Geohydrology and Water Quality of the Calumet Aquifer, in the Vicinity of the Grand Calumet River/Indiana Harbor Canal, Northwestern Indiana

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Prepared in cooperation with the
INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 92-4115

Indianapolis, Indiana
1993

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATIONS

Multiply	By	To Obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
foot per foot (ft/ft)	1.000	meter per meter
foot per year (ft/yr)	0.3048	meter per year
gallon (gal)	3.785	liter
inch (in.)	25.4	millimeter
inch per year (in/yr)	25.4	millimeter per year
mile (mi)	1.609	kilometer
pound per day (lb/d)	0.4536	kilogram per day
square foot (ft^2)	0.09290	square meter
square mile (mi^2)	2.590	square kilometer

Temperature is given in degrees Celsius (°C) which may be converted to degrees Fahrenheit (°F) as follows:

$$°F = 1.8 \times °C + 32$$

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 the United States and Canada, formerly called Sea Level Datum of 1929.

The following abbreviations are used in this report:

Abbreviation	Description
$CaCO_3$	Calcium carbonate
mg/L	Milligram per liter
pH	Negative log base-10 of the hydrogen ion activity, in moles per liter
µg/L	Microgram per liter
µS/cm	Microsiemen per centimeter at 25 degrees Celsius (formerly micromho per centimeter at 25 degrees Celsius)
ERRIS	Emergency Remedial Response Inventory Site
MCL	Maximum Contaminant Level
NPL	National Priority List
SMCL	Secondary Maximum Contaminant Level
USEPA	U.S. Environmental Protection Agency

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By Joseph M. Fenelon *and* Lee R. Watson

ABSTRACT

The water-table configuration of the Calumet aquifer in the vicinity of the Grand Calumet River/Indiana Harbor Canal in Lake County, northwestern Indiana, reflects the complexity of the shallow ground-water-flow system. Large depressions in the water table in sewered areas interrupt broad ground-water divides between rivers. The aquifer/stream interactions along the Grand Calumet River/ Indiana Harbor Canal are directly related to Lake Michigan water levels because of a direct connection of the Grand Calumet River/Indiana Harbor Canal to the lake. Fluctuations in lake levels and evapotranspiration result in reversals in ground-water flow near the river and canal that last from several hours to several months.

Most of the water from the Calumet aquifer discharges into sewers, the Grand Calumet River/Indiana Harbor Canal, Lake Michigan, and Silurian carbonate bedrock. Model simulations of ground-water flow for the study area indicate that the Calumet aquifer discharges about 15 ft^3/s (cubic feet per second) of ground water to sewers, about 10 ft^3/s to the Grand Calumet River/Indiana Harbor Canal, and about 4 ft^3/s to Lake Michigan along a 25-mile section of shoreline. Estimates of ground-water flow from the Calumet aquifer to the bedrock range from 0 to 10 ft^3/s.

Results of analyses of water samples collected from wells in five land-use types—steel industry, petrochemical industry, commercial and light industry, residential, and parks—were compared. The highest median concentrations of inorganic ions and the most detections of organic compounds generally occurred in water samples from wells on the steel and petrochemical land-use areas. Water samples collected from wells on the commercial and light industrial land-use areas generally had lower median chemical concentrations than the samples from the steel and petrochemical land-use areas and greater median concentrations than the samples from the residential and park land-use areas. Seven of 52 acid-extractable and base/neutral-extractable organic compounds and 17 of 36 volatile organic compounds analyzed were detected in a total of 35 wells. Only 4 of the 88 organic analytes—phenols, bis(2-ethylhexyl)phthalate, benzene, and toluene—were detected in more than 5 of the 35 wells.

A comparison of primarily inorganic-constituent data from the five land-use groups to inorganic-constituent data from sites known to be contaminated shows that constituent concentrations in ground waters from wells in the land-use areas generally are lower than those in ground water from contaminated areas.

Likewise, a comparison of inorganic-constituent data from the land-use groups to inorganic-constituent data from areas relatively unaffected by human presence shows that constituent concentrations in ground water from wells in the land-use areas generally are greater than those in ground water from the unaffected areas.

Some documented but unaccounted for chemical loads in the Grand Calumet River are from ground water. Ground water probably contributes more than 10 percent of the total chemical load of ammonia, chromium, and cyanide to the Grand Calumet River. In comparison, about 1 to 3 percent of the total streamflow in the Grand Calumet River is from ground water. Of the four major ground-water sinks in the aquifer, the east branch of the Grand Calumet River and the Indiana Harbor Canal generally receive the greatest chemical loads from ground water, whereas Lake Michigan generally receives the smallest loads.

INTRODUCTION

The southern shoreline of Lake Michigan, in northwestern Indiana, is one of the major urban-industrial centers in the Great Lakes region. Within the area are the cities of East Chicago, Gary, Hammond, and Whiting—all in Lake County (fig. 1). Most of the residential areas are south of the Grand Calumet River and west of the Indiana Harbor Canal. Also located in the area are three large steel mills, a major petrochemical processing plant, several large petroleum-storage facilities, forging and foundry facilities, food and paper industries, and a coal-fired electricity generating plant.

The International Joint Commission on the Great Lakes and the U.S. Environmental Protection Agency (USEPA) have placed the industrial and urban area around the Grand Calumet River/Indiana Harbor Canal on a list of 10 major areas of concern in the Great Lakes Basin (U.S. Environmental Protection Agency, 1984). The area includes many potential sources of contamination located on a thin (0-45 ft thick) sand aquifer, which is in hydraulic connection with the river, the canal, and Lake Michigan. Within the boundary of the aquifer are 4 waste-disposal sites on the USEPA National Priority List (NPL), commonly called Superfund sites, and more than 80 sites on the Emergency Remedial Response Inventory Site (ERRIS) list (Dean Nygard, Indiana Department of Environmental Management, written commun., 1986) (fig. 1). Three of the NPL sites, most of the sites on the ERRIS list, and most of the area's industries are within the Grand Calumet River/Indiana Harbor Canal drainage basin. In spite of documented contamination, many of the sites on the ERRIS list have not been placed on the NPL because the aquifer is seldom used as a source of drinking water.

Discharge of contaminants from the surficial sand aquifer into the area's surface-water bodies is an important concern. Recent field studies of the Grand Calumet River/Indiana Harbor Canal indicate that chemical loadings cannot be completely explained by known industrial and municipal discharges to this surface-water system (Crawford and Wangsness, 1987; HydroQual, 1984). No published studies on the shallow flow system in the Calumet aquifer evaluate the potential for discharge of ground-water contaminants into the Grand Calumet River/Indiana Harbor Canal or Lake Michigan.

Concern for this potential contamination prompted a two-phase study by the U.S. Geological Survey, in cooperation with the Indiana Department of Environmental Management. The study began in 1986. Phase I of the study (Watson and others, 1989) defined the geohydrologic system of the surficial aquifer known as the Calumet aquifer (Hartke and others, 1975) in the vicinity of the Grand Calumet River/Indiana Harbor Canal and Lake Michigan. The study area is within the industrial/residential area in northwestern Lake County, Ind. Only the part of the aquifer that discharges directly to Lake Michigan or to the Grand Calumet River/Indiana Harbor Canal was studied. Phase II of the study used the understanding of the aquifer characteristics and the flow system determined in Phase I to site suitable observation wells for a characterization of ground-water quality in the study area.

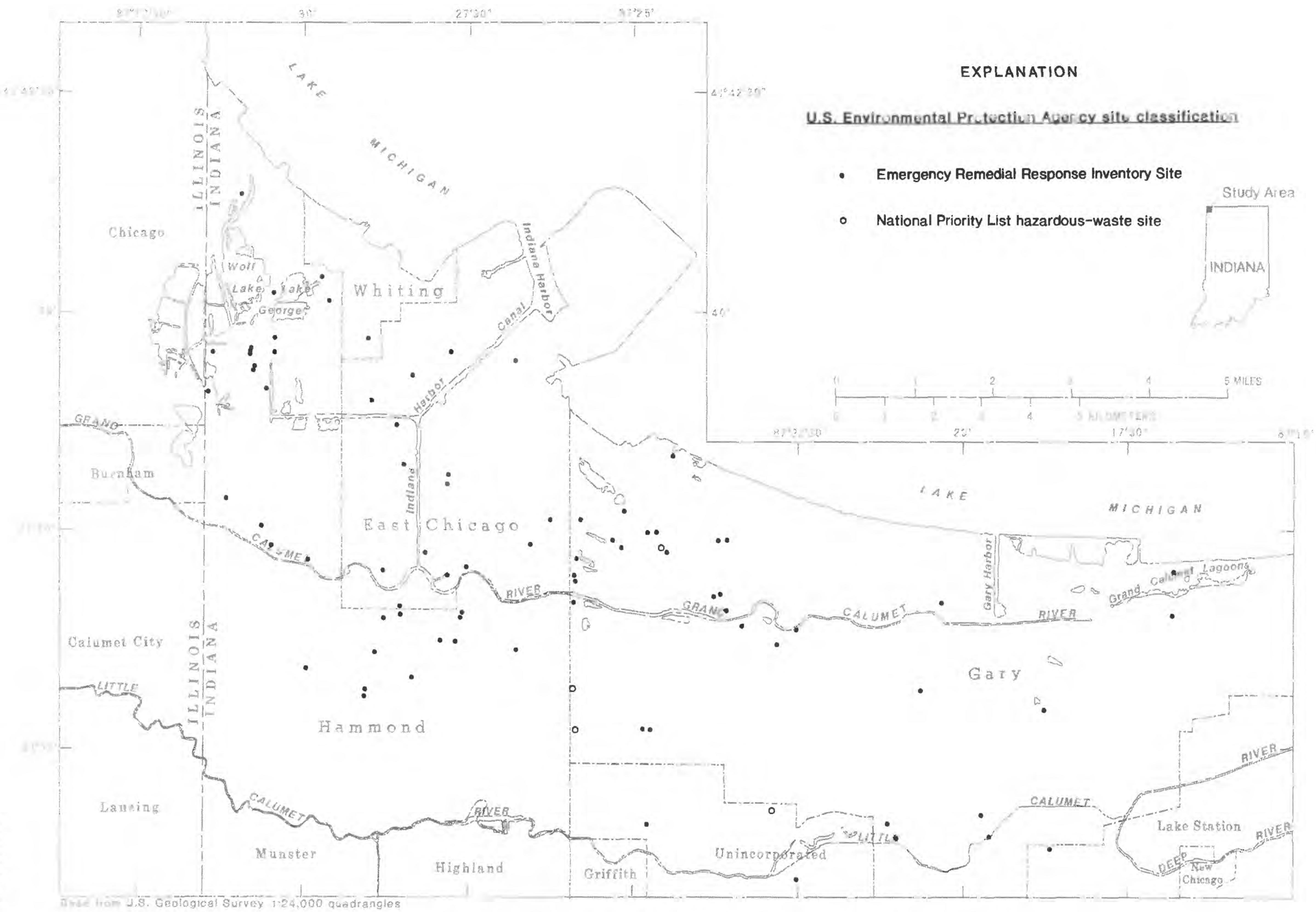


Figure 1. Study area and locations of hazardous-waste sites (modified from Watson and others, 1989).

Purpose and Scope

This report summarizes the geohydrology and the general water quality of the Calumet aquifer, and the potential for contamination of the surface water by ground water in northern Lake County, Ind. Chemical loadings from ground-water discharges to surface-water bodies were estimated to quantify the potential for contamination. This was done by first identifying recharge and discharge sources and then by estimating the quantity and quality of the ground water being discharged to the surface-water bodies. Estimates of ground-water flow were made with a finite-difference ground-water-flow model. The model was constructed from a conceptual model of the flow system based in part on maps of water-table configuration and aquifer geometry developed from Phase I studies (Watson and others, 1989). Water-quality data were collected from a network of 35 monitoring wells installed and sampled by the U.S. Geological Survey. These data were compared by screen depth within the aquifer, among different land-use types, and to U.S. Environmental Protection Agency Drinking Water Regulations. The groups of data defined by land use also were compared with existing data from 16 monitoring wells at known contaminated sites in the study area and from 18 observation wells east of the study area in areas believed to be minimally affected by human activity.

Physical Setting

The study area is in the physiographic province known as the Calumet Lacustrine Plain (Schneider, 1966). Several distinct dune-beach complexes were formed in this province during the Pleistocene and Holocene Epochs when Lake Michigan was at higher levels than it is today (Leverett and Taylor, 1915; Bretz, 1951; Hansel and others, 1985). The dune, beach, and lacustrine silts, sands, and gravels that were deposited form a thin but laterally extensive surficial aquifer, referred to herein as the Calumet aquifer.

Urban development brought about notable changes to the area. Marshlands that formed because of the poor drainage to the Grand Calumet River and the Little Calumet River were drained (Moore and Trusty, 1977). Canals dug from Lake Michigan to the Grand Calumet River for shipping caused changes in the local direction of flow in the river. As a result of the change in flow direction, the former mouth of the Grand Calumet River at Lake Michigan was closed off by decreased streamflow and sand-dune migration. The course of the river was locally altered to accommodate lake harbors and highway construction. In 1907, the Indiana General Assembly passed legislation that allowed the building of artificial land in Lake Michigan by use of slag, a by-product of the steel-making industry. Many industries are currently located on such land. Slag also has been used extensively as fill material in depressions and marshy areas.

Geologic Setting

The following is a brief summary of the geology of the study area. A detailed description that includes maps of the underlying bedrock surface, the base of the Calumet aquifer, the saturated thickness of the Calumet aquifer, and the surficial geology was written by Watson and others (1989).

The Calumet aquifer consists primarily of dune, beach, and lacustrine sands with thin (generally less than 1 ft) interbeds of peat and organic materials of small areal extent and scattered lenses of silt and fine gravel. Watson and others (1989) included slag fill when they mapped the Calumet aquifer because, in general, the slag fill is not vertically extensive. The thickness of the aquifer sand ranges from 0 to 65 ft. The aquifer is thickest in the east, where maximum saturated thickness is about 45 ft. The aquifer thins to the west and pinches out in lacustrine clay near the Indiana-Illinois State line. The aquifer also pinches out in glacial till in the southwestern part of the study area, in the valley of the Little Calumet River.

Glacial till and lacustrine clay immediately underlie the Calumet aquifer. This till and lacustrine clay unit ranges in thickness from 50 to 140 ft and forms a confining unit between the Calumet aquifer and the underlying carbonate bedrock. Lithologic logs indicate that the top of the clay unit is a compact till in most places but that it is locally weathered. The upper surface of the clay unit slopes gently toward Lake Michigan and, in the area of the Indiana Harbor Canal, forms a depression that is 5 to 10 ft deep. In the area of this depression, the upper 20 ft of the clay unit is loosely consolidated lacustrine or paludal clay.

Carbonate bedrock of Silurian and Devonian age underlies the clay unit. The erosional bedrock surface has about 70 ft of relief in the study area and slopes gently toward Lake Michigan. The most prominent feature on the bedrock surface is a north-trending bedrock valley in the area of the Indiana Harbor Canal where the canal flows to the northeast. The bedrock aquifer probably discharges some water up through the clay unit in the eastern half of the study area (R.J. Shedlock, U.S. Geological Survey, written commun., 1985); however, in the central and western parts of the study area, heads in the bedrock and the Calumet aquifers indicate downward discharge of ground water through the clay unit to the underlying bedrock aquifer.

Acknowledgments

The authors acknowledge the assistance of the many State, municipal, and corporate entities who helped make this report possible:

Amoco Oil Company,
Standard Oil Division, Whiting, Ind.

E.I. DuPont DeNemours & Co.,
East Chicago, Ind.

East Chicago, Ind., Parks Department

East Chicago, Ind., Public Schools

Gary, Ind., Municipal Airport

Gary, Ind., Parks Department

Gary, Ind., Public Schools

Hammond, Ind., Parks Department

Hammond, Ind., Public Schools

Indiana Department of Highways

Indiana Department of Natural Resources,
Division of Nature Preserves

Indiana Department of Natural Resources,
Division of Water

Inland Steel Corporation, East Chicago, Ind.

Lake County Parks and Recreation

Lehigh Portland Cement Co., Gary, Ind.

National Park Service,
Indiana Dunes National Lakeshore

Phillips Pipeline Co., East Chicago, Ind.

United States Environmental Protection
Agency, Region V

United States Steel,
USX Corporation, Gary, Ind.

Whiting, Ind., Parks Department

Whiting, Ind., Street Department

METHODS OF INVESTIGATION

Data were collected from approximately 90 ground- and surface-water sites, and a finite-difference model was constructed to understand the geohydrology of and the ground-water flow within the Calumet aquifer. Water samples were collected from 35 monitoring wells and analyzed for a suite of inorganic and organic constituents to characterize the ground-water quality and to estimate ground-water chemical loads discharging to the aquifer.

Ground- and Surface-Water-Level and Rainfall Measurement

Water-level elevations were measured in a network of 60 observation wells installed by the U.S. Geological Survey between 1985-87, in 9 privately owned wells, and at 20 surface-water-sites (fig. 2; tables 1 and 2, at back of report). Elevations were established for all wells by surveying to the wellhead or measuring point from

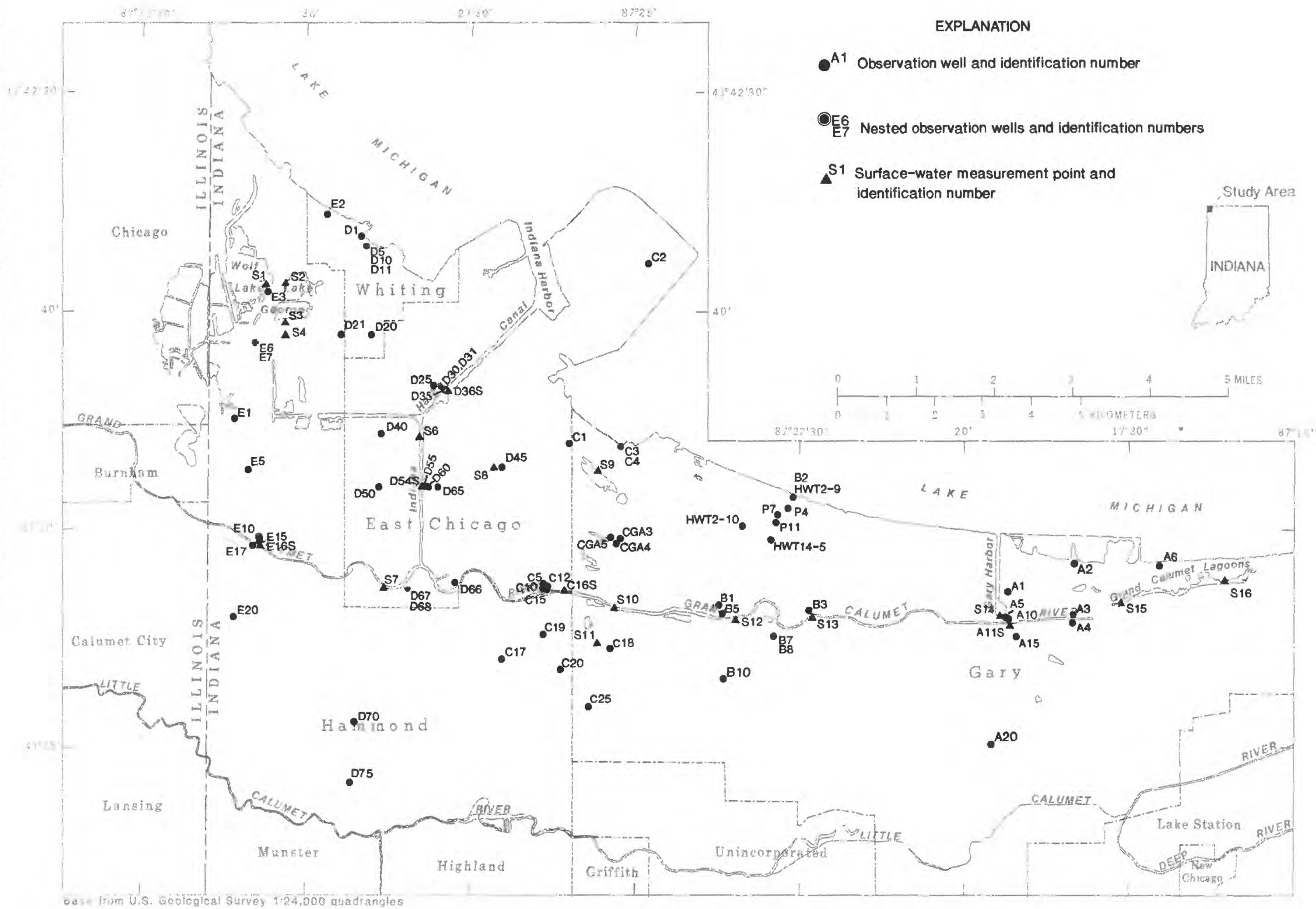


Figure 2. Water-level network in the study area.

bench marks located in the area. Water levels were measured synoptically several times during periods of high and low ground water to compare seasonal changes in hydraulic-head distribution. Ground-water levels also were measured over a range of high and low water levels of Lake Michigan to determine the effects of the lake on ground-water levels in the study area.

