	--	*	*
	Slope	1.4	--	--	--	--	--	0.85	--	--	--
	% median	10.0	--	--	--	--	--	15.5	--	--	--
	n	18	17	17	7	6	15	17	6	7	18
	Record	1988-93	1983-87	1983-87	1988-92	1988-92	1988-92	1988-93	1989-92	1988-92	1988-93
Iron, total (µg/L)	p	*	--	--	--	--	*	0.026	--	*	*
	Slope	--	--	--	--	--	--	-1,200	--	--	--
	% median	--	--	--	--	--	--	-57.4	--	--	--
	n	17	0	0	7	6	17	17	6	7	18
	Record	1988-93	--	--	1988-92	1988-92	1988-92	1988-92	1989-92	1988-92	1988-93
Manganese, total (µg/L)	p	*	--	--	--	--	*	*	--	0.093	*
	Slope	--	--	--	--	--	--	--	--	-55	--
	% median	--	--	--	--	--	--	--	--	-34.4	--
	n	17	0	0	7	6	17	17	6	7	18
	Record	1988-93	--	--	1988-92	1988-92	1988-92	1988-92	1989-92	1988-92	1988-93

Table 12. Summary of seasonal Kendall trend test results for selected ground-water quality data from the Harrisburg Road landfill, 1979-92--Continued

[Only results significant at a probability level of 0.10 are shown. p, probability level; --, data inadequate for analysis; *, trend tests were made but trends were not significant; Slope, trend slope expressed in units per year; µS/cm, microsiemens per centimeter; % median, slope expressed as a percentage of the seasonal median; n, number observations; Record, period of record; mg/L, milligram per liter; µg/L, microgram per liter; <0.001, probability level less than 0.001]

Constituent or property		HBW22	HBW433	HBW721	HBW743A	HBW800	HBW1504	HBW1603	HBW1850	HBW2101
Specific conductance (µS/cm)	p	0.054	*	*	0.088	*	--	0.038	*	*
	Slope	5.0	--	--	1.0	--	--	25	--	--
	% median	6.1	--	--	0.7	--	--	47.2	--	--
	n	16	15	14	30	16	22	14	34	16
	Record	1989-92	1983-92	1983-92	1983-92	1983-87	1982-88	1982-88	1982-92	1983-88
pH, field (standard units)	p	*	*	*	0.040	*	0.097	*	0.058	*
	Slope	--	--	--	0.11	--	0.12	--	-0.03	--
	n	16	15	13	29	16	22	14	33	16
	Record	1989-92	1983-92	1983-92	1983-92	1983-87	1982-88	1982-88	1982-92	1983-88
Chemical-oxygen demand (mg/L)	p	*	*	--	--	*	*	--	*	*
	Slope	--	--	--	--	--	--	--	--	--
	% median	--	--	--	--	--	--	--	--	--
	n	16	8	6	19	7	19	10	27	12
	Record	1989-92	1983-92	1983-91	1983-92	1983-87	1982-87	1982-85	1982-92	1983-88
Biochemical-oxygen demand (mg/L)	p	*	*	0.069	*	*	*	*	*	*
	Slope	--	--	-0.06	--	--	--	--	--	--
	% median	--	--	-21.1	--	--	--	--	--	--
	n	15	14	11	21	15	18	9	26	12
	Record	1989-92	1983-92	1983-91	1983-92	1983-87	1982-87	1982-85	1982-92	1983-88
Alkalinity, total (mg/L as $CaCO_3$)	p	--	*	*	*	*	*	0.065	*	*
	Slope	--	--	--	--	--	--	10.8	--	--
	% median	--	--	--	--	--	--	77.8	--	--
	n	5	11	12	17	17	21	12	27	14
	Record	1989-90	1983-90	1983-90	1983-90	1983-87	1982-87	1982-88	1983-92	1983-88
Chloride, dissolved (mg/L)	p	*	*	*	*	*	0.004	*	0.049	*
	Slope	--	--	--	--	--	0.6	--	-0.15	--
	% median	--	--	--	--	--	28	--	-4.8	--
	n	16	14	11	24	15	20	11	27	15
	Record	1989-92	1983-92	1983-92	1983-92	1983-87	1982-87	1982-85	1982-92	1983-88
Iron, total (µg/L)	p	*	*	--	*	--	--	--	--	--
	Slope	--	--	--	--	--	--	--	--	--
	% median	--	--	--	--	--	--	--	--	--
	n	16	9	6	19	1	3	2	9	2
	Record	1989-92	1988-92	1988-92	1988-92	1983	1983	1983	1982-92	1983
Manganese, total (µg/L)	p	0.025	*	--	*	--	--	--	--	--
	Slope	-10	--	--	--	--	--	--	--	--
	% median	-20	--	--	--	--	--	--	--	--
	n	16	9	6	19	1	3	1	9	2
	Record	1989-92	1988-92	1988-92	1988-92	1983	1983	1983	1982-92	1983

Table 37. Summary of selected ground-water quality data for the York Road landfill, 1986-92

