GEOHDYDROLOGY AND GROUND-WATER QUALITY AT THE PUEBLO DEPOT ACTIVITY LANDFILL NEAR PUEBLO, COLORADO

By Kenneth R. Watts and Roderick F. Ortiz

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CONVERSION FACTORS

Inch-pound units in this report may be converted to International System of units (SI) by using the following conversion factors:

Multiply inch-pound unit	*By*	*To obtain SI unit*
acre	4,047	square meter
cubic foot per day (ft^3/d)	0.028317	cubic meter per day
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
foot per mile (ft/mi)	0.18943	meter per kilometer
foot per second (ft/s)	0.3048	meter per second
gallon (gal)	3.785	liter
gallon per day per foot [(gal/d)/ft]	0.00379	meter squared per day
gallon per minute	0.06308	liter per second
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
pound (lb)	0.4536	kilogram
square foot (ft^2)	0.09294	square meter

Degree Celsius (°C) may be converted to degree Fahrenheit (°F) by using the following equation:

$$°F = 9/5\ (°C) + 32.$$

The following terms and abbreviations also are used in this report.

micrometer (μm)

microgram per liter (μg/L)

microsiemens per centimeter at 25 degrees Celsius (μS/cm)

milligram per kilogram (mg/kg)

milligram per liter (mg/L)

milliliter (mL)

square micrometer (μm^2)

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

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ABSTRACT

The landfill at the Pueblo Depot Activity, a U.S. Department of the Army installation in southeastern Colorado, overlies a shallow unconfined aquifer. The Pueblo County Commissioners have required that an investigation of the geology and ground-water quality be done and that a long-term monitor-well network be established before a certificate of designation for the landfill can be issued.

Nine monitor wells and four piezometers were installed at the landfill during October 1988. The geologic data collected during drilling was used to define the geology of the shallow unconfined aquifer. The unconfined aquifer consists of upland alluvial terrace deposits of moderate permeability that are underlain by about 1,200 feet of almost impermeable shale. Saturated thickness of the aquifer at the landfill generally is between 5 and 10 feet. Ground water discharged at seeps at the edge of the terrace deposits may recharge the alluvial aquifer underlying the nearby Arkansas River valley.

The ground water predominantly is a mixed-cation mixed-anion type water that has dissolved-solids concentrations of 710 to 1,810 milligrams per liter. A downgradient increase in the concentration of dissolved solids occurs across the landfill. Chemical analyses done to evaluate the presence of man made organic compounds indicated that, in parts of the landfill, the aquifer is contaminated with trichloroethylene and trans-1,2-dichloroethylene. Concentrations of these contaminants greater than the detection limit occurred at five of the monitor wells, at a seep, and at an offsite stock tank. The concentrations of trichloroethylene ranged from 5.2 to 2,900 micrograms per liter and of trans-1,2-dichloroethylene from 5 to 720 micrograms per liter.

Contamination of the ground water at the landfill from an upgradient source and from a source within the landfill is indicated by the areal variation in concentrations of contaminants. Analyses of water samples from downgradient domestic-supply wells, indicated that trichloroethylene and trans-1,2-dichloroethylene have not migrated to the alluvial aquifer underlying the nearby Arkansas River valley.

INTRODUCTION

The Pueblo Depot Activity (fig. 1) is a facility of the U.S. Army that began operations in 1942. It primarily operates as a reserve storage and maintenance installation, and it recently was selected as one of the sites for destruction of the Pershing missile systems under the INF treaty between the United States of America and the Union of Soviet Socialist Republics. The destruction consists of mounting the missiles in a stand, static firing the motor, and disposing of the spent casing in a landfill.

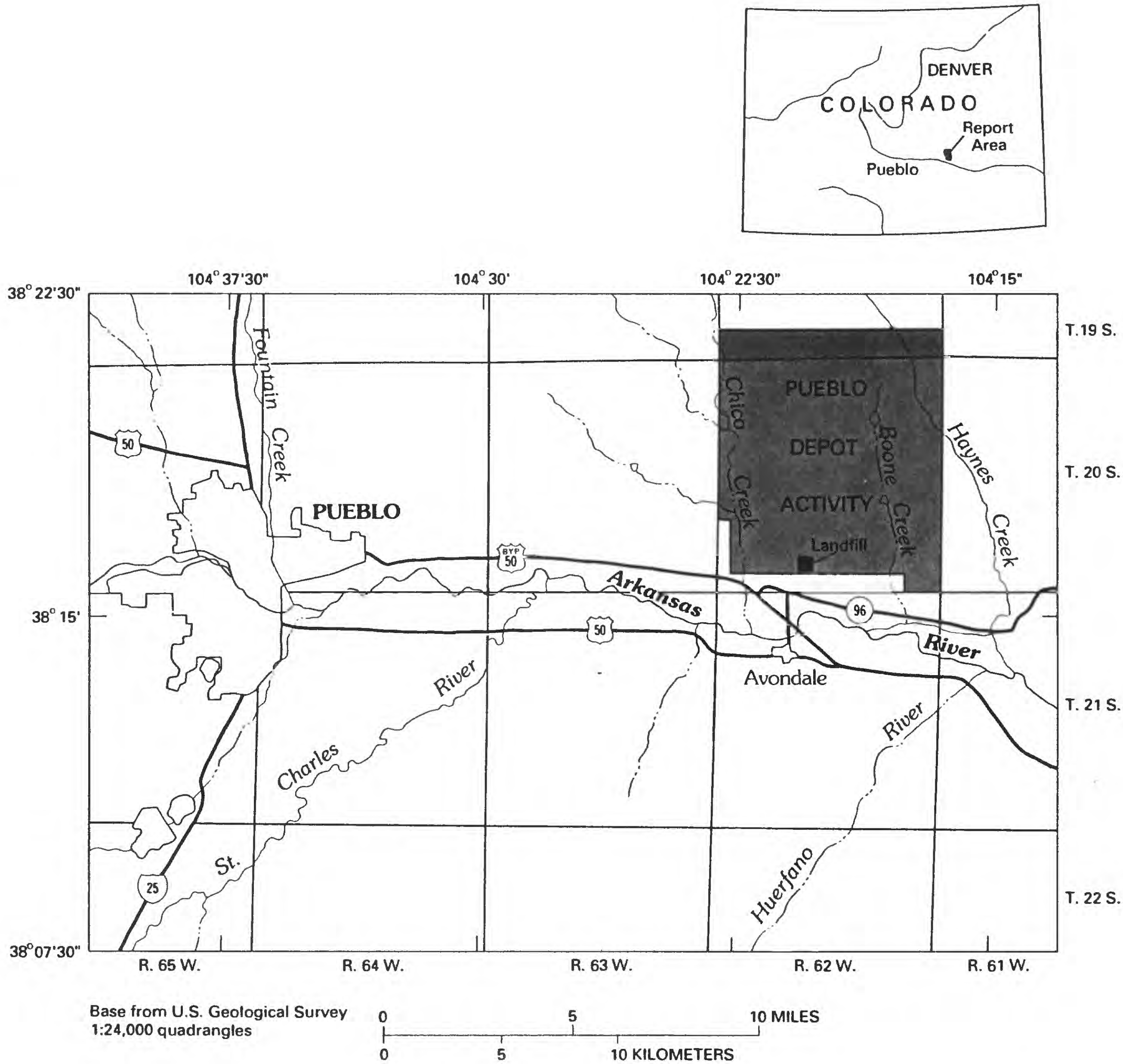

Figure 1.--Location of the Pueblo Depot Activity.

The Pueblo Depot Activity primarily is underlain by shallow unconfined aquifers that consist of unconsolidated alluvial terrace deposits. These aquifers, although relatively thin, may contribute flow to the alluvial aquifer of the Arkansas River valley either directly as underflow from the alluvium of Chico Creek or indirectly as discharge from seeps draining toward the Arkansas River valley.

The destruction and disposal of the Pershing missile systems at the Pueblo Depot Activity presents a potential for contamination of the shallow ground-water system. Because the shallow aquifers are the water supply for the Pueblo Depot Activity and may also provide recharge to the alluvial aquifer of the Arkansas River valley (the principal aquifer system in southeastern Colorado), it is necessary to define the chemical constituents in the ground water prior to destruction and disposal of the Pershing missile systems so that changes in the chemistry of the ground water can be quantified. Geohydrologic data and chemical characteristics of ground water at the disposal site are required by State and local agencies for permitting of landfill operations.

In 1988, the U.S. Geological Survey began a study in cooperation with the U.S. Department of the Army to provide the geohydrologic data that State and local agencies required for obtaining a certificate of designation for a landfill at the Pueblo Depot Activity. The objectives of the study were to characterize the geohydrology and the chemical characteristics of ground water from the shallow unconfined aquifer that underlies the landfill at the Pueblo Depot Activity and to evaluate the potential effects of the landfill on ground-water quality.

Purpose and Scope

This report describes the geohydrologic system and chemical characteristics of ground water at the Pueblo Depot Activity landfill, as required for the issuance of a certificate of designation for the landfill, and describes the potential effects of the landfill on ground-water quality. The data were collected from monitor wells and piezometers that were drilled during Ocotober 1988 and January 1989. Ground-water samples were collected during December 1988 and mid-January 1989 from eight wells, a seep, and an offsite stock tank. These sites and the four piezometers were sampled during February 1989. Water levels were measured in the monitor wells and piezometers to determine depth from land surface to the water table, the water-table altitude, and saturated thickness of the shallow unconfined aquifer at the landfill. Hydraulic characteristics of the aquifer are based on lithologic descriptions and results of aquifer tests in nearby wells with similar lithologic characteristics. Maps and geologic sections are used to depict the spatial variation in geohydrologic characteristics at the landfill.

Description of the Study Area

The study area (fig. 1) is a landfill at the Pueblo Depot Activity. The study area will be referred to as the "landfill" throughout this report. The Pueblo Depot Activity, formerly called the Pueblo Army Depot, occupies a 22,654-acre area on an upland terrace (mesa) about 15 mi east of Pueblo, on the northern side of the Arkansas River valley. The relatively flat surface of the upland terrace slopes at about 25 ft/mi toward the Arkansas River valley. Land-surface altitude of the terrace ranges from about 4,600 to 4,800 ft above sea level. Local relief from the terrace to the valley is about 100 to 150 ft. The terrace is bounded on the west by Chico Creek, on the south by the Arkansas River valley, and on the east by Haynes Creek. The northern boundary of the terrace deposits is obscured by overlying eolian deposits.

The landfill (fig. 2) is located along the southern edge of the upland terrace deposits and occupies a 153-acre parcel of land in the northeast quarter of Section 33 and northwest quarter of Section 34, Township 20 South, Range 62 West of the Sixth Principal Meridian. The landfill has been in use since the early 1940's. Disposal of paper and domestic waste is in unlined trenches that are about 10-ft wide and 10-ft deep. Special areas at the landfill are used for disposal of asbestos, spent missile casings, asphalt, concrete, roofing materials, and fly and bottom ash (fig. 2). The Defense Reutilization Marketing Office of Battle Creek, Michigan, has contracts with a service company for treatment and disposal of all hazardous waste from the Pueblo Depot Activity consistent with State and federal regulations and the Resources Conservation and Recovery Act (RCRA). Hazardous waste is not disposed in the landfill at the Pueblo Depot Activity.

The altitude of the land surface at the landfill ranges from about 4,585 to 4,670 ft above sea level. An ephemeral stream crosses the study area from north to south. The land surface at the landfill slopes toward the stream. A marshy area, which is a ground-water discharge area, occurs near where the stream crosses the southern edge of the landfill.

The climate of the area is semiarid. Annual precipitation averages about 11 in. Soils at the landfill consist of deep, well-drained, sandy and silty loam (Larson and others, 1979). Natural vegetation at the landfill consists of grasses and brush, except in the ground-water discharge area near the ephemeral stream (fig. 2), where cattails and other water plants grow.

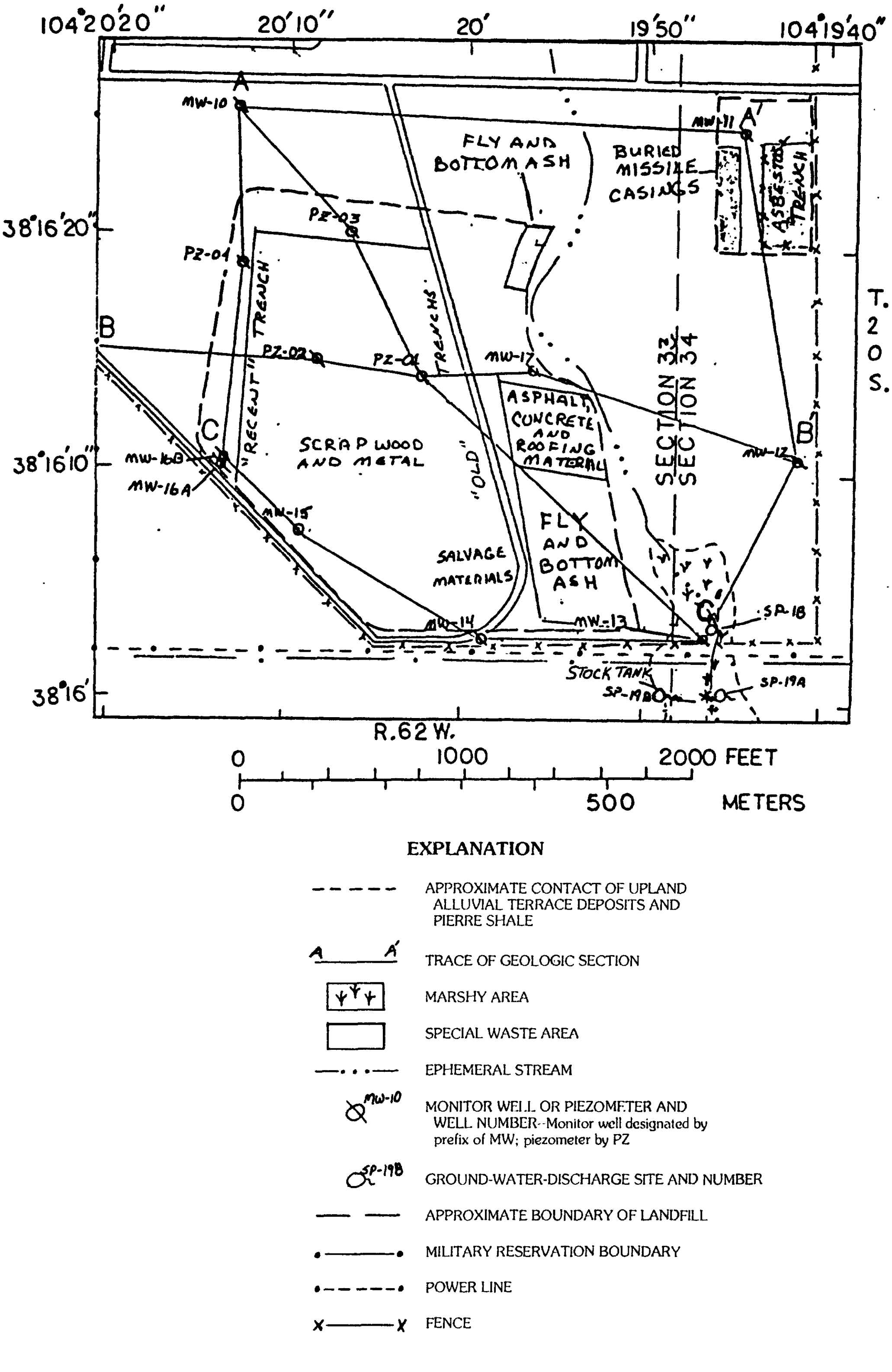

Figure 2.--Locations of monitor wells, piezometers, seeps, and approximate locations of areas for special wastes at the landfill.

Acknowledgments

The assistance and cooperation of personnel of the Pueblo Depot Activity aided in the completion of the data collection. The cooperation of neighboring property owners, who allowed access to their wells and property for collection of ground-water samples, is appreciated.

METHOD OF INVESTIGATION AND DATA COLLECTION

This investigation of the geohydrologic system at the landfill was done in two phases. The first phase consisted of test drilling and installation of monitor wells around the landfill and of piezometers within the landfill. Geologic data collected during drilling consisted of driller's logs and depth to bedrock. The second phase consisted of the collection of ground-water samples and of the measurement of water levels. The hydraulic and storage properties of the unconfined aquifer were determined during a previous investigation (Welder and Hurr, 1971).

Drilling Methods and Well Construction and Development

Nine monitor wells and four piezometers (fig. 2) were installed at the landfill during October 1988. One well, MW-10, was redrilled during January 1989. Monitor well MW-16A, which is a dry well, was completed above a layer of cemented sand and gravel to determine if perched water-table conditions exist. Location coordinates, land-surface and measuring-point altitudes, and measuring-point corrections of the wells and piezometers are listed in table 1. A schematic diagram (fig. 18) and an explanation of the system of designating local well number is provided in the "System of Numbering Wells" subsection in the "Supplemental Data" section at the back of this report.

Table 1.--*Location coordinates and altitudes of monitor wells and piezometers at the landfill*

[MW, monitor well; PZ, piezometer]

Well number (location shown in fig. 2)	Local number	Latitude	Longitude	Land-surface altitude (feet)	Measuring-point correction above datum (feet)	Measuring-point altitude (feet)
MW-10	SC02006233ABB0	38°16'27"	104°20'13"	4,670.21	1.69	4,671.90
MW-11	SC02006234BBB0	38°16'26"	104°19'45"	4,655.07	2.52	4,657.59
MW-12	SC02006234BCB0	38°16'11"	104°19'41"	4,634.82	2.94	4,637.76
MW-13	SC02006234BCC0	38°16'03"	104°19'46"	4,587.99	2.40	4,590.39
MW-14	SC02006233ADC0	38°16'03"	104°19'59"	4,629.66	2.50	4,632.16
MW-15	SC02006233ACD0	38°16'07"	104°20'09"	4,663.23	2.39	4,665.62
MW-16A	SC02006233ACB0	38°16'10"	104°20'14"	4,668.76	2.81	4,671.57
MW-16B	SC02006233ACB1	38°16'10"	104°20'14"	4,669.53	2.22	4,671.75
MW-17	SC02006233ADB0	38°16'14"	104°19'56"	4,629.88	2.68	4,632.56
PZ-01	SC02006233ADB1	38°16'14"	104°20'02"	4,643.54	2.40	4,645.94
PZ-02	SC02006233ACA0	38°16'15"	104°20'08"	4,659.95	2.50	4,662.45
PZ-03	SC02006233ABD0	38°16'20"	104°20'07"	4,654.16	2.42	4,656.58
PZ-04	SC02006233ABC0	38°16'19"	104°20'13"	4,667.25	2.63	4,669.88

Five monitor wells (MW-10, MW-11, MW-13, MW-16A, and MW-17) and the four piezometers were installed using a hollow-stem auger that had a 3.25-in. inside diameter. When monitor well MW-10 was redrilled, a hollow-stem auger that had a 4.25-in. inside diameter was used. Four monitor wells (MW-12, MW-14, MW-15, and MW-16B) were installed, using the hydraulic rotary method. The water supply of the Pueblo Depot Activity was used to supply water for drilling and decontamination. During the drilling of monitor well MW-16B, bentonite was added to the drilling fluid because of circulation losses. After the casing was emplaced at MW-16B, fresh water was circulated in the borehole to remove mudcake on the borehole walls. Circulation loss also occurred during the drilling of monitor wells MW-14 and MW-15; however, bentonite was not needed to complete the drilling of these wells. Because of caving, the casing had to be jetted to bedrock at MW-14 and MW-16B. All downhole equipment was steam cleaned after use in each borehole to prevent contamination between sites.

All wells were constructed using a schedule-40, polyvinyl chloride (PVC) casing, which was pre-cleaned (acid rinsed and wrapped), was flush-joint threaded, and had a 2-in. inside diameter. Well screens consisted of a 10-ft section of machine-slotted PVC casing with a 2-in. inside diameter and a 0.010-in. slot width. A PVC cap was placed on the bottom of the screen section. The bottom of the screen section was set at or slightly into bedrock (shale). O-rings were used on all threaded connections between screen and casing sections. No solvents or cements were used in joining the well casing, screen, and end cap.

A gravel pack of 16 mesh silica sand was emplaced from the bedrock surface to at least 2 ft above the top of the screen. After emplacement of the gravel pack, a minimum of 2 ft of 0.25-in.-diameter bentonite pellets was emplaced above the gravel pack. After the bentonite pellets had hydrated, a cement-bentonite grout was emplaced above the bentonite seal to within about 0-2 ft of land surface. A 5-ft long by 4.5-in. diameter, steel protective casing that had a locking cap was placed over the PVC casing and set in the center of a 4-ft by 4-ft by 6-in.-thick concrete pad. Three 5-ft long by 4-in. diameter steel bumper poles were cemented in place around each concrete pad to protect the well from accidental destruction. A schematic diagram of generalized well construction is shown in figure 3. Driller's logs are listed in table 8 and construction details of the monitor wells and piezometers are listed in table 9 in the "Supplemental Data" section at the back of this report.

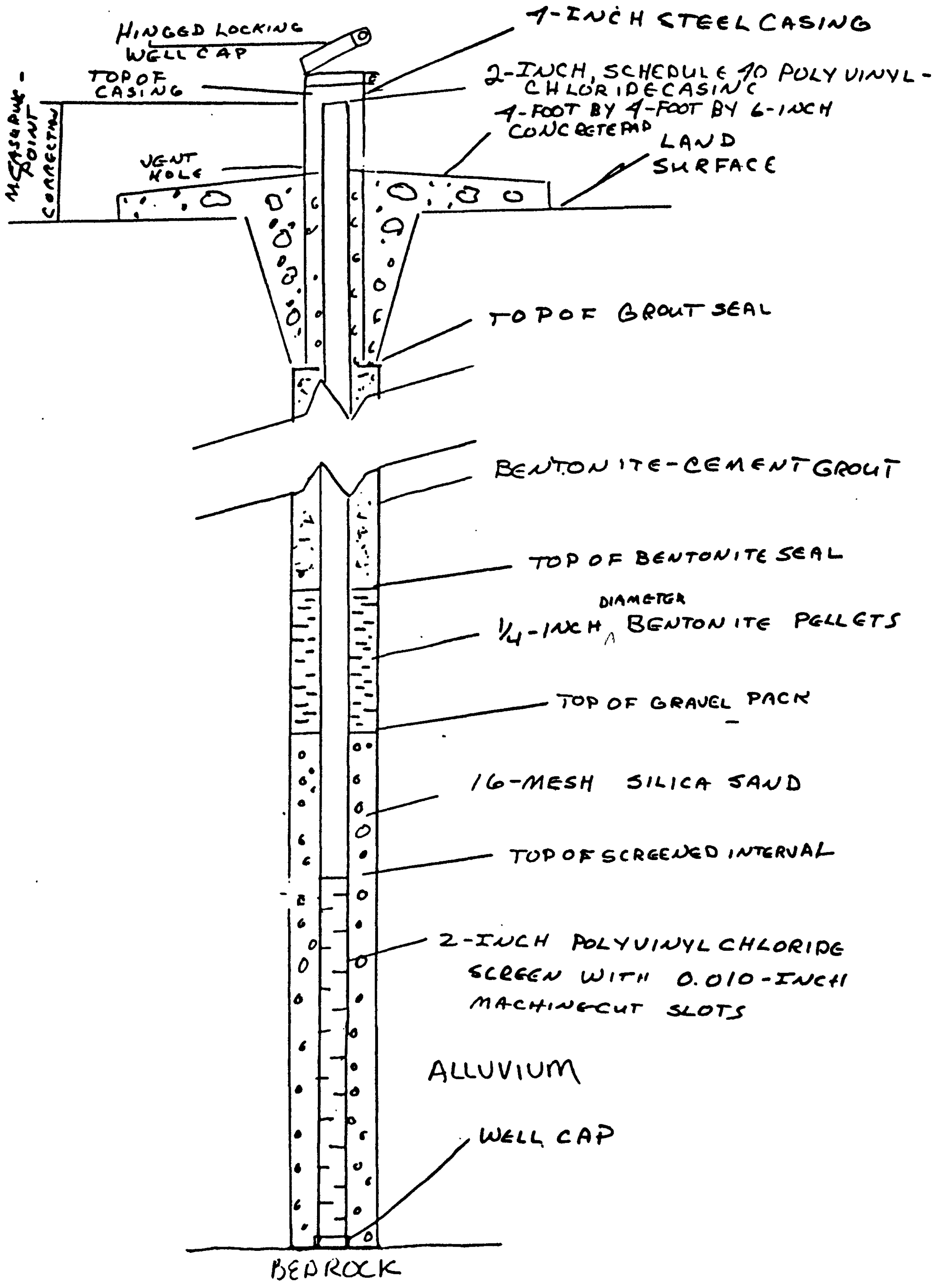

Figure 3.--Generalized well construction of monitor wells and piezometers at the landfill.

Monitor wells and piezometers were developed prior to ground-water sampling. Well development consisted of lowering an air-lift pump and drop pipe into the screened interval and purging the water column to the surface, using a surge of compressed air from an oilless, gas-powered air compressor. The discharge rate was measured and recorded. Water samples were collected at 5- to 10-minute intervals for onsite measurement of specific conductance, water temperature, and pH. Purging of the well continued until all three measurements stabilized and sediment was no longer visible. Generally, the measurements stabilized within 20 minutes; however, pumping continued for an average of 2 hours before sediment was no longer visible in the discharge water. The average volume of water purged was about 35 gal. The pump and air drop pipe were decontaminated after each well was developed to prevent contamination between wells. After development, dedicated Teflon[1] bladder pumps were installed at the monitor wells.