Six sets of closely-spaced wells located along transects perpendicular to the stream were used to record water-level fluctuations near the Grand Calumet River/Indiana Harbor Canal. Wells at four of the transects were equipped with float-actuated, analog-to-digital recorders so that short-term water-level fluctuations could be detected. At these four sites, water levels were recorded either every 15 minutes or every hour during the period January 1986 through July 1988. Water levels at the other two sites were measured with a steel tape when the rest of the well network was being measured. A typical transect consisted of four wells. The first well was a stilling well used to measure the stream level; the other three wells were used to measure ground water levels and were positioned about 6, 60, and 600 ft from the stream (fig. 3). The close spacing of the stream well and the two near-stream wells facilitated the study of aquifer/stream interactions.

Unpublished data on Lake Michigan water levels from January 1986 through July 1988 were used for the analysis of aquifer/stream interactions. Hourly data were acquired from the Lake Survey Center, National Ocean Survey of the National Oceanic and Atmospheric Administration. The Lake Survey Center operates a gaging station at Calumet Harbor, Ill., about 6 mi northwest from the mouth of the Indiana Harbor Canal. This is the closest known lake-level gage to the study area.

Precipitation data also were used in the analysis of aquifer/stream interactions. Data were acquired from two National Weather Service precipitation gages (National Oceanic and Atmospheric Administration, 1986-1987). One of these precipitation gages is about 12 mi east of the center of the study area in Ogden Dunes, Ind., and the other is about 11 mi to the southeast in Hobart, Ind. Rainfall data at Ogden Dunes and Hobart are collected daily, and the quantity reported is a cumulative measurement for the 24-hour period ending at 4 p.m.

Ground-Water Flow Simulation

An areal, quasi-three-dimensional, finite-difference flow simulation (hereafter referred to as the model) of a 70-square-mile region of the Calumet aquifer was constructed to assess the water budget and flow in the ground-water system in the study area. The computer code used was written by McDonald and Harbaugh (1988). Steady-state simulations were evaluated for various sets of recharge rates and aquifer properties to estimate the possible range in quantity of water discharged to the major surface-water bodies in the area. Simulated hydraulic heads were compared with 89 measured water levels from the water-level network, and the best match of simulated to measured heads for each set was chosen.

Selection of Water-Quality Sampling Sites

An initial network of wells screened in the top of the saturated zone was installed in 1985, as part of Phase I, to collect initial water-level data for the Calumet aquifer. Well installations were concentrated near the Grand Calumet River/Indiana Harbor Canal so that aquifer/stream interactions could be studied. Information on the flow system from Phase I (Watson and others, 1989), was used to determine where to install additional wells to investigate the regional ground-water quality (fig. 4). Wells in the water-quality-well network were not placed near NPL sites that were being investigated, nor were wells placed where potentially hazardous sites were being monitored by industries. The goal was to integrate information from NPL and industrial sites with data collected from the project wells.

Wells in the water-quality-well network were specifically installed in different land-use areas to represent various potential sources of contamination. Areal well placement reflected the complexities of the flow system and the need to

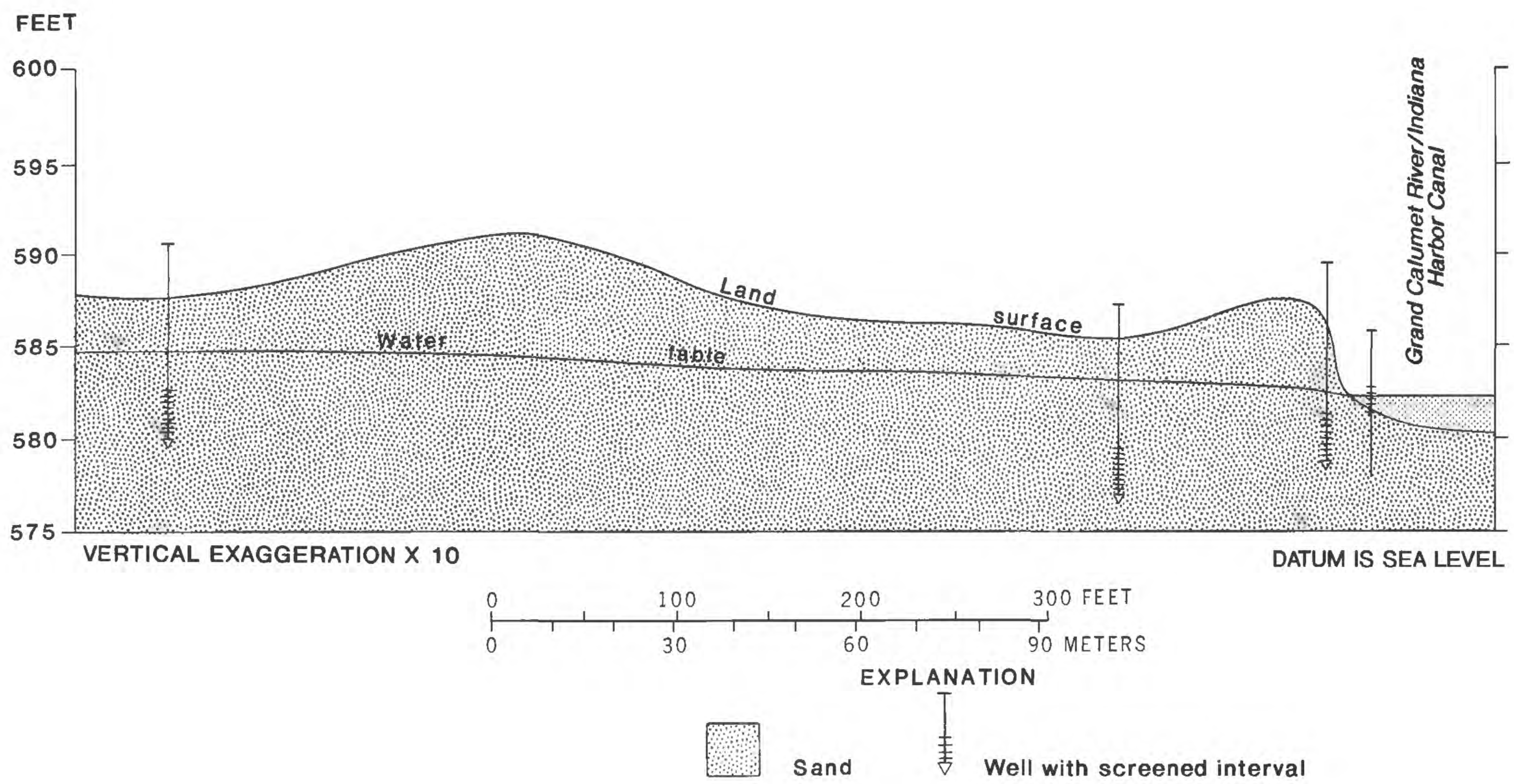


Figure 3. Diagramatic section at aquifer/stream study sites showing typical well placement along transect perpendicular to Grand Calumet River/Indiana Harbor Canal.

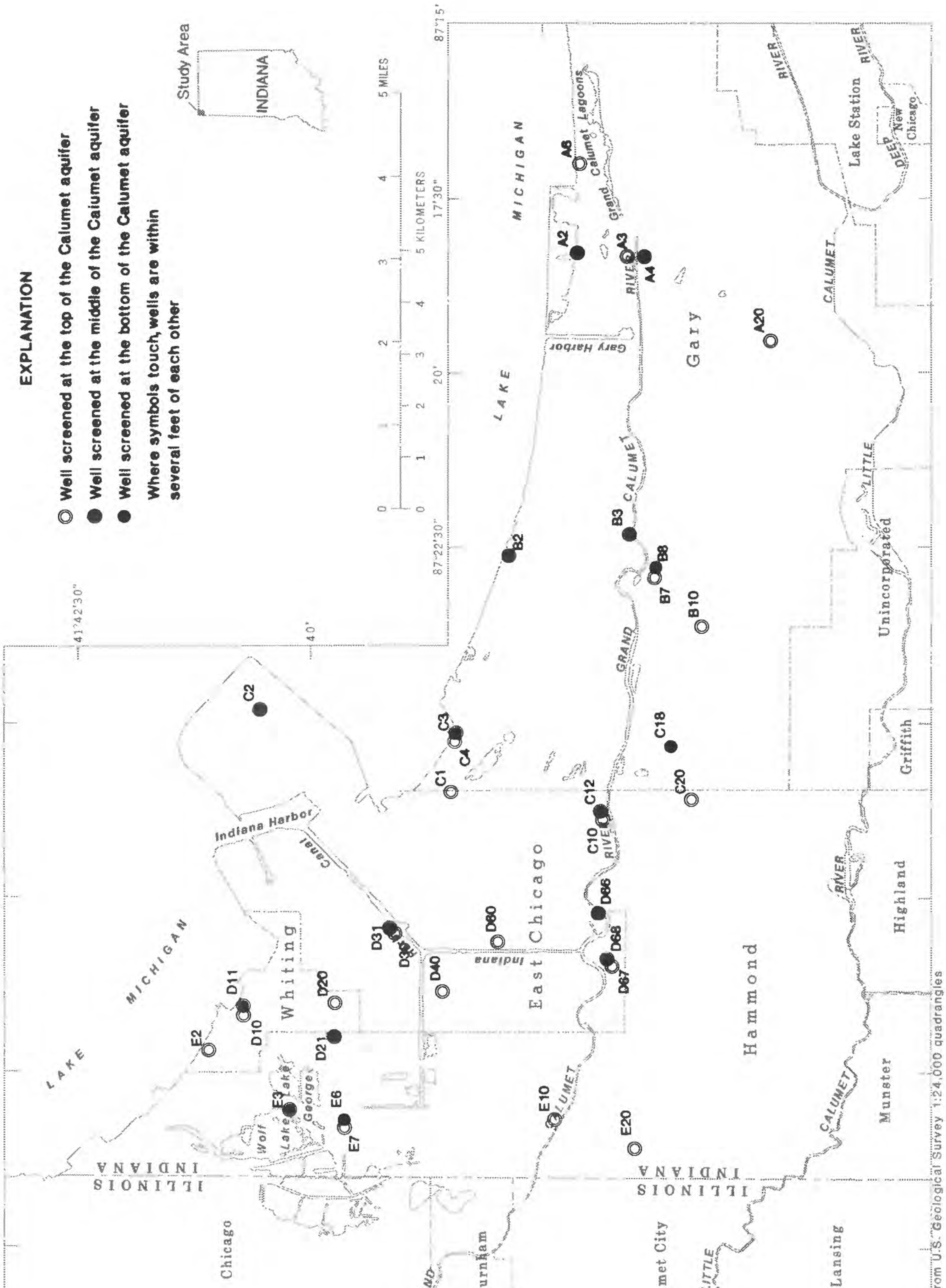


Figure 4. Water-quality-well network in the study area.

detect potential contamination near points of ground-water discharge to surface water. Vertical placement of the well screens reflected knowledge of the flow system, the investigators' expectations of intercepting contaminants, and the intention to characterize the water quality of the aquifer areally and vertically.

The water-quality-well network consists of 12 shallow wells from Phase I and 23 wells that were installed in 1987 for Phase II; most of the wells are along the Grand Calumet River, the Indiana Harbor Canal, and the shore of Lake Michigan. Nineteen of the 35 total wells are screened at the top of the aquifer; these wells are referred to as shallow wells in this report. Thirteen wells are screened in the middle of the aquifer; the three remaining wells are screened near the bottom of the aquifer to detect sinking contaminant plumes, if present. The 16 wells screened in the middle and near the base of the aquifer are referred to as deep wells in this report. Seven of the 19 shallow wells are located near deep wells to enable comparison of water quality and head with depth.

Well Construction

All but one of the 69 wells used in this project have nominal inside diameters of 2 inches. Nine privately owned wells were used for water-level measurements only and were constructed with a variety of materials and drilling methods. The only 6-in. well (C17) used in the study is owned by the U.S. Geological Survey but was not constructed for this project. Fifty-nine stainless-steel wells were installed specifically for this project. Data for all wells used in the study are given in table 1.

In Phase I of the study, 36 wells were installed exclusively to measure water-level altitudes. Stainless-steel well components were chosen because of the potential need to collect water samples in Phase II. Because the water table is close to the land surface in most places, 32 of the wells were installed with a fence-post-type hand-driver. The remaining four wells were installed with a hollow-stem auger.

All 36 wells installed in Phase I were constructed with Type 304 stainless-steel components. The pipe has conventional pipe threads and external couplings. The well screens have 3 ft of open section and a slot size of 0.010 inch. At the base of each screen is a stainless-steel point to enable installation by driving.

In Phase II, five wells in the uppermost part of the aquifer were installed with a hand-driver and were equipped with 3-ft-long screens. Eighteen wells with 5-ft-long screens were installed with a hollow-stem auger drill rig. Before work began at each site, all augers and tools used in the hole were steam-cleaned. Each well component also was steam-cleaned before installation.

All 23 wells installed in Phase II of the study were constructed from Type 316L stainless-steel components with flush threads at each joint. The screens for these wells had either 3 or 5 ft of open section and a slot size of 0.006 in. The wells with 5-ft-long screens were constructed with 2 ft of closed pipe at the bottom and a point on the end to facilitate driving, if necessary. The wells with 3-ft-long screens were equipped with drive points.

In all augered wells except one, the aquifer material that was drilled from the hole was sufficient to backfill the annulus to the land surface. Very fine imported quartz sand was used to fill the annulus around one well where not enough native sand was available for backfill. Each well was finished with a concrete pad 4-in. thick and 2 ft-square at ground surface, and each well cap was equipped with a locking mechanism and a padlock.

Hand-driven wells were developed with a hand-operated piston pump until the discharge of fine material from the aquifer stopped or was greatly reduced. In some wells, a small amount of sand remained in the bottom of the well screen. Wells that were auger-drilled were developed with a centrifugal pump operating at a low rate until the sand in the pump-discharge water was gone or greatly reduced. In these wells, sand that could not be removed by the low pumping rate fell into the pipe below the well screen. Well B2 was developed with a polytetrafluoroethylene (Teflon) bailer because the water level was too deep to allow use of a centrifugal pump.

Sampling Procedures

Wells were sampled during three separate periods: July 7-23, 1987; May 2-12, 1988; and August 2-17, 1988. Before each sampling, water levels were measured with a steel tape. During the 1987 sampling, 34 wells were purged by the removal of 13 well-casing volumes with a peristaltic pump connected to a Tygon intake tube with a stainless-steel weight placed about 1 ft below the water level; one well had 13 well-casing volumes evacuated with a Teflon bailer. While each well was being evacuated, the discharged water was routed to a flow-through chamber and was monitored for temperature, pH, specific conductance, and dissolved-oxygen concentration by use of a multiparameter water-quality meter; values were recorded when they stabilized. Alkalinity as $CaCO_3$ also was measured in the field by titrating a sample with sulfuric acid to a pH of 4.5.

Samples for inorganic analyses were collected from the end of the intake tube that was connected to the peristaltic pump. Samples for all inorganic analytes except alkalinity and nitrate plus nitrite were passed through a 0.45 micron filter. Samples for organic analyses were collected with a double-check valve Teflon bailer with a bottom-emptying device. All samples were collected and preserved according to standard procedures of the U.S. Geological Survey (Wood, 1981; Wershaw and others, 1987). Samples were sent to the U.S. Geological Survey's National Water-Quality Laboratory in Denver, Colo., where they were analyzed for the water-quality properties and constituents (excluding cyanide) listed in tables 3-5. Most of the organic compounds are USEPA "priority pollutants."

In May 1988, 33 of the 35 wells were sampled for cyanide with the same procedures (as above). In August 1988, 34 of the 35 wells were resampled for 36 volatile (purgeable) organic compounds (table 5). Thirteen well-casing volumes were evacuated with either a peristaltic pump (17 wells); a submersible, positive-displacement pump (15 wells); or a bailer (2 wells).

Table 3. Selected-field measured properties and constituents, nutrients, and inorganic constituents for which ground-water samples were analyzed

Field-measured properties and constituents		
Temperature	Specific conductance	
Alkalinity, as $CaCO_3$	Dissolved oxygen	
pH		
Nutrients		
Ammonia, as nitrogen	Nitrite plus nitrate, as nitrogen	
Orthophosphate, as phosphorus		
Inorganic constituents		
Aluminum	Arsenic	Barium
Boron	Bromide	Cadmium
Calcium	Chloride	Chromium
Copper	Cyanide	Fluoride
Iron	Lead	Magnesium
Manganese	Mercury	Potassium
Silica	Sodium	Sulfate
Zinc		

The steel tape, peristaltic-pump head, filter assembly, and Teflon bailer were washed with a 50-percent solution of hexane and deionized water and then rinsed with deionized water after sampling each well for each sampling event. The collection tubing and bailer cord were discarded after each use. The submersible pump was decontaminated by pumping about 1 gal of deionized water through it between wells.

In May and August 1988, duplicate samples were collected from four and five wells, respectively, to compare analytical results between two samples collected consecutively. Duplicate samples for volatile organic compounds were collected by refilling the bailer with well water and then filling additional vials. In May 1988, five sample blanks were collected during sampling for cyanide analysis and, in August 1988, three sample blanks were collected for volatile organic compound analyses. Sample blanks used for quality control were collected in the field by

Table 4. Acid-extractable and base/neutral-extractable organic compounds for which ground-water samples were analyzed

Acid-extractable compounds	
2-Chlorophenol[1]	2,4-Dichlorophenol[1]
2,4,Dimethylphenol	4,6-Dinitroorthocresol[1]
2,4-Dinitrophenol[1]	2-Nitrophenol[1]
4-Nitrophenol[1]	Parachlorometacresol[1]
Pentachlorophenol[1]	Phenol
Phenols	2,4,6-Trichlorophenol[1]

Base/neutral extractable compounds	
Acenaphthene	Acenapthylene[1]
Anthracene[1]	Benzo (a) pyrene[1]
Benzo (b) fluoranthene[1]	Benzo (k) fluoranthene[1]
Benzo(a)anthracene (1,2-benzanthracene)[1]	Benzo (g,h,i) perylene (1,12-benzoperylene)[1]
Bis (2-chloroisopropyl) ether[1]	Bis(2-chloroethoxy) methane[1]
Bis (2-chloroethyl) ether[1]	Bis(2-ethylhexyl)phthalate
4-Bromophenylphenyl-ether[1]	2-Chloronaphthalene[1]
4-Chlorophenylphenyl-ether[1]	Chrysene[1]
Di-n-butyl phthalate	Di-n-octyl phthalate[1]
2,4-Dinitrotoluene[1]	2,6-Dinitrotoluene[1]
1,2,5,6-Dibenzanthracene[1]	Diethyl phthalate[1]
Dimethyl phthalate[1]	Fluoranthene[1]
Fluorene[1]	Hexachlorobenzene[1]
Hexachlorobutadiene[1]	Hexachlorocylcopentadiene[1]
Hexachloroethane[1]	Indeno(1,2,3-cd) pyrene[1]
Isophorone[1]	N-Butyl benzyl phthalate[1]
Naphthalene	Nitrobenzene[1]
N-Nitrosodi-n-propy-lamine[1]	N-Nitrosodimethylamine[1]
N-Nitrosodiphenylamine[1]	Phenanthrene[1]
Pyrene[1]	1,2,4-Trichlorobenzene[1]

[1]Analyte was not detected in any sample.

filling an appropriate bottle or vial with deionized water from a plastic carboy that was in a field vehicle. The deionized water came from a water-purifying system that sends tap water through carbon absorption units, ion-exchange units, and a micro filter. The blanks were submitted for analysis in the same manner as the other samples.

Table 5. Volatile organic compounds for which ground-water samples were analyzed

Benzene	Bromoform[1,2]
Carbontetrachloride[1,2]	Chlorobenzene[2]
Chlorodibromomethane[2]	Chloroethane[1,2]
2-Chloroethlyvinylether[1,2]	Chloroform
Cis-1,3-dichloropropene[1,2]	1,2-Dibromoethane[1]
1,2-Dichlorobenzene[1,2]	1,3-Dichlorobenzene[1,2]
1,4-Dichlorobenzene[1,2]	Dichlorobromomethane[2]
Dichlorodifluoromethane	1,1-Dichloroethane
1,2-Dichloroethane[1,2]	1,1-Dichloroethylene
1,2-Dichloropropane[1,2]	1,3-Dichloropropene[1,2]
Ethylbenzene	Methylbromide[1,2]
Methylchloride[1,2]	Methylene chloride[1,2]
Styrene[1,2]	1,1,2,2-Tetrachloroethane[1,2]
Tetrachloroethylene	Toluene
Trans-1,3-dichloropropene[1,2]	1,2-Transdichloroethylene[1]
1,1,1-Trichloroethane[1,2]	1,1,2-Trichloroethane[1,2]
Trichloroethylene[1]	Trichlorofluoromethane[1]
Vinyl chloride	Xylenes

[1]Analyte was not detected in any of the 1987 samples.
[2]Analyte was not detected in any of the 1988 samples.

Selection of Data from Other Studies

Data from 16 monitoring wells on contaminated sites or potentially contaminated sites (fig. 5) were compiled from data collected by consultants working for private industry or for the USEPA (Geosciences Research Associates, Inc., 1987, 1988; Warzyn Engineering, Inc., 1987; Baker/TSA Division, 1985; Noel Anderson, Indiana Department of Environmental Management, written commun., 1988; Brian Healy, C.C. Johnson & Malhotra, P.C., written commun., 1988). Data from one to four wells were selected to represent a site. The selected wells were upgradient and downgradient from the sites. Data from the wells were not examined until after selection of the wells so as not to bias which wells were chosen.