[µS/cm, microsiemen per centimeter; --, no data or insufficient data for computation of median; mg/L, milligram per liter; <, less than; *, value calculated using a log-probability regression to estimate values below detection limits; >, greater than; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; cols/100 mL, colonies per 100 milliliters; µg/L, microgram per liter]

Constituent or property		YRWA	YRW1	YRW2	YRW3	YRW6	YRW6A	YRW6B
Specific	Range	73-150	425-3,000	78-117	155-188	550-580	375-530	515-1,130
conductance	Median	82	1,400	96	162	565	420	835
(µS/cm)	Samples	4	11	8	8	2	21	18
pH, field	Range	6.0-6.2	5.9-7.2	5.6-7.0	5.0-5.6	6.2-6.4	5.9-7.8	6.1-7.8
(standard	Median	6.1	6.5	6.0	5.4	--	6.4	6.5
units)	Samples	4	11	8	7	2	20	17
Dissolved	Range	--	--	1.9	--	--	1.8	0.1
oxygen	Median	--	--	--	--	--	--	--
(mg/L)	Samples	0	0	1	0	0	1	1
Chemical-	Range	<5	16-2,700	<5-11	<5-9	<5	<5-11	15-48
oxygen	Median	<5	180	<5	<5	<5	7.5	32
demand (mg/L)	Samples	3	5	5	5	2	8	8
Biochemical-	Range	0.6-4.3	2.4->510	0.9-4.5	0.2-17	0.6-1.4	0.4-8.1	1.1-13
oxygen	Median	1.8	31	2.1	1.2	1.0	0.8	3.2
demand (mg/L)	Samples	3	5	5	5	2	10	8
Fecal	Range	--	--	--	--	--	bdl	bdl
coliform	Median	--	--	--	--	--	--	--
(cols/100 mL)	Samples	0	0	0	0	0	2	2
Fecal	Range	--	--	--	--	--	--	--
streptococcus	Median	--	--	--	--	--	--	--
(cols/100 mL)	Samples	0	0	0	0	0	0	0
Alkalinity,	Range	30-33	171-1,470	21-38	50-77	144-164	131-190	230-374
field (mg/L	Median	31	743	30	59	154	171	302
as $CaCO_3$)	Samples	3	10	6	7	2	12	11
Sulfate	Range	<1.0-1.6	<1.0-10	0.8-3.8	bdl-4.0	1.0-2.0	1.3-7.9	1.3-8.0
(mg/L)	Median	--	2.2	1.7	2.0	1.5	4.8	2.3
	Samples	2	6	4	5	2	5	5
Chloride,	Range	2.3-10	21-180	4.9-5.3	2.6-7.5	68-69	27-48	49-97
dissolved	Median	2.9	80	5.1	2.9	68.5	34	80
(mg/L)	Samples	3	5	5	5	2	8	9
Fluoride,	Range	<0.1	--	<0.1	--	--	bdl	bdl
total	Median	--	--	--	--	--	<0.2	<0.2
(mg/L)	Samples	1	0	1	0	0	3	3
Aluminum,	Range	--	160	--	610	--	690-45,000	4,800-52,000
total	Median	--	--	--	--	--	15,000	8,000
(µg/L)	Samples	0	1	0	1	0	4	4
Arsenic,	Range	<25	2	<25	<1	--	bdl-34	bdl
total	Median	--	--	--	--	--	3	<10
(µg/L)	Samples	1	1	1	1	0	5	6
Barium,	Range	100	100	600	100	--	<100-1,400	300-500
total	Median	--	--	--	--	--	<100	300
(µg/L)	Samples	1	1	1	1	0	5	6
Cadmium,	Range	<5	<1	<5	<1	--	bdl	bdl
total	Median	--	--	--	--	--	<2	<2
(µg/L)	Samples	1	1	1	1	0	5	6
Chromium,	Range	<25	7	410	9	--	bdl	15-73
total	Median	--	--	--	--	--	<10	20
(µg/L)	Samples	1	1	1	1	0	5	6
Copper,	Range	<50	<50	310	<50	--	<50-110	bdl-110
total	Median	--	--	--	--	--	<50	<50
(µg/L)	Samples	1	1	1	1	0	5	6
Iron,	Range	5,100	150,000	25,000	8,500	--	1,400-34,000	24,000-81,000
total	Median	--	--	--	--	--	8,200	54,000
(µg/L)	Samples	1	1	1	1	0	5	6
Lead,	Range	1-84	6	84	8	--	bdl-10	2-20
total	Median	42	--	--	--	--	<5	6
(µg/L)	Samples	2	1	1	1	0	5	6
Manganese,	Range	290	35,000	1,800	2,300	--	490-1,300	2,800-4,600
total	Median	--	--	--	--	--	770	3,700
(µg/L)	Samples	1	1	1	1	0	5	6
Mercury,	Range	<1.0	<0.20	<1.0	<0.20	--	bdl	bdl
total	Median	--	--	--	--	--	<0.20	<0.20
(µg/L)	Samples	1	1	1	1	0	5	6
Zinc,	Range	110	110	510	90	--	<50-100	10-210
total	Median	--	--	--	--	--	60	120
(µg/L)	Samples	1	1	1	1	0	5	6
Organic	Range	3.7-7.0	37-80	0.5-7.0	3.6-23	--	1.7-20	8.3-17
carbon,	Median	5.4	53	1.7	13	--	3.8	11
total (mg/L)	Samples	2	4	3	2	0	10	8