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[1]Use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Ground-Water Sampling

Ground-water samples were collected two times and submitted for chemical analyses to a laboratory approved by the U.S. Environmental Protection Agency. The first sampling, which was done during December 1988 and mid-January 1989, included samples from all monitor wells except MW-16A and two of the three ground-water-discharge sites; monitor well MW-16A was completed above the water table to check for perched water-table conditions and was dry during the sampling periods. The ground-water-discharge sites included a seep (SP-18) near the southern boundary of the landfill and the outflow from John Thatcher's stock tank (SP-19A). The stock tank is about 200 ft south of the landfill boundary and is supplied by an infiltration gallery (SP-19B) that is located at the edge of the terrace deposits. The discharge area is approximately located at the contact of the upland alluvial terrace deposits (the unconfined aquifer) with the Pierre Shale (fig. 2).

The physical properties of ground water that were determined onsite were specific conductance, temperature, and pH. Chemical analyses of the ground-water samples included the determination of alkalinity, concentrations of dissolved solids, major ionic constituents, nutrients, trace elements, organic carbon, organic halogens, oil and grease, and volatile organic compounds. Samples for semivolatile organic compounds and priority pollutants, except dioxin, were collected at four of the monitor wells.

During February 1989, a second set of ground-water samples was collected from the previously sampled sites. For this second set, samples also were collected from the four piezometers, which primarily had been installed for measurement of water levels. A sample also was collected from the inflow to the stock tank (SP-19B). Analytical requirements for ground-water samples were revised by the Colorado Department of Health after results from the initial analyses of ground-water samples were known. Analyses for semi-volatile organic compounds, chemical oxygen demand, and phenolic compounds were added to the required analyses for all sites. Analyses for priority pollutants were deleted from the required analyses. The requested analyses, the U.S. Environmental Protection Agency analytical-method numbers for each site, and the sampling dates are listed in table 2.

All monitor wells were sampled by using dedicated Teflon bladder pumps. The piezometers also were sampled by using a Teflon bladder pump; however, one pump was used at all four piezometers. This portable bladder pump was decontaminated after each piezometer was sampled to prevent contamination between wells. The seep (SP-18) was sampled by digging a hole 2 ft deep in the streambed below the seep. After the hole had filled with water and the sediment had settled, the sample was collected by submerging the sample container. The outflow from the stock tank (SP-19A) was sampled below the tank at the overflow discharge pipe. The inflow to the stock tank (SP-19B) was sampled at the inflow pipes in the infiltration gallery.

Prior to sampling, each well was purged to remove stagnant water in the casing, and a purging protocol was used to ensure collection of representative samples. Water levels were measured to determine the volume of water in the well. Samples were collected only after three casing volumes had been purged; after 15 minutes, three consecutive measurements of specific conductance differed by less than 2 percent, water temperature differed by less than 0.5 °C, and pH differed by less than 0.1 standard unit.

Sample containers were repeatedly rinsed using water from the well or seep and readied for sampling. The order of sample collection was: (1) Physical properties (specific conductance, temperature, and pH); (2) volatile organics; (3) raw, unfiltered samples; and (4) filtered samples. The initial measurements of physical properties were recorded and compared with final measurements to ensure continuity of samples collected. Raw, unfiltered samples were collected and preserved as necessary. Filtered samples were collected after 500 mL of water had passed through a 0.45-µm filter. Filtered samples were preserved as required after the sample containers had been rinsed with filtered water. All samples were chilled to 4 °C and prepared for shipment. Chain-of-custody forms were prepared for all samples. During all aspects of sampling, extreme care was used to ensure minimal sample agitation or contamination.

Table 2.--*Analyses requested by Pueblo County Commissioners and*

[Y, analyses requested for this chemical

Well or site number	Date of sample	Alka- linity (A403)	Dis- solved solids, total (E160.1)	Sul- fate, dis- solved (E300)	Chlo- ride, dis- solved (E300)	Fluo- ride, dis- solved (E300)	Nitro- gen, nitrite, dis- solved (E354.1)	Nitro- gen, nitrate, dis- solved (E352.1)	Nitrogen, ammonia + organic, dis- solved (E351.2)	Sele- nium, dis- solved (SW7740)	Metals, Group I, dis- solved (SW6010)
MW-10	01-18-89	Y	Y	Y	Y	N	Y	Y	Y	N	Y
	02-22-89	Y	Y	Y	Y	Y	Y	Y	N	N	Y
MW-11	12-07-88	Y	Y	Y	Y	N	Y	Y	Y	Y	N
	02-23-89	Y	Y	Y	Y	Y	Y	Y	N	N	Y
MW-12	12-06-88	Y	Y	Y	Y	N	Y	Y	Y	N	Y
	02-23-89	Y	Y	Y	Y	Y	Y	Y	N	N	Y
MW-13	12-12-88	Y	Y	Y	Y	N	Y	Y	Y	N	Y
	02-23-89	Y	Y	Y	Y	Y	Y	Y	N	N	Y
MW-14	12-12-88	Y	Y	Y	Y	N	Y	Y	Y	Y	N
	02-23-89	Y	Y	Y	Y	Y	Y	Y	N	N	Y
MW-15	12-13-88	Y	Y	Y	Y	N	Y	Y	Y	Y	N
	02-22-89	Y	Y	Y	Y	Y	Y	Y	N	N	Y
MW-16B	12-07-88	Y	Y	Y	Y	N	Y	Y	Y	N	Y
	02-22-89	Y	Y	Y	Y	Y	Y	Y	N	N	Y
MW-17	12-13-88	Y	Y	Y	Y	N	Y	Y	Y	Y	N
	02-23-89	Y	Y	Y	Y	Y	Y	Y	N	N	Y
PZ-01	02-27-89	Y	Y	Y	Y	Y	Y	Y	N	N	Y
PZ-02	02-24-89	Y	Y	Y	Y	Y	Y	Y	N	N	Y
PZ-03	02-24-89	Y	Y	Y	Y	Y	Y	Y	N	N	Y
PZ-04	02-24-89	Y	Y	Y	Y	Y	Y	Y	N	N	Y
SP-18	12-14-88	Y	Y	Y	Y	N	Y	Y	Y	N	Y
	02-27-89	Y	Y	Y	Y	Y	Y	Y	N	N	Y
SP-19A	12-14-88	Y	Y	Y	Y	N	Y	Y	Y	N	Y
	02-27-89	Y	Y	Y	Y	Y	Y	Y	N	N	Y
SP-19B	02-27-89	Y	N	N	N	N	Y	Y	N	N	N

[1]Metals group I: Calcium, magnesium, potassium, sodium, copper, iron, manganese, and zinc.

[2]Metals group II: All of the above plus, antimony, beryllium, cadmium, chromium, lead, nickel,

Colorado Department of Health and U.S. Environmental Protection Agency

constituent or property; N, no analyses requested]

Metals, Group II, dis- solved (SW6010)	Arsenic, dis- solved (SW9061)	Cyanide, total, dis- solved (SW9010)	Mercury, dis- solved (SW7470)	Chem- ical oxygen demand (E410.1)	Carbon, organic, total, dis- solved (E415.1)	Halogens, organic, total, dis- solved (E450.1)	Oil and grease, total (E413.1)	Pheno- lics, total (SW9065)	Organics, volatile (SW5030/ SW8240)	Organics, semi- volatile (SW3510/ SW8270)	Pesti- cides, chlo- rinated (SW3510/ SW8080)
N	N	N	N	N	Y	Y	Y	N	Y	N	N
N	N	N	N	Y	Y	Y	N	Y	Y	Y	N
Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
N	N	N	N	Y	Y	Y	N	Y	Y	Y	N
N	N	N	N	N	Y	Y	Y	N	Y	N	N
N	N	N	N	Y	Y	Y	N	Y	Y	Y	N
N	N	N	N	N	Y	Y	Y	N	Y	N	N
N	N	N	N	Y	Y	Y	N	Y	Y	Y	N
Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
N	N	N	N	Y	Y	Y	N	Y	Y	Y	N
Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
N	N	N	N	Y	Y	Y	N	Y	Y	Y	N
N	N	N	N	N	Y	Y	Y	N	Y	N	N
N	N	N	N	Y	Y	Y	N	Y	Y	Y	N
Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y
N	N	N	N	Y	Y	Y	N	Y	Y	Y	N
N	N	N	N	Y	Y	Y	N	Y	Y	Y	N
N	N	N	N	Y	Y	Y	N	Y	Y	Y	N
N	N	N	N	Y	Y	Y	N	Y	Y	Y	N
N	N	N	N	Y	Y	Y	N	Y	Y	Y	N
N	N	N	N	N	Y	Y	Y	N	Y	N	N
N	N	N	N	Y	Y	Y	N	Y	Y	Y	N
N	N	N	N	N	Y	Y	Y	N	Y	N	N
N	N	N	N	Y	Y	Y	N	Y	Y	Y	N
N	N	N	N	N	N	Y	N	N	Y	N	N

silver, and thallium.

GEOHYDROLOGIC SETTING

The landfill is located along the southern edge of a mesa that is underlain by upland alluvial terrace deposits. The almost impermeable bedrock that underlies the upland alluvial terrace deposits is the Pierre Shale. The saturated part of the upland alluvial terrace deposits is the unconfined aquifer that is used to supply water to the Pueblo Depot Activity. Ground water is discharged at seeps along the edge of the mesa at the contact of the upland alluvial terrace deposits and the Pierre Shale and is used for domestic and stock supply. Some of the water discharged from the upland alluvial terrace deposits also recharges the alluvium along the ephemeral stream.

The first major water-bearing formation beneath the upland alluvial terrace deposits is the Lower Cretaceous Dakota Sandstone, which is about 2,200 ft below land surface in the vicinity of the landfill (Robson and Banta, 1987). The alluvium underlying the Arkansas River valley is not hydraulically connected to the upland alluvial terrace deposits but may be recharged by ground and surface water discharged from the landfill. The alluvial aquifer underlying the Arkansas River valley is the primary source of ground water in the valley downgradient of the landfill. Lithologic and water-supply characteristics of the geologic units in the vicinity of the landfill are summarized in table 3.

Table 3.--*Lithologic and water-supply characteristics of geologic units in the study area*

[Modified from Welder and Hurr, 1971]

System	Series	Geologic unit	Thickness (feet)	Physical character	Water-supply potential
Quaternary	Holocene and Pleistocene	Upland alluvial terrace deposits	0-77	Fine to coarse sand; very fine gravel, silt, clay, and some fine to coarse gravel and cobbles; poorly sorted.	Yields as much as 150 gallons per minute.
Cretaceous	Upper Cretaceous	Pierre Shale	1,200	Gray to black shale and sandy shale; contains iron concretions and thin limestone lenses.	Not a source of water in area.
		Niobrara Formation	600-700	Gray to dark-gray sandy shale; contains concretionary zones and thick-bedded limestone at base.	Not a source of water in area.
		Carlile Shale	150-250	Gray to dark-gray, thin-bedded shale with light-tan to gray sandstone at top.	Not a source of water in area.
		Greenhorn Limestone	80	Gray to dark-gray limestone, separated by limey shale.	Not a source of water in area.
		Graneros Shale	150-200	Gray to black bentonitic shale; contains thin clay beds.	Not a source of water in area.
	Lower Cretaceous	Dakota Sandstone	80-150	Gray to white to yellow massive sandstone and dark-gray to black sandy shale.	Yields as much as 50 gallons per minute.
		Purgatoire Formation	150-250	Dark-gray to black shale at top and white to light-gray sandstone at base.	Yields as much as 50 gallons per minute.

Pierre Shale

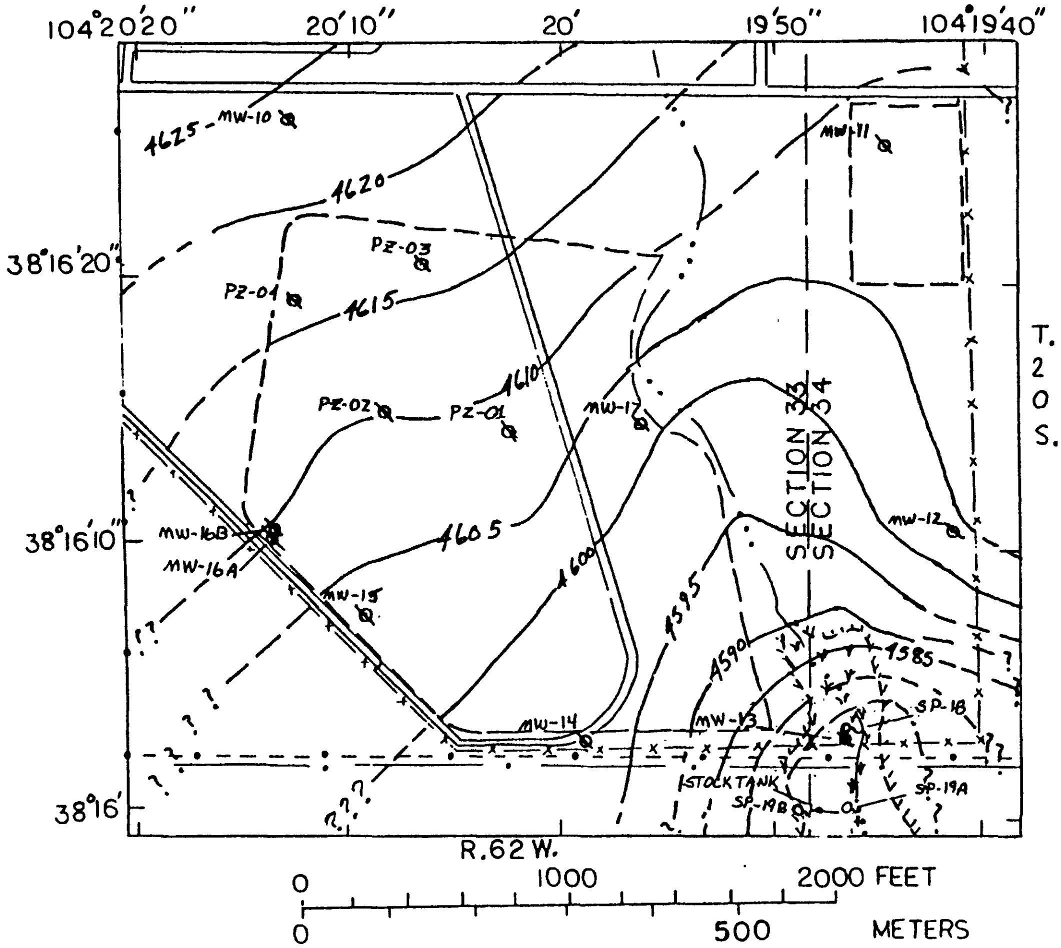
The Upper Cretaceous Pierre Shale is an areally extensive geologic unit in eastern Colorado and underlies all of the Pueblo Depot Activity, including the landfill. The Pierre Shale is estimated to be about 1,200 ft thick in the vicinity of the Pueblo Depot Activity landfill and consists of thinly bedded, dark gray to black shale and sandy shale, with some iron concretions and limestone lenses. The upper part of the Pierre Shale in this area was removed by erosion prior to deposition of the upland alluvial terrace deposits. The hydraulic conductivity of the Pierre Shale is estimated to be 10^{-8}-10^{-11} ft/s, based on results from slug tests and numerical simulation of flow through this confining unit in South Dakota (Bredehoeft and others, 1983). Bredehoeft and others (1983) also reported a specific storage of 10^{-5} per ft for the Pierre Shale.

Because the dip of the bedding in the Pierre Shale, hereinafter referred to as bedrock, near the landfill has a relatively flat slope, onsite measurement of the dip is difficult. Furthermore, the upper surface of the bedrock is an erosional surface and the slope of the surface is not parallel to bedding in the bedrock. Therefore, the dip of the bedrock was estimated from altitudes of a biostratigraphic zone shown on a map of the geology and biostratigraphy of the Pierre Shale (Scott and Cobban, 1986). Regional dip of the Pierre Shale near the landfill is estimated to be 40 to 50 ft/mi (less than 1°) to the north-northeast.

The upper surface of the bedrock (fig. 4) at the landfill is an erosional surface, which is overlain by upland alluvial terrace deposits. The regional slope of the upper bedrock surface is about 25 ft/mi to the south (Welder and Hurr, 1971, pl. 2). Because it is an erosional surface, it is irregular and slopes vary locally.

Welder and Hurr's (1971) map of the bedrock surface beneath the Pueblo Depot Activity indicates an arcuate bedrock trough about 1 mi north of the landfill. Several of the supply wells for the Pueblo Depot Activity are located in the trough because of the greater saturated thickness of the overlying upland alluvial terrace deposits. The altitude of the bedrock surface at the landfill ranges from about 4,575 ft, where the stream crosses the southern boundary of the landfill and where the upland alluvial terrace deposits have been removed by erosion, to about 4,625 ft near the northwestern corner of the landfill (fig. 4).

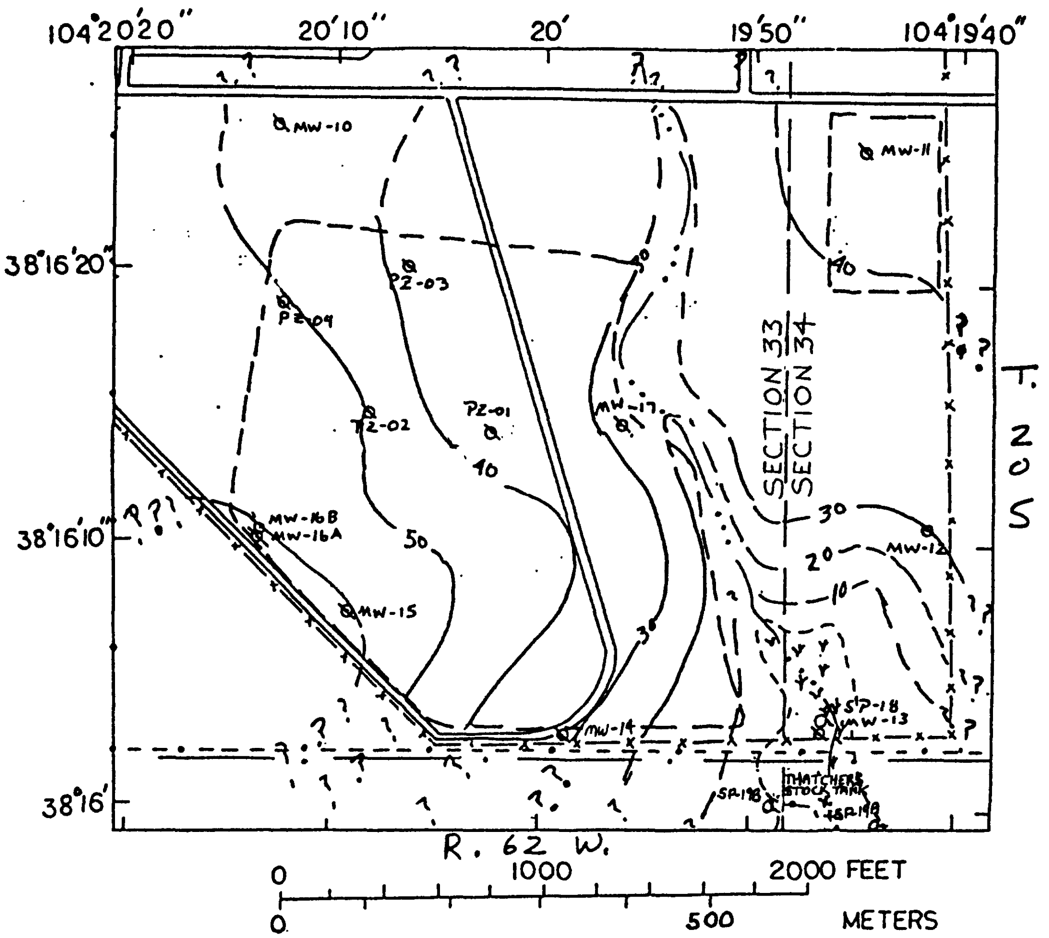
Bedrock is exposed in the sides of the mesa, south of the landfill. Weathered bedrock also is near land surface in the area around the stream near the southern boundary of the landfill. Because soil often obscures the contact between the bedrock and the upland alluvial terrace deposits, the position of the contact is inferred from the location of seeps. The depth to bedrock (the combined thickness of soil and terrace deposits) at the landfill is shown in figure 5 and is based on depths to bedrock at the monitor wells and at the piezometers. Outside the boundary of the terrace deposits, the depth to bedrock is equivalent to the combined thickness of soil, recent alluvial deposits, and weathered shale.



EXPLANATION

— — — —	APPROXIMATE CONTACT OF UPLAND ALLUVIAL TERRACE DEPOSITS AND PIERRE SHALE
(symbol)	MARSHY AREA
—4585—?	BEDROCK CONTOUR--Shows altitude of upper bedrock surface. Dashed where approximately located; queried where unknown. Contour interval 5 feet. Datum is sea level
MW-10	MONITOR WELL OR PIEZOMETER AND WELL NUMBER--Monitor well designated by prefix of MW; piezometer by PZ
SP-18	DISCHARGE SITE AND NUMBER
—• • •—	EPHEMERAL STREAM
—— ——	APPROXIMATE BOUNDARY OF LANDFILL
•———•	MILITARY RESERVATION BOUNDARY
•- - - - -•	POWER LINE
x———x	FENCE

Figure 4.--Configuration and altitude of the upper surface of the bedrock at the landfill.



EXPLANATION

APPROXIMATE CONTACT OF UPLAND ALLUVIAL TERRACE DEPOSITS AND PIERRE SHALE

MARSHY AREA

—40--? LINE OF EQUAL DEPTH TO BEDROCK BENEATH THE UPLAND ALLUVIAL TERRACE DEPOSITS--Dashed where approximately located. Queried where unknown. Interval 10 feet. Datum is land surface

MW-10 MONITOR WELL OR PIEZOMETER AND WELL NUMBER--Monitor well designated by prefix of MW; piezometer by PZ

SP-18 DISCHARGE SITE AND NUMBER

EPHEMERAL STREAM

APPROXIMATE BOUNDARY OF LANDFILL

MILITARY RESERVATION BOUNDARY

POWER LINE

X———X FENCE

Figure 5.--Depth to the upper surface of the bedrock at the landfill.

Upland Alluvial Terrace Deposits

The upland alluvial terrace deposits at the landfill and the Pueblo Depot Activity are an erosional remnant of an extensive Pleistocene alluvial terrace deposits (Welder and Hurr, 1971, p. 4). The upland alluvial terrace deposits at the Pueblo Depot Activity consist of a heterogeneous sequence of thinly bedded and poorly sorted, fine to coarse sand, very fine gravel, silt, and clay. Locally, thin beds of coarse gravel and cobbles are present. A thin layer of calcium carbonate-cemented gravel and cobbles was present in some of the test borings. In general, fine-grained deposits are predominant in the upper part of the upland alluvial terrace deposits and grade into coarser, cleaner sands and gravels near the base of the deposits. The moderately permeable upland alluvial terrace deposits unconformably overlie the almost impermeable Pierre Shale and are the primary aquifer at the Pueblo Depot Activity. The upland alluvial terrace deposits are in places hydraulically connected to the thin alluvium in the ground-water discharge areas along the ephemeral stream. This alluvium consists of a mixture of reworked upland alluvial terrace deposits and weathered Pierre Shale, as indicated by the driller's log of monitor well MW-13 (table 8 in the "Supplemental Data" section at the back of this report). Because this alluvium contains a large proportion of clay and weathered shale it is less permeable than the upland alluvial terrace deposits. The water-supply characteristics of the unconfined aquifer at the Pueblo Depot Activity are described by Welder and Hurr (1971).

The occurence and movement of ground water within the upland alluvial terrace deposits primarily is controlled by the geometric and the lithologic characteristics of the upland alluvial terrace deposits. The geometric configuration of the unconfined aquifer is defined by the configuration of the bedrock surface (fig. 4) at the base of the unconfined aquifer, the configuration of the water table (fig. 6), and these surfaces' relation to the land surface. The depth to water at the landfill ranges from zero where ground water is discharged at seeps to more than 50 ft at monitor wells MW-15 and MW-16B (fig. 7). The thin alluvium along the ephemeral stream is, in places, saturated. Water levels are near land surface, and depth to water is less than 5 ft. Saturated thickness of the upland alluvial terrace deposits, the difference between the bedrock and water-table surfaces, generally ranges from 5 to 10 ft at the landfill (fig. 8), but regional saturated thickness is greater than 30 ft about 1 mi north of the landfill (fig. 9). Saturated thickness of the alluvium along the ephemeral stream downgradient from the landfill is as much as 13 ft, but is not shown in figures 8 or 9 because the water table is discontinuous in this area.

Water levels in the monitor wells and piezometers were measured prior to purging the wells during collection of water samples. Water-level measurements for the monitor wells and piezometers at the landfill are listed in table 4. Water-level measurements of other observation wells in other areas of the Pueblo Depot Activity were used in compilation of a map of regional saturated thickness (fig. 9) but are not included in table 4.