Data from 18 monitoring wells east of the study area were selected to represent the natural water quality of the Calumet aquifer before industrialization and urbanization (fig. 6).

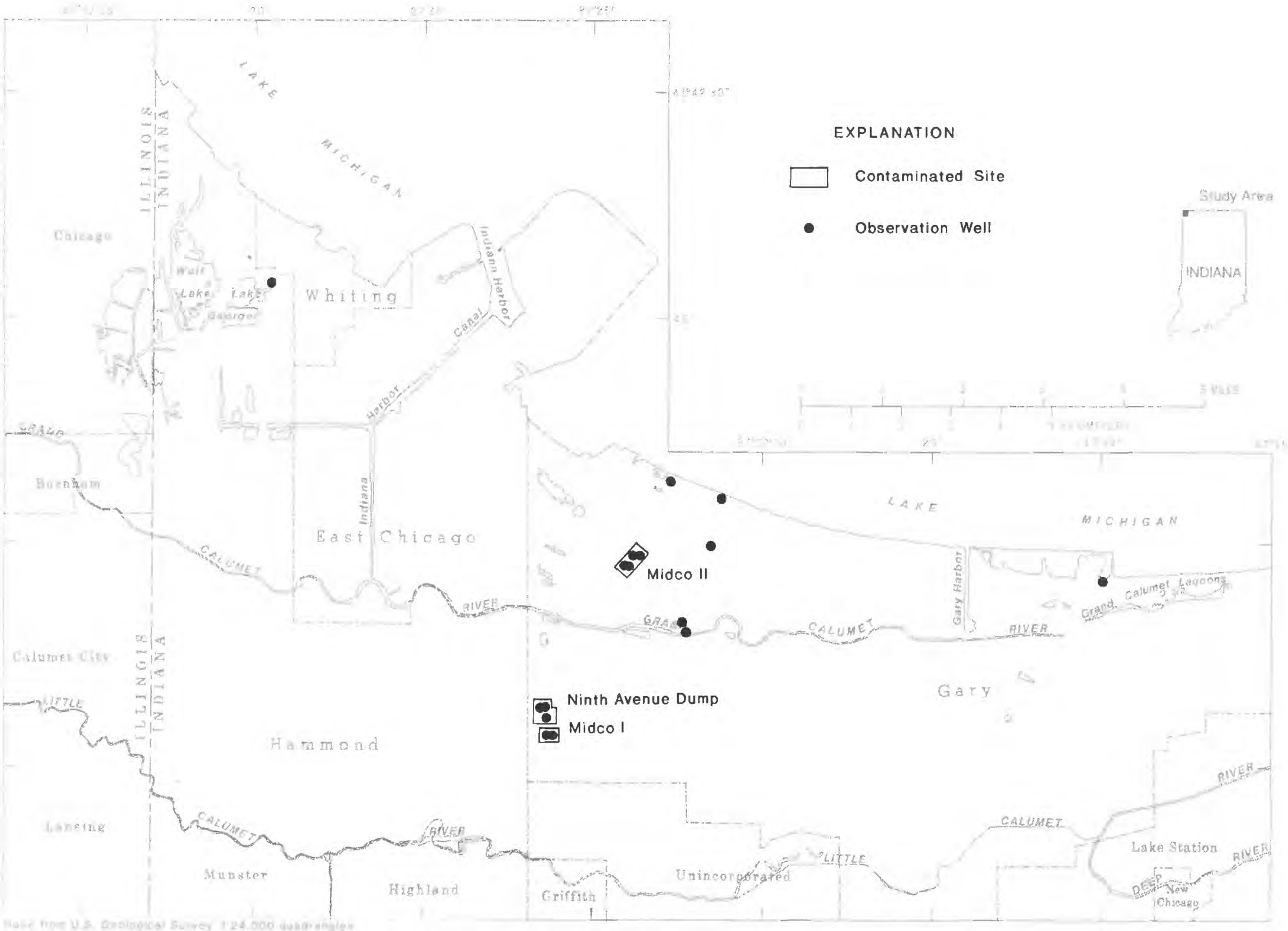


Figure 5. Wells selected to represent ground-water quality near known or suspected sites of contamination in the study area.

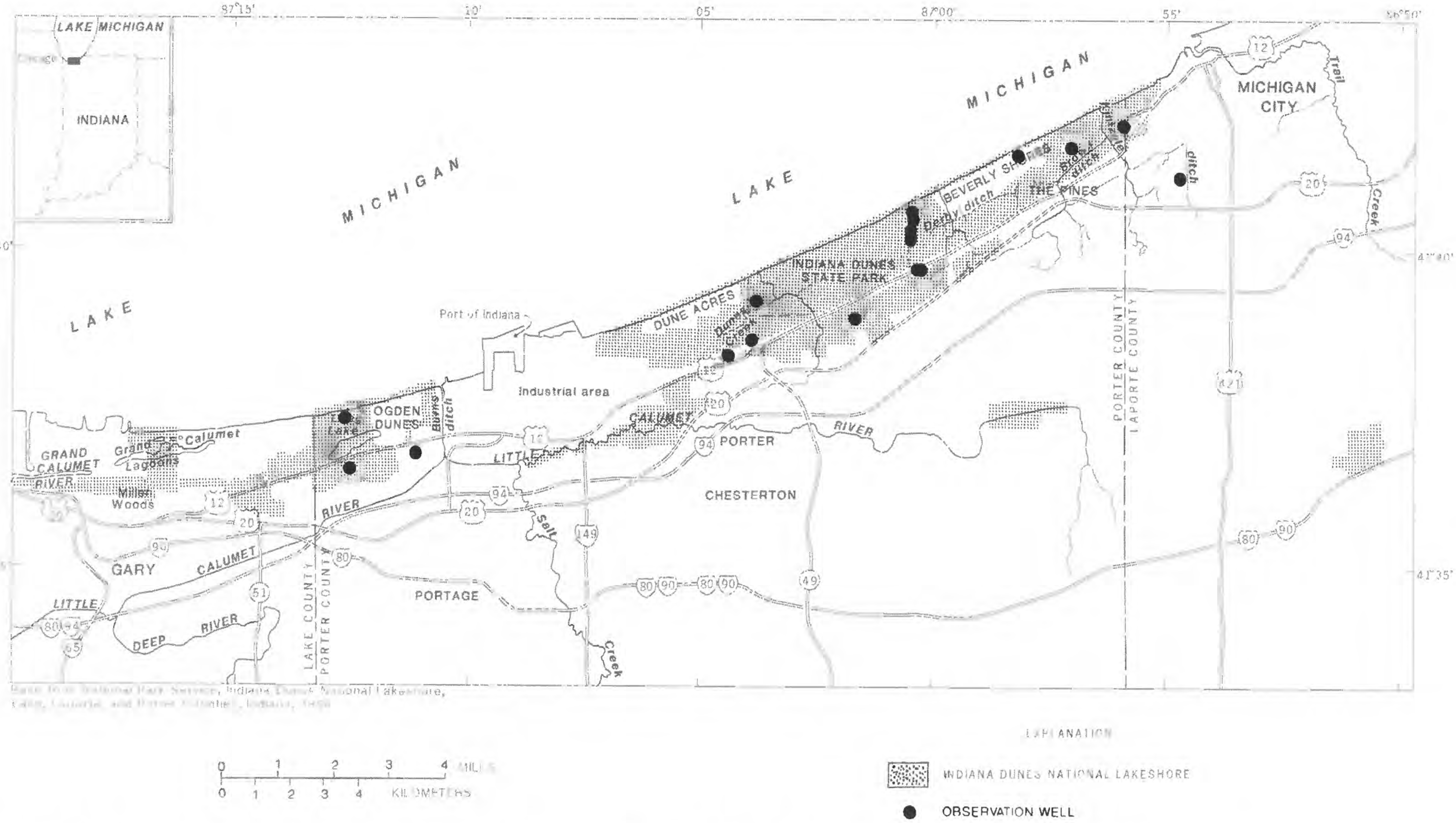


Figure 6. Wells east of the study area selected to represent ground-water quality minimally affected by human activity.

The wells, chosen from a larger network of wells owned by the U.S. Geological Survey, are in the Indiana Dunes National Lakeshore. The wells were screened in the Calumet aquifer and were not downgradient from any known contaminant sources, except for several wells that were near roads or farms.

GEOHYDROLOGY OF THE CALUMET AQUIFER

The following sections provide a detailed discussion of recharge and discharge relations and ground-water flow in the Calumet aquifer. An estimate of ground-water discharge rates from the aquifer also is calculated.

Recharge

Before urbanization and industrialization of the study area, recharge to the Calumet aquifer was primarily from two sources—infiltration of precipitation and upward ground-water flow from the bedrock aquifer. Discharge was primarily to rivers and Lake Michigan and through evapotranspiration. Human activities have altered the natural ground-water-flow system substantially.

In urban and industrial areas, recharge to the aquifer from precipitation probably has been reduced because of increased surface runoff to sewers and streams. Upward recharge through the clay unit from the bedrock aquifer also has been reduced or stopped because of pumpage from the bedrock aquifer. This pumpage has produced a broad cone of depression in the Chicago, Ill., area that extends an unknown distance into Indiana (Harley Young, U.S. Geological Survey, written commun., 1987). Such pumpage may reduce or stop the bedrock contribution of net recharge to the Calumet aquifer in some areas.

Sources of recharge in the study area that are the result of human activities also affect the ground-water budget. For example, sanitary sewers, septic systems, and water-supply lines can lose water to the ground-water system and can function as sources of local recharge.

Average annual precipitation in the study area is about 35 in/yr (National Oceanic and Atmospheric Administration, 1987). Several previous studies of the area have estimated recharge rates that are less than this. Rosenshein and Hunn (1968) estimated that total recharge to the surficial aquifer in Lake County is less than 13 in/yr. Recharge estimates used in finite-difference ground-water-flow models for parts of the Calumet aquifer have ranged from 4 to 23 in/yr (Warzyn Engineering, Inc., 1987, appendix V; Watson and others, 1989; Meyer and Tucci, 1979). Recharge rates used in the model for this study were varied for different areas and ranged from 2 to 17 in/yr. (Recharge rates are discussed in more detail later in the report.)

Discharge

The natural discharge areas for ground water in the study area have been affected by industrial and residential development. Ditches constructed to drain marshes intercept shallow ground water before it reaches the rivers and Lake Michigan. As a result, evapotranspiration probably has decreased because of a reduction in vegetation and a lowering of the water table. A substantial amount of ground water also seeps into leaky sanitary and storm sewers in the cities of Gary, Hammond, East Chicago, and Whiting. A smaller amount of discharge consists of domestic and industrial pumpage from the aquifer. The primary center of industrial pumpage is near oil refineries in the northwestern part of the study area. Domestic pumpage is minimal and is primarily outside the municipal limits of the major cities. Ground-water discharge also results from downward flow of ground water through the clay unit to the underlying bedrock. Downward flow occurs in areas where the bedrock pumpage has caused hydraulic heads to fall below those in the overlying Calumet aquifer and where such head differences are maintained for long periods.

Although most types of ground-water discharge are known, little is known about the quantity of these discharges. An estimate of ground-water discharge to the Grand Calumet River has not been possible to determine by conventional seepage studies because more than 90 percent of the approximate 500 ft^3/s flow in the river is from municipal and industrial effluent (Crawford and Wangsness, 1987). Crawford and Wangsness (1987) estimated that all but about 36 ft^3/s of water in the Grand Calumet River east of the Indiana Harbor Canal could be accounted for by known municipal and industrial discharges to the river. Some of the estimated 36 ft^3/s is thought to be from ground-water seepage.

Ground-water discharge into the sanitary sewers throughout the study area (fig.7) is believed to be substantial. A review of infiltration/inflow studies done for the sewer districts in the study area and discussions with sewer officials indicate that the total leakage of ground water to sanitary sewers in the study area may range from 15 to 45 ft^3/s. The following is a breakdown of the ground-water leakage rates to the three sanitary districts in the study area. During the period of the study, 35 to 50 ft^3/s of sewage entered the Gary sewage treatment plant from the study area on dry days. Of this amount, 5 to 15 ft^3/s was estimated to be ground-water that leaked into sewers (Madison Madison International, 1975; Lincoln Donaldson, Gary Sanitary District, oral commun., 1987). Before the 1986 patching of all sewers that were larger than 36 in. in diameter in Gary, an additional 6 to 12 ft^3/s of ground water leaked into the Gary sewer system (Lincoln Donaldson, Gary Sanitary District, oral commun., 1987). Sanitary sewers in the Hammond District, which includes Whiting, gained an estimated 8 to 15 ft^3/s of ground water that leaked into sewers; the total inflow to the plant from the study area was 40 to 45 ft^3/s on dry days (Consoer. Townsend & Assoc., 1976; Stewart Roth, Hammond Sanitary District, oral commun., 1987). In a third sanitary district, which serves East Chicago, an estimated 2 to 10 ft^3/s of ground water leaked into its sanitary sewers, out of an estimated total of 23 ft^3/s that entered the plant on dry days (Besozzi, Carpenter, and Ignelzi, Inc., 1976; Daniel Olsen, East Chicago Sanitary District, oral commun., 1987).

The high variability of the sewer-infiltration estimates is caused by several factors. First, the amount of leakage into the sewers is estimated by subtracting the estimated amount of domestic and industrial water entering the sanitary sewers from the amount of water received at the sewage-treatment plants during dry days. Estimates by sewer-district officials and results of infiltration studies differ on the amount of domestic and industrial water that discharges into the sewers and the amount of water received at the plants. Second, an estimate of the amount of water infiltrating to the sewers depends on the seasonal ground-water levels because more water infiltrates when ground-water levels are high than when they are low.

Hydraulic Conductivity

The horizontal hydraulic conductivity of the Calumet aquifer within Lake County has been estimated by Rosenshein and Hunn (1968) to range from 10 to 130 ft/d and to average 60 ft/d (table 6). The hydraulic conductivity of the aquifer also was estimated from an aquifer test at a well 1,300 ft northeast of the Midco I site (fig. 5). Calculated values of horizontal hydraulic conductivity ranged from 47 to 63 ft/d and averaged 53 ft/d (Geosciences Research Associates, Inc., 1987). A 15:1 ratio of horizontal to vertical hydraulic conductivity was estimated from the aquifer test. Other estimates of horizontal hydraulic conductivity in local areas within the aquifer have ranged from less than 1 ft/d to 180 ft/d (table 6). Estimated hydraulic conductivities of the underlying clay unit and the carbonate bedrock aquifer are summarized in table 6.

The vertical hydraulic conductivity of the riverbed of the Grand Calumet River is unknown. The bottom sediment is a mixture of organic materials, industrial and sewage wastes, and sand from the aquifer. Because the sand is probably the coarsest material in the sediment, the vertical hydraulic conductivity of the riverbed is probably less than that of the sand, or less than 5 ft/d.

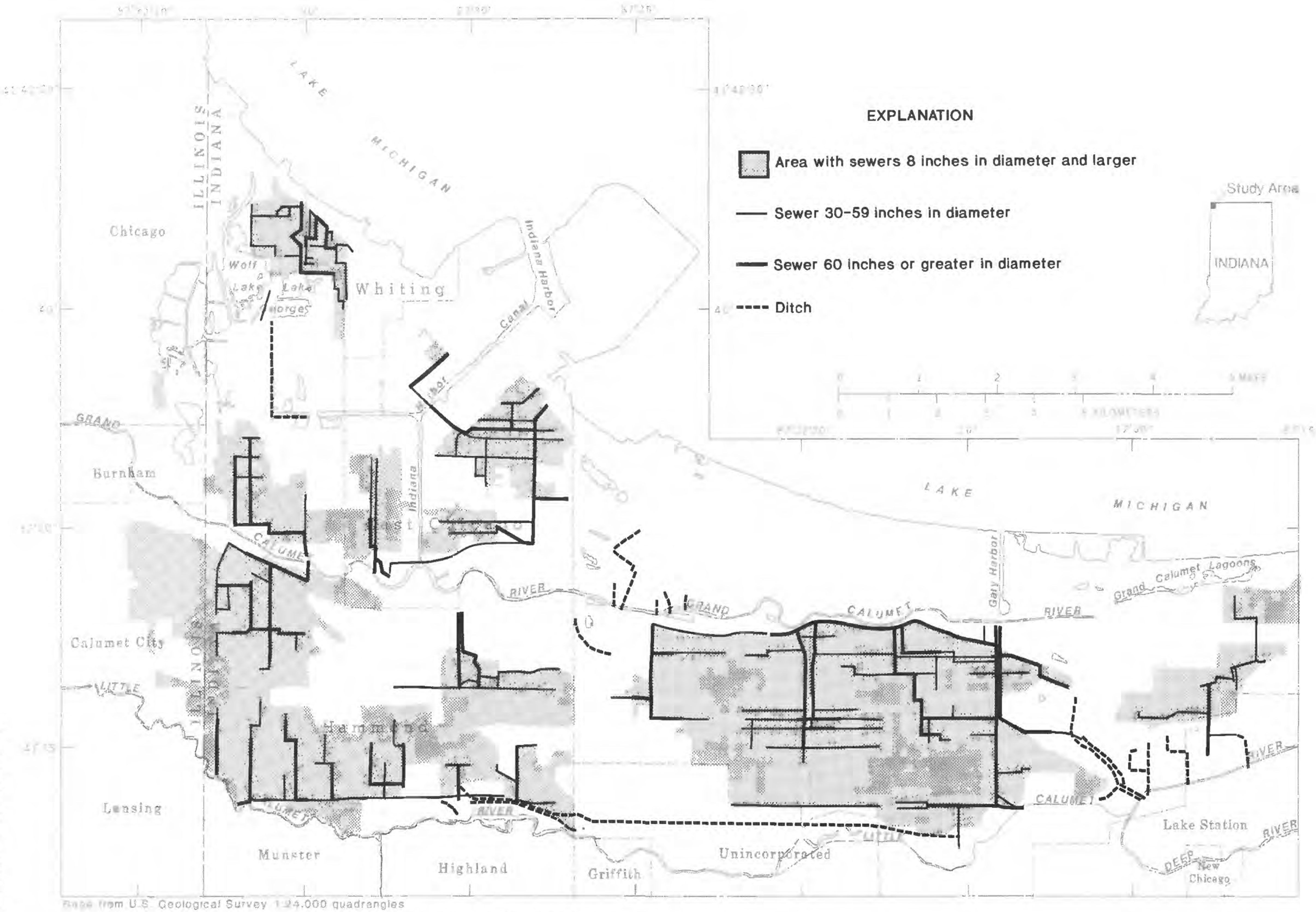


Figure 7. Locations of sewers and ditches in the study area.

Table 6. Estimates of the hydraulic conductivity of the Calumet aquifer, the clay unit below the aquifer, and the carbonate bedrock aquifer

Hydrologic unit	Location[1]	Aquifer test	Hydraulic conductivity	Range of hydraulic conductivity, in feet per day
Calumet aquifer	Lake County	Specific capacity	Horizontal	[2]10 – 130
	Near Midco I	Aquifer test	Horizontal	[3]47 – 63
	Near Midco I	Aquifer test	Vertical	[3]3 – 4
	Near Midco I	Slug test	Horizontal	[3]3 – 84
	Midco I	Slug test	Horizontal	[3]<1 – 21
	Ninth Avenue Dump	Slug test	Horizontal	[4]<1 – 180
	Midco II	Slug test	Horizontal	[5]2 – 26
	Near Lake Michigan	Slug test	Horizontal	[6]<1 – 3
Clay unit	Lake County	Specific capacity	Vertical	[2]0.0004
	Midco I & II	Slug test	Horizontal	[3,5]0.0003 – 0.0006
	Midco I & II	Permeameter test	Vertical	[3,5]0.003 – 0.0002
Carbonate bedrock	Lake County	Specific capacity	Horizontal	[2]0.1 – 70
	Midco I	Slug test	Horizontal	[3]0.02

[1]Locations of Midco I, Midco II, and Ninth Avenue Dump are shown in figure 5. [2]Rosenshein and Hunn (1968). [3]Geosciences Research Associates, Inc. (1987). [4]Warzyn Engineering, Inc. (1987). [5]Geosciences Research Associates, Inc. (1988). [6]Baker/TSA Division (1984).

Ground-Water Flow

Configuration of the Water Table

In Phase I of this study, the water-table configuration, as mapped by Watson and others (1989), was based on measurements of 36 ground-water observation wells that were installed by the U.S. Geological Survey and 9 privately owned wells. In early 1987, 24 additional wells were installed for Phase II of the study and were used for additional water-level measurements.

All hand-measured water levels are listed in tables 7 and 8 in the "Supplemental Data" section in the back of the report. These data include 13 sets of synoptic water-level measurements from April 1986 through August 1989. A table of daily average water levels derived from continuous recorder data for well A20 from February 7, 1986, through July 7, 1988, also is included in the "Supplemental Data" section in table 9. Well A20 is in a residential area that overlies a ground-water divide between the Grand Calumet River and the Little Calumet River.

In this report, three water-table configurations are discussed: (1) spring 1986, when ground-water levels were seasonally high and the level of Lake Michigan also was relatively high (582.2 ft above sea level) as compared to the historic average Lake Michigan water level of 580.11; (2) fall 1986, when ground-water levels were seasonally low and the water level of Lake Michigan was slightly higher than in spring 1986 (582.8 ft above sea level); and (3) spring 1989, when ground-water levels were seasonally high and the Lake Michigan water level was low (579.4 ft above sea level).