Table 37. Summary of selected ground-water quality data for the York Road landfill, 1986-92--Continued

[µS/cm, microsiemen per centimeter; --, no data or insufficient data for computation of median; mg/L, milligram per liter; <, less than; *, value calculated using a log-probability regression to estimate values below detection limits; >, greater than; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; cols/100 mL, colonies per 100 milliliters; µg/L, microgram per liter]

Constituent or property (Continued)		TRW6C	YRW7	YRW7A	YRW7B	YRW8
Specific	Range	200-1,350	103-260	100-160	96-185	85-354
conductance	Median	628	121	112	142	245
(µS/cm)	Samples	18	11	11	14	13
pH, field	Range	5.5-7.0	5.5-6.4	5.5-6.0	5.6-6.6	5.6-6.4
(standard	Median	6.5	5.9	5.7	5.8	6.1
units)	Samples	16	11	9	13	12
Dissolved	Range	0.1	1.1	3.3	1.9	2.4
oxygen	Median	--	--	--	--	--
(mg/L)	Samples	1	1	1	1	1
Chemical-	Range	11-99	<5-41	<5-22	<5-17	<5-61
oxygen	Median	40	10	7*	8	31
demand (mg/L)	Samples	8	5	4	9	7
Biochemical-	Range	0.7->7.2	1.1-8.3	1.6-110	0.7-6.3	0.4-6.6
oxygen	Median	4.0	1.5	2.4	1.6	1.2
demand (mg/L)	Samples	10	5	4	8	7
Fecal	Range	<10	bdl	<100	<100	bdl
coliform	Median	--	--	--	--	<100
(cols/100 mL)	Samples	1	2	1	1	3
Fecal	Range	--	--	--	--	--
streptococcus	Median	--	--	--	--	--
(cols/100 mL)	Samples	0	0	0	0	0
Alkalinity,	Range	95-433	43-74	41-49	41-97	49-148
field (mg/L	Median	351	74	44	68	102
as $CaCO_3$)	Samples	11	3	3	8	5
Sulfate	Range	bdl-7.9	0.20-0.60	2.7-7.4	bdl-1.9	2.9-140
(mg/L)	Median	5.6*	0.40	5.0	<1.0	120
	Samples	6	2	2	4	2
Chloride,	Range	17-140	2.8-8.5	2.3-25	0.8-8.8	1.0-31
dissolved	Median	62	3.5	5.2	3.5	22
(mg/L)	Samples	8	5	4	9	7
Fluoride,	Range	bdl	bdl	0.1-0.2	<0.20	bdl
total	Median	<0.2	0.1	0.15	<0.20	<0.2
(mg/L)	Samples	4	3	2	5	5
Aluminum,	Range	1,700-24,000	3,100-47,000	7,500-75,000	1,600-19,000	730-260,000
total	Median	2,600	36,000	15,000	3,600	89,000
(µg/L)	Samples	3	3	3	7	5
Arsenic,	Range	bdl	bdl	<1-43	bdl	bdl-240
total	Median	<5	5	15*	<2	120
(µg/L)	Samples	5	5	5	9	7
Barium,	Range	100-2,000	bdl-1,400	bdl-1,500	<100-700	<100-900
total	Median	400	200	400	<100	200
(µg/L)	Samples	5	5	5	9	7
Cadmium,	Range	bdl	bdl	bdl	bdl	bdl
total	Median	<2	<1	<1	<2	<2
(µg/L)	Samples	5	5	5	9	7
Chromium,	Range	1-130	bdl-68	bdl-120	bdl	bdl-250
total	Median	2	3*	17	<10	26
(µg/L)	Samples	5	5	5	9	7
Copper,	Range	bdl-120	bdl-90	bdl-220	bdl-50	bdl-260
total	Median	50	<50	100	<50	110
(µg/L)	Samples	5	5	5	9	7
Iron,	Range	6,500-86,000	1,200-72,000	12,000-230,000	530-11,000	640-200,000
total	Median	28,000	3,300	53,000	4,000	49,000
(µg/L)	Samples	5	5	5	9	7
Lead,	Range	3-66	bdl-39	4-97	bdl-19	12-81
total	Median	11	6	26	4*	20
(µg/L)	Samples	5	5	5	9	7
Manganese,	Range	840-2,200	80-500	80-1,800	30-150	50-1,900
total	Median	1,300	270	400	70	480
(µg/L)	Samples	5	5	5	9	7
Mercury,	Range	bdl	bdl	bdl	bdl	bdl-1.5
total	Median	<0.20	<0.20*	<0.20	0.24*	0.30*
(µg/L)	Samples	5	5	5	9	7
Zinc,	Range	20-6,300	40-340	50-510	40-270	30-530
total	Median	140	140	150	100	170
(µg/L)	Samples	5	5	5	9	7
Organic	Range	11-21	0.2-3.7	1.1-5.6	0.2-6.9	6.2-26
carbon, total	Median	13	3.4	4.5	3.9	14
(mg/L)	Samples	7	3	3	4	5