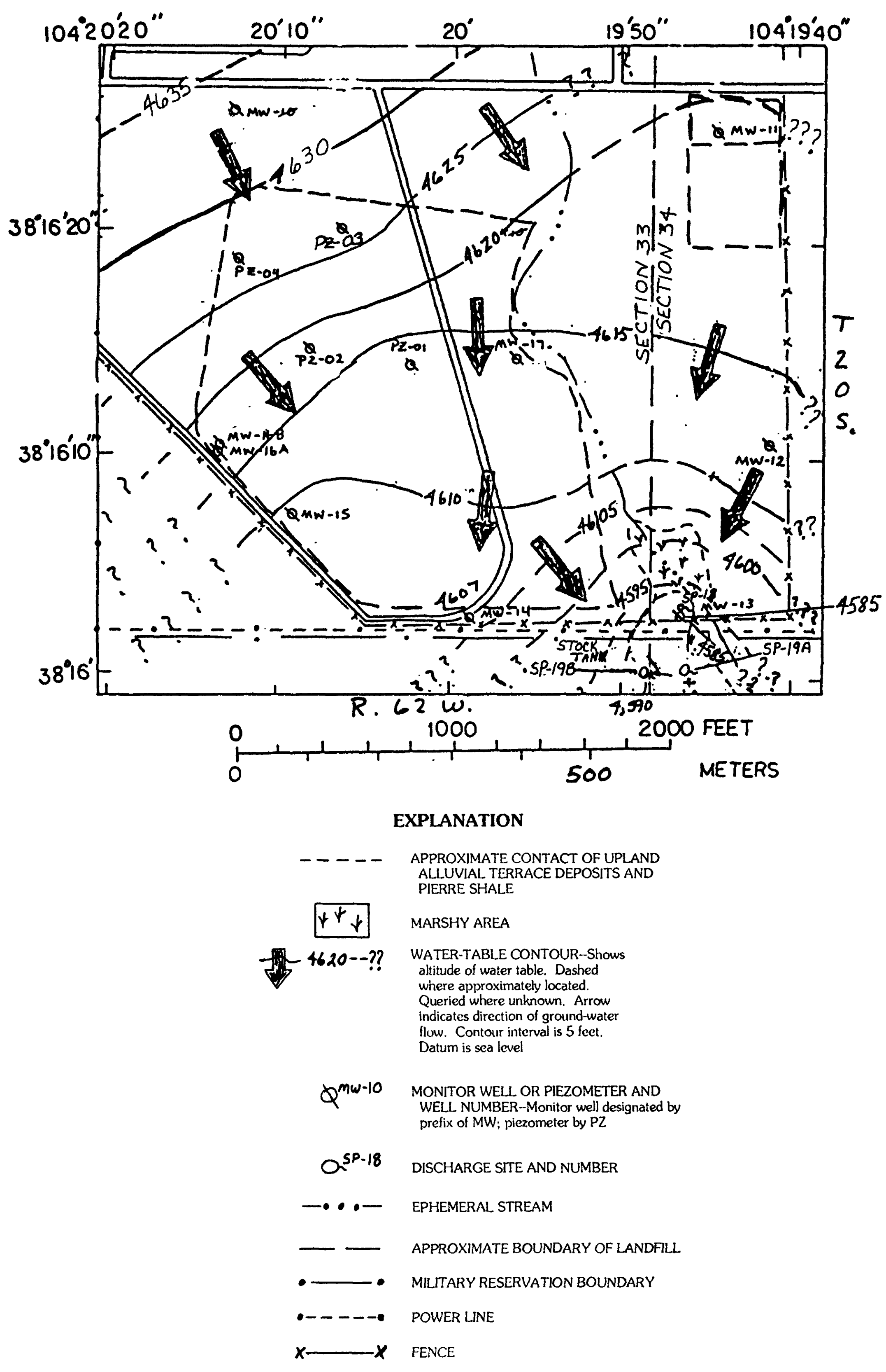
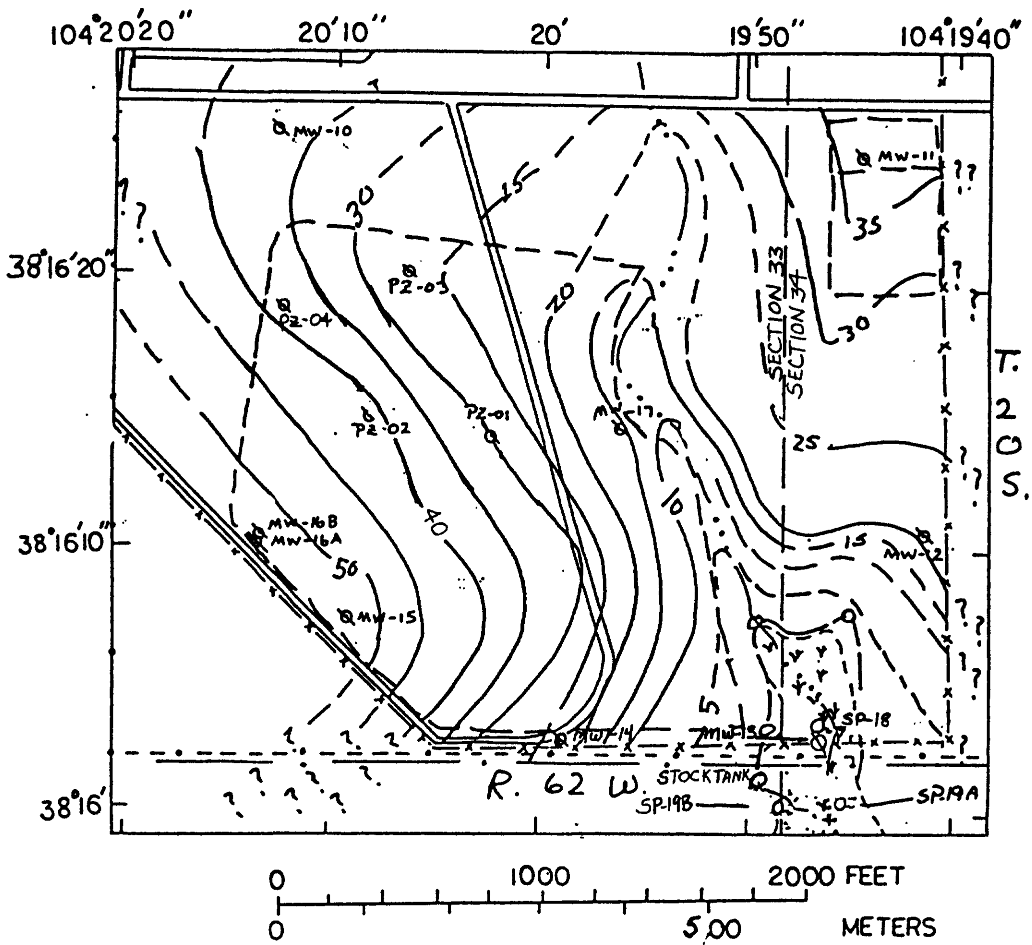


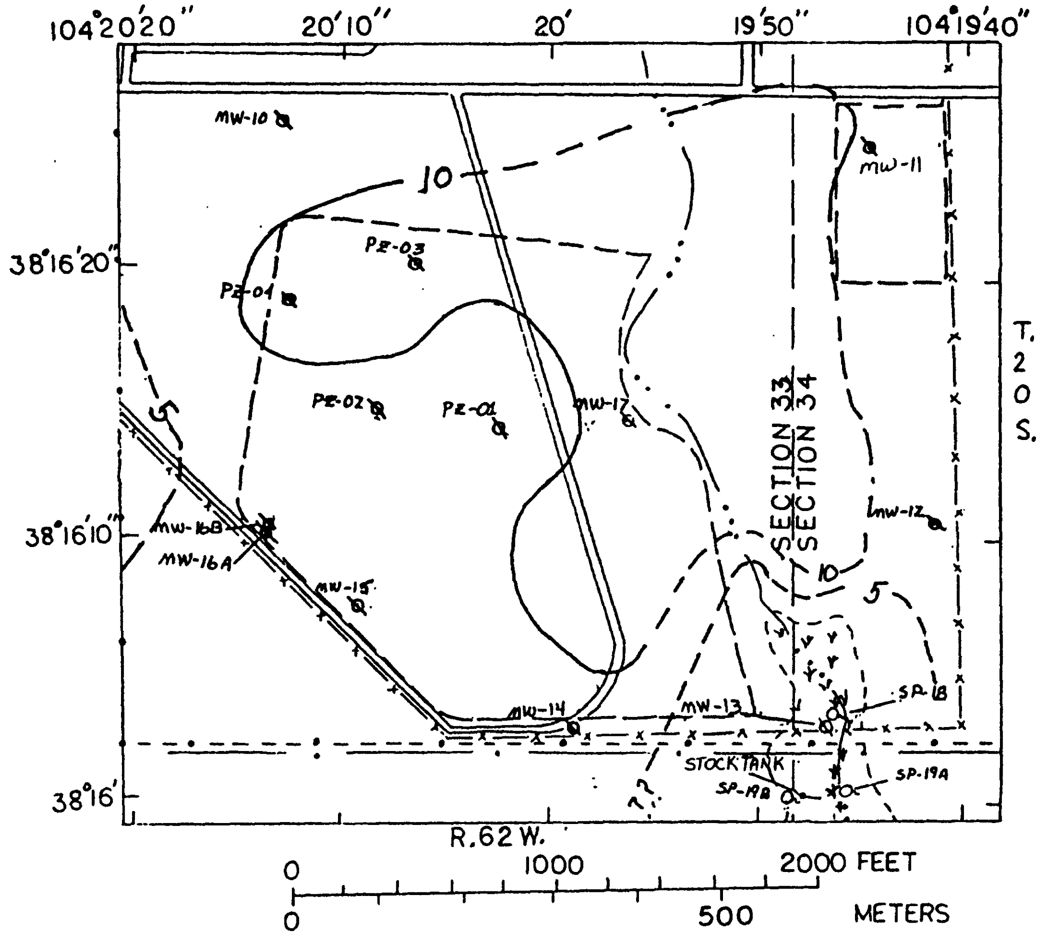
Figure 6.--Configuration of the water table and direction of ground-water flow at the landfill, February 1989.



EXPLANATION

- APPROXIMATE CONTACT OF UPLAND ALLUVIAL TERRACE DEPOSITS AND PIERRE SHALE
- MARSHY AREA
- 10--?? LINE OF EQUAL DEPTH TO WATER--Dashed where approximately located. Queried where unknown. Interval is 5 feet. Datum is land surface
- MW-10 MONITOR WELL OR PIEZOMETER AND WELL NUMBER--Monitor well designated by prefix of MW; piezometer by PZ
- SP-18 DISCHARGE SITE AND NUMBER
- EPHEMERAL STREAM
- APPROXIMATE BOUNDARY OF LANDFILL
- MILITARY RESERVATION BOUNDARY
- POWER LINE
- FENCE

Figure 7.--Depth to water at the landfill, February 1989.



EXPLANATION

APPROXIMATE CONTACT OF UPLAND ALLUVIAL TERRACE DEPOSITS AND PIERRE SHALE

MARSHY AREA

LINE OF EQUAL SATURATED THICKNESS OF THE UPLAND ALLUVIAL TERRACE DEPOSITS--Dashed where approximately located. Queried where unknown. Interval is 5 feet

MONITOR WELL OR PIEZOMETER AND WELL NUMBER--Monitor well designated by prefix of MW; piezometer by PZ

GROUND-WATER DISCHARGE SITE AND NUMBER

EPHEMERAL STREAM

APPROXIMATE BOUNDARY OF LANDFILL

MILITARY RESERVATION BOUNDARY

POWER LINE

FENCE

Figure 8.--Saturated thickness of the upland alluvial terrace deposits at the landfill, February 1989.

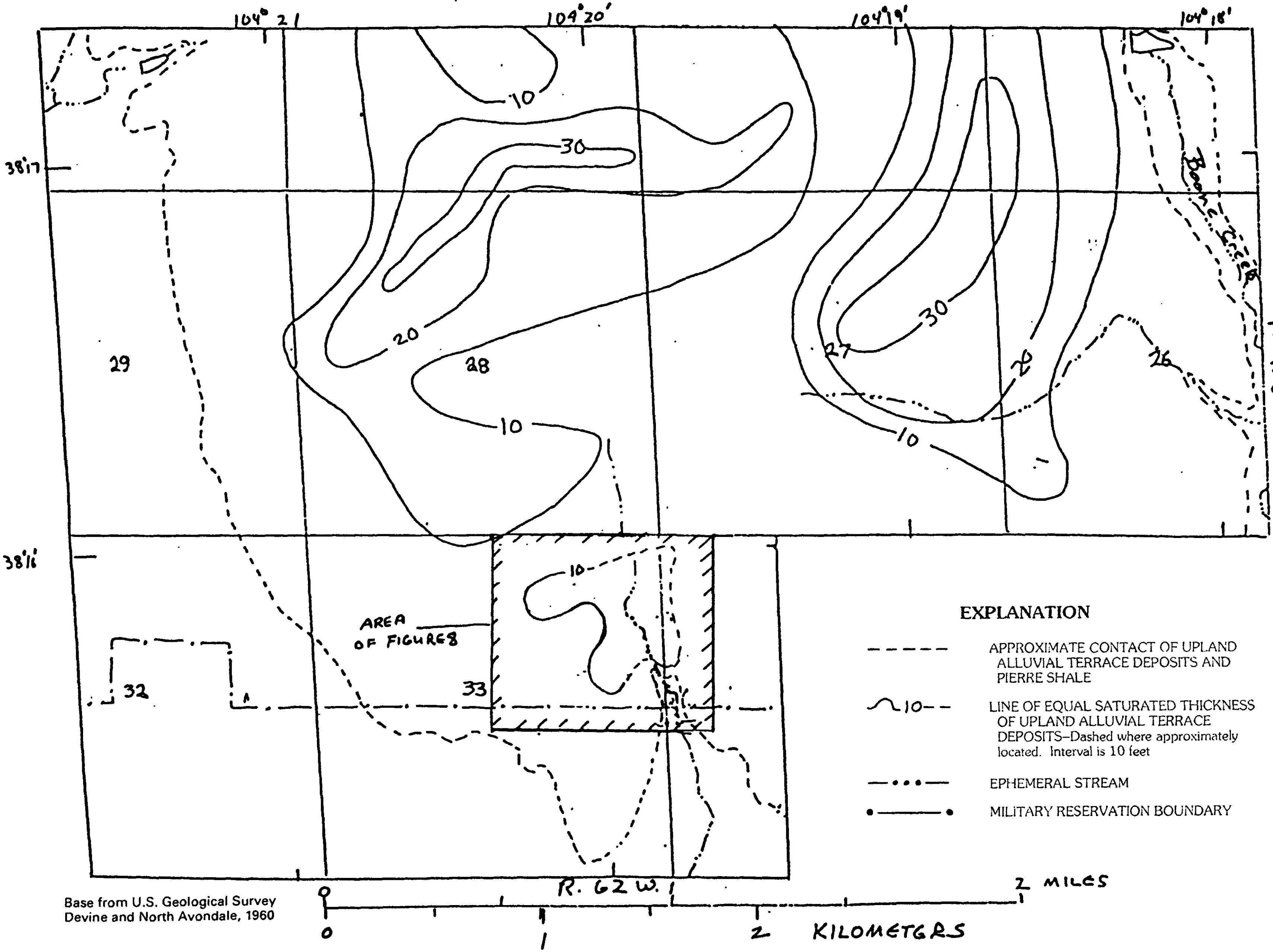


Figure 9.--Regional saturated thickness of the upland alluvial terrace deposits in the southern part of the Pueblo Depot Activity, February 1989.

Table 4.--*Water levels in monitor wells and piezometers at the landfill*

[-- indicates that the depth to water was greater than the depth to the bottom of the screened interval]

Well number (location shown in fig. 2)	Date of measurement	Depth to water below land surface (feet)	Altitude of water level (feet)
[1]MW-10	11-16-88	36.90	4,633.31
	01-18-89	36.65	4,633.56
	01-24-89	37.29	4,632.92
	02-22-89	37.31	4,632.90
	06-28-89	41.31	4,628.90
MW-11	11-16-88	36.74	4,618.33
	12-05-88	36.68	4,618.39
	01-24-89	36.67	4,618.40
	02-23-89	36.73	4,618.34
	06-28-89	36.73	4,618.34
MW-12	11-16-88	20.87	4,613.95
	12-05-88	20.68	4,614.14
	01-24-89	20.82	4,614.00
	02-23-89	20.81	4,614.01
	06-28-89	20.86	4,613.96
MW-13	11-16-88	2.81	4,585.18
	12-12-89	2.90	4,585.09
	01-24-89	3.08	4,584.91
	02-23-89	2.90	4,585.09
	06-29-89	2.55	4,585.44
MW-14	11-16-88	23.11	4,606.55
	12-12-88	23.30	4,606.36
	01-24-89	23.08	4,606.58
	02-23-89	23.00	4,606.66
	06-29-89	23.00	4,606.66
MW-15	11-16-88	54.36	4,608.87
	12-13-88	54.41	4,608.82
	01-24-89	54.31	4,608.92
	02-22-89	54.34	4,608.89
	06-28-89	54.41	4,608.82

Table 4.--*Water levels in monitor wells and piezometers at the landfill*--Continued

Well number (location shown in fig. 2)	Date of measurement	Depth to water below land surface (feet)	Altitude of water level (feet)
MW-16A	11-16-88	--	--
	12-05-88	--	--
	01-24-89	--	--
	02-22-89	--	--
	06-28-89	--	--
MW-16B	11-16-88	51.89	4,617.64
	12-05-88	51.98	4,617.55
	01-24-89	51.96	4,617.57
	02-22-89	52.03	4,617.50
	06-28-89	51.98	4,617.55
MW-17	11-16-88	15.85	4,614.03
	12-12-88	15.92	4,613.96
	01-24-89	15.90	4,613.98
	02-23-89	15.68	4,614.20
	06-28-89	15.92	4,613.96
PZ-01	01-24-89	30.11	4,613.43
	02-27-89	30.05	4,613.49
	06-29-89	30.20	4,613.34
PZ-02	01-24-89	42.37	4,617.58
	02-24-89	42.30	4,617.65
	06-29-89	42.40	4,617.55
PZ-03	01-24-89	26.03	4,628.13
	02-24-89	26.08	4,628.08
	06-29-89	25.98	4,628.18
PZ-04	01-24-89	41.07	4,626.18
	02-22-89	40.03	4,627.22
	02-24-89	39.27	4,627.98
	06-29-89	39.17	4,628.08

[1]Monitor well MW-10 was originally drilled during October 1988, however, because of sand clogging, the well could not be sampled and was redrilled January 11, 1989. Measurements prior to this data are from the original well, which later was destroyed.

Hydraulic and Storage Properties

The hydraulic and storage properties of the unconfined aquifer at the landfill that are described in this report are based partly on the results of aquifer tests described by Welder and Hurr (1971) and partly on values that are typical for porous media of similar lithology. The values of hydraulic conductivity for the unconfined aquifer, as determined from analyses of two aquifer tests that were done in supply wells about 1 mi north of the landfill, were 350 and 600 gal/d/ft^2, or in consistent units, 47 and 80 ft/d. The intrinsic permeability of the unconfined aquifer at the two aquifer-test sites, which is based on the kinematic viscosity of water at 15 °C and the acceleration of gravity at 38° latitude and an altitude of 4,600 ft, is estimated to be 19 and 33 μm^2.

The transmissivity of the unconfined aquifer at the landfill was estimated as the product of the saturated thickness (fig. 8) and an average hydraulic conductivity value of 65 ft/d. Because the transmissivity is a function of saturated thickness, fluctuations of the water table will affect the value for transmissivity of an unconfined aquifer.

The storage properties of an aquifer (storage coefficient and specific yield) are used in determining the response of an aquifer to transient flow conditions. The porosity of the upland alluvial terrace deposits is used to estimate ground-water velocity. The storage coefficient of the upland alluvial terrace deposits was determined by Welder and Hurr (1971) to range between 0.00016 and 0.00033. Because of the short duration of the aquifer tests, these values were assumed to represent the storage properties of the semiconfined gravels. If the aquifer were completely drained, the specific yield would be about 0.15 to 0.20. The porosity of the upland alluvial terrace deposits has not been determined at the landfill. However, the range of porosity values of similar porous materials is 0.25 to 0.40 for gravel, 0.25 to 0.50 for sand, 0.35 to 0.50 for silt, and 0.40 to 0.70 for clay (Freeze and Cherry, 1979, p. 37).

Ground-Water Flow at the Landfill

Regional ground-water flow at the Pueblo Depot Activity landfill, as indicated by the water-table map developed by Welder and Hurr (1971), is toward the south-southeast. The regional hydraulic gradient is disturbed in the vicinity of supply wells and at discharge areas near the edge of the upland alluvial terrace deposits. Generally, seeps and wet spots occur where streams have eroded into the terrace deposits and intercept the water table. Estimated discharge from the discharge area along the southern edge of the landfill and adjacent areas south of the landfill, including Thatcher's stock tank, is about 9,600 to 19,200 ft^3/d. Most of the discharge is lost to evapotranspiration during the growing season. Some ground water also enters the alluvium along the ephemeral stream in the discharge area.

Hydraulic gradients in the unconfined aquifer at the landfill are indicated by the distance between the water-table contours in figure 6--the greater the distance between adjacent contours, the smaller the hydraulic gradient. The arrows in figure 6 indicate the direction of the hydraulic gradient. The value of the hydraulic gradient can be determined by measuring the length of a line drawn perpendicular to two contour lines and dividing the difference in value of the contours by the distance represented by the line.

Although the regional hydraulic gradient of the water table at the Pueblo Depot Activity is 0.0047 to the south (Welder and Hurr, 1971), hydraulic gradients at the landfill range from about 0.0063 to 0.0182 toward the ground-water-discharge area. Geologic sections of the geologic and hydrologic aspects of the unconfined aquifer at the landfill are shown in figures 10*A-F*. The locations and approximate dimensions of the special-waste areas and of the trenches at the landfill also are shown on the appropriate sections.

Average velocities of ground-water flow in the unconfined aquifer can be estimated by use of the following equation:

$$V = \frac{KI}{\emptyset},$$

where V = average ground-water velocity;

K = hydraulic conductivity;

I = hydraulic gradient, and

$\emptyset$ = porosity. Near monitor well MW-10, the hydraulic gradient is about 0.0089; assuming a value of 65 ft/d for hydraulic conductivity and a porosity of 0.25 to 0.40, then average ground-water velocity at this location is about 1.4 to 2.3 ft/d. The average traveltime between monitor wells MW-10 and MW-14, which are along the same flow path, have a difference in water-table altitude of 27 ft, and are about 2,500 ft apart, is estimated to be about 900 to 1,400 days. If hydraulic gradients are larger, ground-water velocities will increase and traveltimes will decrease, proportionately.

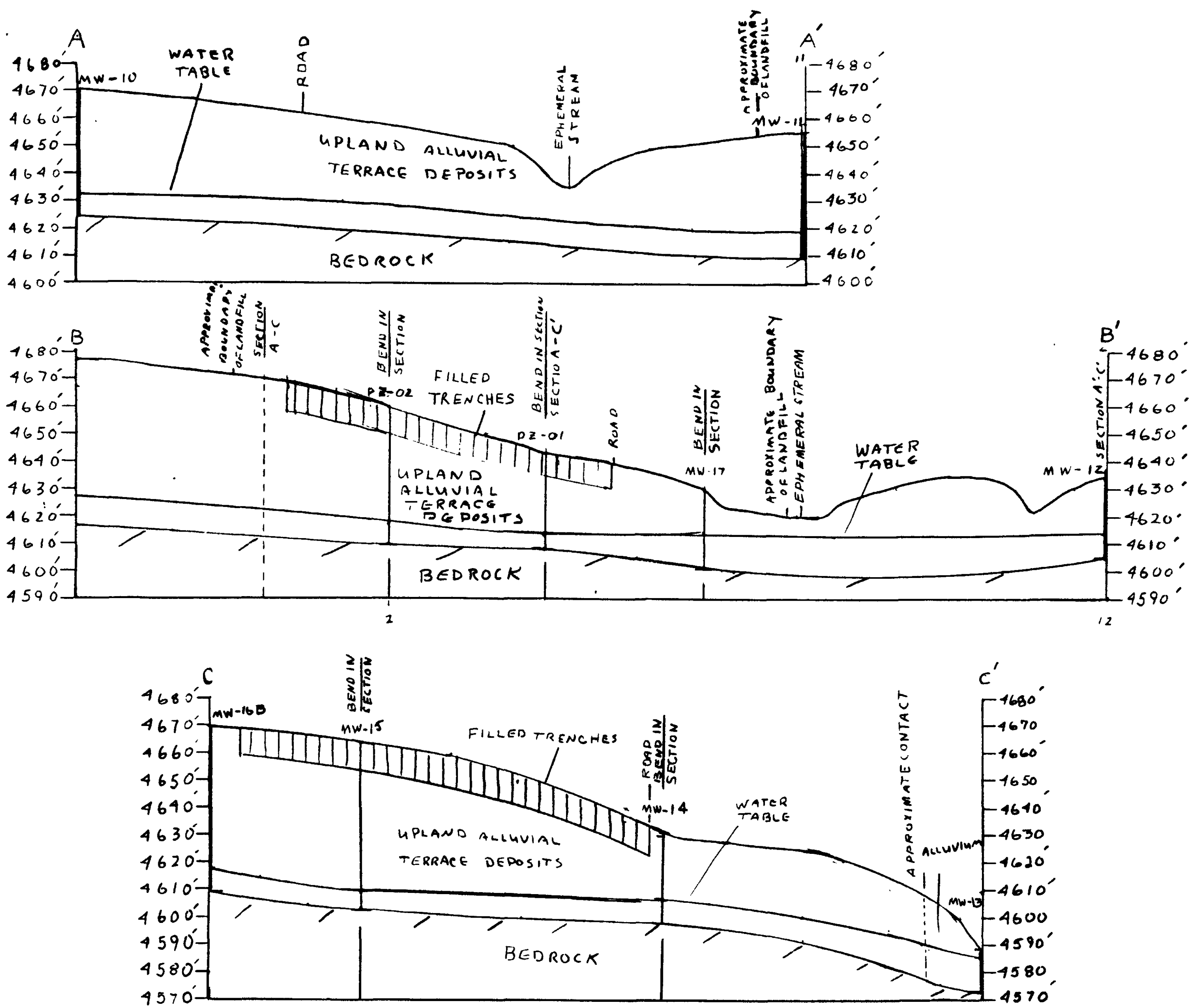


Figure 10.--Geologic sections showing the geology and hydrology of the unconfined aquifer at the landfill. *A*, Section A-A'; *B*, Section B-B'; *C*, Section C-C'; *D*, Section A-C; *E*, Section A'-C'; *F*, Section A-C'.