Spring 1986

The configuration of the water table for March 31-April 4, 1986, was described by Watson and others, (1989, fig. 13). The water level of Lake Michigan during this period was approximately 582.2 ft. The water-table map (fig. 8) shows two major ground-water divides: one is between the Grand Calumet River and the Little Calumet River; the other is between the Grand Calumet River and Lake Michigan, east of the Indiana Harbor Canal.

Other important features of the water-table map are the depressions of the water-table surface, such as those in East Chicago. These localized depressions are caused by ground-water discharge into sanitary sewers.

Fall 1986

In late September 1986, the Lake Michigan water level was near the peak of a rise that ended in October 1986. The water-table configuration for September 22-26, 1986, when the water level of Lake Michigan was approximately 582.8 ft above sea level, is shown in figure 9. The water-table configuration is very much the same as that described by Watson and others (1989) in spring 1986 (fig. 8, this report). The divide between the Grand Calumet River and the Little Calumet River is in approximately the same location; however, the crest of the divide was lower in September 1986 than in March 1986 because of the normal seasonal changes in ground-water levels. Ground-water levels more than one-half mile from the lake and the Grand Calumet River/Indiana Harbor Canal declined less than 1.5 ft between spring and fall 1986. The water level in well A20, which is near the crest of the divide, fluctuated by only about 1 ft from June 1986 through June 1988 (table 9). The small range in water-table fluctuation near this well may be attributable to its proximity to a large buried sewer which, in turn, may control the ground-water level in the area by functioning as a local drain.

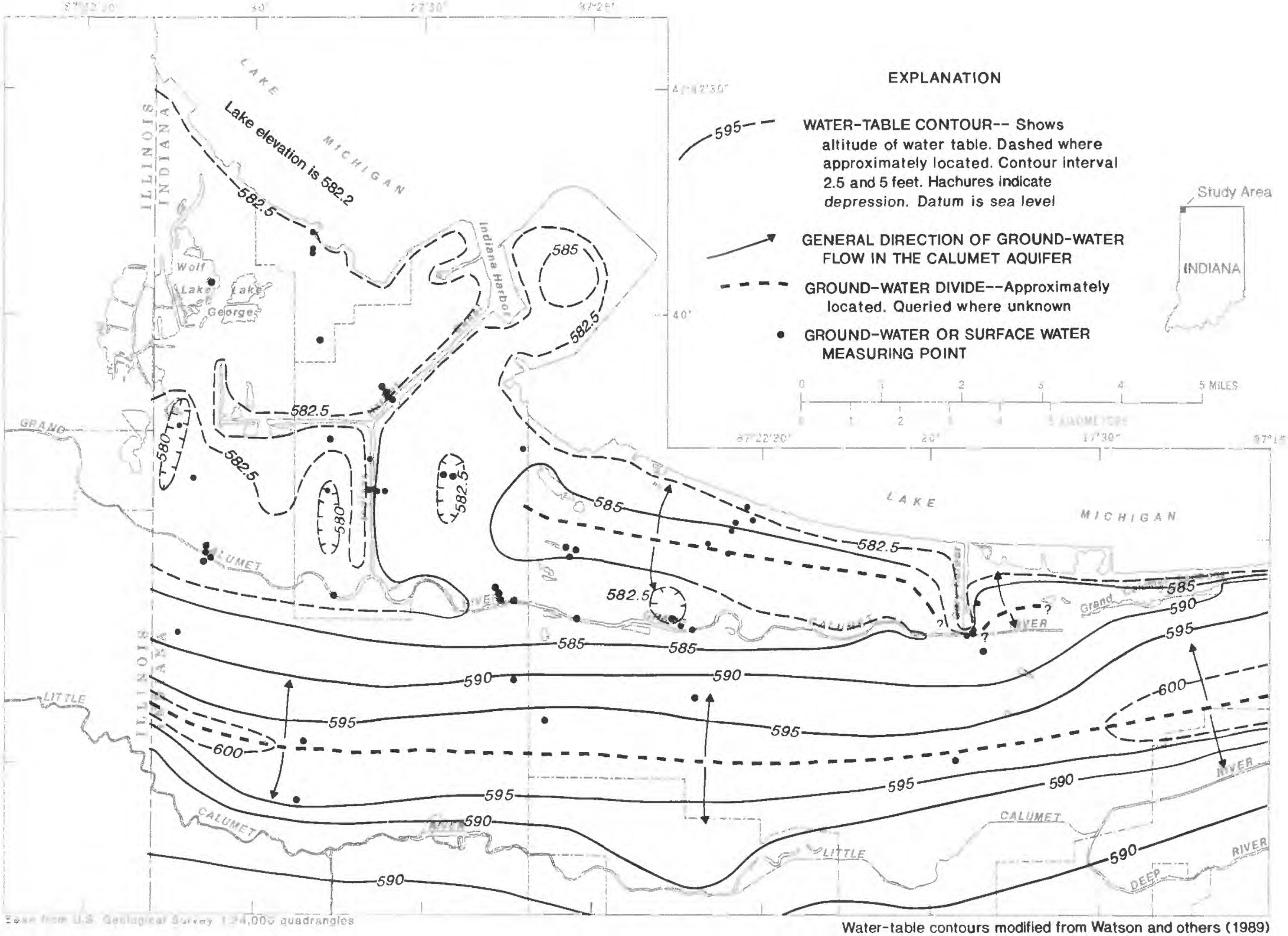
The divide between the Grand Calumet River and Lake Michigan was very nearly in the same place during spring and fall 1986. The water-table configuration in the area northwest of the Indiana Harbor Canal appears different, but the configuration is fundamentally the same as in spring 1986. The difference in appearance is caused by a slight lowering of gradients when the lake level rose approximately 0.5 ft. Ground-water gradients northwest of the Indiana Harbor Canal are small, and water levels measured in this area were within 1.6 ft of each other.

As previously noted, depressions of the water table are the result of the leakage of ground water into sewers. A sand-pit dewatering operation also caused a localized depression that remained fairly constant over the study period.

Spring 1989

The water-table configuration for April 18-20, 1989, is shown in figure 10. The water level of Lake Michigan fell approximately 3.5 ft to 579.4 ft above sea level from September 1986 through April 1989. The decline of lake level is partially attributed to a drought in 1988. The locations and elevations of the crests of the major divides changed very little from September 1986 through April 1989.

The water-table depressions caused by leakage of ground water to sewers were still present and at approximately the same altitudes in 1989, and a new depression was evident northwest of the Indiana Harbor Canal. The depression, which underlies a broad area, was the result of continuous ground-water pumping by an oil refinery as part of a remediation effort. A system of hundreds of shallow wells pump the ground water, which is then cleaned and discharged to Lake Michigan. This system was operating in 1986, but it apparently was not causing enough drawdown near the observation wells to be shown as a depression on the earlier water-table maps.



Base from U.S. Geological Survey 1:24,000 quadrangles

Water-table contours modified from Watson and others (1989)

Figure 8. Configuration and altitude of the water table in the Calumet aquifer, March 31–April 4, 1986.

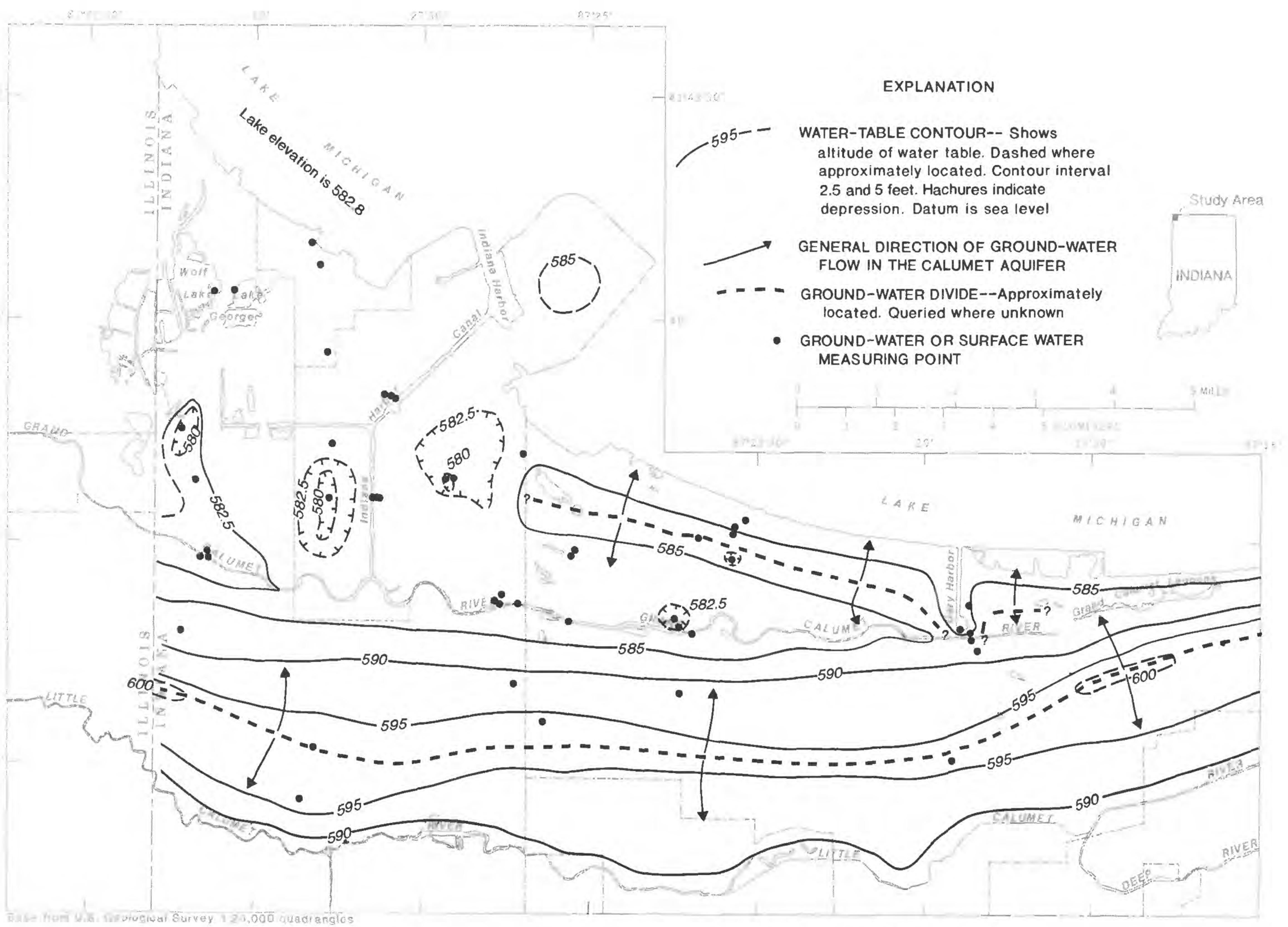


Figure 9. Configuration and altitude of the water table in the Calumet aquifer, September 22–26, 1986.

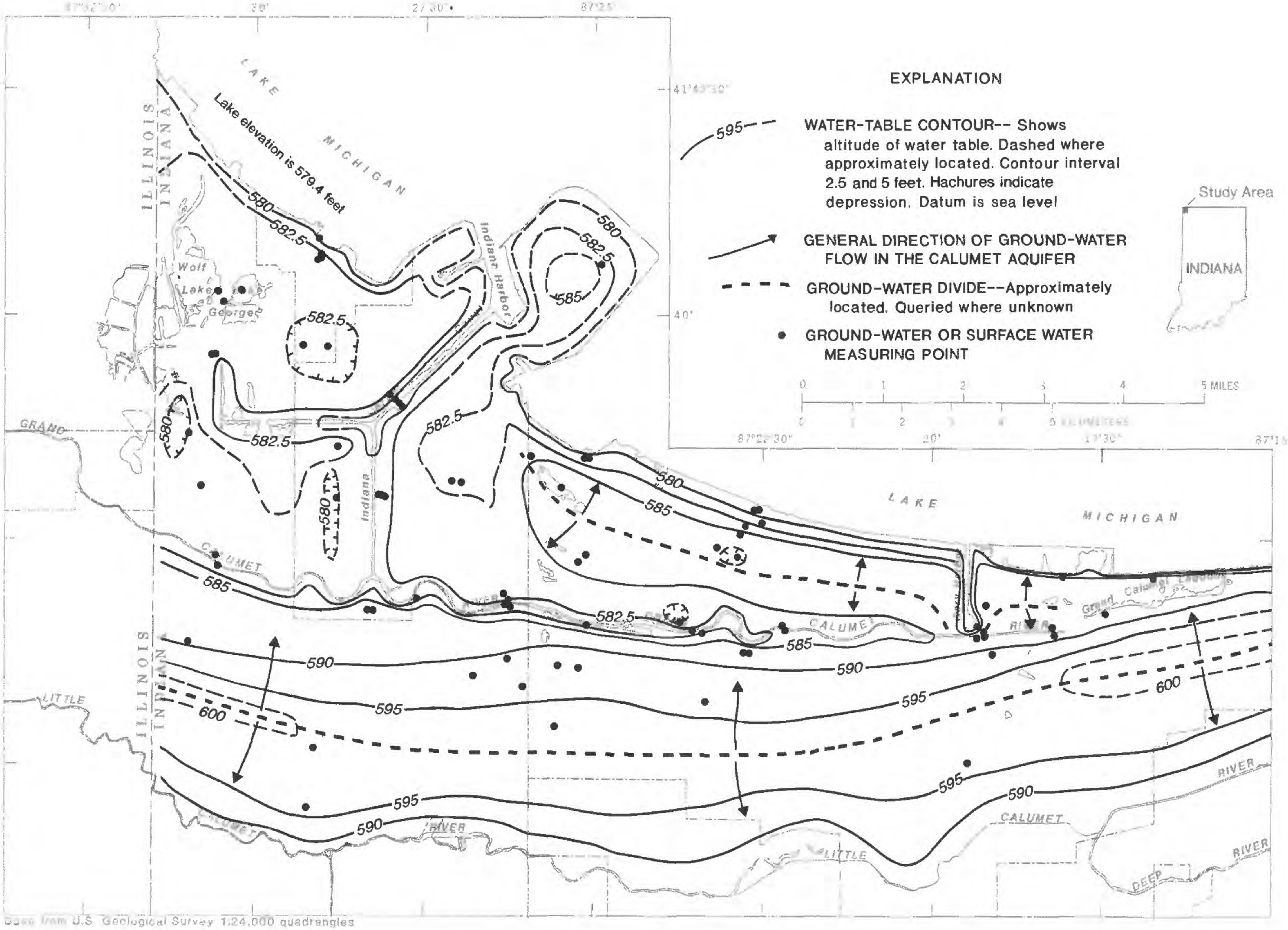


Figure 10. Configuration and altitude of the water table in the Calumet aquifer, April 18-20, 1989.

The major differences between the water-table maps shown in figures 9 and 10 are north of the Grand Calumet River. The water levels of Lake Michigan and the downstream one-half of the Grand Calumet River/Indiana Harbor Canal declined, causing ground-water gradients around these surface-water bodies to more than double. There was as much as 5 feet of difference between the highest and lowest ground-water-level measurements northwest of the Indiana Harbor Canal between September 1986 and April 1989.

The water-table configuration during the study period can be summarized as follows.

1. The crest of the two major ground-water divides shifted vertically by only 1 to 2 ft, and horizontal change was minimal in response to seasonal changes and change in Lake Michigan water levels.
2. The water level of Lake Michigan affects water levels at least 7 mi upstream along both branches of the Grand Calumet River; the east branch probably is affected 10 mi upstream.
3. Sanitary and storm sewers affect water-table configuration by functioning as drains on the ground-water system and, thus, limiting water-level fluctuations nearby.
4. The size of the area contributing ground water to a particular stream or to Lake Michigan is fairly constant from season to season. The possible exception to this constancy is in the area northwest of the Indiana Harbor Canal; there, water-table gradients are low, and small changes in the water-table altitude can alter the size of contributing areas considerably.
5. Normal regional gradients in the aquifer are toward the streams and Lake Michigan and are fairly stable south of the Grand Calumet River. North of the Grand Calumet River, gradients depend on the water level of Lake Michigan and, to a lesser degree, on seasonal water-level variations.

Ground-Water Gradients and Velocities

Two extremes in ground-water levels for the period of study are shown in figures 9 and 10. In fall 1986 (fig. 9), gradients adjacent to the rivers and the lake were low because the water level of Lake Michigan was high and ground-water levels were seasonally low. In spring 1989 (fig. 10), however, gradients were steeper in areas adjacent to the rivers and the lake because the lake level was low and ground-water levels were seasonally high. Average regional horizontal ground-water gradients generally ranged from 0.0005 to 0.003 ft/ft. In some areas within several tenths of a mile from a discharge area, gradients were steeper, about 0.005 ft/ft.

Vertical gradients between paired wells were generally about the same as the horizontal gradient, ranging from about 0.0005 to 0.005 ft/ft both upwards and downwards; however, temporal variations and even reversals in gradient were noted at many of the paired-well sites. Where reversals occur, the average gradient over several years could be much lower than those measured and could even approach zero.

Average ground-water velocities are estimated to be about 50 ft/yr if one assumes that the horizontal hydraulic conductivity of the aquifer is 50 ft/d, the average ground-water gradient is 0.001, and the porosity of the aquifer sand is 40 percent. Local, short-term velocities could be as great as 200 to 300 ft/yr, especially near discharge areas and particularly when Lake Michigan levels are low.

Aquifer/Stream Interactions

The Grand Calumet River can be divided into two stream reaches, one east of the confluence of the Grand Calumet River with the Indiana Harbor Canal and the other west of the confluence. The headwaters area of the east branch of the Grand Calumet River is known as the Grand Calumet River Lagoons (fig. 1). An underground culvert connects these lagoons to the main channel of the Grand Calumet River. Discharge from the lagoons to the river is estimated to be 1 ft^3/s or less throughout most of the year. The east branch of the Grand Calumet River flows west and into the Indiana Harbor Canal. A surface-water drainage divide is approximately 1 mi west of the Indiana Harbor Canal on the west branch of the Grand Calumet River. The divide separates surface water flowing east and into the Indiana Harbor Canal from surface water flowing west into Illinois. The location of the divide shifts in response to changes in the Lake Michigan water level, industrial and municipal discharges to the river, and, to a lesser degree, storm runoff.

Factors Affecting the Water Level of the Grand Calumet River/Indiana Harbor Canal

The water level of the Grand Calumet River/ Indiana Harbor Canal is predominantly controlled by the discharge of municipal and industrial effluent to the Grand Calumet River/Indiana Harbor Canal and by changes in the water level of Lake Michigan. During periods of dry weather, the discharge of the Grand Calumet River/Indiana Harbor Canal is estimated to consist of more than 90 percent municipal and industrial effluent (Crawford and Wangsness, 1987). The industrial effluent is primarily water withdrawn from Lake Michigan that is used in noncontact cooling processes and then discharged into the Grand Calumet River/Indiana Harbor Canal. Municipal effluent also consists of water withdrawn from Lake Michigan for domestic and industrial purposes and discharged to sanitary-sewer systems. Sewage is treated at the municipal sewage-treatment plants and is discharged into the Grand Calumet River. Storm runoff also enters the sewer system, as does ground water. During periods of heavy precipitation, the capacity of the sewage treatment plant can be exceeded, and untreated sewage is discharged directly into the Grand Calumet River.

The water level of the Grand Calumet River/ Indiana Harbor Canal also is affected by changes in the water level of Lake Michigan. During the study, the monthly average water level of Lake Michigan fluctuated between 582.92 ft in October 1986 and 579.44 ft in November 1988.[1] From October 1985 through January 1987, 16 new monthly record high levels were set for Lake Michigan. In July 1988, the level of Lake Michigan fell below the long-term average for the first time since October 1977 (Vander Els, 1988). The lake fluctuations over the period of the study were almost as large as those during the long-term period 1860-1986. During this period, the maximum annual average level for Lake Michigan was 582.57 ft in 1886, whereas the minimum annual average for that period was 576.95 ft in 1964. The mean annual level for the lake over the same period was 580.11 ft (Quinn, 1988).

In addition to the long-term fluctuations, lake levels can temporarily fluctuate more than 3 ft in a matter of hours because of wave setup (a build-up of lake water near the shore because of winds blowing toward the shore). During the period from January 1986 through July 1987, instantaneous lake levels were as high as 584.21 ft (in August 1986) and as low as 578.50 ft (in February 1988). Effects of these short-term fluctuations were recorded 7 river miles upstream from Lake Michigan on the Grand Calumet River/ Indiana Harbor Canal and were probably measurable for several more miles upstream.

Lake Michigan probably has little effect on water levels in the east branch of the Grand Calumet River upstream from well B3 (fig. 2) (about 11 mi upstream from Lake Michigan). River gradients are more than 1 ft/mi upstream from this point, and the effects of the lake are dampened out. Downstream from well B3, gradients decrease and Lake Michigan has a major effect on the water levels of the river and canal. Gradients range from about 0.2 ft per river mile at high levels of Lake Michigan to 0.5 ft per river mile at low levels of Lake Michigan.

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[1] All Lake Michigan altitudes are given in feet above the National Geodetic Vertical Datum of 1929 (sea level) rather than the commonly used International Great Lakes Datum (IGLD). The IGLD is 1.30 ft lower than the National Geodetic Vertical Datum of 1929.