Table 37. Summary of selected ground-water quality data for the York Road landfill, 1986-92--Continued

[µS/cm, microsiemen per centimeter; --, no data or insufficient data for computation of median; mg/L, milligram per liter; <, less than; *, value calculated using a log-probability regression to estimate values below detection limits; >, greater than; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; cols/100 mL, colonies per 100 milliliters; µg/L, microgram per liter]

Constituent or property		YRW8A	YRW9	YRW9A	YRW9B	YRW10A	YRW10B
Specific	Range	100-265	168-300	123-170	250-920	700-1,540	710-1,020
conductance	Median	130	250	140	380	1,010	892
(µS/cm)	Samples	12	9	10	11	13	12
pH, field	Range	6.1-6.9	6.1-6.7	6.1-6.9	5.8-6.9	6.0-6.5	6.2-6.7
(standard	Median	6.5	6.4	6.5	6.1	6.3	6.6
units)	Samples	11	10	11	11	13	11
Dissolved	Range	3.6	0.3	1.1	0.9	0.2	0.2
oxygen	Median	--	--	--	--	--	--
(mg/L)	Samples	1	1	1	1	1	1
Chemical-	Range	<5-16	<5-11	<5-22	20-50	44-140	29-80
oxygen	Median	6	7	9*	39	60	40
demand (mg/L)	Samples	6	5	6	7	8	5
Biochemical-	Range	1.0-11	1.2-12	1.4-9.2	0.3-5.9	1.1->20	3.2-16
oxygen demand	Median	2.4	1.8	3.6	2.3	11	8.1
(mg/L)	Samples	6	5	6	7	8	5
Fecal	Range	<100	<10-120	<10	<100-210	bdl	<100
coliform	Median	--	--	--	190	--	--
(cols/100 mL)	Samples	1	2	1	3	2	1
Fecal	Range	--	--	--	310	--	--
streptococcus	Median	--	--	--	--	--	--
(cols/100 mL)	Samples	0	0	0	1	0	0
Alkalinity,	Range	44-74	103-115	62-69	67-302	246-335	256-426
field (mg/L	Median	59	112	64	112	269	286
as $CaCO_3$)	Samples	4	3	4	6	5	6
Sulfate	Range	4.0-5.6	2.2-8.4	0.70-8.4	36-110	<0.10-34	bdl-56
(mg/L)	Median	4.2	5.3	2.8	73	<0.10	<1.0
	Samples	3	2	3	2	3	3
Chloride,	Range	1.6-18	1.0-20	1.5-2.4	1.5-41	100-320	86-150
dissolved	Median	2.8	16	2.0	30	220	110
(mg/L)	Samples	6	5	6	7	8	5
Fluoride,	Range	bdl	bdl	<0.2-0.2	bdl-0.2	0.2-0.3	0.2
total	Median	<0.2	0.1	0.2	<0.2	0.2	0.2
(mg/L)	Samples	3	3	3	5	5	2
Aluminum,	Range	1,800-340,000	240-5,300	1,000-65,000	730-420,000	<100-15,000	100-18,000
total	Median	20,000	4,600	5,300	2,400	600	8,000
(µg/L)	Samples	4	3	4	5	5	4
Arsenic,	Range	bdl-72	bdl	bdl	bdl-170	bdl	bdl
total	Median	5*	6	2*	3*	<2	<1
(µg/L)	Samples	6	5	6	7	8	5
Barium,	Range	<100-2,000	<100-1,400	bdl-300	bdl-3,200	300-4,300	200-3,000
total	Median	200	200	100*	300	500	200
(µg/L)	Samples	6	5	6	7	8	5
Cadmium,	Range	bdl	bdl	bdl	bdl	bdl	bdl
total	Median	<2	<1	<2	<2	<2	<1
(µg/L)	Samples	6	5	6	7	8	5
Chromium,	Range	4-440	1-86	3-90	<2-1,400	<2-68	3-43
total	Median	30	7	16	5*	8	6
(µg/L)	Samples	6	5	6	7	8	5
Copper,	Range	bdl-1,600	bdl-110	bdl-190	bdl-650	bdl-140	bdl-130
total	Median	50*	<50	<50	50	<50	60
(µg/L)	Samples	6	5	6	7	8	5
Iron,	Range	840-190,000	3,700-39,000	970-52,000	3,500-340,000	67,000-100,000	42,000-120,000
total	Median	7,200	18,000	1,800	7,700	86,000	69,000
(µg/L)	Samples	6	5	6	7	8	5
Lead,	Range	bdl-150	<1-13	bdl-14	2-87	1-14	1-8
total	Median	7	4	7	6	6	4
(µg/L)	Samples	6	5	6	7	8	5
Manganese,	Range	20-11,000	630-700	150-620	3,000-22,000	4,000-5,900	5,900-6,400
total	Median	490	680	200	5,300	5,200	6,200
(µg/L)	Samples	6	5	6	7	8	5
Mercury,	Range	bdl	bdl	bdl	bdl-2.6	bdl	bdl-0.30
total	Median	<0.20	<0.20	<0.20	0.20*	<0.20	<0.20
(µg/L)	Samples	6	5	6	7	8	5
Zinc,	Range	30-1,700	<10-180	<50-190	<50-960	30-220	<10-120
total	Median	100	90	60	110	70	60
(µg/L)	Samples	6	5	6	7	8	5
Organic	Range	6.9-20	0.9-5.7	1.9-5.0	5.4-92	11-28	15-67
carbon,	Median	7.1	4.8	4.3	9.3	18	36
total (mg/L)	Samples	3	3	4	6	6	5