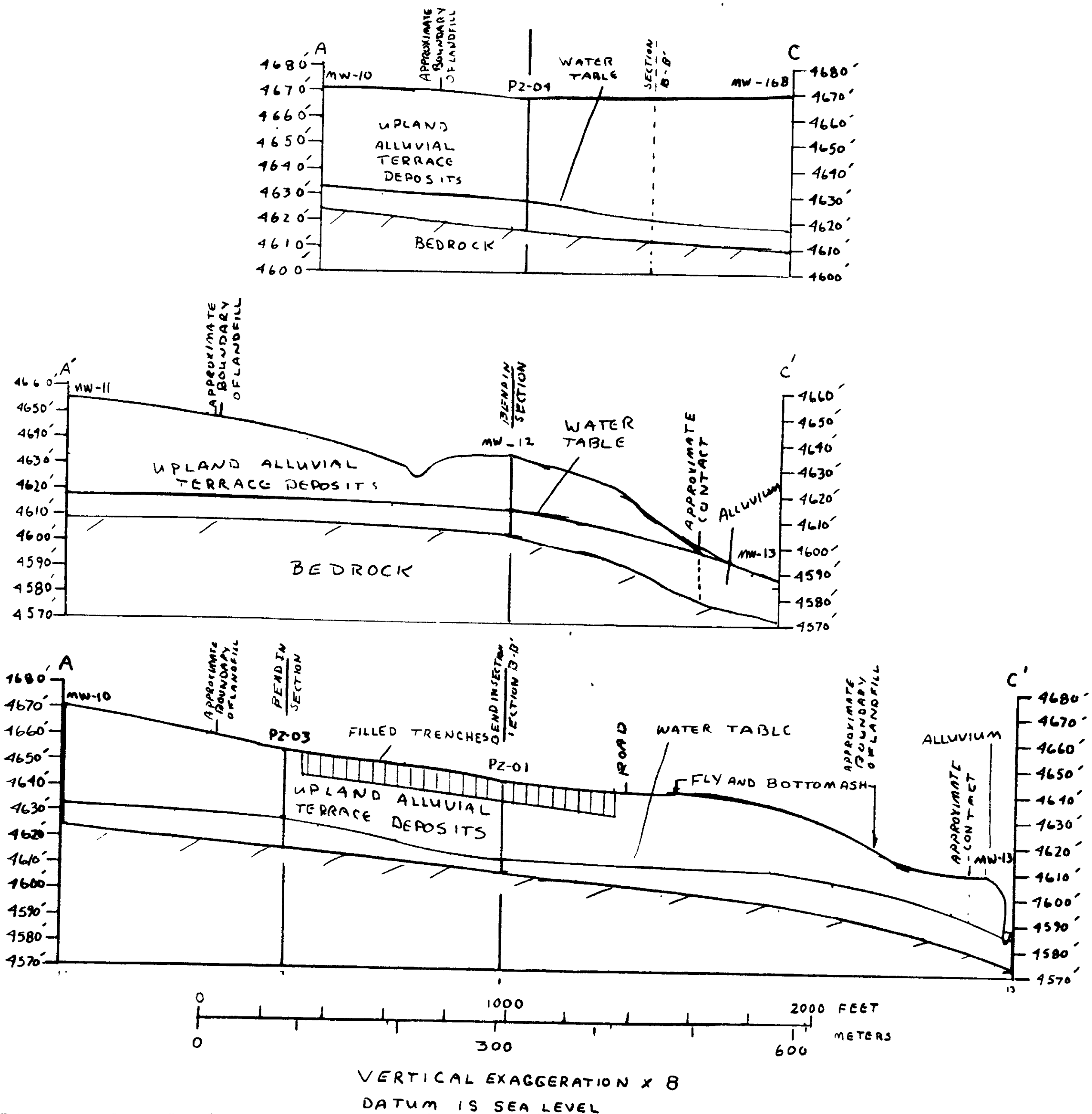


Figure 10.--Geologic sections showing the geology and hydrology of the unconfined aquifer at the landfill. *A*, Section A-A'; *B*, Section B-B'; *C*, Section C-C'; *D*, Section A-C; *E*, Section A'-C'; *F*, Section A-C'--Continued.

GROUND-WATER QUALITY

The physical properties and chemical characteristics of the ground water in the unconfined aquifer at the Pueblo Depot Activity landfill were determined from analyses of water samples collected from eight monitor wells, four piezometers, a seep, and an offsite stock tank. The physical properties and chemical characteristics of the ground water at the landfill indicate a downgradient increase in the dissolved-solids concentration and specific conductance. The physical properties and results from the chemical analyses of the ground-water samples are listed in table 10, in the "Supplemental Data" section at the back of the report, and those constituents that exceeded drinking-water standards (U.S. Environmental Protection Agency, 1986a and 1986b) are listed in table 5. Nitrate plus nitrite as nitrogen listed in table 5 is the sum of nitrate and nitrite in table 10.

Quality-assurance and quality-control data (QA/QC data) are not listed in table 10. These data are available in the files at the U.S. Geological Survey office at Pueblo and were provided to the Pueblo Depot Activity and the Colorado Department of Health.

Analytical results from analyses for volatile organic compounds in the domestic water supplies at downgradient sites also are not listed in table 10, in the "Supplemental Data" section at the back of the report. However, no volatile organic compounds were detected for these water samples from the alluvial aquifer underlying the Arkansas River valley. The analytical results for these samples also are available at the U.S. Geological Survey office in Pueblo and were provided to the Pueblo Depot Activity and the Colorado Department of Health.

Table 5.--*Selected chemical constituents in ground water at the landfill that exceed drinking-water standards*

[mg/L, milligrams per liter; μg/L, micrograms per liter; SMCL, secondary maximum contaminant level; MCL, maximum contaminant level; RMCL, recommended maximum contaminant level; --, standard not exceeded; NA, not applicable; BDL, below detection level; drinking-water standards from U.S. Environmental Protection Agency, 1986a and 1986b]

Well or site number (location shown in fig. 2)	Date of sample	Drinking-water standards					
		500 mg/L	250 mg/L	10 mg/L	0.01 mg/L	0 μg/L	7.0 μg/L
		Dissolved solids, total SMCL (mg/L)	Sulfate, dissolved SMCL (mg/L)	Nitrate plus nitrite as nitrogen MCL (mg/L)	Selenium, dissolved MCL (mg/L)	Trichloroethylene[1] RMCL (μg/L)	trans-1,2-Dichloroethylene[2] RMCL (μg/L)
MW-10	01-18-89	940	447	--	NA	BDL	BDL
	02-22-89	940	426	11.0	NA	BDL	BDL
MW-11	12-07-88	1,120	372	15.2	0.018	380	51
	02-23-89	1,010	356	12.0	NA	340	42
MW-12	12-06-88	1,030	475	--	NA	58	--
	02-23-89	1,000	437	--	NA	75	--
MW-13	12-12-88	1,770	668	BDL	NA	67	540
	02-23-89	1,810	633	BDL	NA	60	720
MW-14	12-12-88	940	320	--	0.015	2,400	560
	02-23-89	920	310	--	NA	2,900	540
MW-15	12-13-88	910	466	14.1	0.022	BDL	BDL
	02-22-89	1,230	444	11.0	NA	BDL	BDL
MW-16B	12-07-88	1,540	626	12.0	NA	BDL	BDL
	02-22-89	1,530	617	11.0	NA	BDL	BDL
MW-17	12-13-88	710	--	--	0.020	BDL	BDL
	02-23-89	730	--	--	NA	5.2	BDL
PZ-01	02-27-89	1,420	519	--	NA	BDL	BDL
PZ-02	02-24-89	840	328	--	NA	BDL	BDL
PZ-03	02-24-89	1,480	720	12.0	NA	BDL	BDL
PZ-04	02-24-89	920	421	--	NA	BDL	BDL
SP-18	12-14-88	1,610	668	--	NA	42	170
	02-27-89	1,520	643	--	NA	24	77
SP-19A	12-14-88	1,000	354	--	NA	560	110
	02-27-89	1,000	337	--	NA	500	92
SP-19B	02-27-89	NA	NA	--	NA	780	130

[1]Detection level for trichloroehtylene was 3.0 μg/L.
[2]Detection level for trans-1,2-dichloroethylene was 5.0 μg/L.

Physical Properties, Dissolved Solids, and Major Ions

Analytical results for individual sites for December 1988 to mid-January 1989 and for February 1989, indicated minimal temporal variation in the water chemistry. However, differences in water chemistry occur between sites at the landfill. Specific conductance ranged from 1,080 to 2,690 µS/cm. The largest specific-conductance values occured at sites located near the discharge area. The average specific conductance of ground water at the landfill was 1,680 µS/cm, which is more than twice the average value reported by Welder and Hurr (1971). Water temperature was the most variable physical property, ranging from 4.5 to 16.0 °C. If temperature values are excluded for the samples that were affected by ambient air temperatures (MW-13, SP-18, SP-19A, and SP-19B), the water temperature ranged from 13.0 to 16.0 °C, which is a more accurate representation of actual ground-water temperatures. The slightly higher temperatures measured at all four piezometers are attributed to an increase in sample residence time in the longer tubing of the mobile pump. Onsite pH values ranged from 6.6 to 7.8.

Concentration of dissolved solids in the ground water ranged from 710 to 1,810 mg/L at the landfill (table 5). As with specific conductance, concentration of dissolved solids increased downgradient across the landfill. The trend of increasing concentration of dissolved solids may be related to longer contact time with the underlying bedrock or may be a result of concentration by evapotranspiration. The recommended secondary drinking-water standard for dissolved solids of 500 mg/L (U.S. Environmental Protection Agency, 1977) was exceeded in all water samples collected at the Pueblo Depot Activity landfill.

An anion-cation balance (table 6) was calculated for the major cations (calcium, magnesium, potassium, and sodium) and the major anions (bicarbonate chloride, nitrate, and sulfate) of the samples listed in table 10 as a check on the accuracy of major dissolved-constituent values. Nitrate generally is referred to as a nutrient but is included in the anion-cation balance because concentrations were relatively substantial when compared to other ions. Because concentrations of dissolved solids were equal to or greater than 1,000 mg/L in 15 of the 24 analyses listed in table 10 the anion-cation balance may not adequately evaluate the accuracy of the lesser constituents (Hem, 1985). Values for the major ions are converted from concentrations in milligrams per liter to concentrations in milliequivalents per liter (table 6) using the conversion factors listed by Hem (1985, table 9). Bicarbonate is listed as one of the major anions in table 6; however, alkalinity in milligrams per liter as calcium carbonate is listed in table 10. To convert alkalinity, expressed as milligrams per liter calcium carbonate, to bicarbonate, in milliequivalents per liter, multiply the value in table 10 by a conversion factor of 0.02 (Hem, 1985, p. 106). Because nitrate and nitrite were reported as milligrams per liter of nitrogen, the conversion factor used was 0.0714, not 0.01613, as given in Hem (1985).

Table 6.--*Anion-cation balance for ground-water samples collected at the landfill*

Well or site number (location shown in figure 2)	Date of sample	Cations (in milliequivalents per liter)				Anions (in millequivalents per liter)				Percent difference[1]
		Calcium	Magnesium	Potassium	Sodium	Bicarbonate	Chloride	Nitrate plus nitrite	Sulfate	
MW-10	01-18-89	4.59	2.30	<0.13	7.44	4.18	1.10	0.51	9.31	-2.2
	02-22-89	4.69	2.47	<0.13	7.83	4.04	1.07	0.79	8.87	1.2
MW-11	12-07-88	5.69	2.88	<0.13	6.79	6.06	1.95	1.09	7.75	-4.2
	02-23-89	6.34	3.04	<0.13	7.40	6.18	1.92	0.86	7.41	1.6
MW-12	12-06-88	5.84	2.55	<0.13	7.09	3.94	1.69	0.47	9.89	-1.2
	02-23-89	6.14	2.55	<0.13	7.35	4.14	1.64	0.44	9.10	2.7
MW-13	12-12-88	8.08	3.87	<0.13	16.6	13.6	3.81	<0.01	13.9	-4.4
	02-23-89	8.98	4.28	<0.13	17.2	14.1	3.58	<0.01	13.2	-0.5
MW-14	12-12-88	4.54	2.30	<0.13	7.96	5.80	2.12	0.56	6.66	-0.7
	02-23-89	4.84	2.30	<0.13	7.79	6.04	2.09	0.50	6.45	-0.1
MW-15	12-13-88	7.83	3.21	<0.13	7.57	6.48	2.40	1.01	9.70	-2.2
	02-22-89	8.58	3.54	<0.13	7.79	6.54	2.29	0.79	9.24	3.0
MW-16B	12-07-88	7.49	5.51	<0.13	9.83	7.90	2.60	0.86	13.0	-3.0
	02-22-89	8.23	6.09	<0.13	10.7	7.06	2.56	0.79	12.8	4.0
MW-17	12-13-88	3.29	1.56	<0.13	6.74	4.48	1.55	0.55	4.73	1.8
	02-23-89	3.64	1.56	<0.13	6.48	4.64	1.58	0.50	4.62	2.0
PZ-01	02-27-89	10.1	3.54	<0.13	8.22	9.86	1.78	0.57	10.8	-2.3
PZ-02	02-24-89	4.99	2.63	<0.13	5.52	3.94	1.66	0.71	6.83	0.5
PZ-03	02-24-89	7.39	4.77	<0.13	10.3	3.44	2.88	0.86	15.0	0.9
PZ-04	02-24-89	4.89	2.47	<0.13	7.09	3.78	1.16	0.46	8.77	1.4
SP-18	12-14-88	8.33	4.20	0.18	12.7	9.24	3.16	0.29	13.9	-2.3
	02-27-89	7.63	3.79	0.13	11.3	7.54	2.88	0.24	13.4	-2.6
SP-19A	12-14-88	5.54	2.39	<0.13	7.79	6.32	2.12	0.69	7.37	-2.0
	02-27-89	5.49	2.39	<0.13	7.35	6.26	2.06	0.69	7.02	-2.1

[1]Percent difference was calculated as: Percent difference = 100[(cation - anion)/(cation + anion)].

The percent difference in anions and cations was calulated using the following equation:

$$\text{Percent difference} = 100(\text{cations} - \text{anions})/(\text{cations} + \text{anions}).$$

If the difference in the anion-cation balance is greater than 1 to 2 percent the analytical results may be in error or a major ion was not included in the anion-cation balance. Percent differences in the anion-cation balances (table 6) ranged from -4.4 to 4.0 percent with 19 of 24 values exceeding a ± 1 percent difference and 14 of 24 at or exceeding a ± 2 percent difference. These errors may be a result of: (1) Analytical errors, particularly determination of alkalinity by titration; (2) the omission of ions from the balance; and (3) effects of organic compounds on determination of alkalinity.

The average concentrations in milliequivalents per liter of the major ionic constituents for each site are shown in figure 11. Spatial variation in concentrations of dissolved solids are shown in figure 12. Ground water at the Pueblo Depot Activity landfill generally is a mixed-cation mixed-anion type water. Sodium is the predominant (greater than 50 percent of total cations) cation at four of the sites (MW-10, MW-13, MW-14, and MW-17). There is no predominant cation at the remaining sites. Sulfate is the predominant anion at seven sites (MW-10, MW-12, MW-16B, PZ-02, PZ-03, PZ-04, and SP-18).

Sulfate concentrations (fig. 13) for all samples, except those from MW-17 which averaged 225 mg/L, exceeded the Colorado water-quality standard of 250 mg/L for water supply (Colorado Department of Health, 1979). The sulfate concentration ranged from 222 to 720 mg/L. Bicarbonate (alkalinity) concentrations ranged from 172 to 703 mg/L as calcium carbonate, and the average value was 323 mg/L as calcium carbonate.

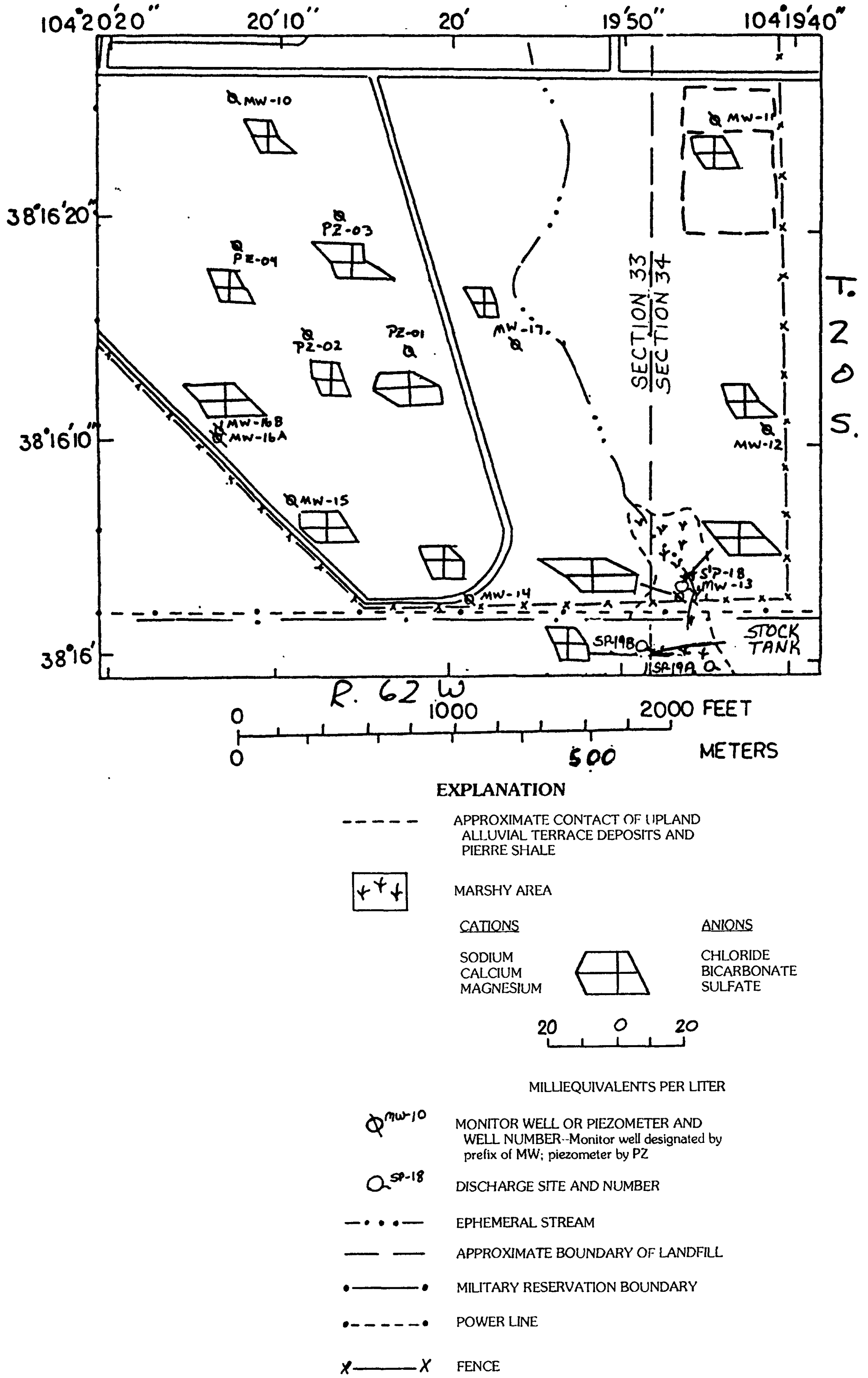


Figure 11.--Concentrations of major ions in ground water at the landfill.

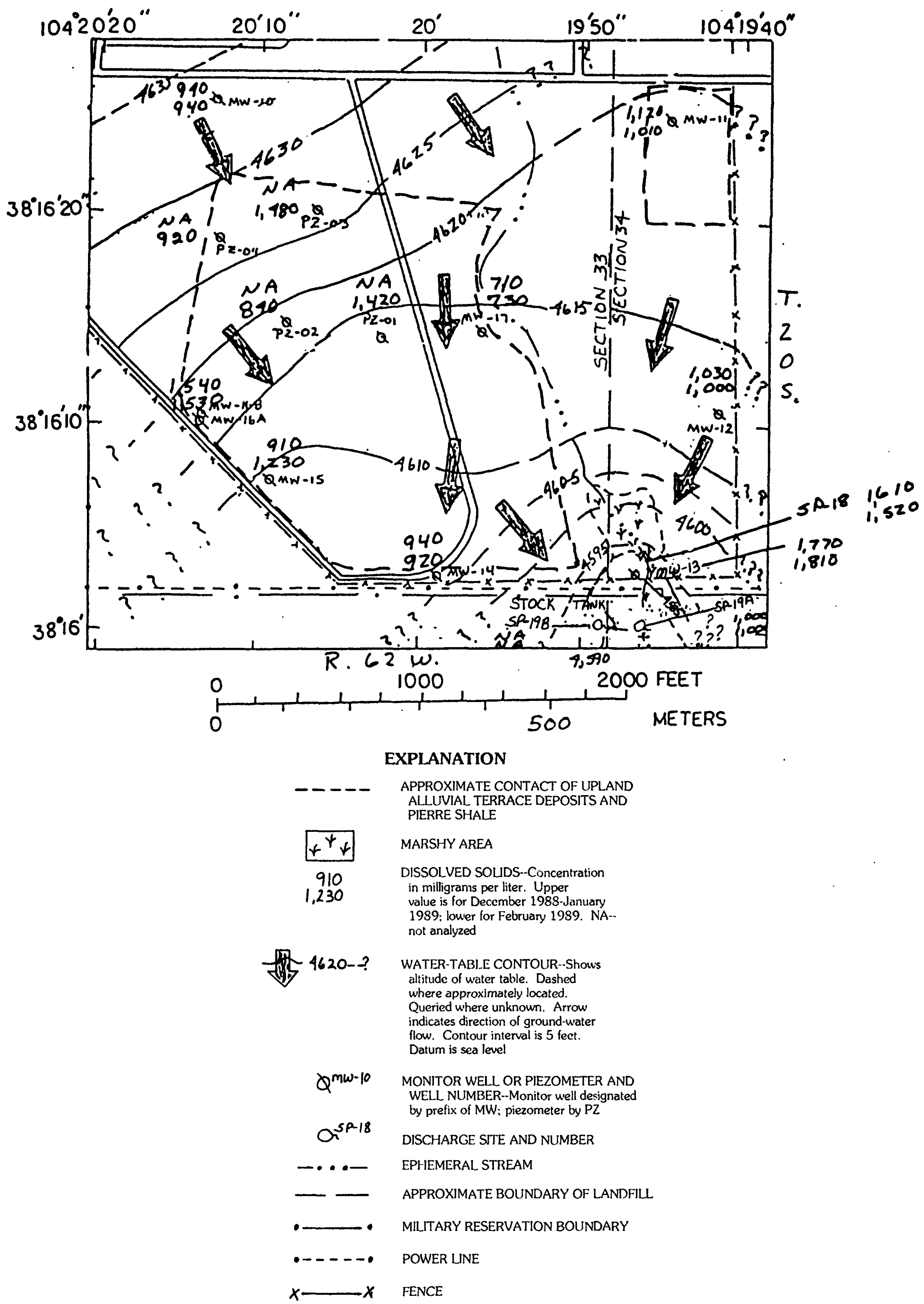
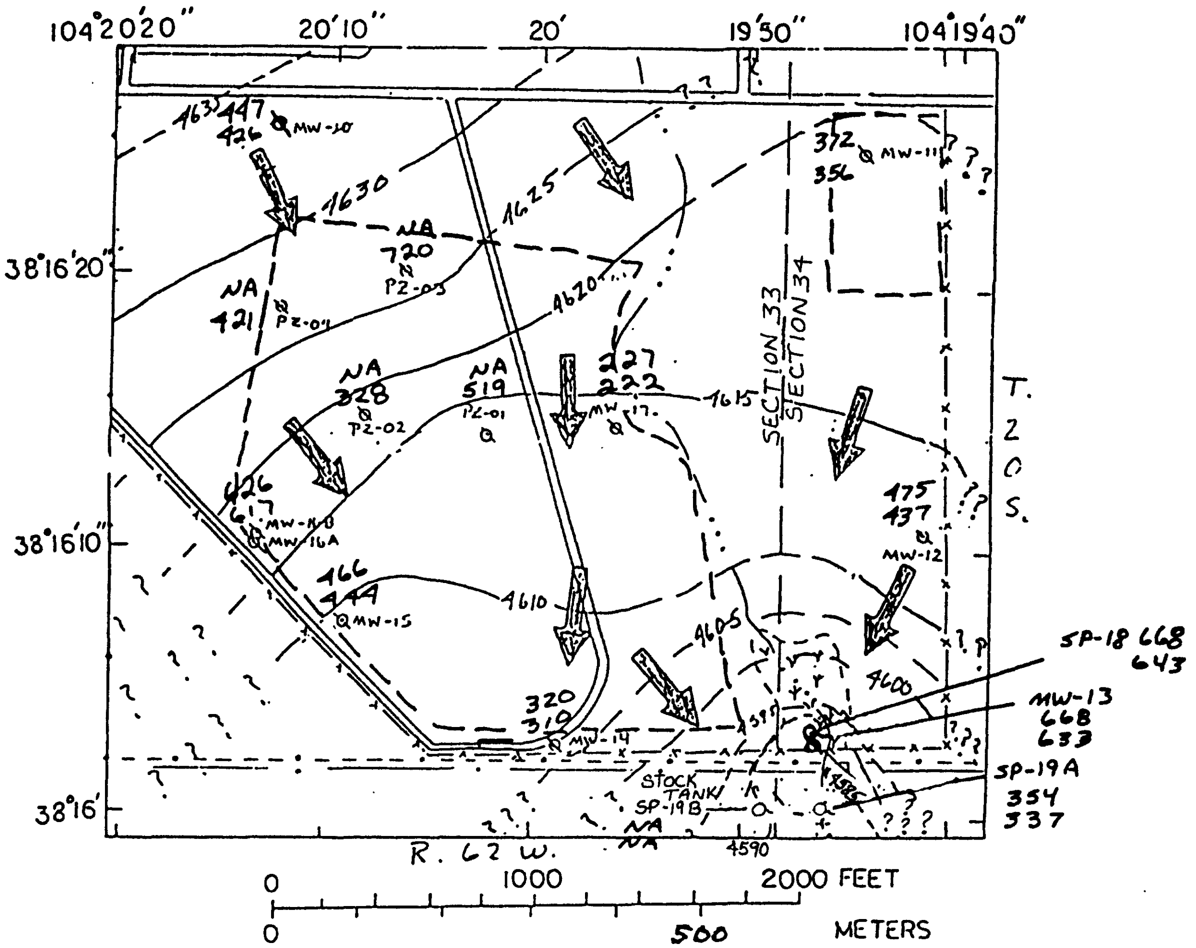


Figure 12.--Concentrations of dissolved solids in ground water at the landfill.