Water levels at four sites were monitored in a series of wells along transects. The wells were equipped with continuous water-level recorders from 1986 to mid-1988 (figs. 3 and 11). Site 1 is on the east branch of the Grand Calumet River, site 2 is on the west branch, and sites 3 and 4 are on the Indiana Harbor Canal. Information about the distance from the stream, period of record, and data tables for each well in this report is listed in table 10. Daily values of water levels in wells at these sites are listed in tables 11 through 25 in the "Supplemental Data" section in the back of the report.

Hydrographs of water levels at the four sites are shown in figure 12. A noticeable feature on the hydrographs is the way the water level of the Grand Calumet River/Indiana Harbor Canal parallels that of Lake Michigan. The water level of the Indiana Harbor Canal, even near the confluence with the Grand Calumet River, is almost identical to that of Lake Michigan. Response of the Grand Calumet River/Indiana Harbor Canal to changes in the water level of Lake Michigan are virtually immediate. Only short-term spikes in the Lake Michigan water level (those of less than several hours' duration) are not translated to the canal. Most of the short-term spikes lasting less than one-half day do not appear or are very dampened at the site 7 mi upstream from Lake Michigan on the east branch. On the west branch of the Grand Calumet River, where the river flows west into Illinois, the hydrograph of the Grand Calumet River parallels that of Lake Michigan, but to a lesser extent than along the east branch.

The magnitude of changes in the water level of the Indiana Harbor Canal is about the same as that of Lake Michigan. On June 1, 1986, the lake level rose approximately 1 ft in several hours. The water level of the Indiana Harbor Canal, both near the lake and near the confluence with the Grand Calumet River, also rose about 1 ft. Seven miles upstream on the east branch of the Grand Calumet River, the rise in river level was about 0.7 ft. On the west branch of the Grand Calumet River, 7 mi upstream from Lake Michigan, the water level rose only about 0.4 ft in response to the 1 ft change in lake level.

Table 10. Distance from stream or canal, period of record, and supplementary-data table number for wells at four ground-water/surface-water study sites

Site number	Well name	Distance from stream or canal (feet)	Period of record	Supplementary data table
1	C16S	0	12/18/85 - 09/08/86	11
1	C15	50	02/04/86 - 07/06/88	12
1	C10	200	12/18/85 - 05/04/88	13
1	C5	450	05/15/86 - 06/29/88	14
2	E16S	0	12/19/85 - 04/05/87	15
2	E15	30	02/06/86 - 08/04/87	16
2	E10	300	10/30/85 - 04/28/87	17
3	D54S	0	12/12/85 - 02/08/87	18
3	D55	10	10/29/85 - 07/06/88	19
3	D60	250	10/29/85 - 07/06/88	20
3	D65	600	11/05/85 - 04/08/88	21
4	D36S	0	05/15/86 - 08/17/87	22
4	D35	5	01/23/86 - 05/11/88	23
4	D30	120	01/23/86 - 06/12/88	24
4	D25	630	01/23/86 - 07/05/88	25

Changes in Ground-Water Gradients Near the Grand Calumet River/Indiana Harbor Canal

In most areas along the Grand Calumet River/Indiana Harbor Canal, ground-water gradients are usually toward the river and canal. These gradients, in part, control the amount of ground-water discharge to the stream. Local ground-water gradients immediately adjacent to the river change through time because of a number of factors that include recharge, evapotranspiration, and changes in river and canal levels caused by changes in the water level of Lake Michigan. Steep gradients toward the river and canal downstream from well B3 result from a relatively low lake level (less than 581 ft) combined with seasonally high ground-water levels (fig. 13). Flat gradients are caused by a high lake level (greater than 582 ft) and seasonally low ground-water levels (fig. 13).

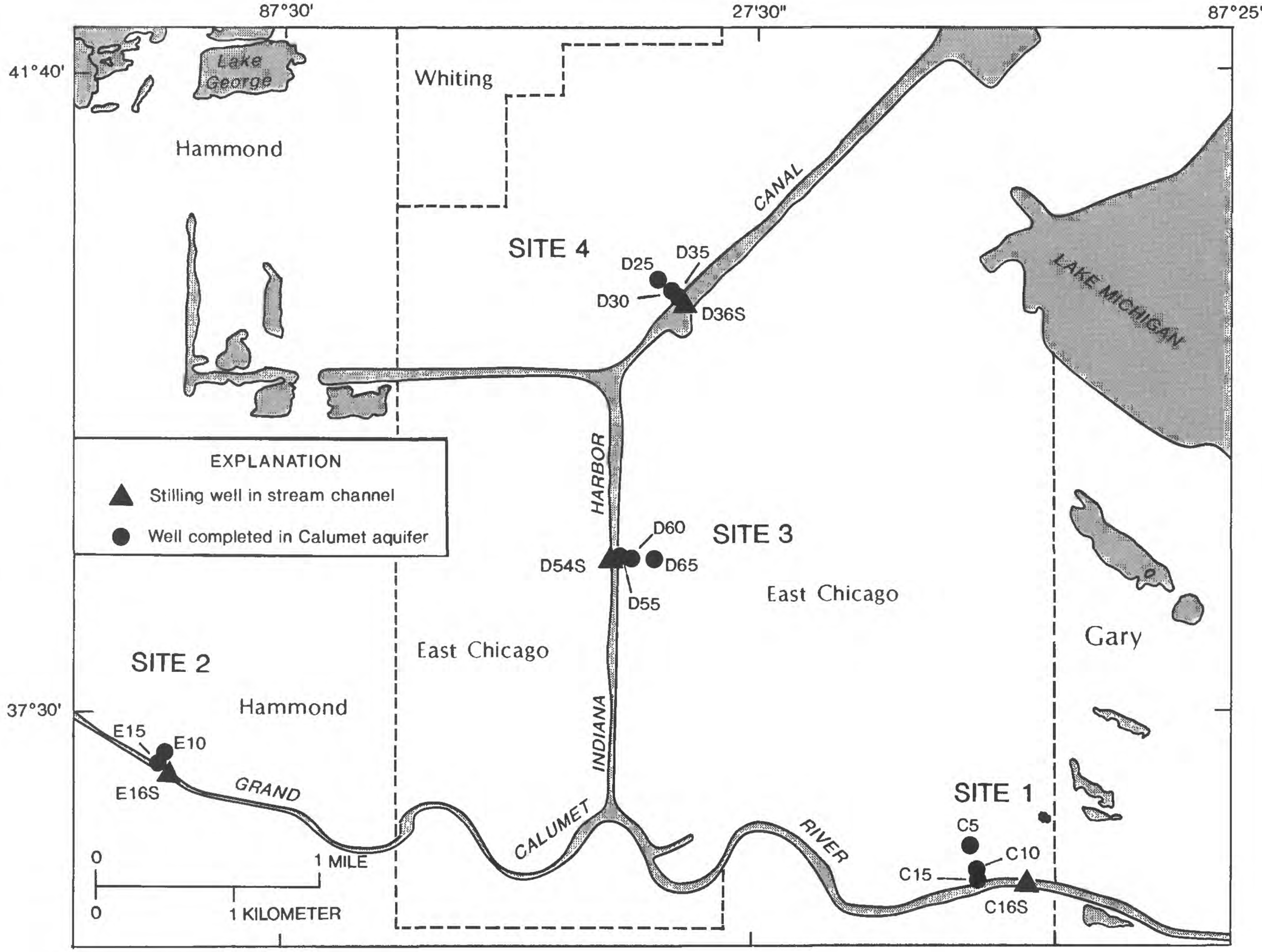

Figure 11. Locations of four transects of observation wells adjacent to the Indiana Harbor Canal and the Grand Calumet River.

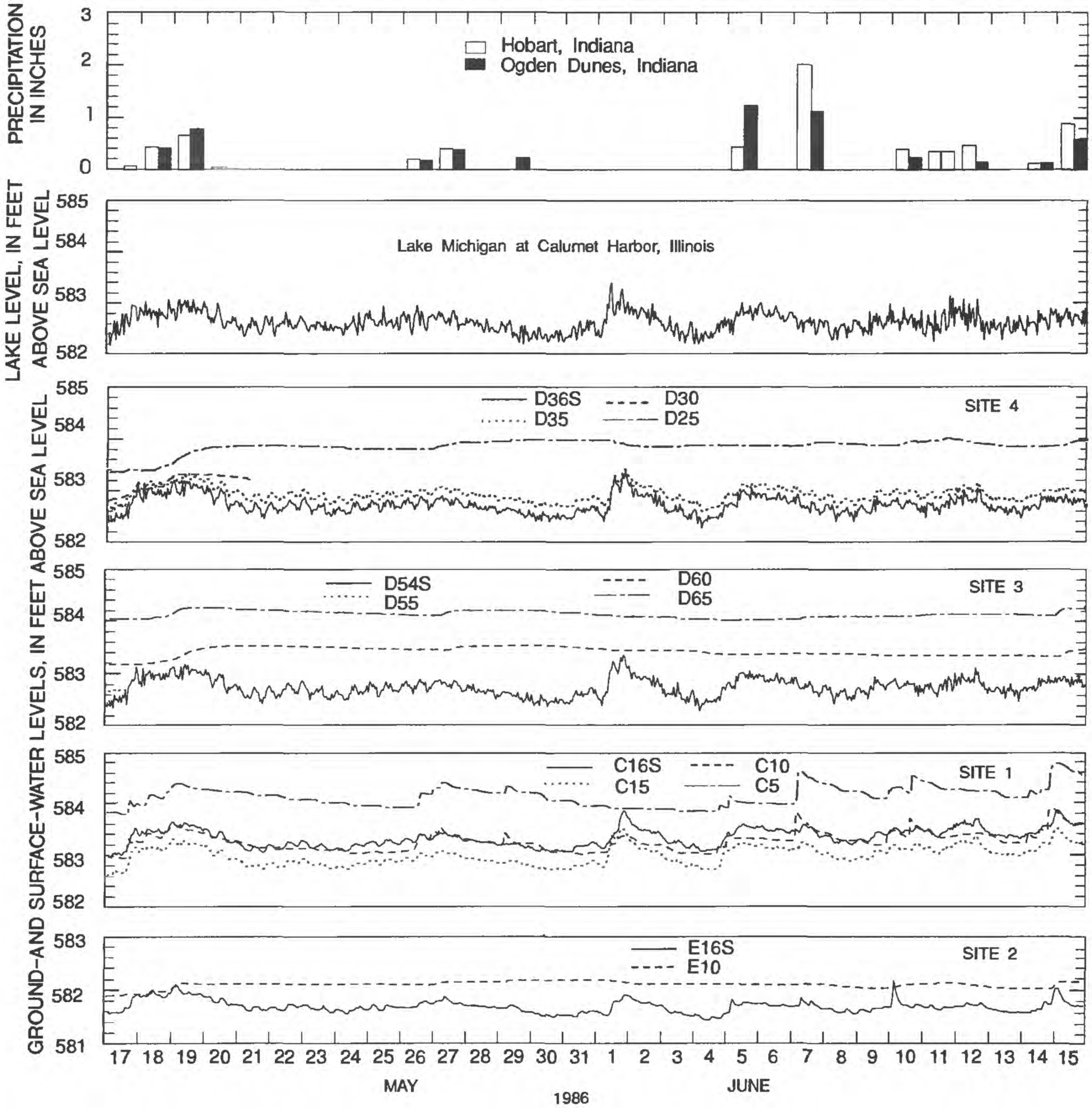

Figure 12. Stream levels in and ground-water levels near the Indiana Harbor Canal and the Grand Calumet River compared to Lake Michigan levels and precipitation. (Solid line on hydrographs is surface-water stage, dotted line is near-stream well, dashed line is well mid-distance from stream, and chain-dashed line is well farthest from stream.)

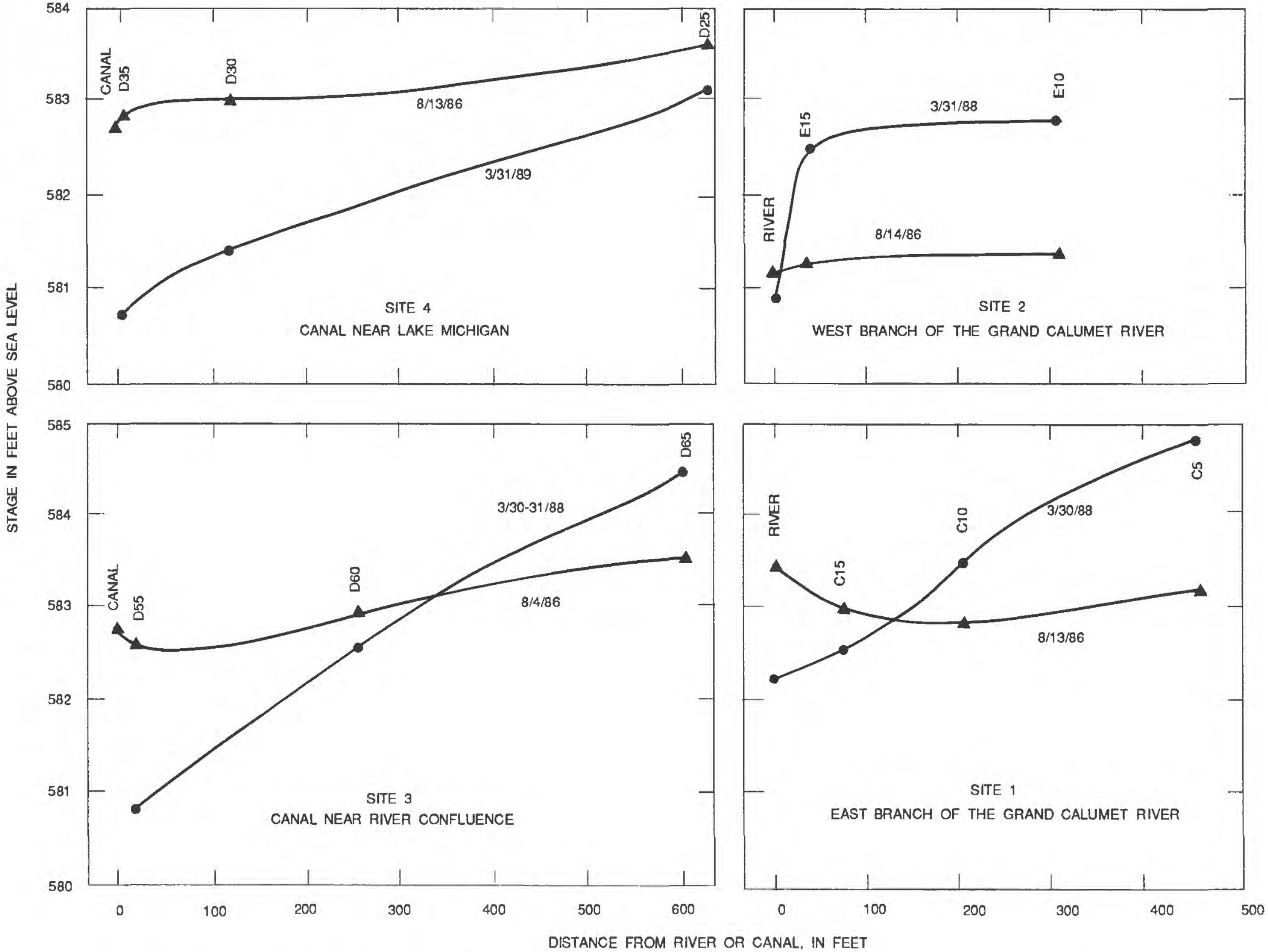

Figure 13. Water-level profiles along the Grand Calumet River/Indiana Harbor Canal for a period of high ground-water and low Lake Michigan levels (March 1988) and of low ground-water and high Lake Michigan levels (August 1986). (The location of the four sites is shown on figure 11.)

Moderate gradients result from either a combination of high lake and high ground-water levels or low lake and low ground-water levels (fig. 14). Upstream from well B3, most changes in ground-water gradients are probably due to seasonal changes in ground-water levels and changes in the water level of the Grand Calumet River that are caused by industrial discharges to the river.

At the four monitored sites (fig. 11) ground-water gradients flattened in the summer because of low ground-water levels. In addition, evapotranspiration was significant during the summer at those sites that were densely vegetated (sites 1 and 3), and ground-water levels were lowered enough to locally reverse the ground-water gradient (fig. 13). As a result of such reversals, transient ground-water troughs as much as 1 ft below the river and canal are created. The troughs are parallel to the river and canal and are normally within several hundred feet of the river and canal bank. The low points in the troughs can move as much as 500 ft away from the river and canal during the growing season.

Reversals of ground-water gradient are primarily caused by a lowering of the water table by evapotranspiration and(or) a lack of precipitation. Reversals are enhanced when the river or canal level is raised and the gradient sloping away from the river and canal is increased. Gradient reversals lasted for relatively long periods of time (several days to several months) in areas that were vegetated; however, at site 4 on the canal near Lake Michigan (a site without vegetation), ground-water-gradient reversals lasted only a few hours. Short-term reversals were common at all sites along the Grand Calumet River/Indiana Harbor Canal when ground-water gradients were small or fluctuations in river and canal levels were large.

Simulation of Ground-Water Flow

An areal model of a 70-mi^2 area of the Calumet aquifer was constructed to estimate a ground-water budget for the area. Water levels in the model were adjusted to match water levels measured in August 1987. Of primary interest was the amount of water discharging to the Grand Calumet River and Lake Michigan and the effect that sewers have on the ground-water system.

A three-dimensional, finite difference, ground-water-flow model (McDonald and Harbaugh, 1988) was used to simulate the ground-water flow and water budget in the Calumet aquifer. The model, run on a computer, solves a set of finite-difference equations for the three-dimensional flow of ground water through porous materials by means of an iterative solution. For the Calumet aquifer, the model was used to evaluate (1) recharge to the aquifer, (2) movement of water through the aquifer as a homogeneous aquifer, (3) flow of water between bedrock and the aquifer, (4) flow of water between the aquifer and surface-water bodies, and (5) discharge of ground water to sewers and ditches.

The model was used to evaluate only steady state conditions. Ground-water conditions in the aquifer are believed to be near steady state because (1) seasonal changes in water levels within the aquifer are relatively small (0 to 2 ft), (2) industrial and municipal ground-water withdrawals are minor, and (3) rapid ground-water-level fluctuations of up to 2 ft near the surface-water bodies are confined to a small area of the aquifer adjacent to these bodies and, thus, do not affect water levels throughout most of the aquifer. When rapid fluctuations do occur, equilibrium between the ground- and surface-water levels is quickly re-established. Because the model was constructed to simulate conditions when the water-table was lower than the seasonal average, the ground-water budget determined here is comprised of individual fluxes that are each less than their respective long-term averages. This is because ground-water gradients increase by about 5 percent over large areas of the aquifer between the low ground-water levels of summer and the high ground-water levels of spring.

The 1-layer model was constructed with a block-centered grid consisting of 33 rows and 47 columns (fig. 15). Most cells are 2,000 ft on a side except for those along the Grand Calumet River and Indiana Harbor Canal where cell size is 1,000 by 1,000 ft or 1,000 by 2,000 ft.

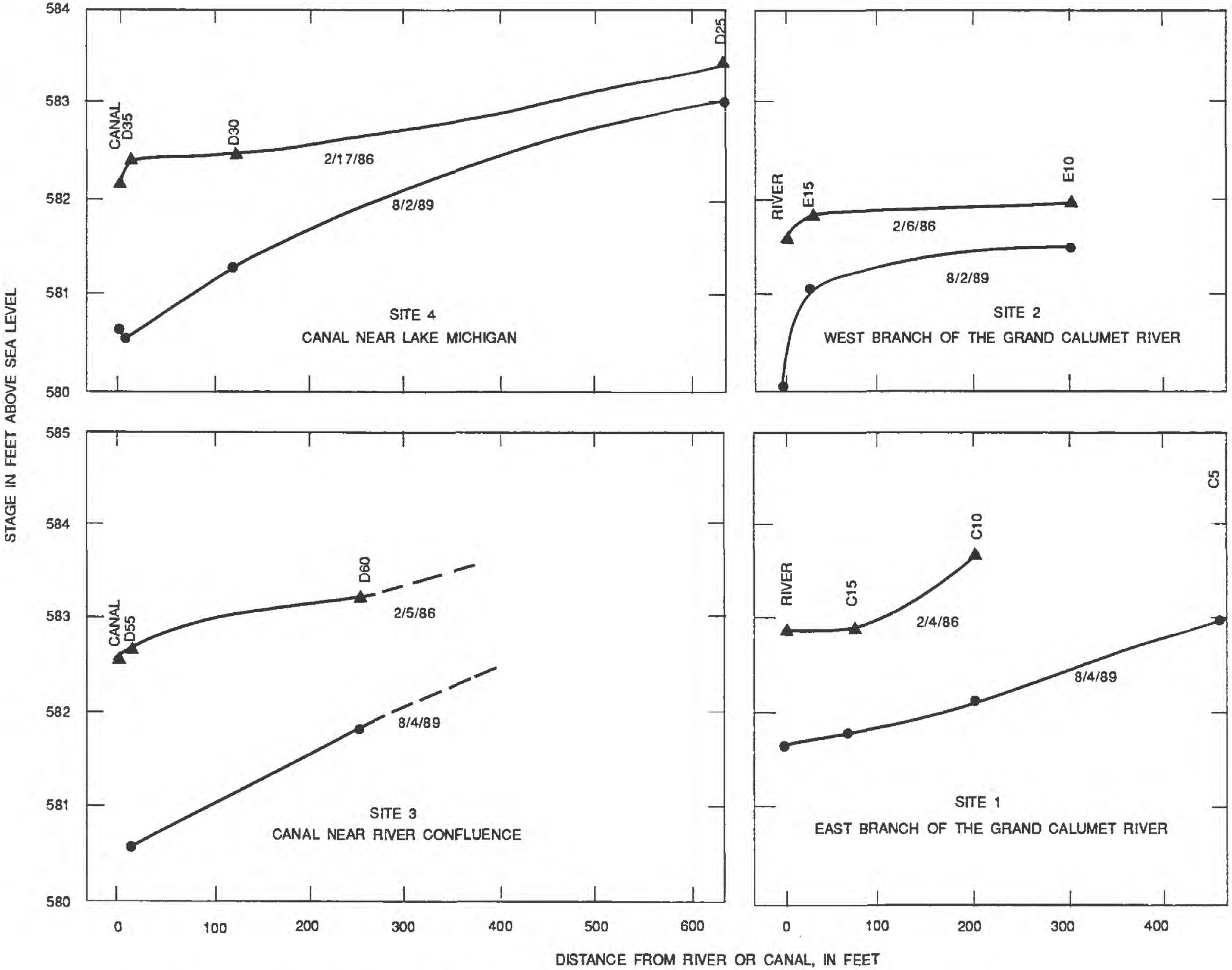

Figure 14. Water-level profiles along the Grand Calumet River/Indiana Harbor Canal for a period of high ground-water and high Lake Michigan levels (February 1986) and of low ground-water and low Lake Michigan levels (August 1989). (The location of the four sites is shown on figure 11.)