Table 37. Summary of selected ground-water quality data for the York Road landfill, 1986-92--Continued

[μS/cm, microsiemen per centimeter; --, no data or insufficient data for computation of median; mg/L, milligram per liter; <, less than; *, value calculated using a log-probability regression to estimate values below detection limits; >, greater than; bdl, value below the least sensitive analytical detection limit where multiple detection levels were used; cols/100 mL, colonies per 100 milliliters; μg/L, microgram per liter]

Constituent or property		YRW10C	YRW11A	YRW11B	YRW11C	YRWB12
Specific	Range	503-950	178-525	218-522	175-285	45-68
conductance	Median	800	270	266	204	65
(μS/cm)	Samples	11	11	14	10	3
pH, field	Range	6.0-6.5	5.7-6.4	5.3-7.2	5.3-6.0	6.1-6.5
(standard	Median	6.3	6.0	5.7	5.8	6.4
units)	Samples	11	10	13	10	3
Dissolved	Range	0.2	0.4	1.1	0.4	--
oxygen	Median	--	--	--	--	--
(mg/L)	Samples	1	1	1	1	0
Chemical-	Range	32-100	10-53	<5-29	<5-37	<5-6
oxygen	Median	61	21	16	14	<5
demand (mg/L)	Samples	6	5	8	4	2
Biochemical-	Range	6.9-20	1.0-15	0.7-6.7	0.6-3.9	0.5-3.4
oxygen	Median	14	5.2	1.2	1.6	2.0
demand (mg/L)	Samples	6	5	8	4	2
Fecal	Range	bdl	<10	<10	<100	--
coliform	Median	--	<10	<10	--	--
(cols/100 mL)	Samples	2	2	2	1	0
Fecal strepto-	Range	--	--	--	--	--
coccus	Median	--	--	--	--	--
(cols/100 mL)	Samples	0	0	0	0	0
Alkalinity,	Range	358-446	98-177	95-256	74-92	20-23
field (mg/L	Median	440	116	116	89	21
as $CaCO_3$)	Samples	3	3	8	3	3
Sulfate	Range	2.1-150	0.30-2.6	<1.0-1.1	9.1	2.9-4.3
(mg/L)	Median	76	1.4	<1.0	--	3.6
	Samples	2	2	4	1	2
Chloride,	Range	9.5-65	1.3-29	2.8-32	1.3-18	2.3-3.2
dissolved	Median	16	10	15	13	2.8
(mg/L)	Samples	2	5	8	5	2
Fluoride,	Range	bdl	<0.2-0.3	bdl	bdl-0.3	<0.2
total	Median	<0.2	0.2	<0.2	<0.2	<0.2
(mg/L)	Samples	4	3	4	3	2
Aluminum,	Range	430-56,000	1,600-26,000	460-23,000	1,400-170,000	680
total	Median	30,000	10,000	800	48,000	--
(μg/L)	Samples	3	3	6	3	1
Arsenic,	Range	bdl	bdl	bdl	bdl	6
total	Median	<10	2	<2	2	--
(μg/L)	Samples	6	5	8	4	1
Barium,	Range	300-5,600	<100-1,000	<100-1,500	bdl-1,200	<100
total	Median	500	<100	<100	200	--
(μg/L)	Samples	6	5	8	5	1
Cadmium,	Range	bdl	bdl	bdl	bdl	<1
total	Median	<1	<1	<1	<1	--
(μg/L)	Samples	6	5	8	5	1
Chromium,	Range	3-64	bdl	bdl	<2-120	4
total	Median	26	6	8	10	--
(μg/L)	Samples	6	5	8	5	1
Copper,	Range	bdl-150	bdl-70	bdl	bdl-170	<50
total	Median	<50	<50	<50	<50	--
(μg/L)	Samples	6	5	8	5	1
Iron,	Range	81,000-190,000	17,000-85,000	830-23,000	7,600-210,000	3,100
total	Median	120,000	68,000	3,800	34,000	--
(μg/L)	Samples	6	5	8	5	1
Lead,	Range	<1-10	2-14	3-22	6-110	14
total	Median	6	8	4	12	--
(μg/L)	Samples	6	5	8	5	1
Manganese,	Range	2,700-7,400	5,300-12,000	3,100-15,000	4,800-11,000	320
total	Median	5,600	8,300	6,200	6,500	--
(μg/L)	Samples	6	5	8	5	1
Mercury,	Range	bdl	bdl	bdl	bdl	<0.20
total	Median	0.20*	<0.20	<0.20	<0.20	--
(μg/L)	Samples	6	5	8	5	1
Zinc,	Range	10-120	30-130	50-170	20-540	80
total	Median	80	110	70	110	--
(μg/L)	Samples	6	5	8	5	1
Organic	Range	16-47	1.7-9.7	2.3-7.4	1.2-10	4.7-7.5
carbon,	Median	21	6.5	3.1	3.1	6.1
total (mg/L)	Samples	3	3	6	3	2