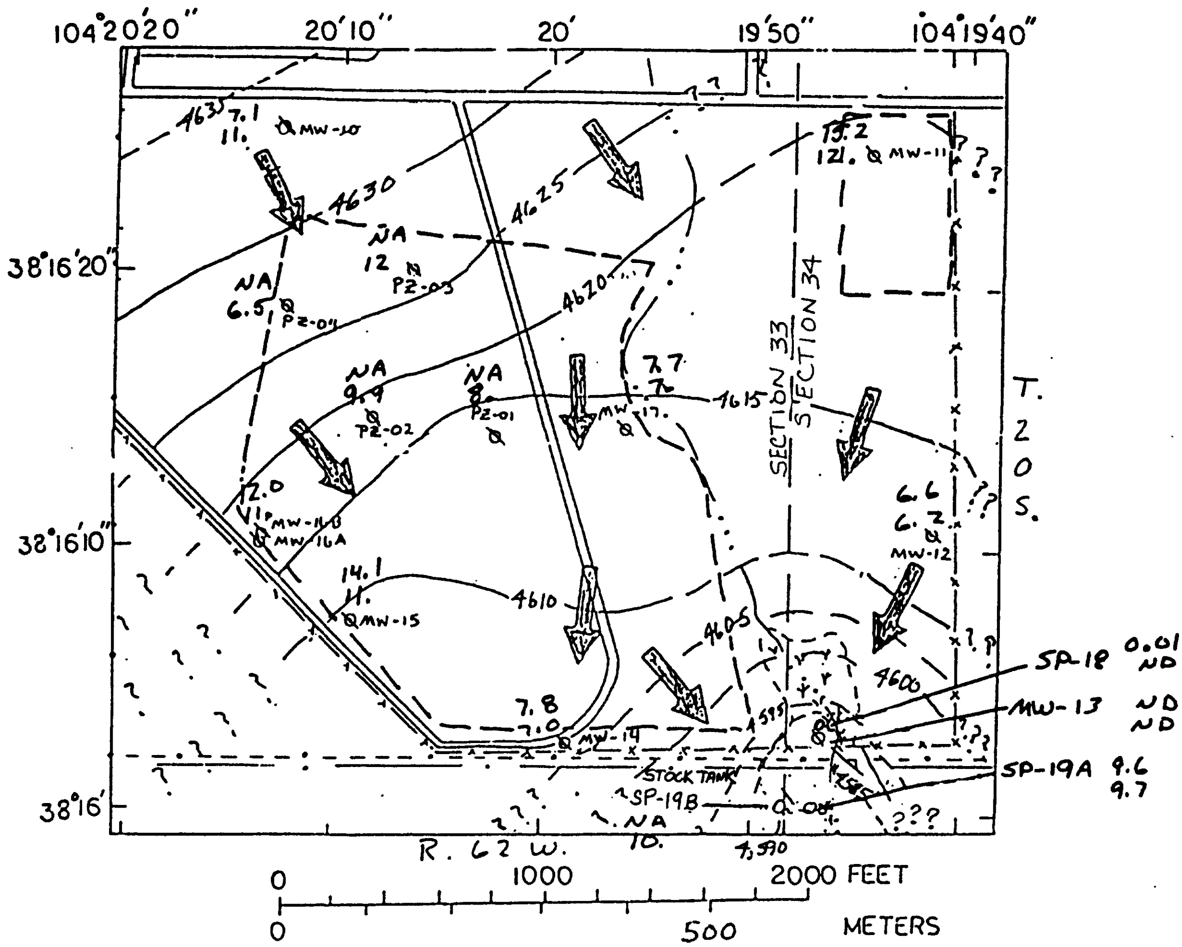
EXPLANATION

– – – – –	APPROXIMATE CONTACT OF UPLAND ALLUVIAL TERRACE DEPOSITS AND PIERRE SHALE
	MARSHY AREA
466 444	DISSOLVED SULFATE--Concentration in milligrams per liter. Upper value is for December 1988-January 1989; lower for February 1989. NA--not analyzed
4620--?	WATER-TABLE CONTOUR--Shows altitude of water table. Dashed where approximately located. Queried where unknown. Arrow indicates direction of ground-water flow. Contour interval is 5 feet. Datum is sea level
MW-10	MONITOR WELL OR PIEZOMETER AND WELL NUMBER--Monitor well designated by prefix of MW; piezometer by PZ
SP-18	DISCHARGE SITE AND NUMBER
	EPHEMERAL STREAM
	APPROXIMATE BOUNDARY OF LANDFILL
	MILITARY RESERVATION BOUNDARY
	POWER LINE
X———X	FENCE

Figure 13.--Concentrations of sulfate in ground water at the landfill.

Standards for nitrate plus nitrite as nitrogen have been set at 10 mg/L, because excessive concentrations of nitrate in drinking water may cause methemoglobinemia in infants (U.S. Environmental Protection Agency, 1977). Almost one-third of the samples analyzed (table 5) had values of nitrate plus nitrite as nitrogen that exceeded 10 mg/L (fig. 14). Generally, excessive nitrate concentrations are associated with human activity.

Only one of the trace elements, selenium, was present in concentrations that exceeded the primary standards for drinking water in Colorado (fig. 15). Water from all four sites sampled for selenium contained concentrations of selenium that exceeded the value of 0.01 mg/L set by the Colorado Department of Health (1977). The concentrations of selenium ranged from 0.015 to 0.022 mg/L. Selenium is a naturally occurring trace element in southeastern Colorado. Selenium commonly is detected in ground water from alluvial aquifers that overlie the Pierre Shale (Cain and others, 1980).



EXPLANATION

APPROXIMATE CONTACT OF UPLAND ALLUVIAL TERRACE DEPOSITS AND PIERRE SHALE

MARSHY AREA

14.1
11.

DISSOLVED NITRATE PLUS NITRITE AS NITROGEN--Concentrations in milligrams per liter. Upper value for December 1988-January 1989; lower for February 1989. NA--not analyzed. ND--not detected

4620--?

WATER-TABLE CONTOUR--Shows altitude of water table. Dashed where approximately located. Queried where unknown. Arrow indicates direction of ground-water flow. Contour interval is 5 feet. Datum is sea level

MW-10

MONITOR WELL OR PIEZOMETER AND WELL NUMBER--Monitor well designated by prefix of MW; piezometer by PZ

SP-18

DISCHARGE SITE AND NUMBER

EPHEMERAL STREAM

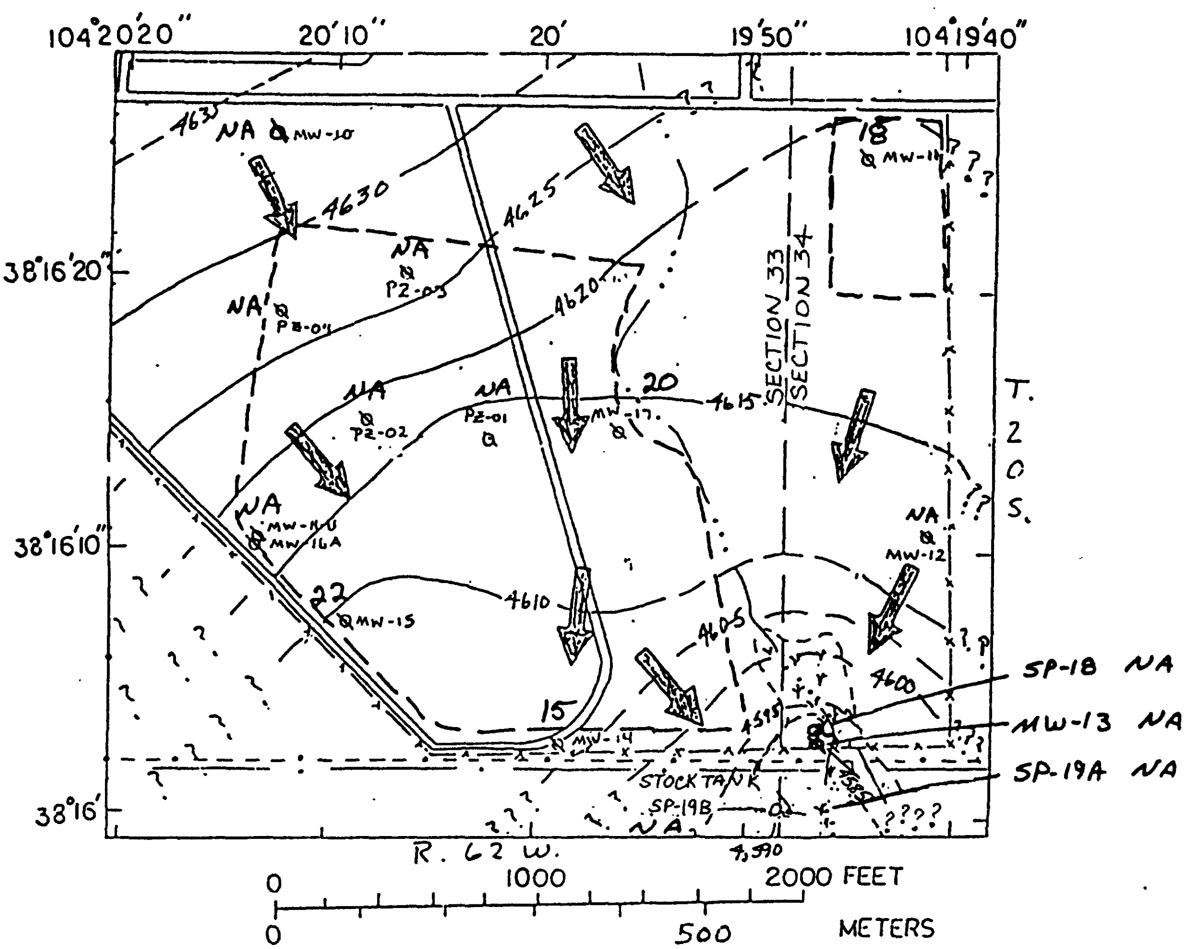
APPROXIMATE BOUNDARY OF LANDFILL

MILITARY RESERVATION BOUNDARY

POWER LINE

FENCE

Figure 14.--Concentrations of nitrate plus nitrite as nitrogen in ground water at the landfill.



EXPLANATION

- - - - - APPROXIMATE CONTACT OF UPLAND ALLUVIAL TERRACE DEPOSITS AND PIERRE SHALE

MARSHY AREA

22 DISSOLVED SELENIUM--Concentrations in micrograms per liter. NA--not analyzed

4620--? WATER-TABLE CONTOUR--Shows altitude of water table. Dashed where approximately located. Queried where unknown. Arrow indicates direction of ground-water flow. Contour interval is 5 feet. Datum is sea level

MW-10 MONITOR WELL OR PIEZOMETER AND WELL NUMBER--Monitor well designated by prefix of MW; piezometer by PZ

SP-18 DISCHARGE SITE AND NUMBER

EPHEMERAL STREAM

APPROXIMATE BOUNDARY OF LANDFILL

MILITARY RESERVATION BOUNDARY

POWER LINE

X———X FENCE

Figure 15.--Concentrations of selenium in ground water at the landfill.

Organic Compounds and Priority Pollutants

Analyses for a target list of volatile organic compounds (table 10) identified two compounds, trichloroethylene (TCE) and trans-1,2-dichloroethylene (DCE), which were present in the ground-water samples in concentrations greater than individual detection limits. The analytical method used could not distinguish between the isomers of DCE. DCE therefore is reported as trans-1,2-dichloroethylene. The reporting limits for any one compound may not be consistent in table 10 because of analytical dilutions that were necessary when concentrations of target compounds were large. The areal distribution of TCE is shown in figure 16, and DCE is shown in figure 17. Five monitor wells (MW-11, MW-12, MW-13, MW-14, and MW-17) and the seeps and the stock tanks (SP-18, SP-19A, and SP-19B) had concentrations of TCE greater than the detection level of 3 μg/L. Concentrations of TCE ranged from 5.2 to 2,900 μg/L. DCE also was detected at these sites, except at MW-17. Concentrations of DCE ranged from 5 (the detection limit) to 720 μg/L. Volatilization of TCE and DCE occurred between the infiltration gallery (SP-19B) and the outflow of the stock tank (SP-19A), as indicated by the decrease in concentrations of TCE from 780 to 500 μg/L and DCE from 130 to 92 μg/L (table 5).

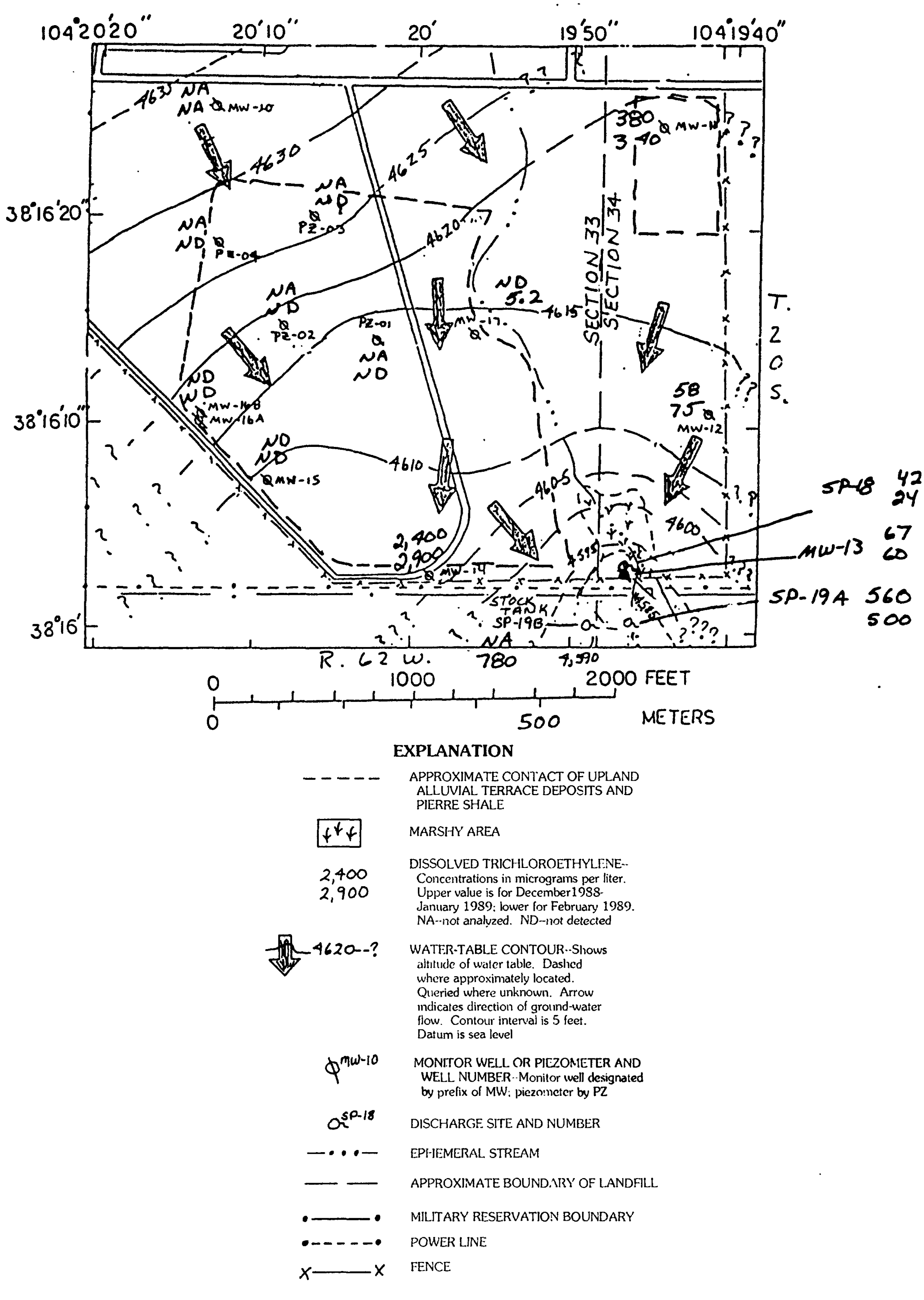


Figure 16.--Concentrations of trichloroethylene in ground water at the landfill.

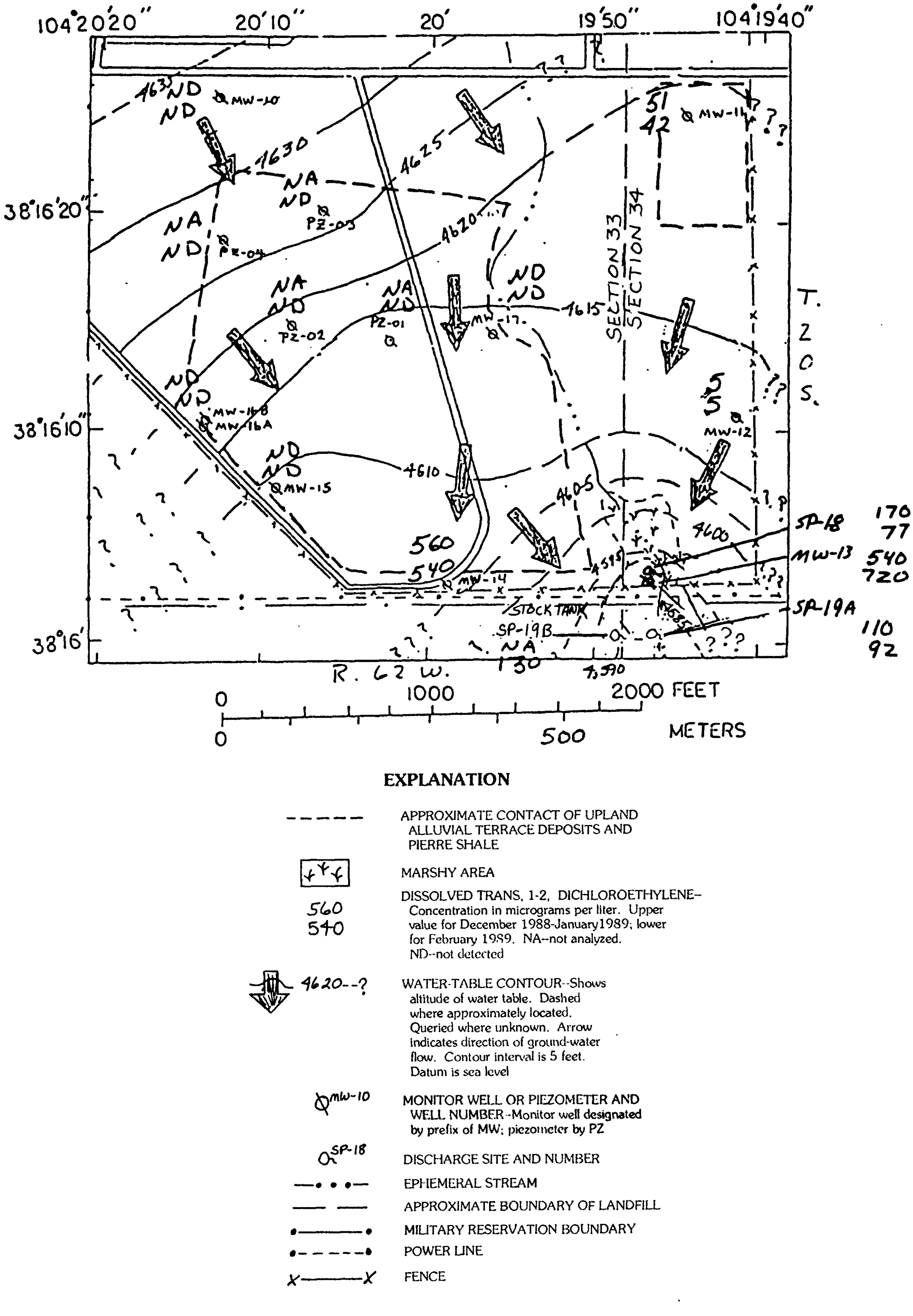


Figure 17.--Concentrations of trans-1,2-dichloroethylene in ground water at the landfill.

Tentative to confident identifications of volatile organic and of semi-volatile compounds with estimated concentrations were reported for samples from MW-10, MW-11, MW-14, MW-15, MW-16B, PZ-01, SP-18, and SP-19A and for two trip blanks (table 7). These compounds may represent laboratory artifacts and may not be present in ground water at the landfill. These compounds are not listed in table 10 because they were not included in the target list of compounds and because they are only tentative identifications.

Organochlorine pesticides, polychlorobiphenyl, and semi-volatile organic compounds from the target list were not detected. A complete list of target compounds and reporting limits are listed in table 10.

Table 7.--*Tentatively identified compounds in samples and trip blanks from the landfill*

[µg/L, micrograms per liter; MW, monitor well; PZ, piezometer; SP, spring or seep; TB, trip blank; S, semi-volatile organics; V, volatile organics]

Well or site number	Date sampled	Sample fraction	Compound name	Confidence level and qualifier[1]	Estimated concentration (µg/L)
MW-10	02-22-89	S	Ethyenylcyclobutane	2I	120.0
MW-11	12-07-88	S	1,1'-Oxybis[2-Ethoxyethane]	1	20
MW-14	12-12-88	S	1,2,3-Trichloropropane	2I	15
MW-15	12-13-88	V	Unknown	1	8.4
	02-22-89	S	Ethenylcyclobutane	2I	100
MW-16B	02-22-89	V	Oxygenated hydrocarbon	2C	5.7
		S	Ethenylcyclobutane	2I	130
		S	Unknown	1	10
PZ-01	02-27-89	V	Oxygenated hydrocarbon	2C	5.9
SP-18	02-27-89	V	Unknown	1	12
SP-19A	02-27-89	V	Methylguaridine	1I	32
TB	12-07-88	V	Unknown	1	7.8
	02-27-89	V	Oxygenated hydrocarbon	1	8.3

[1]Confidence levels:
Level 3 - Confirmed identification
Level 2 - Confident identification
Level 1 - Tentative identification

Qualifiers:
B - Blank contaminant
I - Isomer
C - Class of compound

Potential Effects of the Landfill on Water Quality

Water samples collected from five monitor wells and a seep at the Pueblo Depot Activity landfill and from a stock tank located south (downgradient) of the landfill contained concentrations of TCE and DCE that exceeded detection limits and drinking-water standards. TCE is a volatile organic compound that was formerly used at the Pueblo Depot Activity as a degreaser. DCE is a degradation product of TCE. These compounds are present in ground water in two areas of the landfill (figs. 16 and 17). Contamination of the ground water at monitor wells MW-11 and MW-12 and the direction of ground-water flow indicates the presence of an upgradient source to the north. The concentrations of TCE and DCE at monitor wells MW-13, MW-14, and MW-17 (TCE only), the seep (SP-18), and the stock tank (SP-19A and SP-19B) and the lack of concentrations greater than the detection level at the upgradient wells and piezometers (MW-10, MW-15, MW-16B, PZ-01, PZ-02, PZ-03, and PZ-04) indicate a source of contamination within the landfill that is north or northwest of MW-14 and the discharge area, but downgradient from the monitor wells and piezomters at which no contamination was detected. Because of small concentrations of TCE at MW-17, it also is probable that this source of contamination is west of the ephemeral stream.