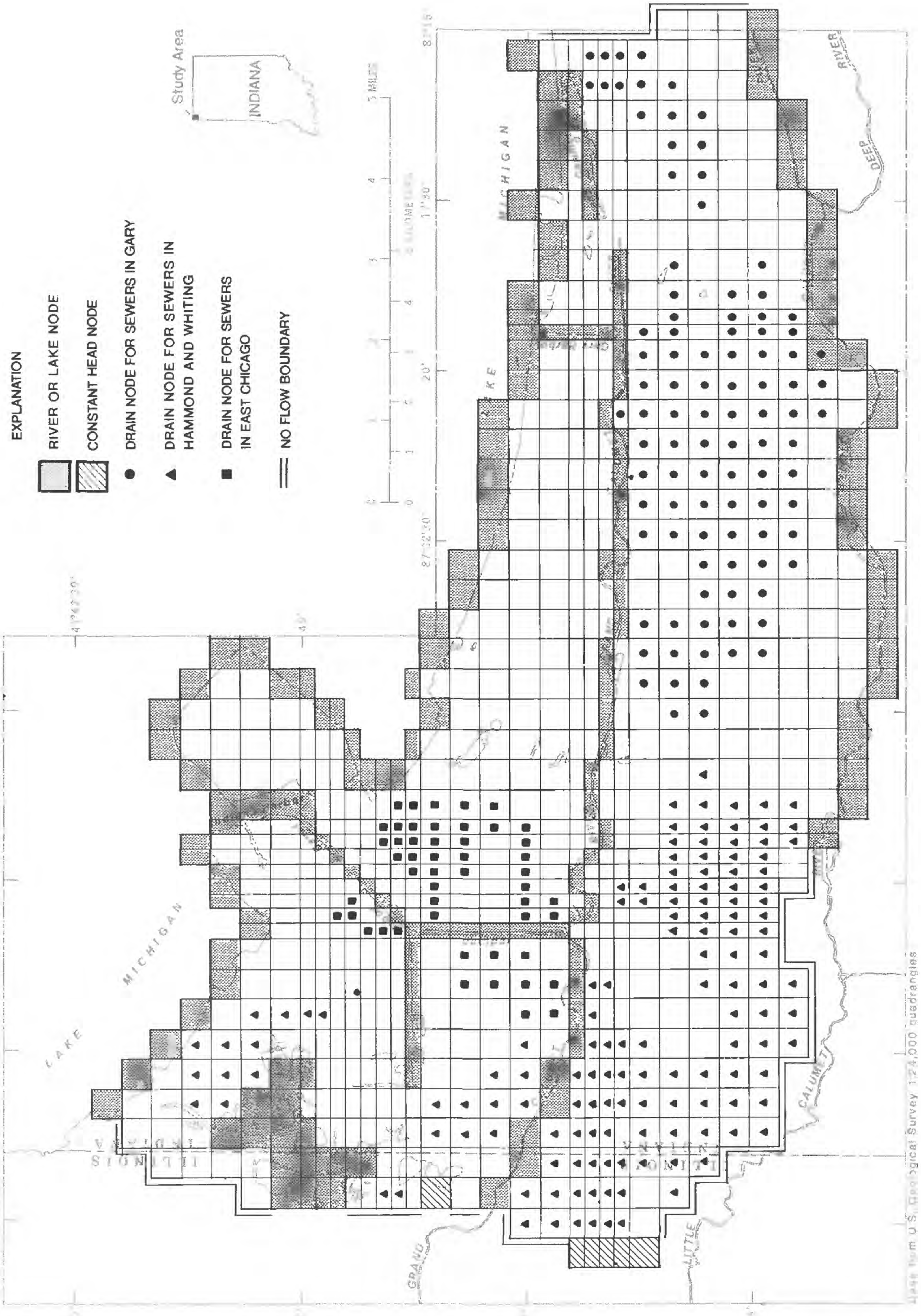

Figure 15. Finite-difference model grid used to simulate shallow ground-water flow in the study area.

Model Boundaries

Some of the model-boundary terms discussed in the following section are defined in the glossary at the back of the report. Additional detail on model terminology is given in McDonald and Harbaugh (1988).

The bottom of the modeled layer is the contact between the Calumet aquifer and the underlying clay unit. It is represented in the model as a **general-head boundary**[2] to simulate ground-water flow between the bedrock aquifer (through the clay unit) and the Calumet aquifer. Vertical hydraulic conductivity of 1×10^{-3} ft/d for the clay and heads in the bedrock aquifer that ranged from 540 ft above sea level in the northwest to 584 ft above sea level in the southeast were used to simulate flow through the clay unit. The vertical hydraulic conductivity value was within the range of field-measured values (table 6). Head distribution in the bedrock aquifer was determined on the basis of several known heads in the model area at the Midco I and Midco II sites (fig. 5) (Geosciences Research Associates, Inc., 1987, 1988) and an unpublished map of ground-water heads in northeastern Illinois and extreme northwestern Indiana (Harley Young, U.S. Geological Survey, written commun., 1987).

The upper boundary of the model layer is the water table and is represented in the model as a **recharge boundary**. Areal recharge to the water table is a conceptual sum consisting of several unmeasured recharge components (precipitation and leaking water lines and septic systems) and discharge components (evapotranspiration and pumpage) of the area's water budget. Four different zones are represented in the model, each by a specific range of recharge rates. These zones are (1) undeveloped areas, (2) slag-covered areas, (3) oil-refinery areas, and (4) areas of pavement and buildings (fig. 16). Undeveloped areas (hereafter called nonurban areas) are generally sewered. Areas covered by hot-poured or crushed-aggregate slag are located along the Lake Michigan shoreline. Oil-refinery areas contain oil tanks enclosed by lined dikes designed to keep oil and precipitation from entering ground water. Many pumped wells are within the refinery areas. Ranges of recharge rates used during the simulations are shown in figure 16.

The northern boundary of the model is the Lake Michigan shoreline and is represented by river nodes (fig. 15). The conductance of the lake-bottom sediments was calculated from an estimated vertical hydraulic conductivity of 5 ft/d and an estimated sediment thickness of 10 ft. The hydraulic head used in the river nodes, 581.5 ft above sea level, was the approximate water level in Lake Michigan during August 1987 (Harry Lippincott, National Oceanic and Atmospheric Administration, written commun., 1988).

The western and southwestern boundaries are located where the Calumet aquifer pinches out at the top of the underlying clay unit. In the west, the aquifer pinches out less than a mile west of the Indiana-Illinois State line and, in the southwest, less than a mile north of the Little Calumet River. Both boundaries are represented as no-flow boundaries, except for five **constant-head nodes** along the western boundary where surficial deposits of sand extend into Illinois. The constant-head nodes were insignificant in the model, accounting for about 0.3 percent of the total water budget. The remainder of the southern boundary is the Little Calumet River and is simulated with river nodes assigned an arbitrary riverbed thickness of 10 ft and a vertical hydraulic conductivity of 1 ft/d for the riverbed.

The eastern boundary is arbitrary and was constructed parallel to a ground-water flowline. As such, it is considered to be a no-flow boundary. The boundary trends north from the Little Calumet River to Lake Michigan.

The Grand Calumet River and Indiana Harbor Canal are **river boundaries** that were simulated with river nodes (fig. 15). Riverbed thicknesses for the eastern half of the Grand Calumet River range from 3 to 9 ft (Indiana Department of

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[2]Terms in bold are defined in the Glossary, p. 72.

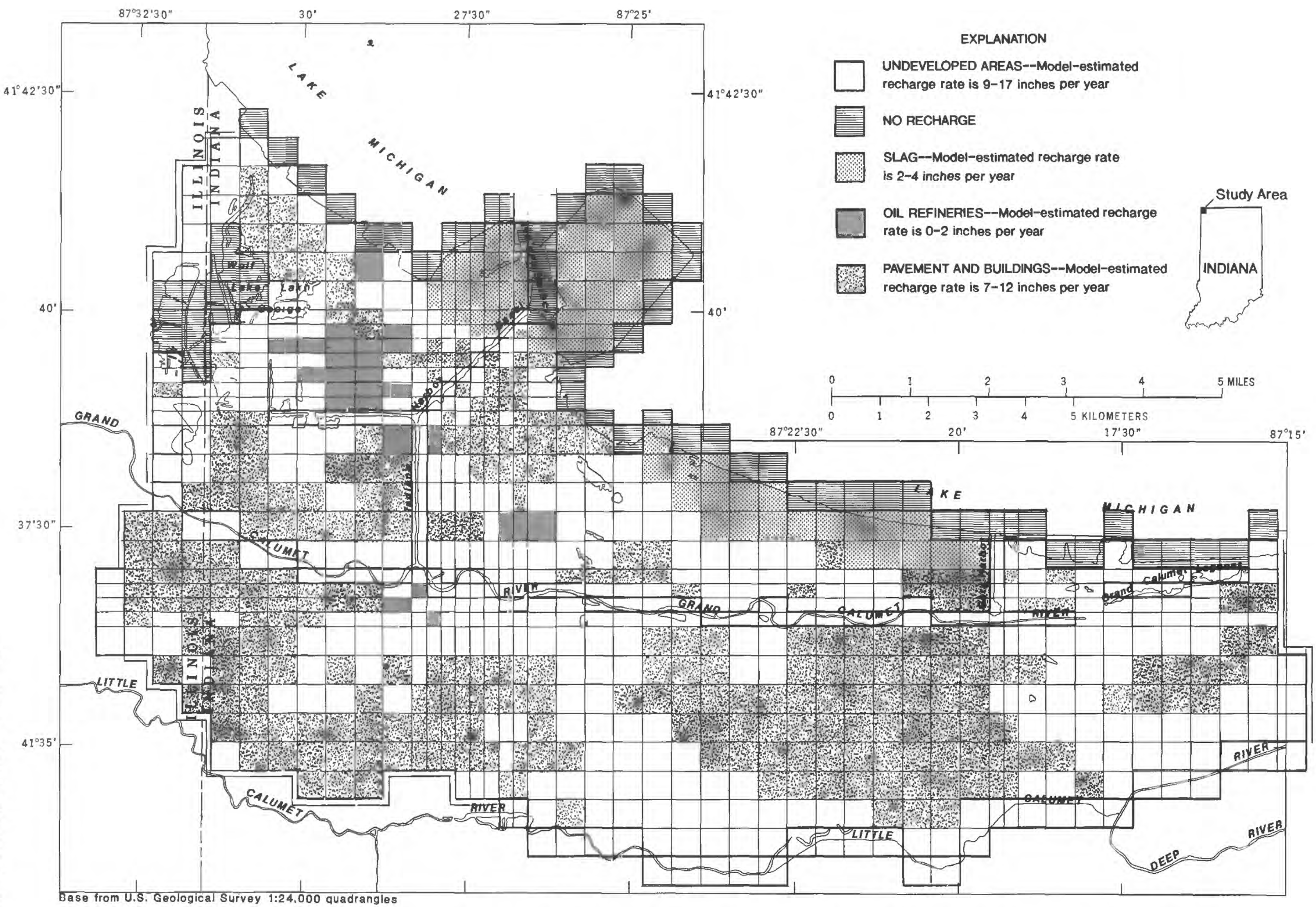

Figure 16. Zones of simulated recharge and their respective ranges of recharge rates used in the finite-difference model.

Environmental Management, written commun., 1987). Thicknesses of the bottom sediments in the Indiana Harbor Canal and the western half of the Grand Calumet River were unknown and were arbitrarily set at 8 ft. A vertical hydraulic conductivity of the riverbed material of 1 ft/d was chosen as the best value during model simulations. Wolf Lake and Lake George in the northwestern part of the model also were simulated as river nodes.

Leaky sewers were simulated in the Gary, East Chicago, and Hammond sewer districts (fig. 15). All sewers in East Chicago and Hammond and all sewers less than 3 ft in diameter in Gary were assumed to be receiving ground water and, therefore, were modeled with **drain nodes**. Drain conductance was calculated by creating a conceptual model drain for each cell to represent all the leaky sewers in that cell. The surface area of the conceptual drain was calculated by adding up the surface areas of all sewers greater than or equal to 3 ft in diameter within a cell. Added to this sum was a modelwide estimate of the surface area of all the smaller sewers in the node. The surface area used for the smaller sewers was 0.011 ft^2 of sewer surface area per square foot of model-cell area or the equivalent surface area of approximately one 7 ft-diameter sewer per 2,000 ft by 2,000 ft cell. The thickness of the drain was arbitrarily set at 1 ft, and values of the hydraulic conductivity of the drains were varied from 0.01 to 0.04 ft/d during model simulations. The drains were set at an elevation of 10 ft below land surface if the model cell contained only sewers less than 3 ft in diameter, and at 15 ft below land surface if the cell contained sewers that were larger that 3 ft in diameter. Ditches also were simulated as drains. Conductance was calculated by assigning the ditches an arbitrary bottom-sediment thickness of 3 ft, and the hydraulic conductivity of the sediment was varied between simulations.

Results of Model Simulations

The model of the Calumet aquifer could not be calibrated because of too many unknown parameters (see "Model Evaluation and Limitations" section). Even though no single simulation was able to uniquely represent the hydrologic system of the aquifer, model simulations produced useful results. The steps used during model simulations were similar to those for model calibration; that is, model-input data were refined in a trial-and-error procedure based on the reliability of the data and the match of simulated results with field data. Ground-water recharge rates and leakage rates to sewers and rivers could not be refined to single values, although a range of viable recharge rates and budgets and an understanding of what factors are important to the hydrologic system were obtained from the modeling exercise.

The complexity of the drains caused the most problems in model simulations. For example, one model node in a sewered part of the Calumet aquifer may represent hundreds of sewers whose diameters, lengths, **hydraulic conductances,** and elevations all differ. Yet, the model node can be assigned only one drain that represents the total of all sewers. As a result, the model drain may grossly overestimate or underestimate the effects of these sewers. Scarcity of field measurements of water levels in sewered areas also hindered the description of depressional areas beneath the sewers; hence, a unique match between field-measured and simulated heads was difficult to find.

A second problem with simulating the drains is the result of the wide range of estimates of aquifer-recharge rates and leakage rates to sewers within the study area. Because of the wide range, simulated water levels in the sewered areas can be matched with field levels for almost any recharge rate by simply adjusting the conductances of the drains.

Two model simulations were used to describe the water budget of the Calumet aquifer. In the first simulation, a horizontal hydraulic conductivity of 50 ft/d was used for the Calumet aquifer. The lowest reported amounts of ground water leaking into the sewers are believed by the authors to be the most reasonable (and conservative) estimate of how much ground water actually leaks into the sewers. These amounts (8 ft^3/s for Hammond, 5 ft^3/s for Gary, and 2 ft^3/s for East Chicago) were derived from sewer-leakage studies that were done during dry-weather periods. Model parameter values were adjusted to these leakage values and the approximately 90 heads that were measured in the field in August 1987. This resulted in simulated ground-water leakage rates to sewers of 8 ft^3/s for Hammond, 4 ft^3/s for Gary, and 3 ft^3/s for East Chicago. From these rates, recharge rates were estimated on the basis of the model simulation to be about 7 in/yr for urban areas, 9 in/yr for nonurban areas, and 2 in/yr for refinery and slag areas. Discharge rates for this combination of values are listed in the first column of table 26. The rates indicate the probable base-flow contribution to the major discharge areas based on the best estimates of leakage rates to sewers and the hydraulic characteristics of the aquifer.

A second combination of values consisting of increased recharge rates and increased horizontal hydraulic conductivities were evaluated with the model. The justification for simulating higher recharge rates and hydraulic conductivities was that leakage rates to sewers were reported to be as great as 50 ft^3/s and that ground-water discharge to the east branch of the Grand Calumet River was estimated on the basis of base-flow measurements to be as much as 36 ft^3/s (Crawford and Wangsness, 1987). Additional ground-water discharge was allowed for by use of a horizontal hydraulic conductivity of 100 ft/d as part of the second combination of values. This hydraulic conductivity may be overly high, although it is within the range of 10 to 130 ft/d given by Rosenshein and Hunn (1968). In urban areas, simulated and measured heads could be matched for virtually any urban recharge rate by adjusting the hydraulic conductances of the sewers. Therefore, an urban recharge rate of 12 in/yr was chosen as a reasonable value of urban recharge that also allowed reasonable amounts of ground water to discharge to the sewers. The best match was obtained from recharge rates of 17 in/yr in nonurban areas and 2 in/yr in refinery and slag areas. The total recharge increased 82 percent from the first combination of values. The discharge rates listed in the second column of table 26 show that sewer infiltration rates more than doubled, discharge to the rivers increased almost 90 percent, and discharge to Lake Michigan increased about 75 percent.

Table 26. Simulated amounts of ground-water discharge *from the Calumet aquifer for two simulated horizontal* hydraulic conductivities

[K, modeled horizontal hydraulic conductivity of the Calumet aquifer; ft/d, feet per day]

Discharge to:	Discharge from Calumet aquifer, in cubic feet per second	
	K=50 ft/d	K=100 ft/d
Sewers	14.9	31.6
East branch of Grand Calumet River and Indiana Harbor Canal[1]	9.6	18.0
West branch of Grand Calumet River	.4	.8
Little Calumet River [1,2]	8.1	14.3
Lake Michigan	4.0	7.0
Bedrock	6.0	6.0
Wolf Lake, Lake George	1.0	2.2
TOTAL	44.0	79.9

[1]Includes ground-water discharge to ditches that flow into the river.

[2]Includes only ground-water discharge to the north side of modeled part of the river.

The simulated water-table maps for high and low hydraulic conductivities look similar, therefore, only one water-table map is presented (fig. 17). This map was created with a horizontal hydraulic conductivity of 50 ft/d—the average value from an aquifer test (Geosciences Research Associates, Inc., 1987) and from a countywide estimate (Rosenshein and Hunn, 1968). Head distribution in the simulated water-table map is similar to that of the water-table maps that were constructed from measured water levels (figs. 8, 9, and 10). The map shows ground-water divides between the Grand Calumet and Little Calumet Rivers and between the Grand Calumet River and Lake Michigan east of the Indiana Harbor Canal. The divide between the two rivers is not a broad linear ridge from east to west; rather, the simulated divide is a series of ground-water mounds caused by increased recharge rates and a lack of sewers in nonurban areas that are dissected by ground-water depressions in the urban areas. The depressions are the result of leakage of ground water into sanitary and storm sewers.