Table 39. Summary of synthetic organic compounds detected in ground-water samples from the York Road landfill, 1986-92

[mg/L, milligram per liter; Max. detected, maximum concentration detected; --, not detected; µg/L, microgram per liter]

Total organic halogens (mg/L)	YRWA	YRW1	YRW2	YRW3	YRW6A	YRW6B	YRW6C	YRW7	YRW7A
Samples	3	2	3	2	8	7	6	5	5
Detections	2	2	0	2	8	7	5	3	5
Max. detected	0.32	0.64	--	0.07	0.05	0.24	0.33	0.11	0.02

	YRW7B	YRW8	YRW8A	YRW9	YRW9A	YRW9B	YRW10A	YRW10B	YRW10C
Samples	5	5	5	5	5	5	6	4	6
Detections	3	4	3	3	1	4	5	4	6
Max. detected	0.13	0.04	0.04	0.05	0.02	0.10	0.10	0.07	0.04

	YRW11A	YRW11B	YRW11C	YRWB12
Samples	5	5	5	1
Detections	5	4	5	1
Max. detected	0.29	0.33	0.16	0.01

Pesticides (µg/L)		YRW6A	YRW6B	YRW6C	YRW7	YRW7A	YRW7B	YRW8	YRW8A	YRW9
Perthane,	Samples	1	1	3	1	1	3	3	1	1
total	Detections	0	0	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--	--	--
2,4-D,	Samples	1	1	3	1	1	3	3	1	1
total	Detections	0	0	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--	--	--
2,4-DP,	Samples	1	1	3	1	1	3	3	1	1
total	Detections	0	0	1	0	0	0	0	0	0
	Max. detected	--	--	0.07	--	--	--	--	--	--
2,4,5-T,	Samples	1	1	3	1	1	3	3	1	1
total	Detections	0	0	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--	--	--

Pesticides (µg/L) (Continued)		YRW9A	YRW9B	YRW10A	YRW10B	YRW10C	YRW11A	YRW11B	YRW11C
Perthane,	Samples	2	3	3	2	1	1	2	1
total	Detections	0	0	0	0	0	0	1	0
	Max. detected	--	--	--	--	--	--	1.0	--
2,4-D,	Samples	2	3	3	2	1	1	3	1
total	Detections	0	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--	--
2,4-DP,	Samples	2	3	3	2	1	1	3	1
total	Detections	0	1	0	0	0	0	0	0
	Max. detected	--	0.05	--	--	--	--	--	--
2,4,5-T,	Samples	2	3	3	2	1	1	3	1
total	Detections	0	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--	--

Halogenated aliphatic compounds (µg/L)		YRWA	YRW2	YRW6A	YRW6B	YRW6C	YRW7	YRW7A	YRW7B	YRW8
Methyl	Samples	1	1	1	1	2	2	1	2	2
chloride,	Detections	0	0	0	0	0	1	0	0	0
total	Max. detected	--	--	--	--	--	15	--	--	--
Chlorodibromo-	Samples	1	1	1	1	2	2	1	2	2
methane,	Detections	0	0	0	0	0	0	0	0	0
total	Max. detected	--	--	--	--	--	--	--	--	--
Dichlorobromo-	Samples	1	1	1	1	2	2	1	2	2
methane,	Detections	0	0	0	0	0	0	0	0	0
total	Max. detected	--	--	--	--	--	--	--	--	--
Methylene	Samples	1	1	1	1	2	2	1	2	2
chloride,	Detections	1	0	0	1	0	2	0	2	0
total	Max. detected	14	--	--	11	--	110	--	18	--
Chloroform,	Samples	1	1	1	1	2	2	1	2	2
total	Detections	0	0	0	0	0	1	0	0	0
	Max. detected	--	--	--	--	--	0.5	--	--	--

Table 39. Summary of synthetic organic compounds detected in ground-water samples from the York Road landfill, 1986-92--Continued

[mg/L, milligram per liter; Max. detected, maximum concentration detected; --, not detected; μg/L, microgram per liter]