Because both contaminants are present in ground water that is in the discharge area, there is a possibility of downgradient contamination of ground and surface water. The alluvial aquifer underlying the Arkansas River valley is about 0.5 mi downstream from the discharge area at the landfill. Because TCE and DCE are volatile, they are discharged to the atmosphere close to where ground water is discharged at the land surface. Concentrations of TCE decreased from 780 to 500 μg/L between the infiltration gallery (SP-19B) and the outflow of the stock tank (SP-19A) (table 5). Furthermore, TCE and DCE contamination of the water in the alluvial aquifer underlying the Arkansas River valley downgradient from the landfill was not indicated by analyses done on samples from domestic supplies (wells and developed seeps) within 0.5 to 1 mi south and southeast of the landfill.

Although none of the other target compounds (table 10 in the "Supplemental Data" section at the back of the report) were detected in analyses of water samples from the landfill, the potential for contamination of downgradient water exists, because seepage from the unconfined aquifer underlying the landfill may recharge the downgradient alluvial aquifer underlying the Arkansas River valley.

Movement of water through the unsaturated zone, particularly the fly and bottom ash (fig. 2), may increase concentrations of dissolved solids in the ground water. Analytical results from samples of the boiler (bottom) ash and leachate of the boiler ash (Curtis Turner, U.S. Department of the Army, Pueblo Depot Activity, Pueblo, Colorado, written commun., 1989) indicated that concentrations of the trace elements (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) were less than regulatory limits; sulfide concentrations ranged from 30 to 90 mg/kg; pH was 6.6 to 6.7. Concentrations of the leachate cations ranged from: 250 to 260 mg/L for calcium; 6.7 to 7.0 mg/L for magnesium; 0.03 to 13 mg/L for sodium; concentrations of the leachate trace elements ranged from 0.4 to less than 2.0 mg/L for aluminum; and 0.08 to 13 mg/L for iron. The ash was not classifiable as fly ash (Curtis Turner, U.S. Department of the Army, Pueblo Depot Activity, Pueblo, Colorado, written commun., 1989). The concentration of selenium in the ash was as large as 5 μg/L, about one-fourth the concentration of selenium in ground water at the landfill (tables 5 and 10).

SUMMARY

Nine monitor wells and four piezometers were completed in the shallow unconfined aquifer that underlies the landfill at the Pueblo Depot Activity. One of the monitor wells, MW-16A, was completed above the water table to evaluate the possibility of perched water-table conditions. The unconfined aquifer consists of a heterogenous sequence of thinly bedded and poorly sorted, fine to coarse sand, very fine gravel, silt, and clay that has some coarse gravel and cobbles and cemented layers. Depth to bedrock, the Upper Cretaceous Pierre Shale, ranged from near land surface to about 60 ft. Depth to water ranged from zero at seeps to more than 50 ft. Saturated thickness of the unconfined aquifer at the landfill generally is between 5 and 10 ft. Water is discharged from the unconfined aquifer at the edge of the upland alluvial terrace deposits as seepage, and the estimated rate was 9,600 to 19,200 ft^3/d.

Water in the unconfined aquifer is a mixed-cation mixed-anion type that has concentrations of dissolved solids that range from 710 to 1,810 mg/L. A downgradient increase in concentrations of dissolved solids occurs, which may be related to longer contact times at the interface between the terrace deposits and the underlying shale and may be due to concentration by evapotranspiration where the water table is near land surface. Movement of water through the fly and bottom ash also may increase dissolved solids in the ground water.

Chemical analyses for the priority pollutants, except dioxin, indicated the presence of TCE and its degradation product DCE. Concentrations of TCE that were above the detection levels were measured at five of the monitor wells (MW-11, MW-12, MW-13, MW-14, and MW-17), the seep (SP-18), and the stock tank (SP-19A and SP-19B); and concentrations ranged from 5.2 to 2,900 μg/L. DCE also was detected at these wells, except for MW-17, at the seep, and at the stock tank. DCE concentrations above the detection level ranged from 5 to 720 μg/L.

The presence of TCE and DCE at MW-11 and MW-12 indicated a source of contamination upgradient (north) of the landfill. The presence of TCE and DCE in water in and near the discharge area (MW-13, MW-14, MW-17, SP-18, SP-19A, and SP-19B) indicated a source of contamination within the landfill north of MW-14, south and east of the upgradient sites (MW-10, MW-15, MW-16B, and the piezometers), and west of the stream bed. Partial volatilization of both contaminants was indicated by the downgradient decrease in concentrations between the infiltration gallery (SP-19B) and the outflow to the stock tank (SP-19A). Contamination of the water in the alluvial aquifer of the Arkansas River valley by water discharged from the terrace deposits was not detected. However, a potential for contamination of water in the alluvial aquifer underlying the Arkansas River valley exists because of the proximity of the discharge area at the landfill to the limits of the alluvium.

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SUPPLEMENTAL DATA

System of Numbering Wells

The well locations in this report are given numbers based on the U.S. Bureau of Land Management system of land subdivision, and show the location of the well by quadrant, township, range, section, and position within the section (fig. 18). The first letter "S" preceding the location number indicates that the well or spring is located in the area governed by the Sixth Principal Meridian. The second letter indicates the quadrant in which the well or spring is located. Four quadrants are formed by the intersection of the base line and the principal meridian--A indicates the northeast quadrant, B the northwest, C the southwest, and D the southeast.

The first three digits of the number indicate the township, the next three digits the range, and the last two digits the section in which the well or spring is located. The letters following the section number locate the well or spring within the section. The first letter denotes the quarter section, the second the quarter-quarter section, and the third the quarter-quarter-quarter section. The letters are assigned within the section in a counterclockwise direction, beginning with (A) in the northeast section and within each quarter-quarter section in the same manner. Where two or more locations are within the smallest subdivision, consecutive numbers beginning with 1 are added in the order in which the data from the wells or springs were collected.

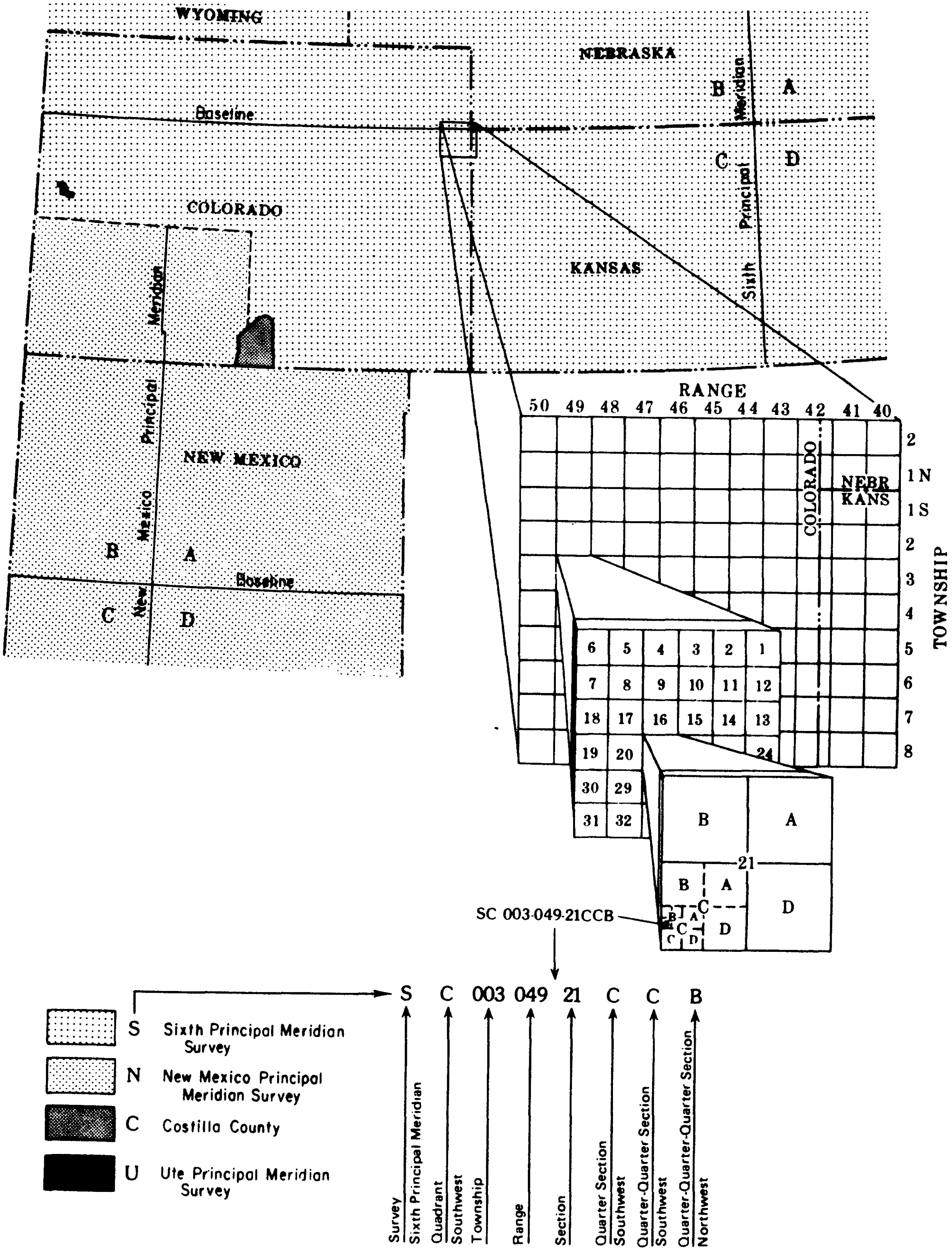

Figure 18.--System of numbering wells to obtain local well number.

Table 8.--*Driller's logs for monitor wells and piezometers at the landfill*

[mo/d/yr, month/day/year; --, no data]

Local number	Land-surface altitude (feet)	Date drilled (m/d/yr)	Lithology	Thick-ness (feet)	Depth (feet)
			MONITORING WELL MW-10 (REPLACEMENT WELL)		
SC02006233ABBO	4,670.21	01/11/89	Terrace alluvium:		
			Silt, fine, dark brown	1.5	1.5
			Silt, light tan	2.5	4.0
			Silt, medium tan, caliche at 7 feet.	4.0	8.0
			Silt, light brown with caliche.	1.0	9.0
			Silt, fine with caliche	4.5	13.5
			Silt, with caliche, fine sand at 14 feet.	0.5	14.0
			Sand, fine, coarser at 15 feet, moist at 17 feet.	4.5	18.5
			Sand, fine and small gravel	15.0	33.5
			No return, probably wet gravel.	12.0	45.5
			Pierre Shale:		
			Shale, clayey, dark gray	--	45.5

Table 8.--*Driller's logs for monitor wells and piezometers at the landfill*--Continued

Local number	Land-surface altitude (feet)	Date drilled (mo/d/yr)	Lithology	Thickness (feet)	Depth (feet)
			MONITORING WELL MW-11		
SC02006234BBB0	4,655.07	10/11/88	Terrace alluvium:		
			Silt, fine, dark brown	3.0	3.0
			Silt, fine, light tan, with some caliche.	12.0	15.0
			Sand and gravel, not saturated.	15.0	30.0
			Clay, brown	6.0	36.0
			Sand (?), no return, wet	10.0	46.0
			Pierre Shale:		
			Shale, clayey, dark gray	--	46.0

Table 8.--*Driller's logs for monitor wells and piezometers at the landfill*--Continued

Local number	Land-surface altitude (feet)	Date drilled (mo/d/yr)	Lithology	Thickness (feet)	Depth (feet)
			MONITORING WELL MW-12		
SC02006234BCB0	4,634.82	10/14/88	Terrace alluvium:		
			Silt, sandy, clayey, light-dark tan.	2.0	2.0
			Sand, silty	8.0	10.0
			Sand, gravel, and cobbles, cemented, dry.	0.5	10.5
			Sand and gravel, with some clay.	18.5	30.0
			Pierre Shale:		
			Shale, clayey, dark gray	4.0	34.0

Table 8.--*Driller's logs for monitor wells and piezometers at the landfill*--Continued

Local number	Land-surface altitude (feet)	Date drilled (mo/d/yr)	Lithology	Thickness (feet)	Depth (feet)
			MONITORING WELL MW-13		
SC02006234BCCO	4,587.99	10/13/88	Alluvial and colluvial deposits:		
			Fill material	2.0	2.0
			Clay, organic rich, black, wet at 3 feet.	3.0	5.0
			Sand and gravel with black clay (weathered shale).	11.0	16.0
			Pierre Shale:		
			Shale, clayey, dark gray	--	16.0

Table 8.--*Driller's logs for monitor wells and piezometers at the landfill*--Continued

Local number	Land-surface altitude (feet)	Date drilled (mo/d/yr)	Lithology	Thickness (feet)	Depth (feet)
			MONITORING WELL MW-14		
SC02006233ADC0	4,629.66	10/14/88	Terrace alluvium:		
			Fill material	2.0	2.0
			Sand and gravel	7.0	9.0
			Sand and gravel, cemented dry.	0.5	9.5
			Sand and gravel, large cobble at 16 feet.	22.5	32.0
			Pierre Shale:		
			Clay, dark gray weathered shale.	1.1	33.1

Table 8.--*Driller's logs for monitor wells and piezometers at the landfill*--Continued

Local number	Land-surface altitude (feet)	Date drilled (mo/d/yr)	Lithology	Thick-ness (feet)	Depth (feet)
			MONITORING WELL MW-15		
SC02006233ACD0	4,663.23	10/15/88	Terrace alluvium:		
			Silt, sandy	5.0	5.0
			Sand, with small gravel	10.0	15.0
			Sand and gravel	5.0	20.0
			Sand, fine to coarse with small gravel.	10.0	30.0
			Gravel, small to large	10.0	40.0
			Sand and gravel, with cemented streak at 43 feet.	21.0	61.0
			Pierre Shale:		
			Shale, clayey, dark gray	6.0	66.0

Table 8.--*Driller's logs for monitor wells and piezometers at the landfill*--Continued

Local number	Land-surface altitude (feet)	Date drilled (mo/d/yr)	Lithology	Thickness (feet)	Depth (feet)
			MONITORING WELL MW-16A		
SC02006233ACB0	4,668.76	10/13/88	Terrace alluvium:		
			Silt, very fine, sandy	3.0	3.0
			Silt, very fine, sandy, with some caliche.	5.0	8.0
			Sand, very fine, silty	5.0	13.0
			Sand, fine to medium, silty, some coarse sand, damp.	5.0	18.0
			Sand, fine to medium, silty, 5 to 10 percent ¼-inch gravel, very hard at 44 feet, not to shale.	26.0	44.0

Table 8.--*Driller's logs for monitor wells and piezometers at the landfill*--Continued

Local number	Land-surface altitude (feet)	Date drilled (mo/d/yr)	Lithology	Thick-ness (feet)	Depth (feet)
			MONITORING WELL MW-16B		
SC02006233ACB1	4,669.53	10/17/88	Terrace alluvium:		
			Sand, silty, with caliche and some fill material.	11.0	11.0
			Sand, silty, with some caliche.	5.0	16.0
			Sand and gravel, hard streak at 42 feet.	29.0	60.0
			Pierre Shale:		
			Shale, clayey, dark gray	--	60.0

Table 8.--*Driller's logs for monitor wells and piezometers at the landfill*--Continued

Local number	Land-surface altitude (feet)	Date drilled (mo/d/yr)	Lithology	Thickness (feet)	Depth (feet)
			MONITORING WELL MW-17		
SC02006233ADBO	4,629.88	10/13/88	Terrace alluvium:		
			Silt, sandy	5.0	5.0
			Clay, sandy	4.0	9.0
			Sand and gravel, with small pebbles.	4.0	13.0
			Sand and gravel, clayey, damp.	5.0	18.0
			No return, probably saturated sand and gravel.	5.0	23.0
			Sand and gravel, clayey	6.0	29.0
			Pierre Shale:		
			Shale, clayey, dark gray	--	29.0

Table 8.--*Driller's logs for monitor wells and piezometers at the landfill*--Continued

Local number	Land-surface altitude (feet)	Date drilled (mo/d/yr)	Lithology	Thickness (feet)	Depth (feet)
			PIEZOMETER PZ-01		
SC02006233ADB1	4,643.54	10/14/88	Terrace alluvium:		
			Sand, silty	5.0	5.0
			Sand and gravel, hard streak at 16 feet.	11.2	16.2
			Sand and gravel, clayey	11.8	28.0
			Clay, sandy, tan	7.0	35.0
			Pierre Shale:		
			Shale, clayey, dark gray	1.0	36.0

Table 8.--*Driller's logs for monitor wells and piezometers at the landfill*--Continued

Local number	Land-surface altitude (feet)	Date drilled (mo/d/yr)	Lithology	Thickness (feet)	Depth (feet)
			PIEZOMETER PZ-02		
SC02006233ACA0	4,659.95	10/15/88	Terrace alluvium:		
			Fill material, sandy silt	6.0	6.0
			Sand, silty	6.0	12.0
			Sand, fine to coarse with silt.	13.0	25.0
			Sand and gravel, hard streak at 25.0.	5.0	30.0
			Sand and gravel, hard streak at 33 to 34 feet.	16.0	46.0
			Sand and gravel	4.0	50.0
			Pierre Shale:		
			Shale, clayey, dark gray	--	50.0

Table 8.--*Driller's logs for monitor wells and piezometers at the landfill*--Continued

Local number	Land-surface altitude (feet)	Date drilled (mo/d/yr)	Lithology	Thickness (feet)	Depth (feet)
			PIEZOMETER PZ-03		
SC02006233ABD0	4,654.16	10/15/88	Terrace alluvium:		
			Sand, silty	10.0	10.0
			Sand, fine to coarse	14.0	24.0
			Hard streak, cemented sand and gravel (?).	1.0	25.0
			Sand, silty, clayey	13.0	38.0
			Pierre Shale:		
			Shale, clayey, dark gray	--	38.0

Table 8.--*Driller's logs for monitor wells and piezometers at the landfill*--Continued

Local number	Land-surface altitude (feet)	Date drilled (mo/d/yr)	Lithology	Thick-ness (feet)	Depth (feet)
			PIEZOMETER PZ-04		
SC02006233ABC0	4,667.25	10/15/88	Terrace alluvium:		
			Silt, sandy with caliche	5.0	5.0
			Sand, silty	7.0	12.0
			Clay	1.0	13.0
			Sand, hard streak at 17 feet	4.0	17.0
			Sand and gravel, hard streak at 35 to 36 feet.	23.0	40.0
			No return, drills like wet clay.	5.0	45.0
			Clay	6.0	51.0
			Pierre Shale:		
			Shale, clayey, dark gray	1.0	52.0

Table 9.--*Well-construction details for monitor wells and piezometers at the landfill*

[MW, monitor well; --, no data; PZ, piezometer]

Well number (location shown in fig. 2)	Date drilled	Altitude of land-surface datum (feet)	Height of top of casing above datum (feet)	Depth to top of[1] (feet)					Depth to bottom of well (feet)[1]	Drilling methods and remarks
				Grout	Bentonite seal	Sand pack	Screen	Bedrock		
MW-10	01-11-89	4,670.21	1.69	0	22	29	35.5	45.5	45.5	4.25-inch hollow-stem auger.
MW-11	10-11-88	4,655.07	2.52	2	31	33	36	46	46	3.25-inch hollow-stem auger.
MW-12	10-14-88	4,634.82	2.94	2	16	19	21	30	31	4.25-inch hydraulic rotary.
MW-13	10-13-88	4,587.99	2.40	1	1	3	6	16	16	3.25-inch hollow-stem auger.
MW-14	10-14-88	4,629.66	2.50	2	18	21	23	32.0	32	4.25-inch hydraulic rotary, jetted casing to bottom.
MW-15	10-15-88	4,663.23	2.39	2	32.5	36.5	50	61	60	4.25-inch hydraulic rotary.
MW-16A	10-13-88	4,668.76	2.81	2	30	32	34	--	44	3.25-inch hollow-stem auger.
MW-16B	10-17-88	4,669.53	2.22	2	31	38	50	60	60	4.25-inch hydraulic rotary, 200 pounds bentonite gel, jetted casing to bottom.
MW-17	10-13-88	4,629.88	2.68	2	14	17	19	29	29	3.25-inch hollow-stem auger.
PZ-01	10-14-88	4,643.54	2.40	2	15	17	24	35	34	4.25-inch hydraulic rotary.
PZ-02	10-15-88	4,659.95	2.50	2	35	37	40	50	50	4.25-inch hollow-stem auger.
PZ-03	10-15-88	4,654.16	2.42	2	14	17	28	38	38	4.25-inch hollow-stem auger.
PZ-04	10-15-88	4,667.25	2.63	2	36	39	42	51	52	4.25-inch hollow-stem auger.

[1]Datum for depth is land surface.

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*

[μS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; MW, monitor well; SP, spring or seep; PZ, piezometer; μg/L, micrograms per liter; --, data not available]