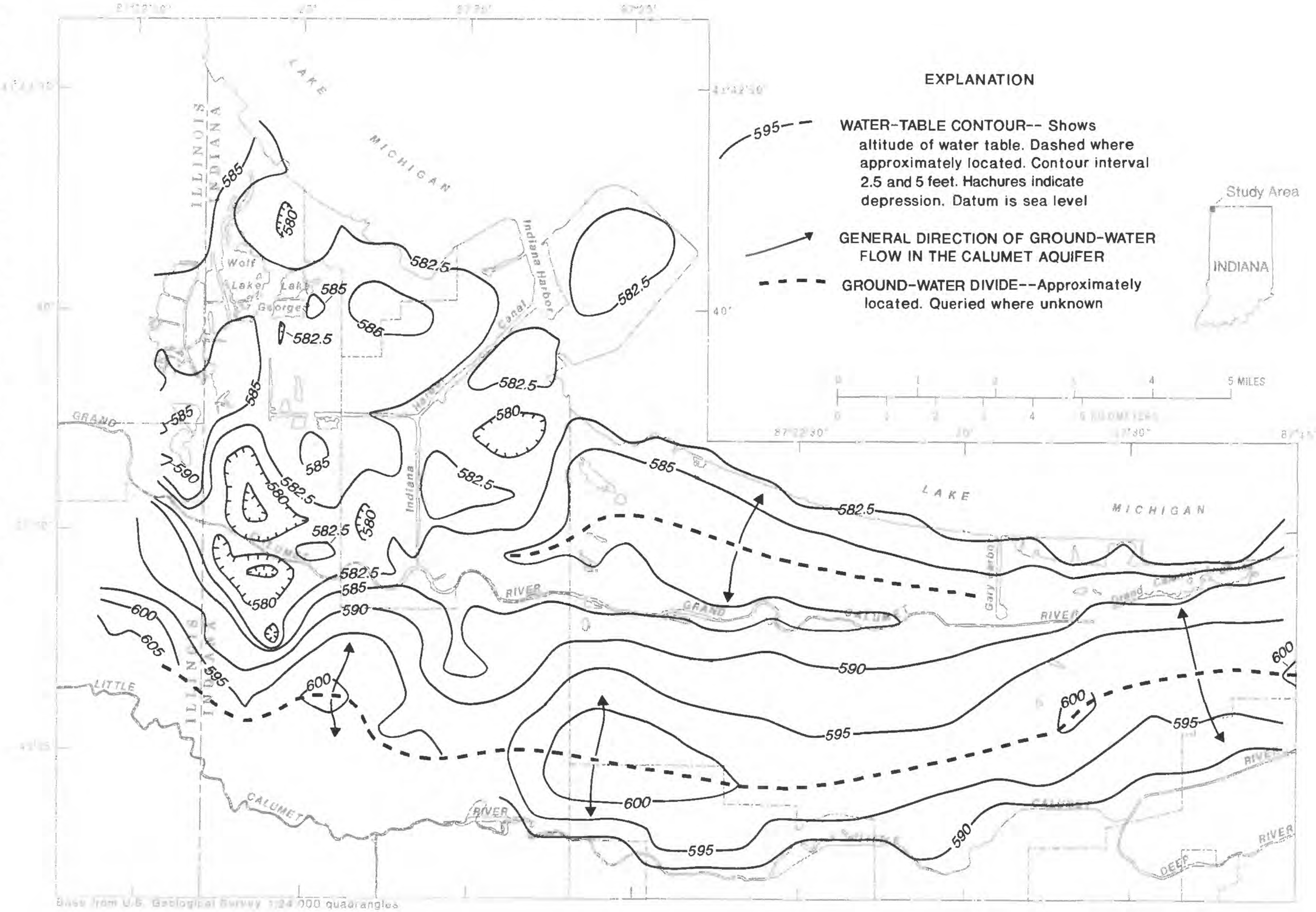

Figure 17. Simulated water-table altitude and configuration for hydrologic conditions of August 1987.

The simulated water-table configuration indicates that some of the sewers along the western branch of the Grand Calumet River could induce infiltration of river water into the aquifer; however, water levels measured in a transect of observation wells on the north side of the river in this area (site 2) showed a ground-water gradient toward the river during most of 1986 except for late summer. Leaking sewers near Lake Michigan could also induce flow from the Lake into the ground-water system, especially when lake levels are high. Simulated depressions in this area are the result of sewers and low recharge rates in the East Chicago and Whiting areas; however, the depressions cannot be verified because of the absence of observation wells in these areas.

The simulated water-table map indicates that the configuration of the water table is probably much more complex than the configuration constructed from about 90 measured water levels (figs. 8, 9, and 10). It also shows that ground-water-flow directions are not readily discernible in many areas. Because of this, many more observation wells would be needed to understand the local details of the ground-water-flow system.

Model Sensitivity

A comprehensive sensitivity analysis was not done because the model was not calibrated. Several model parameters were varied, however, to determine the sensitivity of the model to those parameters. The first sensitivity analysis was evaluated with drains in the model raised to 5 ft below land surface to determine whether drain altitudes were critical to the matching of simulated and measured heads and the matching of simulated and measured leakages into the sewers. Field-measured and simulated heads could be matched only by tripling drain hydraulic conductances to compensate for lower gradients between the heads in the drain and the aquifer. Ground-water discharge to sewers decreased about 10 percent; the extra ground water discharged directly to rivers and the ditches that supply the rivers. The decreased infiltration rate is primarily due to the 5-foot drain depth, which placed some of the drains above the water table and thus removed them from the simulation.

Model sensitivity to a range of vertical hydraulic conductivities of the bed material of the Grand Calumet River was tested. A value of 0.1 ft/d caused simulated heads along the Grand Calumet River to be 4 to 6 ft too high. If the vertical hydraulic conductivity of the riverbed is near 0.1 ft/d, recharge needs to be significantly lower than what was simulated to reduce simulated gradients along the river. A value of 1 ft/d produced heads along the Grand Calumet River that were as much as 2 ft too high. Some of the simulated heads along the river were too high because they are in cattail marshes, where the water table was lowered by evapotranspiration. Because evapotranspiration was modeled only as a component of recharge, simulated heads were expected to be too high where evapotranspiration was greater than average. Therefore, a vertical hydraulic conductivity of 1 ft/d is probably a reasonable value for the riverbed.

Model Evaluation and Limitations

All models have limitations because they are simplifications of natural systems. The simpler the natural system, the easier the system is to model accurately. Models also are limited because estimates of hydrogeologic parameters for the modeled system are based on only a few measured data values. The accuracy of simulation results is dependent on the reliability of these data values. The values of several recharge, discharge, and hydraulic factors used to simulate ground-water flow in the Calumet aquifer are unknown or are known only within a large range. These include the following:

1. The recharge rate of the Calumet aquifer is virtually unknown; values of 4 to 23 in/yr were used by investigators in several modeling studies of the aquifer. Estimating recharge rates in a given area is complicated by urban and industrial development, which increases surface-water runoff and lowers recharge rates.

2. Ground-water discharge into the Grand Calumet River cannot be measured because more than 95 percent of the flow in the river is from industrial and municipal sources. Traditional seepage measurements cannot be used to measure ground-water-flow rates because measurement error for surface-water flow is of the same order of magnitude as ground-water flow into the river.

3. Estimates of ground-water leakage into sewer lines varied widely from 15 to 50 ft^3/s. Even if the rate of ground-water leakage into sewer lines was refined to a single value, information is needed on the distribution of leaky sewer lines—specifically, which sewer lines intercept ground water and how much ground water they remove.

4. Ground-water pumpage in the refinery areas was not modeled, except as a component of recharge because there is little information on the distribution of pumping wells and rates of pumpage in the refinery areas.

5. The areal distribution of horizontal hydraulic conductivity of the aquifer is uncertain. Its variability has been demonstrated in several studies that estimated hydraulic conductivities from less than 5 to more than 100 ft/d.

   The sand aquifer was assumed to be homogeneous in the model although there are several different kinds of sand deposits (including dune, beach, and lacustrine deposits) that form the aquifer.

6. Slag, which covers the northern part of the aquifer along Lake Michigan, was not modeled with a different horizontal hydraulic conductivity than the sand aquifer because of insufficient data on its hydraulic characteristics.

A calibrated model was not constructed because poor estimates of recharge, discharge, and hydraulic parameters did not allow for a unique solution. Rather, two models were used to describe potential ground-water-flow systems in the aquifer. The two models bracket the probable rates of ground-water flow into different discharge areas (table 26).

On the basis of the ground-water-flow system analysis using the two numerical models, sewers received ground water at an approximate rate of 15 to 30 ft^3/s, or 90 to 100 percent of the areal recharge in the sewered area of the model. Not only did the sewers remove virtually all of the areal recharge in the sewered area, but they also removed additional ground water that flowed laterally into the sewered area. Model simulations indicate that the sewers removed about 65 to 75 percent of the combined areal recharge and ground-water inflow to the sewered area.

The rivers received most of the remaining ground water that discharged from the system. Within the modeled area, the Grand Calumet River/Indiana Harbor Canal received about 10 to 20 ft^3/s of ground water, and the Little Calumet River received about 8 to 15 ft^3/s of ground water (only the northern side of the Little Calumet River was modeled; therefore, the total discharge to the Little Calumet River is greater than 8 to 15 ft^3/s). Most of the modeled river cells incorporated several hundred feet of land adjacent to the rivers, including marsh areas that have the potential for intensive evapotranspiration. Because evapotranspiration was not included in model-calculated ground-water discharge to the river, the actual ground-water discharge to the rivers is probably somewhat less than that calculated by the model.

The remaining ground water discharged to Lake Michigan and the underlying bedrock. The lake has a small area of discharge and received only about 4 to 7 ft^3/s along a 25-mile section of shoreline. The bedrock probably received about 6 ft^3/s, but this amount could range from zero to 10 ft^3/s depending on the actual head distribution in the bedrock and the actual vertical hydraulic conductivity of the overlying clay unit. The flow of water from the bedrock to the aquifer is directly proportional to the vertical hydraulic conductivity of the clay unit. For example, if the vertical hydraulic conductivity of the clay is 1 x 10^{-4} ft/d rather than the simulated value of 1 x 10^{-3} ft/d, then the flow from the bedrock would be less than 1 ft^3/s.

WATER QUALITY IN THE CALUMET AQUIFER

The quality of water in the Calumet aquifer and its relation to type of land use is characterized in the following sections. Chemical loads are estimated for ground water entering the Grand Calumet River/Indiana Harbor Canal, Lake Michigan, the sewer system, and the carbonate bedrock.

Effects of Land Use on Ground-Water Quality

The various uses of the land overlying the Calumet aquifer can potentially have different effects on the ground-water quality. The type of land use adjacent to a surface-water body is likely to have the greatest effect on the quality of the ground water discharging to that surface-water body.

The six major types of land use in the study area are shown in figure 18. Residential land occupies about 40 percent of the study area; commercial areas or light industry occupy 25 percent; the steel industry occupies 15 percent; the petrochemical industry occupies 10 percent; and parks and agricultural areas occupy the remaining 10 percent. As a direct result of the intense industrial and urban development, 84 sites have been included on the ERRIS and 4 on the NPL by the USEPA (fig. 1).

The residential areas are primarily the cities of Gary, Hammond, East Chicago, and Whiting. All are paved, sewered, and densely populated. The combined population of the four cities was about 290,000 in 1980 (U.S. Department of Commerce, 1982). The main drinking-water supply for the cities is Lake Michigan. Ground water is used for domestic purposes only in unincorporated or recently annexed areas.

A variety of chemicals that are widely used in residential areas could potentially contaminate ground water. These include gasoline, oil, lead paint, pesticides, and road-deicing salt. Because most of the residential areas are sewered, much of the ground water is probably discharged to the sewers before it reaches surface water. Therefore, most of the residential ground water is probably routed to a sewage treatment plant before being discharged to a surface-water body.

A variety of commercial and light industries are located in the area, and most are within 2 mi of the Grand Calumet River. These industries use, produce, and process numerous chemicals. Potential contaminants include industrial chemicals, solvents, heavy metals, aviation fuel, and sewage. Contaminants reaching the ground water would likely enter the Grand Calumet River because many of the industries are adjacent to the river.

Within the area classified as commercial or light industrial are areas of relatively undeveloped land. These areas, which are part of the parcels owned by various companies, are commonly fenced and have roads. Some of these areas contain remnants of natural beach ridges, native vegetation, and marshes; however, the undeveloped areas also include landfills and industrial waste sites that have the potential to contaminate the ground-water resources.

The steel industry land-use area includes almost 75 percent of the 25 mi of Lake Michigan shoreline property. Much of the steel-industry land within one-half mile of the shore is lake-fill composed of slag and industrial refuse. The steel-industry land is intensively developed, is generally lacking in vegetation, and is covered with buildings, railroads, pavement, and piles of slag, coke, or ores that are associated with the steel industry.

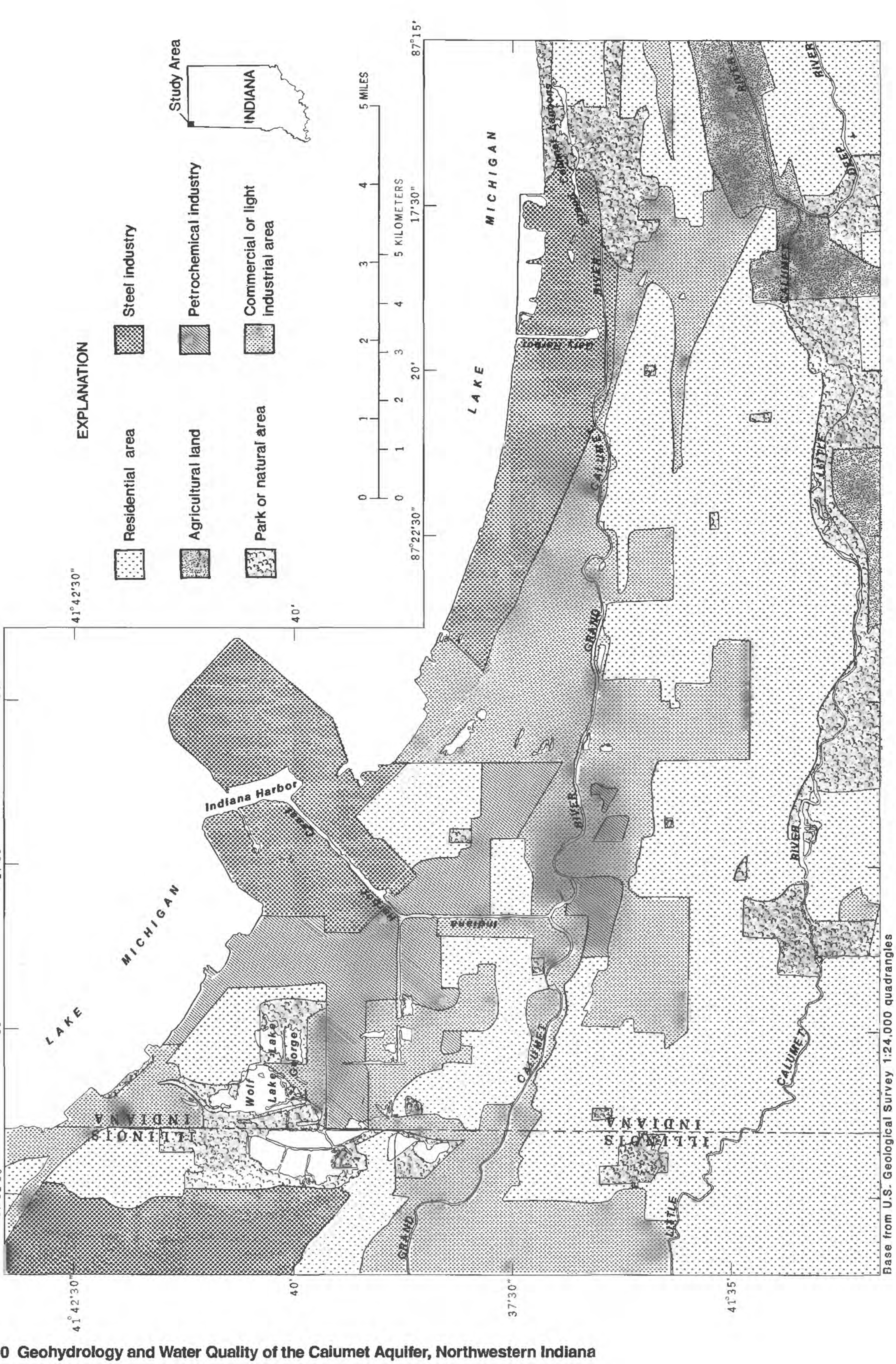

Figure 18. Major land uses in the study area (modified from Watson and others, 1989, figure 3.)

Many of the chemicals produced in a steel mill come from the production of coke, the fuel source for blast furnaces. By-products of coke-making include ammonia, sulfate, napthalene, light oil, benzene, toluene, xylenes, phenols, cyanide, and heavy solvents (Russell and Vaughan, 1976). Materials used for the production of steel and by-products of the process include alloy metals, slag, lime, chloride, sulfate, and oil (Russell and Vaughan, 1976). Contaminants that reach the ground water in these areas probably will be discharged to Lake Michigan and the upper reach of the Grand Calumet River.

Most of the petrochemical industry areas are near the Indiana Harbor Canal. The land is sparsely vegetated; large areas consist of clusters of oil tanks separated by dikes. Pumpage from a system of shallow wells is used as a means to reduce the flow of oil-contaminated ground water from the oil refinery property. The pumpage lowers the water table in places beneath and adjacent to the oil refinery, and the contaminated water is treated and then discharged into Lake Michigan.

A wide variety of chemicals, mostly organic in nature, are used and produced in the refinery area. These include benzene, toluene and xylenes (found in gasoline, oil, and tar); lead products; phenols; aluminum chloride; and acid and caustic substances (Burdick and Leffler, 1983; Houlihan, 1987). If these chemicals enter the ground-water system and are not subsequently intercepted by the shallow-well pumpage, they are likely to be discharged to the Indiana Harbor Canal, sewers, and Lake Michigan.

Park or natural area land use is primarily along the eastern, southern, and western boundaries of the study area. The largest park is located on the eastern edge of the study area and includes the western end of the Indiana Dunes National Lakeshore. Other tracts of parkland serve as wildlife preserves. Ground-water quality is probably minimally affected by human activities in these areas, although land use upgradient from these parks could have an effect.

One large parkland around Wolf Lake has been modified by human development and is a potential source of ground-water contamination. Original marshland was filled and Wolf Lake sand was mined to provide material for construction of the Indiana Toll Road. Most of the fill on the site is slag; however, other rubbish also may be buried there (Rosenshein, 1961, p. 200-207).

Land use adjacent to the Little Calumet River and immediately southeast of the study area is agricultural. Pesticides and nutrients are the most likely contaminants to reach the water table in the area, and the Little Calumet River is the most likely surface-water body to be affected.

Comparisons of Water-Quality Data

Results of the water-quality measurements are discussed by comparing them (1) to USEPA Drinking-Water Regulations, (2) by depth (shallow compared to deep), and (3) between different data sets, including five land-use groups (commercial, steel, petrochemical, residential, and park), and a "natural" and "contaminated" data set. The water quality data from the 35 wells in the sampling network (tables 27 through 31, in the "Supplemental Data" section in the back of the report) were grouped by the primary land use that surrounds them. The land-use data sets discussed in the following sections are compared with two other data sets: a "contaminated" data set and a "natural" data set. The "contaminated" data set consists of data published by private consulting firms and includes data from 16 wells throughout the study area at which some type of contamination was known or suspected. The "natural" data set consists of U.S. Geological Survey data from 18 wells in the Calumet aquifer east of the study area in which the quality of the ground water is thought to be minimally affected by human activity. Primary and secondary drinking-water regulations for many water-quality constituents have been established by the USEPA (1986) (table 32). Primary drinking-water regulations, termed Maximum Contaminant Levels (MCL's) are health-related and legally enforceable. Secondary drinking-water regulations, termed Secondary Maximum Contaminant Levels (SMCL's) apply to esthetic qualities and are recommended guidelines for drinking water.

Table 32. Maximum Contaminant Levels and Secondary Maximum Contaminant Levels set by the U.S. Environmental Protection Agency for selected constituents

[mg/L, milligram per liter; --, no established regulation; contaminant levels are from U.S. Environmental Protection Agency (1986)]

Constituent	Primary Maximum Contaminant Level (mg/L)	Secondary Maximum Contaminant Level (mg/L)
Arsenic	0.05	--
Barium	1.0	--
Cadmium	.010	--
Chloride	--	250
Chromium	.05	--
Copper	--	1
Fluoride	4.0	2.0
Iron	--	0.3
Lead	.05	--
Manganese	--	.05
Mercury	.002	--
Nitrate	10.0	--
Sulfate	--	250
Total dissolved solids	--	500
Zinc	--	5
Volatile organic compounds		
Benzene	.005	--
Carbontetrachloride	.005	--
1,1-Dichloroethylene	.007	--
1,2-Dichloroethane	.005	--
Para-dichlorobenzene	.075	--
1,1,1-Trichloroethane	.2	--
Trichloroethylene	.005	--
Vinyl chloride	.002	--

Field-Measured Properties and Constituents

A statistical summary of specific conductance, alkalinity, pH, temperature, and dissolved oxygen concentration within the sampling network is presented in table 33.

Specific Conductance and Alkalinity

Water from wells in "natural" areas has a median specific conductance that is 1.5 to 5 times less than the median specific conductances of the land-use data sets and the "contaminated" data set (fig. 19). The highest median specific conductance of the land-use data sets was from wells on steel-industry property. Specific conductances of water from the wells sampled during summer 1987 included seven extreme values, which ranged from 2,310 to 5,460 µS/cm. Three of these samples were from wells screened in fresh slag, and two were from wells contaminated by petroleum products.

If a conservative estimate of 0.5 mg/L were used as the constant of proportionality between specific conductance and total dissolved solids concentration (Hem, 1985), 20 of the 35 water samples would exceed the SMCL of 500 mg/L of total dissolved solids set by the USEPA (1986). Of these 20 samples, 8 would be considered "slightly saline" (Hem, 1985) or "brackish" (Freeze and Cherry, 1979). If total dissolved solids were calculated by summing the concentrations reported for the dissolved inorganic constituents (Hem, 1985), 23 of the 35 water samples would exceed the SMCL and 10 would be considered "slightly saline" or "brackish."