Halogenated aliphatic compounds (μg/L) (Continued)		YRWA	YRW2	YRW6A	YRW6B	YRW6C	YRW7	YRW7A	YRW7B	YRW8
Dichlorodifluoro-	Samples	0	0	0	0	1	1	0	1	1
methane,	Detections	--	--	--	--	0	1	--	1	0
total	Max. detected	--	--	--	--	--	46	--	21	--
Trichlorofluoro-	Samples	0	0	0	0	1	1	0	1	1
methane,	Detections	--	--	--	--	0	1	--	1	0
total	Max. detected	--	--	--	--	--	26	--	16	--
Vinyl	Samples	1	1	1	1	2	2	1	2	2
chloride,	Detections	0	0	0	0	0	0	0	0	0
total	Max. detected	--	--	--	--	--	--	--	--	--
Chloroethane,	Samples	1	1	1	1	2	2	1	2	2
total	Detections	0	0	0	0	0	2	0	0	0
	Max. detected	--	--	--	--	--	22	--	--	--
1,1-Dichloro-	Samples	1	1	1	1	2	2	1	2	2
ethane,	Detections	1	0	0	0	0	2	0	2	0
total	Max. detected	5	--	--	--	--	50	--	5.3	--
1,2-Dichloro-	Samples	1	1	1	1	2	2	1	2	2
ethane,	Detections	1	0	0	0	0	0	0	0	0
total	Max. detected	5	--	--	--	--	--	--	--	--
1,1,1-Trichloro-	Samples	1	1	1	1	2	2	1	2	2
ethane,	Detections	0	0	0	0	0	2	0	1	0
total	Max. detected	--	--	--	--	--	19	--	12	--
1,1,2,2-Tetra-	Samples	1	1	1	1	2	2	1	1	2
chloroethane,	Detections	0	0	0	0	0	1	1	1	0
total	Max. detected	--	--	--	--	--	26	3	4	--
trans-1,2-	Samples	0	0	0	0	1	1	0	1	1
Dichloroethylene,	Detections	--	--	--	--	0	1	--	0	0
total	Max. detected	--	--	--	--	--	0.7	--	--	--
1,1-Dichloro-	Samples	1	1	1	1	2	2	1	2	2
ethylene,	Detections	0	0	0	0	0	1	0	1	0
total	Max. detected	--	--	--	--	--	2.0	--	1.1	--
1,2-Dichloro-	Samples	1	1	1	1	1	1	1	1	1
ethylene,	Detections	0	0	1	0	0	1	0	0	0
total	Max. detected	--	--	14	--	--	4	--	--	--
Trichloro-	Samples	1	1	1	1	2	2	1	2	2
ethylene,	Detections	0	0	1	0	0	2	0	1	0
total	Max. detected	--	--	6	--	--	12	--	1.7	--
Tetrachloro-	Samples	1	1	1	1	2	2	1	2	2
ethylene,	Detections	0	0	0	0	0	2	1	2	0
total	Max. detected	--	--	--	--	--	29	3	6.3	--

Halogenated aliphatic compounds (μg/L) (Continued)		YRW8A	YRW9	YRW9A	YRW9B	YRW10A	YRW10C	YRW11A	YRW11B	YRW11C
Methyl	Samples	1	1	1	1	2	2	1	1	1
chloride,	Detections	0	0	0	0	0	0	1	1	0
total	Max. detected	--	--	--	--	--	--	21	15	--
Chlorodibromo-	Samples	1	1	1	1	3	2	1	1	1
methane,	Detections	0	0	0	0	0	0	0	0	0
total	Max. detected	--	--	--	--	--	--	--	--	--
Dichlorobromo-	Samples	1	1	1	1	3	2	1	1	1
methane,	Detections	0	0	0	0	0	0	0	0	0
total	Max. detected	--	--	--	--	--	--	--	--	--
Methylene	Samples	1	1	1	1	3	2	1	1	1
chloride,	Detections	0	0	0	0	0	1	0	0	0
total	Max. detected	--	--	--	--	--	22	--	--	--
Chloroform,	Samples	1	1	1	1	3	1	1	1	1
total	Detections	0	0	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--	--	--

Table 39. Summary of synthetic organic compounds detected in ground-water samples from the York Road landfill, 1986-92--Continued

[mg/L, milligram per liter; Max. detected, maximum concentration detected; --, not detected; µg/L, microgram per liter]