		Properties						Cations			
Well or site number (location shown in fig. 2)	Date of sample	Specific conductance (μS/cm)	pH (standard units)	Temperature (°C)	Chemical oxygen demand (mg/L)	Alkalinity, total (mg/L as $CaCO_3$)	Dissolved solids, total (mg/L)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)
MW-10	01-18-89	1,390	7.7	14.5	--	209	940	92	28	171	<5
	02-22-89	1,350	7.6	14.0	12	202	940	94	30	180	<5
MW-11	12-07-88	1,510	7.4	13.0	--	303	1,120	114	35	156	<5
	02-23-89	1,500	7.2	14.5	11	309	1,010	127	37	170	<5
MW-12	12-06-88	1,460	7.5	14.5	--	197	1,030	117	31	163	<5
	02-23-89	1,440	7.4	15.0	6	207	1,000	123	31	169	<5
MW-13	12-12-88	2,610	7.2	11.5	--	678	1,770	162	47	381	<5
	02-23-89	2,690	7.2	10.5	21	703	1,810	180	52	395	<5
MW-14	12-12-88	1,410	7.4	14.5	--	290	940	91	28	183	<5
	02-23-89	1,280	7.3	15.5	14	302	920	97	28	179	<5
MW-15	12-13-88	1,740	7.0	15.0	--	324	910	157	39	174	<5
	02-22-89	1,700	7.0	15.5	12	327	1,230	172	43	179	<5
MW-16B	12-07-88	2,100	7.2	14.0	--	395	1,540	150	67	226	<5
	02-22-89	2,080	7.1	14.5	18	353	1,530	165	74	247	<5
MW-17	12-13-88	1,080	7.5	15.5	--	224	710	66	19	155	<5
	02-23-89	1,080	7.5	14.5	12	232	730	73	19	149	<5
PZ-01	02-27-89	1,980	6.6	16.0	78	493	1,420	202	43	189	<5
PZ-02	02-24-89	1,250	7.6	16.0	11	197	840	100	32	127	<5
PZ-03	02-24-89	2,000	7.7	15.5	18	172	1,480	148	58	237	<5
PZ-04	02-24-89	1,370	7.7	14.5	7	189	920	98	30	163	<5
SP-18	12-14-88	2,300	7.7	7.0	--	462	1,610	167	51	292	7
	02-27-89	2,125	7.8	4.5	24	377	1,520	153	46	259	5
SP-19A	12-14-88	1,500	7.4	13.5	--	316	1,000	111	29	179	<5
	02-27-89	1,480	7.7	12.0	21	313	1,000	110	29	169	<5
SP-19B	02-27-89	1,480	7.4	12.5	--	311	--	--	--	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Anions: Sulfate, dis-solved (mg/L)	Anions: Chlo-ride, dis-solved (mg/L)	Anions: Fluo-ride, dis-solved (mg/L)	Nutrients: Nitro-gen, nitrite, dis-solved (mg/L)	Nutrients: Nitro-gen, nitrate, dis-solved (mg/L)	Nutrients: Nitrogen, ammonia + organic dissolved (mg/L)	Trace elements: Anti-mony, dis-solved (mg/L)	Trace elements: Arsenic, dis-solved (mg/L)	Trace elements: Beryl-lium, dis-solved (mg/L)
MW-10	01-18-89	447	39	--	0.01	7.1	<0.1	--	--	--
	02-22-89	426	38	1.3	<0.01	11	--	--	--	--
MW-11	12-07-88	372	69	--	2.2	13	<0.1	<0.2	<0.003	<0.002
	02-23-89	356	68	<0.5	<0.01	12	--	--	--	--
MW-12	12-06-88	475	60	--	<0.01	6.6	<0.1	--	--	--
	02-23-89	437	58	<0.5	<0.01	6.2	--	--	--	--
MW-13	12-12-88	668	135	--	<0.01	<0.5	0.9	--	--	--
	02-23-89	633	127	1.3	<0.01	<0.5	--	--	--	--
MW-14	12-12-88	320	75	--	0.5	7.3	1.0	<0.2	0.006	<0.002
	02-23-89	310	74	<0.5	<0.01	7.0	--	--	--	--
MW-15	12-13-88	466	85	--	1.1	13	<0.1	<0.2	<0.003	<0.002
	02-22-89	444	81	0.5	<0.01	11	--	--	--	--
MW-16B	12-07-88	626	92	--	1.0	11	0.4	--	--	--
	02-22-89	617	91	<0.5	<0.01	11	--	--	--	--
MW-17	12-13-88	227	55	--	1.0	6.7	0.3	<0.2	<0.003	<0.002
	02-23-89	222	56	<0.5	<0.01	7.0	--	--	--	--
PZ-01	02-27-89	519	63	0.6	0.01	8.0	--	--	--	--
PZ-02	02-24-89	328	59	0.9	<0.01	9.9	--	--	--	--
PZ-03	02-24-89	720	102	0.7	<0.01	12	--	--	--	--
PZ-04	02-24-89	421	41	1.4	<0.01	6.5	--	--	--	--
SP-18	12-14-88	668	112	--	0.01	4.0	0.8	--	--	--
	02-27-89	643	102	0.9	<0.01	3.4	--	--	--	--
SP-19A	12-14-88	354	75	--	<0.01	9.6	0.8	--	--	--
	02-27-89	337	73	<0.5	<0.01	9.7	--	--	--	--
SP-19B	02-27-89	--	--	--	<0.01	10	--	--	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Trace elements								
		Cadmium, dis- solved (mg/L)	Cyanide, total, dis- solved (mg/L)	Chro- mium, dis- solved (mg/L)	Copper, dis- solved (mg/L)	Iron, dis- solved (mg/L)	Lead, dis- solved (mg/L)	Manga- nese, dis- solved (mg/L)	Mercury, dis- solved (mg/L)	Nickel, dis- solved (mg/L)
MW-10	01-18-89	--	--	--	<0.006	<0.05	--	0.015	--	--
	02-22-89	--	--	--	<0.03	<0.05	--	0.03	--	--
MW-11	12-07-88	<0.005	<0.01	<0.03	<0.03	0.14	<0.2	0.10	<0.0001	0.07
	02-23-89	--	--	--	<0.03	0.21	--	0.03	--	--
MW-12	12-06-88	--	--	--	<0.03	<0.05	--	<0.01	--	--
	02-23-89	--	--	--	<0.03	0.07	--	<0.01	--	--
MW-13	12-12-88	--	--	--	<0.03	0.24	--	1.4	--	--
	02-23-89	--	--	--	<0.03	<0.05	--	1.4	--	--
MW-14	12-12-88	<0.005	<0.01	<0.03	<0.03	<0.05	<0.2	<0.01	0.0002	0.04
	02-23-89	--	--	--	<0.03	0.07	--	<0.01	--	--
MW-15	12-13-88	<0.005	<0.01	<0.03	<0.03	<0.05	<0.2	0.01	0.0001	<0.01
	02-22-89	--	--	--	<0.03	0.15	--	<0.01	--	--
MW-16B	12-07-88	--	--	--	<0.03	<0.05	--	<0.01	--	--
	02-22-89	--	--	--	<0.03	<0.05	--	<0.01	--	--
MW-17	12-13-88	<0.005	<0.01	<0.03	<0.03	<0.05	<0.2	<0.01	<0.0001	<0.01
	02-23-89	--	--	--	<0.03	1.1	--	0.10	--	--
PZ-01	02-27-89	--	--	--	<0.03	<0.05	--	0.21	--	--
PZ-02	02-24-89	--	--	--	<0.03	<0.05	--	<0.01	--	--
PZ-03	02-24-89	--	--	--	<0.03	0.10	--	<0.01	--	--
PZ-04	02-24-89	--	--	--	<0.03	0.09	--	<0.01	--	--
SP-18	12-14-88	--	--	--	<0.03	0.66	--	0.58	--	--
	02-27-89	--	--	--	<0.03	1.3	--	0.30	--	--
SP-19A	12-14-88	--	--	--	<0.03	<0.05	--	<0.01	--	--
	02-27-89	--	--	--	<0.03	<0.05	--	<0.01	--	--
SP-19B	02-27-89	--	--	--	--	--	--	--	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Trace elements: Selenium, dissolved (mg/L)	Trace elements: Silver, dissolved (mg/L)	Trace elements: Thallium, dissolved (mg/L)	Trace elements: Zinc, dissolved (mg/L)	Carbon: Carbon, organic, total, dissolved (mg/L)	Carbon: Halides, organic, total, as chloride, dissolved (μg/L)	Oil and grease, total (mg/L)	Phenolics, total (mg/L)
MW-10	01-18-89	--	--	--	0.06	2.9	11	<1	--
	02-22-89	--	--	--	<0.01	2.3	20	--	0.10
MW-11	12-07-88	0.018	<0.03	<2	<0.01	4.4	224	1	--
	02-23-89	--	--	--	<0.01	3.2	235	--	<0.01
MW-12	12-06-88	--	--	--	<0.01	2.9	49	5	--
	02-23-89	--	--	--	<0.01	2.4	85	--	<0.01
MW-13	12-12-88	--	--	--	<0.01	7.6	429	4	--
	02-23-89	--	--	--	<0.01	8.8	428	--	<0.01
MW-14	12-12-88	0.015	<0.03	<2	<0.01	3.6	1,360	<1	--
	02-23-89	--	--	--	<0.01	3.8	1,030	--	<0.01
MW-15	12-13-88	0.022	<0.03	<2	0.02	3.2	79	<1	--
	02-22-89	--	--	--	<0.01	3.3	110	--	<0.01
MW-16B	12-07-88	--	--	--	<0.01	3.6	33	<1	--
	02-22-89	--	--	--	<0.01	4.9	39	--	<0.01
MW-17	12-13-88	0.020	<0.03	<2	<0.01	2.5	48	<1	--
	02-23-89	--	--	--	<0.01	2.2	25	--	<0.01
PZ-01	02-27-89	--	--	--	<0.01	3.9	36	--	<0.01
PZ-02	02-24-89	--	--	--	<0.01	2.4	24	--	<0.01
PZ-03	02-24-89	--	--	--	<0.01	3.9	81	--	<0.01
PZ-04	02-24-89	--	--	--	<0.01	2.0	22	--	<0.01
SP-18	12-14-88	--	--	--	<0.01	6.2	140	<1	--
	02-27-89	--	--	--	<0.01	6.0	99	--	<0.01
SP-19A	12-14-88	--	--	--	<0.01	4.1	370	1	--
	02-27-89	--	--	--	<0.01	3.3	328	--	<0.01
SP-19B	02-27-89	--	--	--	--	--	438	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Volatile organic compounds							
		Carbon disulfide, (µg/L)	Carbon tetra-chloride, (µg/L)	Chloro-benzene, (µg/L)	Chloro-dibromo-methane, (µg/L)	Chloro-ethane, (µg/L)	Chloro-form, (µg/L)	2-Chloro-ethyl vinyl ether, (µg/L)	Chloro-methane, (µg/L)
MW-10	01-18-89	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<10	<10
	02-22-89	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<10	<10
MW-11	12-07-88	<25	<15	<25	<25	<50	<25	<50	<50
	02-23-89	<12	<7.5	<12	<12	<25	<12	<250	<35
MW-12	12-06-88	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<10	<10
	02-23-89	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<100	<14
MW-13	12-12-88	<50	<30	<50	<50	<100	<50	<100	<100
	02-23-89	<50	<30	<50	<50	<100	<50	<1,000	<140
MW-14	12-12-88	<120	<75	<120	<120	<250	<120	<250	<250
	02-23-89	<100	<60	<100	<100	<200	<100	<2,000	<280
MW-15	12-13-88	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<10	<10
	02-22-89	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<10	<10
MW-16B	12-07-88	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<10	<10
	02-22-89	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<10	<10
MW-17	12-13-88	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<10	<10
	02-23-89	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<100	<14
PZ-01	02-27-89	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<100	<14
PZ-02	02-24-89	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<10	<10
PZ-03	02-24-89	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<10	<10
PZ-04	02-24-89	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<10	<10
SP-18	12-14-88	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<10	<10
	02-27-89	<5.0	<3.0	<5.0	<5.0	<10	<5.0	<100	<14
SP-19A	12-14-88	<16	<9.9	<16	<16	<33	<16	<33	<33
	02-27-89	<25	<15	<25	<25	<50	<25	<500	<70
SP-19B	02-27-89	<25	<15	<25	<25	<50	<25	<500	<70

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Volatile organic compounds							
		Acetone (µg/L)	Acrolein (µg/L)	Acrylo-nitrile (µg/L)	Benzene (µg/L)	Bromodi-chloro-methane (µg/L)	Bromo-form (µg/L)	Bromo-methane (µg/L)	2-Butanone (µg/L)
MW-10	01-18-89	<10	--	--	<3.0	<5.0	<5.0	<10	<10
	02-22-89	<10	--	--	<3.0	<5.0	<5.0	<10	<10
MW-11	12-07-88	<50	--	--	<15	<25	<25	<50	<50
	02-23-89	<120	<40	<25	<7.5	<12	<12	<25	<120
MW-12	12-06-88	<10	--	--	<3.0	<5.0	<5.0	<10	<10
	02-23-89	<50	<16	<10	<3.0	<5.0	<5.0	<10	<50
MW-13	12-12-88	<100	--	--	<30	<50	<50	<100	<100
	02-23-89	<500	<160	<100	<30	<50	<50	<100	<500
MW-14	12-12-88	<250	--	--	<75	<120	<120	<250	<250
	02-23-89	<1,000	<320	<200	<60	<100	<100	<200	<1,000
MW-15	12-13-88	<10	--	--	<3.0	<5.0	<5.0	<10	<10
	02-22-89	<10	--	--	<3.0	<5.0	<5.0	<10	<10
MW-16B	12-07-88	<10	--	--	<3.0	<5.0	<5.0	<10	<10
	02-22-89	<10	--	--	<3.0	<5.0	<5.0	<10	<10
MW-17	12-13-88	<10	--	--	<3.0	<5.0	<5.0	<10	<10
	02-23-89	<50	<16	<10	<3.0	<5.0	<5.0	<10	<50
PZ-01	02-27-89	<50	<16	<10	<3.0	<5.0	<5.0	<10	<50
PZ-02	02-24-89	<10	--	--	<3.0	<5.0	<5.0	<10	<10
PZ-03	02-24-89	<10	--	--	<3.0	<5.0	<5.0	<10	<10
PZ-04	02-24-89	<10	--	--	<3.0	<5.0	<5.0	<10	<10
SP-18	12-14-88	<10	--	--	<3.0	<5.0	<5.0	<10	<10
	02-27-89	<50	<16	<10	<3.0	<5.0	<5.0	<10	<50
SP-19A	12-14-88	<33	--	--	<9.9	<16	<16	<33	<33
	02-27-89	<250	<80	<50	<15	<25	<25	<50	<250
SP-19B	02-27-89	<250	<80	<50	<15	<25	<25	<50	<250

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Volatile organic compounds							
		Dibromo-methane (µg/L)	1,2-Dichloro-benzene (µg/L)	1,3-Dichloro-benzene (µg/L)	1,4-Dichloro-benzene (µg/L)	trans-1,4-Dichloro-2-butene (µg/L)	Dichloro-difluoro-methane (µg/L)	1,1-Dichloro-ethane (µg/L)	1,2-Dichloro-ethane (µg/L)
MW-10	01-18-89	--	<5.0	<5.0	<5.0	--	--	<5.0	<3.0
	02-22-89	--	<5.0	<5.0	<5.0	--	--	<5.0	<3.0
MW-11	12-07-88	--	<25	<25	<25	--	--	<5.0	<15
	02-23-89	<25	--	--	--	<120	<25	<12	<7.5
MW-12	12-06-88	--	<5.0	<5.0	<5.0	--	--	<5.0	<3.0
	02-23-89	<10	--	--	--	<50	<10	<5.0	<3.0
MW-13	12-12-88	--	<50	<50	<50	--	--	<50	<30
	02-23-89	<100	--	--	--	<500	<100	<50	<30
MW-14	12-12-88	--	<120	<120	<120	--	--	<120	<75
	02-23-89	<200	--	--	--	<1,000	<200	<100	<60
MW-15	12-13-88	--	<5.0	<5.0	<5.0	--	--	<5.0	<3.0
	02-22-89	--	<5.0	<5.0	<5.0	--	--	<5.0	<3.0
MW-16B	12-07-88	--	<5.0	<5.0	<5.0	--	--	<5.0	<3.0
	02-22-89	--	<5.0	<5.0	<5.0	--	--	<5.0	<3.0
MW-17	12-13-88	--	<5.0	<5.0	<5.0	--	--	<5.0	<3.0
	02-23-89	<10	--	--	--	<50	<10	<5.0	<3.0
PZ-01	02-27-89	<10	--	--	--	<50	<10	<5.0	<3.0
PZ-02	02-24-89	--	<5.0	<5.0	<5.0	--	--	<5.0	<3.0
PZ-03	02-24-89	--	<5.0	<5.0	<5.0	--	--	<5.0	<3.0
PZ-04	02-24-89	--	<5.0	<5.0	<5.0	--	--	<5.0	<3.0
SP-18	12-14-88	--	<5.0	<5.0	<5.0	--	--	<5.0	<3.0
	02-27-89	<10	--	--	--	<50	<10	<5.0	<3.0
SP-19A	12-14-88	--	<16	<16	<16	--	--	<16	<9.9
	02-27-89	<50	--	--	--	<250	<50	<25	<15
SP-19B	02-27-89	<50	--	--	--	<250	<50	<25	<15

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Volatile organic compounds							
		1,1-Dichloro-ethene (µg/L)	trans-1,2-Dichloro-ethylene (µg/L)	1,2-Dichloro-propane (µg/L)	cis-1,3-Dichloro-propene (µg/L)	trans-1,3-Dichloro-propene (µg/L)	Ethanol (µg/L)	Ethyl benzene (µg/L)	Ethyl-methac-rylate (µg/L)
MW-10	01-18-89	<3.0	<5.0	<5.0	<5.0	<5.0	--	<5.0	--
	02-22-89	<3.0	<5.0	<5.0	<5.0	<5.0	--	<5.0	--
MW-11	12-07-88	<15	51	<25	<25	<25	--	<25	--
	02-23-89	<10	42	<12	<12	<12	<120	<12	<25
MW-12	12-06-88	<3.0	5.0	<5.0	<5.0	<5.0	--	<5.0	--
	02-23-89	<4.0	5.1	<5.0	<5.0	<5.0	<50	<5.0	<10
MW-13	12-12-88	<30	540	<50	<50	<50	--	<50	--
	02-23-89	<40	720	<50	<50	<50	<500	<50	<100
MW-14	12-12-88	<75	560	<120	<120	<120	--	<120	--
	02-23-89	<80	540	<100	<100	<100	<1,000	<100	<200
MW-15	12-13-88	<3.0	<5.0	<5.0	<5.0	<5.0	--	<5.0	--
	02-22-89	<3.0	<5.0	<5.0	<5.0	<5.0	--	<5.0	--
MW-16B	12-07-88	<3.0	<5.0	<5.0	<5.0	<5.0	--	<5.0	--
	02-22-89	<3.0	<5.0	<5.0	<5.0	<5.0	--	<5.0	--
MW-17	12-13-88	<3.0	<5.0	<5.0	<5.0	<5.0	--	<5.0	--
	02-23-89	<4.0	<5.0	<5.0	<5.0	<5.0	<50	<5.0	<10
PZ-01	02-27-89	<4.0	<5.0	<5.0	<5.0	<5.0	<50	<5.0	<10
PZ-02	02-24-89	<3.0	<5.0	<5.0	<5.0	<5.0	--	<5.0	--
PZ-03	02-24-89	<3.0	<5.0	<5.0	<5.0	<5.0	--	<10	--
PZ-04	02-24-89	<3.0	<5.0	<5.0	<5.0	<5.0	--	<5.0	--
SP-18	12-14-88	<3.0	170	<5.0	<5.0	<5.0	--	<5.0	--
	02-27-89	<4.0	77	<5.0	<5.0	<5.0	<50	<5.0	<10
SP-19A	12-14-88	<9.9	110	<16	<16	<16	--	<16	--
	02-27-89	<20	92	<25	<25	<25	<250	<25	<50
SP-19B	02-27-89	<20	130	<25	<25	<25	<250	<25	<50

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Volatile organic compounds					
		2-Hexanone (µg/L)	Iodo-methane (µg/L)	Methylene chloride (µg/L)	4-Methyl-2-pentanone (µg/L)	Styrene (µg/L)	1,1,2,2-Tetra-chloro-ethane (µg/L)
MW-10	01-18-89	--	--	<5.0	<10	--	<5.0
	02-22-89	--	--	<5.0	<10	--	<5.0
MW-11	12-07-88	--	--	<25	<50	--	<25
	02-23-89	<120	<25	<42	<120	<12	<18
MW-12	12-06-88	--	--	<5.0	<10	--	<5.0
	02-23-89	<50	<10	<17	<50	<5.0	<7.0
MW-13	12-12-88	--	--	<50	<100	--	<50
	02-23-89	<500	<100	<170	<500	<50	<70
MW-14	12-12-88	--	--	<120	<250	--	<120
	02-23-89	<1,000	<200	<340	<1,000	<100	<140
MW-15	12-13-88	--	--	<5.0	<10	--	<5.0
	02-22-89	--	--	<5.0	<10	--	<5.0
MW-16B	12-07-88	--	--	<5.0	<10	--	<5.0
	02-22-89	--	--	<5.0	<10	--	<5.0
MW-17	12-13-88	--	--	<5.0	<10	--	<5.0
	02-23-89	<50	<10	<17	<50	<5.0	<7.0
PZ-01	02-27-89	<50	<10	<17	<50	<5.0	<7.0
PZ-02	02-24-89	--	--	<5.0	<10	--	<5.0
PZ-03	02-24-89	--	--	<5.0	<10	--	<5.0
PZ-04	02-24-89	--	--	<5.0	<10	--	<5.0
SP-18	12-14-88	--	--	<5.0	<10	--	<5.0
	02-27-89	<50	<10	<17	<50	<5.0	<7.0
SP-19A	12-14-88	--	--	<16	<33	--	<16
	02-27-89	<250	<50	<85	<250	<25	<35
SP-19B	02-27-89	<250	<50	<85	<250	<25	<35

Table 10--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Volatile organic compounds: Tetra-chloro-ethene (µg/L)	Toluene (µg/L)	1,1,1-Tri-chloro-ethane (µg/L)	1,1,2-Tri-chloro-ethane (µg/L)	Tri-chloro-ethylene (µg/L)	Tri-chloro-fluoro-methane (µg/L)	1,2,3-Tri-chloro-propane (µg/L)	Vinyl acetate (µg/L)
MW-10	01-18-89	<3.0	<5.0	<5.0	<5.0	<3.0	<10	--	--
	02-22-89	<3.0	<5.0	<5.0	<5.0	<3.0	<10	--	--
MW-11	12-07-88	<15	<25	<25	<25	380	<50	--	--
	02-23-89	<7.5	<12	<12	<12	340	<25	<25	<120
MW-12	12-06-88	<3.0	<5.0	<5.0	<5.0	58	<10	--	--
	02-23-89	<3.0	<5.0	<5.0	<5.0	75	<10	<10	<50
MW-13	12-12-88	<30	<50	<50	<50	67	<100	--	--
	02-23-89	<30	<50	<50	<50	60	<100	<100	<500
MW-14	12-12-88	<75	<120	<120	<120	2,400	<250	--	--
	02-23-89	<60	<100	<100	<100	2,900	<200	<200	<1,000
MW-15	12-13-88	<3.0	<5.0	<5.0	<5.0	<3.0	<10	--	--
	02-22-89	<3.0	<5.0	<5.0	<5.0	<3.0	<10	--	--
MW-16B	12-07-88	<3.0	<5.0	<5.0	<5.0	<3.0	<10	--	--
	02-22-89	<3.0	<5.0	<5.0	<5.0	<3.0	<10	--	--
MW-17	12-13-88	<3.0	<5.0	<5.0	<5.0	<3.0	<10	--	--
	02-23-89	<3.0	<5.0	<5.0	<5.0	5.2	<10	<10	<50
PZ-01	02-27-89	<3.0	<5.0	<5.0	<5.0	<3.0	<10	<10	<50
PZ-02	02-24-89	<3.0	<5.0	<5.0	<5.0	<3.0	<10	--	--
PZ-03	02-24-89	<3.0	<5.0	<5.0	<5.0	<3.0	<10	--	--
PZ-04	02-24-89	<3.0	<5.0	<5.0	<5.0	<3.0	<10	--	--
SP-18	12-14-88	<3.0	<5.0	<5.0	<5.0	42	<10	--	--
	02-27-89	<3.0	<5.0	<5.0	<5.0	24	<10	<10	<50
SP-19A	12-14-88	<9.9	<16	<16	<16	560	<33	--	--
	02-27-89	<15	<25	<25	<25	500	<50	<50	<250
SP-19B	02-27-89	<15	<25	<25	<25	780	<50	<50	<250

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Volatile organic compounds		Organochlorine pesticides/polychlorobiphenyls						
		Vinyl chloride, (µg/L)	Xylenes total (µg/L)	alpha-BHC (µg/L)	beta-BHC (µg/L)	delta-BHC (µg/L)	gamma-BHC (µg/L)	Toxa-phene (µg/L)	Hepta-chlor (µg/L)	Aldrin (µg/L)
MW-10	01-18-89	<3.0	<5.0	--	--	--	--	--	--	--
	02-22-89	<3.0	<5.0	--	--	--	--	--	--	--
MW-11	12-07-88	<15	<25	<0.050	<0.050	<0.050	<0.050	<1.0	<0.020	<0.050
	02-23-89	<28	<12	--	--	--	--	--	--	--
MW-12	12-06-88	<3.0	<5.0	--	--	--	--	--	--	--
	02-23-89	<11	<5.0	--	--	--	--	--	--	--
MW-13	12-12-88	<30	<50	--	--	--	--	--	--	--
	02-23-89	<110	<50	--	--	--	--	--	--	--
MW-14	12-12-88	<75	<120	<0.050	<0.050	<0.050	<0.050	<1.0	<0.020	<0.050
	02-23-89	<220	<100	--	--	--	--	--	--	--
MW-15	12-13-88	<3.0	<5.0	<0.050	<0.050	<0.050	<0.050	<1.0	<0.020	<0.050
	02-22-89	<3.0	<5.0	--	--	--	--	--	--	--
MW-16B	12-07-88	<3.0	<5.0	--	--	--	--	--	--	--
	02-22-89	<3.0	<5.0	--	--	--	--	--	--	--
MW-17	12-13-88	<3.0	<5.0	<0.050	<0.050	<0.050	<0.050	<1.0	<0.020	<0.050
	02-23-89	<11	<5.0	--	--	--	--	--	--	--
PZ-01	02-27-89	<11	<5.0	--	--	--	--	--	--	--
PZ-02	02-24-89	<3.0	<5.0	--	--	--	--	--	--	--
PZ-03	02-24-89	<3.0	<5.0	--	--	--	--	--	--	--
PZ-04	02-24-89	<3.0	<5.0	--	--	--	--	--	--	--
SP-18	12-14-88	<3.0	<5.0	--	--	--	--	--	--	--
	02-27-89	<11	<5.0	--	--	--	--	--	--	--
SP-19A	12-14-88	<9.9	<16	--	--	--	--	--	--	--
	02-27-89	<55	<25	--	--	--	--	--	--	--
SP-19B	02-27-89	<55	<25	--	--	--	--	--	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Organochlorine pesticides/polychlorobiphenyls								
		Hepta-chlor-epoxide (µg/L)	Endo-sul-fan I (µg/L)	Diel-drin (µg/L)	4,4'-DDE (µg/L)	Endrin (µg/L)	Endo-sul-fan II (µg/L)	4,4'-DDD (µg/L)	Endo-sulfan sulfate (µg/L)	4,4'-DDT (µg/L)
MW-10	01-18-89	--	--	--	--	--	--	--	--	--
	02-22-89	--	--	--	--	--	--	--	--	--
MW-11	12-07-88	<0.050	<0.050	<0.020	<0.10	<0.060	<0.10	<0.10	<0.10	<0.10
	02-23-89	--	--	--	--	--	--	--	--	--
MW-12	12-06-88	--	--	--	--	--	--	--	--	--
	02-23-89	--	--	--	--	--	--	--	--	--
MW-13	12-12-88	--	--	--	--	--	--	--	--	--
	02-23-89	--	--	--	--	--	--	--	--	--
MW-14	12-12-88	<0.050	<0.050	<0.020	<0.10	<0.060	<0.10	<0.10	<0.10	<0.10
	02-23-89	--	--	--	--	--	--	--	--	--
MW-15	12-13-88	<0.050	<0.050	<0.020	<0.10	<0.060	<0.10	<0.10	<0.10	<0.10
	02-22-89	--	--	--	--	--	--	--	--	--
MW-16B	12-07-88	--	--	--	--	--	--	--	--	--
	02-22-89	--	--	--	--	--	--	--	--	--
MW-17	12-13-88	<0.050	<0.050	<0.020	<0.10	<0.060	<0.10	<0.10	<0.10	<0.10
	02-23-89	--	--	--	--	--	--	--	--	--
PZ-01	02-27-89	--	--	--	--	--	--	--	--	--
PZ-02	02-24-89	--	--	--	--	--	--	--	--	--
PZ-03	02-24-89	--	--	--	--	--	--	--	--	--
PZ-04	02-24-89	--	--	--	--	--	--	--	--	--
SP-18	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	--	--	--	--	--	--	--	--	--
SP-19A	02-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	--	--	--	--	--	--	--	--	--
SP-19B	02-27-89	--	--	--	--	--	--	--	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Organochlorine pesticides/polychlorobiphenyls								
		Endrin alde-hyde (µg/L)	Chloradane (µg/L)	Aro-clor-1016 (µg/L)	Aro-clor-1221 (µg/L)	Aro-clor-1232 (µg/L)	Aro-clor-1242 (µg/L)	Aro-clor-1248 (µg/L)	Aro-clor-1254 (µg/L)	Aro-clor-1260 (µg/L)
MW-10	01-18-89	--	--	--	--	--	--	--	--	--
	02-22-89	--	--	--	--	--	--	--	--	--
MW-11	12-07-88	<0.10	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<1.0
	02-23-89	--	--	--	--	--	--	--	--	--
MW-12	12-06-88	--	--	--	--	--	--	--	--	--
	02-23-89	--	--	--	--	--	--	--	--	--
MW-13	12-12-88	--	--	--	--	--	--	--	--	--
	02-23-89	--	--	--	--	--	--	--	--	--
MW-14	12-12-88	<0.10	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<1.0
	02-23-89	--	--	--	--	--	--	--	--	--
MW-15	12-13-88	<0.10	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<1.0
	02-22-89	--	--	--	--	--	--	--	--	--
MW-16B	12-07-88	--	--	--	--	--	--	--	--	--
	02-22-89	--	--	--	--	--	--	--	--	--
MW-17	12-13-88	<0.10	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50	<1.0	<1.0
	02-23-89	--	--	--	--	--	--	--	--	--
PZ-01	02-27-89	--	--	--	--	--	--	--	--	--
PZ-02	02-24-89	--	--	--	--	--	--	--	--	--
PZ-03	02-24-89	--	--	--	--	--	--	--	--	--
PZ-04	02-24-89	--	--	--	--	--	--	--	--	--
SP-18	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	--	--	--	--	--	--	--	--	--
SP-19A	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	--	--	--	--	--	--	--	--	--
SP-19B	02-27-89	--	--	--	--	--	--	--	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Semi-volatile organic compounds									
		Ace-naph-thene (μg/L)	Ace-naph-thy-lene (μg/L)	Aceto-phe-none (μg/L)	4-amino-bi-phenyl (μg/L)	Ani-line (μg/L)	Anthra-cene (μg/L)	Benzi-dine (μg/L)	Ben-zoic acid (μg/L)	Benzo-(a) anthra-cene (μg/L)	Benzo-(b) fluor-anthene (μg/L)
MW-10	01-18-89	--	--	--	--	--	--	--	--	--	--
	02-22-89	<10	<10	--	--	--	<10	--	--	<10	<10
MW-11	12-07-88	<10	<10	--	--	--	<10	--	--	<10	<10
	02-23-89	<10	<10	<50	<50	<50	<10	<170	<50	<10	<10
MW-12	12-06-88	--	--	--	--	--	--	--	--	--	--
	02-23-89	<10	<10	<50	<50	<50	<10	<170	<50	<10	<10
MW-13	12-12-88	--	--	--	--	--	--	--	--	--	--
	02-23-89	<10	<10	<50	<50	<50	<10	<170	<50	<10	<10
MW-14	12-12-88	<10	<10	--	--	--	<10	--	--	<10	<10
	02-23-89	<10	<10	<50	<50	<50	<10	<170	<50	<10	<10
MW-15	12-13-88	<10	<10	--	--	--	<10	--	--	<10	<10
	02-22-89	<10	<10	--	--	--	<10	--	--	<10	<10
MW-16B	12-07-88	--	--	--	--	--	--	--	--	--	--
	02-22-89	<10	<10	--	--	--	<10	--	--	<10	<10
MW-17	12-13-88	<10	<10	--	--	--	<10	--	--	<10	<10
	02-23-89	<10	<10	<50	<50	<50	<10	<170	<50	<10	<10
PZ-01	02-27-89	<10	<10	<50	<50	<50	<10	<170	<50	<10	<10
PZ-02	02-24-89	<10	<10	--	--	<50	<10	--	--	<10	<10
PZ-03	02-24-89	<10	<10	--	--	<50	<10	--	--	<10	<10
PZ-04	02-24-89	<10	<10	--	--	<50	<10	--	--	<10	<10
SP-18	12-14-88	--	--	--	--	--	--	--	--	--	--
	02-27-89	<10	<10	<50	<50	<50	<10	<170	<50	<10	<10
SP-19A	12-14-88	--	--	--	--	--	--	--	--	--	--
	02-27-89	<10	<10	<50	<50	<50	<10	<170	<50	<10	<10
SP-19B	02-27-89	--	--	--	--	--	--	--	--	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Semi-volatile organic compounds: Benzo-(k) fluor-anthene (µg/L)	Benzo-(g,h,i) pery-lene (µg/L)	Benzo-(a) pyrene (µg/L)	Benzyl alcohol (µg/L)	4-Bromo-phenyl phenyl ether (µg/L)	Butyl benzyl phtha-late (µg/L)	4-Chloro-ani-line (µg/L)	bis(2-Chloro-ethoxy) methane (µg/L)	bis(2-Chloro-ethyl) ether (µg/L)
MW-10	01-18-89	--	--	--	--	--	--	--	--	--
	02-22-89	<10	<10	<10	--	<10	<10	--	<10	<10
MW-11	12-07-88	<10	<10	<10	--	<10	<10	--	<10	<10
	02-23-89	<10	<10	<10	<20	<10	<10	<20	<10	<10
MW-12	12-06-88	--	--	--	--	--	--	--	--	--
	02-23-89	<10	<10	<10	<20	<10	<10	<20	<10	<10
MW-13	12-12-88	--	--	--	--	--	--	--	--	--
	02-23-89	<10	<10	<10	<20	<10	<10	<20	<10	<10
MW-14	12-12-88	<10	<10	<10	--	<10	<10	--	<10	<10
	02-23-89	<10	<10	<10	<20	<10	<10	<20	<10	<10
MW-15	12-13-88	<10	<10	<10	--	<10	<10	--	<10	<10
	02-22-89	<10	<10	<10	--	<10	<10	--	<10	<10
MW-16B	12-07-88	--	--	--	--	--	--	--	--	--
	02-22-89	<10	<10	<10	--	<10	<10	--	<10	<10
MW-17	12-13-88	<10	<10	<10	--	<10	<10	--	<10	<10
	02-23-89	<10	<10	<10	<20	<10	<10	<20	<10	<10
PZ-01	02-27-89	<10	<10	<10	<20	<10	<10	<20	<10	<10
PZ-02	02-24-89	<10	<10	<10	--	<10	<10	--	<10	<10
PZ-03	02-24-89	<10	<10	<10	--	<10	<10	--	<10	<10
PZ-04	02-24-89	<10	<10	<10	--	<10	<10	--	<10	<10
SP-18	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	<10	<10	<10	<20	<10	<10	<20	<10	<10
SP-19A	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	<10	<10	<10	<20	<10	<10	<20	<10	<10
SP-19B	02-27-89	--	--	--	--	--	--	--	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Semi-volatile organic compounds: bis(2-Chloro-iso-propyl) ether (µg/L)	4-Chloro-3-methyl-phenol (µg/L)	1-Chloro-naph-tha-lene (µg/L)	2-Chloro-naph-tha-lene (µg/L)	2-Chloro-phenol (µg/L)	4-Chloro-phenyl phenyl ether (µg/L)	Chry-sene (µg/L)	Dibenz (a,j) acri-dine (µg/L)	Dibenz (a,h) anthra-cene (µg/L)	Di-benzo-furan (µg/L)
MW-10	01-18-89	--	--	--	--	--	--	--	--	--	--
	02-22-89	<10	<10	--	<10	<10	<10	<10	--	<10	<10
MW-11	12-07-88	<10	<10	--	<10	<10	<10	<10	--	<10	<10
	02-23-89	<10	<10	<50	<10	<10	<10	<10	--	<10	<10
MW-12	12-06-88	--	--	--	--	--	--	--	--	--	--
	02-23-89	<10	<10	<50	<10	<10	<10	<10	--	<10	<10
MW-13	12-12-88	--	--	--	--	--	--	--	--	--	--
	02-23-89	<10	<10	<50	<10	<10	<10	<10	--	<10	<10
MW-14	12-12-88	<10	<10	--	<10	<10	<10	<10	--	<10	<10
	02-23-89	<10	<10	<50	<10	<10	<10	<10	--	<10	<10
MW-15	12-13-88	<10	<10	--	<10	<10	<10	<10	--	<10	<10
	02-22-89	<10	<10	--	<10	<10	<10	<10	--	<10	<10
MW-16B	12-07-88	--	--	--	--	--	--	--	--	--	--
	02-22-89	<10	<10	--	<10	<10	<10	<10	--	<10	<10
MW-17	12-13-88	<10	<10	--	<10	<10	<10	<10	--	<10	<10
	02-23-89	<10	<10	<50	<10	<10	<10	<10	--	<10	<10
PZ-01	02-27-89	<10	<10	<50	<10	<10	<10	<10	--	<10	<10
PZ-02	02-24-89	<10	<10	--	<10	<10	<10	<10	--	<10	<10
PZ-03	02-24-89	<10	<10	--	<10	<10	<10	<10	--	<10	<10
PZ-04	02-24-89	<10	<10	--	<10	<10	<10	<10	--	<10	<10
SP-18	12-14-88	--	--	--	--	--	--	--	--	--	--
	02-27-89	<10	<10	<50	<10	<10	<10	<10	--	<10	<10
SP-19A	12-14-88	--	--	--	--	--	--	--	--	--	--
	02-27-89	<10	<10	<50	<10	<10	<10	<10	--	<10	<10
SP-19B	02-27-89	--	--	--	--	--	--	--	--	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Semi-volatile organic compounds								
		1,2-Di-chloro-benzene (µg/L)	1,3-Di-chloro-benzene (µg/L)	1,4-Di-chloro-benzene (µg/L)	3,3'-Di-chloro-benzi-dine (µg/L)	2,4-Di-chloro-phenol (µg/L)	2,6-Di-chloro-phenol (µg/L)	Di-ethyl phtha-late (µg/L)	p-Di methyl-aminoazo-benzene (µg/L)	7,12,-Dimethyl benz-anthra-cene (µg/L)
MW-10	01-18-89	--	--	--	--	--	--	--	--	--
	02-22-89	<5.0	<5.0	<5.0	<20	<10	--	<20	--	--
MW-11	12-07-88	<5.0	<5.0	<5.0	<20	<10	--	<20	--	--
	02-23-89	<5.0	<5.0	<5.0	<20	<10	<50	<20	<50	<50
MW-12	12-06-88	--	--	--	--	--	--	--	--	--
	02-23-89	<5.0	<5.0	<5.0	<20	<10	<50	<20	<50	<50
MW-13	12-12-88	--	--	--	--	--	--	--	--	--
	02-23-89	<5.0	<5.0	<5.0	<20	<10	<50	<20	<50	<50
MW-14	12-12-88	<5.0	<5.0	<5.0	<20	<10	--	<20	--	--
	02-23-89	<5.0	<5.0	<5.0	<20	<10	<50	<20	<50	<50
MW-15	12-13-88	<5.0	<5.0	<5.0	<20	<10	--	<20	--	--
	02-22-89	<5.0	<5.0	<5.0	<20	<10	--	<20	--	--
MW-16B	12-07-88	--	--	--	--	--	--	--	--	--
	02-22-89	<5.0	<5.0	<5.0	<20	<10	--	<20	--	--
MW-17	12-13-88	<5.0	<5.0	<5.0	<20	<10	--	<20	--	--
	02-23-89	<5.0	<5.0	<5.0	<20	<10	<50	<20	<50	<50
PZ-01	02-27-89	<5.0	<5.0	<5.0	<20	<10	<50	<20	<50	<50
PZ-02	02-24-89	<5.0	<5.0	<5.0	<20	<10	--	<20	--	--
PZ-03	02-24-89	<5.0	<5.0	<5.0	<20	<10	--	<20	--	--
PZ-04	02-24-89	<5.0	<5.0	<5.0	<20	<10	--	<20	--	--
SP-18	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	<5.0	<5.0	<5.0	<20	<10	<50	<20	<50	<50
SP-19A	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	<5.0	<5.0	<5.0	<20	<10	<50	<20	<50	<50
SP-19B	02-27-89	--	--	--	--	--	--	--	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Semi-volatile organic compounds: a,a-Dimethylphenethylamine (µg/L)	2,4-Dimethylphenol (µg/L)	Dimethyl phthalate (µg/L)	Di-n-butyl phthalate (µg/L)	Di-n-octyl phthalate (µg/L)	4,6-Dinitro-2-methylphenol (µg/L)	2,4-Dinitrophenol (µg/L)	2,6-Dinitrophenol (µg/L)	2,4-Dinitrotoluene (µg/L)
MW-10	01-18-89	--	--	--	--	--	--	--	--	--
	02-22-89	--	<10	<10	<10	<10	<50	<50	--	<10
MW-11	12-07-88	--	<10	<10	<10	<10	<50	<50	--	<10
	02-23-89	--	<10	<10	<10	<10	<50	<50	<50	<10
MW-12	12-06-88	--	--	--	--	--	--	--	--	--
	02-23-89	--	<10	<10	<10	<10	<50	<50	<50	<10
MW-13	12-12-88	--	--	--	--	--	--	--	--	--
	02-23-89	--	<10	<10	<10	<10	<50	<50	<50	<10
MW-14	12-12-88	--	<10	<10	<10	<10	<50	<50	--	<10
	02-23-89	--	<10	<10	<10	<10	<50	<50	<50	<10
MW-15	12-13-88	--	<10	<10	<10	<10	<50	<50	--	<10
	02-22-89	--	<10	<10	<10	<10	<50	<50	--	<10
MW-16B	12-07-88	--	--	--	--	--	--	--	--	--
	02-22-89	--	<10	<10	<10	<10	<50	<50	--	<10
MW-17	12-13-88	--	<10	<10	<10	<10	<50	<50	--	<10
	02-23-89	--	<10	<10	<10	<10	<50	<50	<50	<10
PZ-01	02-27-89	--	<10	<10	<10	<10	<50	<50	<50	<10
PZ-02	02-24-89	--	<10	<10	<10	<10	<50	<50	<50	<10
PZ-03	02-24-89	--	<10	<10	<10	<10	<50	<50	<50	<10
PZ-04	02-24-89	--	<10	<10	<10	<10	<50	<50	<50	<10
SP-18	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	--	<10	<10	<10	<10	<50	<50	<50	<10
SP-19A	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	--	<10	<10	<10	<10	<50	<50	<50	<10
SP-19B	02-27-89	--	--	--	--	--	--	--	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Semi-volatile organic compounds: 2,6-Dinitrotoluene (µg/L)	Diphenylamine (µg/L)	1,2-Diphenylhydrazine (µg/L)	bis(2-Ethylhexyl) phthalate (µg/L)	Ethyl methanesulfonate (µg/L)	Fluoranthene (µg/L)	Fluorene (µg/L)	Hexachlorobenzene (µg/L)	Hexachlorobutadiene (µg/L)
MW-10	01-18-89	--	--	--	--	--	--	--	--	--
	02-22-89	<10	--	--	<10	--	<10	<10	<10	<10
MW-11	12-07-88	<10	--	--	<10	--	<10	<10	<10	<10
	02-23-89	<10	<50	<50	<10	<50	<10	<10	<10	<10
MW-12	12-06-88	--	--	--	--	--	--	--	--	--
	02-23-89	<10	<50	<50	<10	<50	<10	<10	<10	<10
MW-13	12-12-88	--	--	--	--	--	--	--	--	--
	02-23-89	<10	<50	<50	<10	<50	<10	<10	<10	<10
MW-14	12-12-88	<10	--	--	<10	--	<10	<10	<10	<10
	02-23-89	<10	<50	<50	<10	<50	<10	<10	<10	<10
MW-15	12-13-88	<10	--	--	<10	--	<10	<10	<10	<10
	02-22-89	<10	--	--	<10	--	<10	<10	<10	<10
MW-16B	12-07-88	--	--	--	--	--	--	--	--	--
	02-22-89	<10	--	--	<10	--	<10	<10	<10	<10
MW-17	12-13-88	<10	--	--	<10	--	<10	<10	<10	<10
	02-23-89	<10	<50	<50	<10	<50	<10	<10	<10	<10
PZ-01	02-27-89	<10	<50	<50	<10	<50	<10	<10	<10	<10
PZ-02	02-24-89	<10	--	--	<10	--	<10	<10	<10	<10
PZ-03	02-24-89	<10	--	--	<10	--	<10	<10	<10	<10
PZ-04	02-24-89	<10	--	--	<10	--	<10	<10	<10	<10
SP-18	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	<10	<50	<50	<10	<50	<10	<10	<10	<10
SP-19A	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	<10	<50	<50	<10	<50	<10	<10	<10	<10
SP-19B	02-27-89	--	--	--	--	--	--	--	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Semi-volatile organic compounds								
		Hexa-chloro-ethane (µg/L)	Hexa-chloro-cyclo-penta-diene (µg/L)	Indeno-(1,2,3-c,d) pyrene (µg/L)	Iso-phorone (µg/L)	3-Methyl-cholo-anth-rene (µg/L)	Methyl methane-sulfo-nate (µg/L)	2-Methyl-naph-tha-lene (µg/L)	2-Methyl-phenol (µg/L)	4-Methyl-phenol (µg/L)
MW-10	01-18-89	--	--	--	--	--	--	--	--	--
	02-22-89	<10	--	<10	<10	--	--	--	--	--
MW-11	12-07-88	<10	--	<10	<10	--	--	--	--	--
	02-23-89	<10	<10	<10	<10	<50	<50	<10	<10	<10
MW-12	12-06-88	--	--	--	--	--	--	--	--	--
	02-23-89	<10	<10	<10	<10	<50	<50	<10	<10	<10
MW-13	12-12-88	--	--	--	--	--	--	--	--	--
	02-23-89	<10	<10	<10	<10	<50	<50	<10	<10	<10
MW-14	12-12-88	<10	--	<10	<10	--	--	--	--	--
	02-23-89	<10	<10	<10	<10	<50	<50	<10	<10	<10
MW-15	12-13-88	<10	--	<10	<10	--	--	--	--	--
	02-22-89	<10	--	<10	<10	--	--	--	--	--
MW-16B	12-07-88	--	--	--	--	--	--	--	--	--
	02-22-89	<10	--	<10	<10	--	--	--	--	--
MW-17	12-13-88	<10	--	<10	<10	--	--	--	--	--
	02-23-89	<10	<10	<10	<10	<50	<50	<10	<10	<10
PZ-01	02-27-89	<10	<10	<10	<10	<50	<50	<10	<10	<10
PZ-02	02-24-89	<10	--	<10	<10	--	--	--	--	--
PZ-03	02-24-89	<10	--	<10	<10	--	--	--	--	--
PZ-04	02-24-89	<10	--	<10	<10	--	--	--	--	--
SP-18	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	<10	<10	<10	<10	<50	<50	<10	<10	<10
SP-19A	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	<10	<10	<10	<10	<50	<50	<10	<10	<10
SP-19B	02-27-89	--	--	--	--	--	--	--	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

		Semi-volatile organic compounds									
Well or site number (location shown in fig. 2)	Date of sample	Naphthalene (µg/L)	1-Naphthylamine (µg/L)	2-Naphthylamine (µg/L)	2-Nitroaniline (µg/L)	3-Nitroaniline (µg/L)	4-Nitroaniline (µg/L)	Nitrobenzene (µg/L)	2-Nitrophenol (µg/L)	4-Nitrophenol (µg/L)	N-Nitrosodi-n-butylamine (µg/L)
MW-10	01-18-89	--	--	--	--	--	--	--	--	--	--
	02-22-89	<10	--	--	--	--	--	<10	<10	<50	--
MW-11	12-07-88	<10	--	--	--	--	--	<10	<10	<50	--
	02-23-89	<10	<50	<50	<50	<50	<50	<10	<10	<50	<50
MW-12	12-06-88	--	--	--	--	--	--	--	--	--	--
	02-23-89	<10	<50	<50	<50	<50	<50	<10	<10	<50	<50
MW-13	12-12-88	--	--	--	--	--	--	--	--	--	--
	02-23-89	<10	<50	<50	<50	<50	<50	<10	<10	<50	<50
MW-14	12-12-88	<10	--	--	--	--	--	<10	<10	<50	--
	02-23-89	<10	<50	<50	<50	<50	<50	<10	<10	<50	<50
MW-15	12-13-88	<10	--	--	--	--	--	<10	<10	<50	--
	02-22-89	<10	--	--	--	--	--	<10	<10	<50	--
MW-16B	12-07-88	--	--	--	--	--	--	--	--	--	--
	02-22-89	<10	--	--	--	--	--	<10	<10	<50	--
MW-17	12-13-88	<10	--	--	--	--	--	<10	<10	<50	--
	02-23-89	<10	<50	<50	<50	<50	<50	<10	<10	<50	<50
PZ-01	02-27-89	<10	<50	<50	<50	<50	<50	<10	<10	<50	<50
PZ-02	02-24-89	<10	--	--	--	--	--	<10	<10	<50	--
PZ-03	02-24-89	<10	--	--	--	--	--	<10	<10	<50	--
PZ-04	02-24-89	<10	--	--	--	--	--	<10	<10	<50	--
SP-18	12-14-88	--	--	--	--	--	--	--	--	--	--
	02-27-89	<10	<50	<50	<50	<50	<50	<10	<10	<50	<50
SP-19A	12-14-88	--	--	--	--	--	--	--	--	--	--
	02-27-89	<10	<50	<50	<50	<50	<50	<10	<10	<50	<50
SP-19B	02-27-89	--	--	--	--	--	--	--	--	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

		Semi-volatile organic compounds								
Well or site number (location shown in fig. 2)	Date of sample	N-Nitrosodimethylamine (µg/L)	N-Nitrosodi-n-propylamine (µg/L)	N-Nitrosodiphenylamine (µg/L)	N-Nitrosopiperidine (µg/L)	Pentachlorobenzene (µg/L)	Pentachloronitrobenzene (µg/L)	Pentachlorophenol (µg/L)	Phenacetin (µg/L)	Phenanthrene (µg/L)
MW-10	01-18-89	--	--	--	--	--	--	--	--	--
	02-22-89	--	<10	--	--	--	--	<30	--	<10
MW-11	12-07-88	--	<10	--	--	--	--	<30	--	<10
	02-23-89	<50	<10	<10	<50	<50	<50	<30	<50	<10
MW-12	12-06-88	--	--	--	--	--	--	--	--	--
	02-23-89	<50	<10	<10	<50	<50	<50	<30	<50	<10
MW-13	12-12-88	--	--	--	--	--	--	--	--	--
	02-23-89	<50	<10	<10	<50	<50	<50	<30	<50	<10
MW-14	12-12-88	--	<10	--	--	--	--	<30	--	<10
	02-23-89	<50	<10	<10	<50	<50	<50	<30	<50	<10
MW-15	12-13-88	--	<10	--	--	--	--	<30	--	<10
	02-22-89	--	<10	--	--	--	--	<30	--	<10
MW-16B	12-07-88	--	--	--	--	--	--	--	--	--
	02-22-89	--	<10	--	--	--	--	<30	--	<10
MW-17	12-13-88	--	<10	--	--	--	--	<30	--	<10
	02-23-89	<50	<10	<10	<50	<50	<50	<30	<50	<10
PZ-01	02-27-89	<50	<10	<10	<50	<50	<50	<30	<50	<10
PZ-02	02-24-89	--	<10	--	--	--	--	<30	--	<10
PZ-03	02-24-89	--	<10	--	--	--	--	<30	--	<10
PZ-04	02-24-89	--	<10	--	--	--	--	<30	--	<10
SP-18	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	<50	<10	<10	<50	<50	<50	<30	<50	<10
SP-19A	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	<50	<10	<10	<50	<50	<50	<30	<50	<10
SP-19B	02-27-89	--	--	--	--	--	--	--	--	--

Table 10.--*Ground-water quality for the unconfined aquifer at the landfill*--Continued

Well or site number (location shown in fig. 2)	Date of sample	Semi-volatile organic compounds								
		Phenol (µg/L)	2-Picoline (µg/L)	Pronamide (µg/L)	Pyrene (µg/L)	1,2,4,5-Tetrachlorobenzene (µg/L)	2,3,4,6-Tetrachlorophenol (µg/L)	1,2,4-Trichlorobenzene (µg/L)	2,4,5-Trichlorophenol (µg/L)	2,4,6-Trichlorophenol (µg/L)
MW-10	01-18-89	--	--	--	--	--	--	--	--	--
	02-22-89	<10	--	--	<10	--	--	<10	<50	<10
MW-11	12-07-88	<10	--	--	<10	--	--	<10	<50	<10
	02-23-89	<10	<50	<50	<10	<50	<50	<10	<50	<10
MW-12	12-06-88	--	--	--	--	--	--	--	--	--
	02-23-89	<10	<50	<50	<10	<50	<50	<10	<50	<10
MW-13	12-12-88	--	--	--	--	--	--	--	--	--
	02-23-89	<10	<50	<50	<10	<50	<50	<10	<50	<10
MW-14	12-12-88	<10	--	--	<10	--	--	<10	<50	<10
	02-23-89	<10	<50	<50	<10	<50	<50	<10	<50	<10
MW-15	12-13-88	<10	--	--	<10	--	--	<10	<50	<10
	02-22-89	<10	--	--	<10	--	--	<10	<50	<10
MW-16B	12-07-88	--	--	--	--	--	--	--	--	--
	02-22-89	<10	--	--	<10	--	--	<10	<50	<10
MW-17	12-13-88	<10	--	--	<10	--	--	<10	<50	<10
	02-23-89	<10	<50	<50	<10	<50	<50	<10	<50	<10
PZ-01	02-27-89	<10	<50	<50	<10	<50	<50	<10	<50	<10
PZ-02	02-24-89	<10	--	--	<10	--	--	<10	<50	<10
PZ-03	02-24-89	<10	--	--	<10	--	--	<10	<50	<10
PZ-04	02-24-89	<10	--	--	<10	--	--	<10	<50	<10
SP-18	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	<10	<50	<50	<10	<50	<50	<10	<50	<10
SP-19A	12-14-88	--	--	--	--	--	--	--	--	--
	02-27-89	<10	<50	<50	<10	<50	<50	<10	<50	<10
SP-19B	02-27-89	--	--	--	--	--	--	--	--	--