Halogenated aliphatic compounds (µg/L) (Continued)		YRW8A	YRW9	YRW9A	YRW9B	YRW10A	YRW10C	YRW11A	YRW11B	YRW11C
Dichlorodifluoro-	Samples	0	0	0	0	2	0	0	0	0
methane,	Detections	--	--	--	--	0	--	--	--	--
total	Max. detected	--	--	--	--	--	--	--	--	--
Trichlorofluoro-	Samples	0	0	0	0	2	0	0	0	0
methane,	Detections	--	--	--	--	0	--	--	--	--
total	Max. detected	--	--	--	--	--	--	--	--	--
Vinyl	Samples	1	1	1	1	3	2	1	1	1
chloride,	Detections	0	0	0	0	0	0	1	1	1
total	Max. detected	--	--	--	--	--	--	23	77	24
Chloroethane,	Samples	1	1	1	1	3	2	1	1	1
total	Detections	0	0	0	0	1	0	1	1	0
	Max. detected	--	--	--	--	0.3	--	24	29	--
1,1-Dichloro-	Samples	1	1	1	1	3	2	1	1	1
ethane,	Detections	0	0	0	0	2	0	1	1	1
total	Max. detected	--	--	--	--	0.7	--	180	75	41
1,2-Dichloro-	Samples	1	1	1	1	3	2	1	1	1
ethane,	Detections	0	0	0	0	0	0	1	1	0
total	Max. detected	--	--	--	--	--	--	36	11	--
1,1,1-Trichloro-	Samples	1	1	1	1	3	2	0	1	1
ethane,	Detections	0	0	0	0	0	0	--	0	0
total	Max. detected	--	--	--	--	--	--	--	--	--
1,1,2,2-Tetra-	Samples	1	1	1	1	3	2	1	1	1
chloroethane,	Detections	0	0	0	0	0	0	1	0	0
total	Max. detected	--	--	--	--	--	--	11	--	--
trans-1,2-	Samples	0	0	0	0	2	0	0	0	0
Dichloroethylene,	Detections	--	--	--	--	0	--	--	--	--
total	Max. detected	--	--	--	--	--	--	--	--	--
1,1-Dichloro-	Samples	1	1	1	1	3	2	1	1	1
ethylene,	Detections	0	0	0	0	0	0	0	0	0
total	Max. detected	--	--	--	--	--	--	--	--	--
1,2-Dichloro-	Samples	1	1	1	1	1	2	1	1	1
ethylene,	Detections	0	0	0	0	0	0	1	1	1
total	Max. detected	--	--	--	--	--	--	80	318	39
Trichloro-	Samples	1	1	1	1	3	2	1	1	1
ethylene,	Detections	0	0	0	0	0	0	1	1	1
total	Max. detected	--	--	--	--	--	--	12	22	3
Tetrachloro-	Samples	1	1	1	1	3	2	1	1	1
ethylene,	Detections	0	0	0	0	0	0	1	0	0
total	Max. detected	--	--	--	--	--	--	13	--	--

Aromatic compounds (µg/L)		YRWA	YRW2	YRW6A	YRW6B	YRW6C	YRW7	YRW7A	YRW7B	YRW8
Benzene,	Samples	1	1	1	1	2	2	1	2	2
total	Detections	0	0	0	0	0	1	0	0	0
	Max. detected	--	--	--	--	--	0.2	--	--	--
Toluene,	Samples	1	1	1	1	2	2	1	2	2
total	Detections	0	0	0	0	0	1	0	0	0
	Max. detected	--	--	--	--	--	0.3	--	--	--

Aromatic compounds (µg/L) (Continued)		YRW8A	YRW9	YR9A	YR9B	YR10A	YRW10C	YRW11A	YRW11B	YRW11C
Benzene,	Samples	1	1	1	1	3	2	1	1	1
total	Detections	0	0	0	0	2	0	0	0	0
	Max. detected	--	--	--	--	1.4	--	--	--	--
Toluene,	Samples	1	1	1	1	3	2	1	1	1
total	Detections	0	0	0	0	1	0	0	0	0
	Max. detected	--	--	--	--	0.8	--	--	--	--

Table 39. Summary of synthetic organic compounds detected in ground-water samples from the York Road landfill, 1986-92--Continued

[mg/L, milligram per liter; Max. detected, maximum concentration detected; --, not detected; µg/L, microgram per liter]

Ketones and phthalates (µg/L)		YRWA	YRW1	YRW2	YRW6A	YRW6B	YRW6C	YRW7
Methyl-isobutyl ketone, total	Samples	1	0	1	1	1	1	1
	Detections	1	--	0	0	0	0	0
	Max. detected	88	--	--	--	--	--	--
Bis(2-ethylhexyl) phthalate, total	Samples	1	1	1	3	1	2	1
	Detections	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--
Diethyl phthalate, total	Samples	1	1	1	3	1	2	1
	Detections	0	1	0	0	0	0	0
	Max. detected	--	13	--	--	--	--	--
Dibutyl phthalate, total	Samples	1	1	1	3	1	2	1
	Detections	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--

Ketones and phthalates (µg/L) (Continued)		YRW7A	YRW7B	YRW8	YRW8A	YRW9	YR9A	YR9B
Methyl-isobutyl ketone, total	Samples	1	1	1	1	1	1	1
	Detections	0	0	0	0	0	0	1
	Max. detected	--	--	--	--	--	--	5
Bis(2-ethylhexyl) phthalate, total	Samples	2	2	1	1	1	1	1
	Detections	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--
Diethyl phthalate, total	Samples	2	2	1	1	1	1	1
	Detections	0	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--	--
Dibutyl phthalate, total	Samples	2	2	1	1	1	1	1
	Detections	0	0	0	0	0	0	1
	Max. detected	--	--	--	--	--	--	5

Ketones and phthalates (µg/L) (Continued)		YR10A	YRW10B	YRW10C	YRW11A	YRW11B	YRW11C
Methyl-isobutyl ketone, total	Samples	2	1	2	1	1	1
	Detections	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--
Bis(2-ethylhexyl) phthalate, total	Samples	2	1	2	1	2	1
	Detections	1	1	0	0	1	0
	Max. detected	6.0	11	--	--	35	--
Diethyl phthalate, total	Samples	2	1	2	1	2	1
	Detections	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--
Dibutyl phthalate, total	Samples	2	1	2	1	2	1
	Detections	0	0	0	0	0	0
	Max. detected	--	--	--	--	--	--