In the group of wells sampled in 1987, the median values for both specific conductance and alkalinity in the ground water from the 19 shallow wells were lower than those in water from the 16 deep wells. Eight of the 10 lowest values for alkalinity and specific conductance were found in water from wells that were screened at the top of the aquifer. Some of the apparent differences between samples from shallow and deep wells may be related to differences in land use rather than the depth of the aquifer from which the samples were collected. Among samples from the seven sets of paired wells, medians of alkalinity and specific conductance in water from the seven shallow wells were lower than those for water from the seven deep wells, regardless of land use. Lithologic factors, length of flow paths, dilution in shallow wells, density plumes, or upward flow of ground water from the clay unit could increase mineralization of water with depth.

Table 33. Statistical summary of the water-quality characteristics measured in the field
[µS/cm, microsiemen per centimeter at 25° Celsius; mg/L, milligram per liter; °C, degree Celsius; <, less than]

Characteristic	Period of analysis	Number of samples	Median	First quartile	Third quartile	Minimum	Maximum
Specific conductance (µS/cm)	Summer 1987	34	1,270	595	1,802	241	5,460
	Spring 1988	33	1,200	758	1,820	275	4,960
	Summer 1988	31	1,200	850	2,070	234	4,390
Alkalinity (mg/L as $CaCO_3$)	Summer 1987	33	288	191	410	28	975
pH	Summer 1987	35	7.3	7.0	7.7	6.7	11.8
	Spring 1988	34	7.3	6.9	7.7	5.6	11.8
	Summer 1988	31	7.1	6.9	7.4	6.5	11.9
Temperature, °C, in samples from shallow wells	Summer 1987	19	18.9	16.5	19.7	12.5	20.0
	Spring 1988	19	10.5	10.0	11.4	8.7	15.9
	Summer 1988	16	19.1	17.2	20.6	16.7	22.0
Temperature, °C, in samples from deep wells	Summer 1987	15	14.7	13.3	16.3	12.1	19.0
	Spring 1988	13	12.3	11.5	13.0	9.3	15.1
	Summer 1988	15	15.6	13.6	17.4	13.1	19.5
Oxygen (mg/L)	Summer 1987	34	0.7	0.3	2.1	<0.1	8.0
	Spring 1988	33	.5	.4	1.4	.2	7.1

pH

The median pH in the 35 well samples was about 7.3; however, four extreme values of pH (three above 11.0 and one at 9.7) were measured in samples from wells screened in slag. Because slag is dominantly alkaline-earth-silicate glass, an elevated pH of water in contact with it is not unexpected.

Temperature

Comparison of temperature values for all three sampling periods (fig. 20) showed differences between the water from shallow wells and water from deep wells. In summer 1987, the median-ground-water temperature from shallow wells was 18.9°C (66°F), about 4°C warmer than the water from deep wells. By spring 1988, the median temperature of the water from shallow wells dropped about 8.5°C to 10.4°C (50.7°F), whereas the water from deep wells dropped only about 2.5°C. This resulted in a reversal in temperature in which the deep water was warmer than the shallow water. By the summer of 1988, the ground-water temperatures reversed again and median values were similar to the previous summer. These reversals are the result of the shallow ground-water being affected by the temperature of seasonal atmospheric recharge; water tapped by the deep wells is isolated from this effect.

Dissolved Oxygen

Dissolved oxygen was detected in most of the ground-water samples collected from the Calumet aquifer. Dissolved oxygen concentrations were higher in the shallow ground water than in the deep ground water. Of the seven groups of paired wells, the ground water from the shallow wells contained

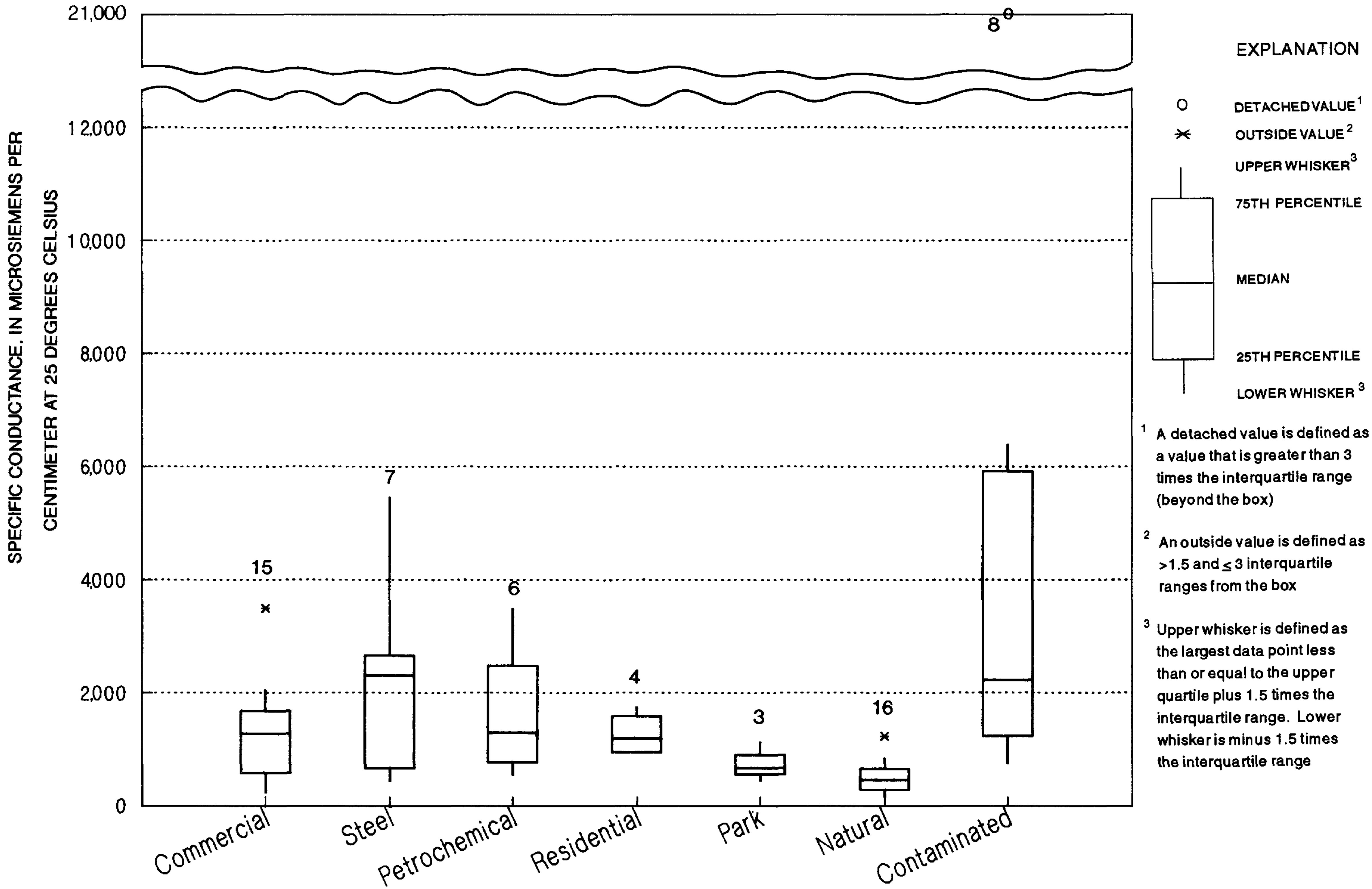

Figure 19. Box plots of specific conductance among seven data sets. (The number of measurements is shown at the top of each plot.)

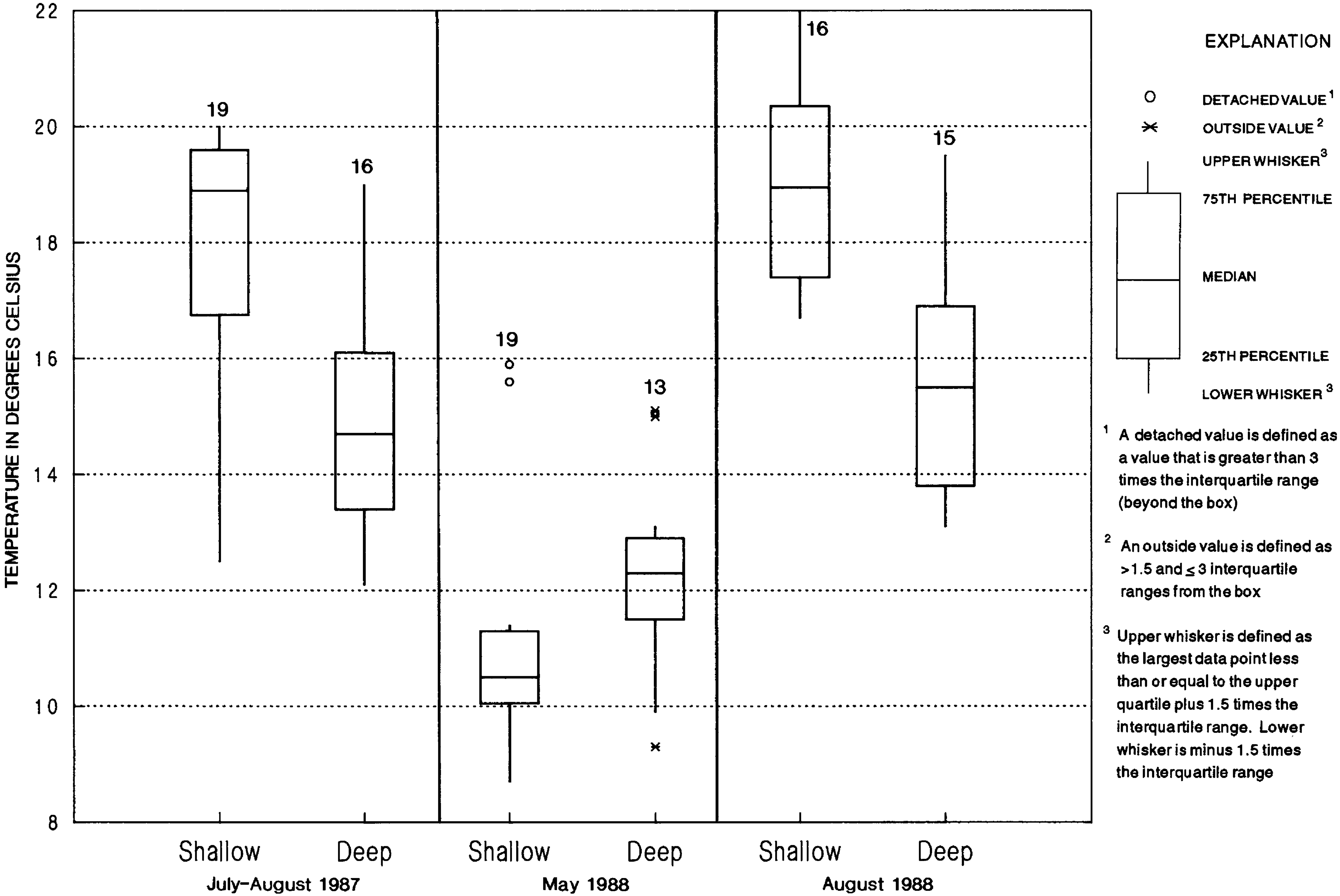

Figure 20. Box plots of temperatures in shallow and deep wells in the water-quality network for three time periods. (The number of measurements is shown at the top of each plot.)

more dissolved oxygen than that from the deep wells during summer 1987 and spring 1988 samplings. The median dissolved-oxygen concentration in the 35 samples was 0.3 mg/L in summer 1987; dissolved oxygen was not detected in water from five wells. Four of the five wells in which dissolved oxygen was not detectable were deep wells, whereas the six highest concentrations of dissolved oxygen (all greater than 3 mg/L) were measured in water from shallow wells. Higher concentrations of dissolved oxygen in the shallow wells are not unexpected because the aquifer is primarily a well-sorted sand in which oxygenated recharge waters can quickly reach the shallow water table.

Inorganic Constituents

A statistical summary of inorganic constituents in the 35 wells that were sampled in 1987 is listed in table 34. These constituents consist of 3 common anions, 4 common cations, 3 nutrients, 10 metals, and arsenic, bromide, boron, cyanide, and silica.

Selected Ions and Hardness

Sample medians from the 19 shallow and the 16 deep wells for seven major ions—calcium, magnesium, potassium, sodium, chloride, fluoride, and sulfate—were compared. The median concentrations in water from the shallow wells were lower than those in water from the deep wells for all ions except fluoride. Some of the difference can be attributed to the use of the land in which the wells are located rather than the depth of the screen in the aquifer. A comparison of the concentrations of the major ions in the seven groups of paired wells was done to determine how depth alone might affect water quality. In five of the seven pairs, concentrations of magnesium, chloride, and sulfate were higher in the deep wells; in four of seven pairs, concentrations of calcium and sodium were higher in the deep wells. Potassium concentrations were higher in three of the deep wells, and fluoride was higher in only one of the seven deep wells.

A statistical summary of the four common cations, three common anions, and boron, bromide, silica, and cyanide, grouped by land use, is shown in table 35. The constituents at the highest concentrations are generally from the "contaminated" group and the constituents at the lowest concentrations are generally from the "natural" group. Among median concentrations for the seven major ions, the highest median concentrations of four of the constituents (calcium, magnesium, sodium, potassium) are from the "contaminated" data set. The steel land-use data set had the highest median concentration for chloride and sulfate and shared the highest median concentration of fluoride with the petrochemical land-use data set. The "contaminated" data set had the maximum concentration for all of the constituents except sulfate, which was highest in the steel land-use data set. The "natural" data set had the lowest median concentrations of six of the seven major ions, whereas the park land-use data set had the lowest median concentration for magnesium.

If the five land-use data sets are compared without the "natural" or "contaminated" data sets, 10 of the 11 highest median concentrations for the constituents are from the steel or petrochemical land-use data sets. The individual maximum concentration for each constituent was in either the steel or the commercial land-use data sets, however.

Hardness

Water from all but two of the 35 wells sampled generally is considered very hard; that is, hardness[3] is greater than 180 mg/L. The median hardness for the petrochemical, steel, commercial, and residential data sets ranges from about 400 to 500 mg/L, whereas the median hardness for the park data set is 250 mg/L (fig. 21). Only the steel land-use data set had values of hardness greater than 800 mg/L, possibly due to the effects of slag. The "natural" data set had a median concentration that was much lower than most of the data sets (200 mg/L), although this concentration also is representative of very hard water. The median hardness for the "contaminated" data set was about 800 mg/L.

[3]All hardnesses are given as equivalents of $CaCO_3$.

Table 34. Statistical summary of inorganic constituents in water from 35 wells sampled in July 1987
[µg/L, microgram per liter; mg/L, milligram per liter; <, less than]

Constituent	Number of samples	Number above detection	Detection limit	Median	First quartile	Third quartile	Minimum	Maximum
Aluminum (µg/L)	35	15	10	<10	<10	20	<10	1,100
Ammonia, as nitrogen (mg/L)	26	26	0.01	0.80	0.10	4.6	0.01	640
Arsenic (µg/L)	35	26	1	3	<1	9	<1	76
Barium (µg/L)	30	27	1	80	19	130	<1	1,000
Boron (µg/L)	31	31	10	300	90	470	20	1,900
Bromide (mg/L)	31	20	.01	.03	< .01	0.08	< .01	4.4
Cadmium (µg/L)	35	2	1	<1	<1	<1	<1	2
Calcium (mg/L)	35	35	1	130	92	160	36	610
Chloride (mg/L)	35	35	.10	109	15	240	1.8	1,200
Chromium (µg/L)	35	12	10	<10	<10	10	<10	100
Copper (µg/L)	35	13	1	<1	<1	2	<1	70
Cyanide (mg/L)	33	10	.01	< .01	< .01	.02	< .01	8.3
Fluoride (mg/L)	35	35	.10	.9	.7	1.6	.1	10
Iron (µg/L)	29	25	1	420	8	4,150	<1	66,000
Lead (µg/L)	35	4	5	<5	<5	<5	<5	200
Magnesium (mg/L)	35	32	.10	21	13	38	< .10	94
Manganese (ug/L)	30	25	1	160	18	458	<1	2,100
Mercury (µg/L)	35	29	.10	.20	.10	.30	< .10	3.90
Nitrate plus nitrite, as nitrogen (mg/L)	28	12	.01	< .01	< .01	1.20	< .01	5.50
Orthophosphate, as phosphorus (mg/L)	25	11	.01	< .01	< .01	.05	< .01	0.26
Potassium (mg/L)	35	35	.10	5.9	3.3	19	1.0	219
Silica (mg/L)	35	35	.10	20	12	31	7.4	55
Sodium (mg/L)	35	35	.10	62	15	150	1.9	860
Sulfate (mg/L)	35	35	.10	93	35	250	7.2	1,200
Zinc (µg/L)	35	29	3	9	4	11	<3	130

Table 35. Statistical summary of cations and anions for seven data sets

[Samples for the residential, commercial, steel, petrochemical, and park data sets were collected in 1987, and samples for the natural and contaminated data sets were collected from 1980 through 1988; µg/L, microgram per liter; mg/L, milligram per liter; <, less than; ≤, less than or equal; ?, detection limit unknown; leaders (--), constituent not sampled]

Constituent	Data aets	Number of samplea	Number above detection	Detection limit	Median	Minimum	Maximum
Calcium (mg/L)	Residential	4	4	0.10	130	57	220
	Commercial	15	15	.10	130	36	240
	Steel	7	7	.10	140	66	610
	Petrochemical	6	6	.10	150	77	250
	Park	3	3	.10	92	59	95
	Natural	18	18	.10	48	13	120
	Contaminated	11	11	?	155	0.72	942
Magnesium (mg/L)	Residential	4	4	.10	19	16	26
	Commercial	15	15	.10	22	6.0	94
	Steel	7	4	.10	18	<.10	50
	Petrochemical	6	6	.10	38	12	68
	Park	3	3	.10	8.0	3.3	48
	Natural	18	18	.10	15	3.0	37
	Contaminated	11	11	?	53	.7	310
Sodium (mg/L)	Residential	4	4	.10	78	9.3	150
	Commercial	15	15	.10	62	1.9	860
	Steel	7	7	.10	100	3.1	170
	Petrochemical	6	6	.10	66	8.4	360
	Park	3	3	.10	21	15	58
	Natural	18	18	.10	8.2	.60	70
	Contaminated	16	16	?	415	12	13,600
Potassium (mg/L)	Residential	4	4	.10	4.2	1.5	34
	Commercial	15	15	.10	5.5	1.0	12
	Steel	7	7	.10	41	1.7	220
	Petrochemical	6	6	.10	10	1.5	27
	Park	3	3	.10	32	1.6	48
	Natural	18	18	.10	1.3	.30	6.1
	Contaminated	11	11	?	107	4.6	15,600
Sulfate (mg/L)	Residential	4	4	1	53	13	540
	Commercial	15	15	1	93	19	1,100
	Steel	7	7	1	370	52	1,200
	Petrochemical	6	6	1	30	7.2	210
	Park	3	3	1	71	60	190
	Natural	18	18	1	30	3.3	120
	Contaminated	8	8	?	185	21	690

Table 35. Statistical summary of cations and anions for seven data sets--Continued

Constituent	Data sets	Number of samples	Number above detection	Detection limit	Median	Minimum	Maximum
Chloride (mg/L)	Residential	4	4	0.10	98	40	250
	Commercial	15	15	.10	110	1.8	420
	Steel	7	7	.10	290	4.6	1,200
	Petrochemical	6	6	.10	114	11	840
	Park	3	3	.10	11	10	52
	Natural	18	18	.10	8.4	1.0	120
	Contaminated	8	8	?	93	22	1,300
Fluoride (mg/L)	Residential	4	4	.10	1.0	0.50	1.3
	Commercial	15	15	.10	0.80	.10	3.2
	Steel	7	7	.10	1.3	.70	10
	Petrochemical	6	6	.10	1.3	.50	2.7
	Park	3	3	.10	.80	.40	1.8
	Natural	10	9	.05–.10	.10	≤ .05	0.30
	Contaminated	12	10	.10	1.0	< .1	62
Silica (mg/L)	Residential	4	4	.10	16	8.3	22
	Commercial	15	15	.10	19	7.4	55
	Steel	7	7	.10	16	8.5	49
	Petrochemical	6	6	.10	29	19	38
	Park	3	3	.10	17	13	26
	Natural	8	8	.10	15	6.2	21
	Contaminated	--	--	--	--	--	--
Boron (µg/L)	Residential	4	4	10	130	90	590
	Commercial	14	14	10	290	50	1,900
	Steel	7	7	10	340	20	510
	Petrochemical	3	3	10	580	190	590
	Park	3	3	10	460	190	1,200
	Natural	8	8	10	150	30	890
	Contaminated	--	--	--	--	--	--
Bromide (mg/L)	Residential	4	4	.01	.05	.02	.11
	Commercial	14	9	.01	.03	< .01	4.4
	Steel	7	3	.01	< .01	< .01	3.3
	Petrochemical	3	2	.01	.03	< .01	.06
	Park	3	2	.01	.08	< .01	.10
	Natural	--	--	--	--	--	--
	Contaminated	--	--	--	--	--	--
Cyanide (mg/L)	Residential	4	0	.01	< .01	< .01	< .01
	Commercial	14	3	.01	< .01	< .01	8.2
	Steel	6	5	.01	.25	< .01	8.3
	Petrochemical	6	1	.01	< .01	< .01	.04
	Park	3	1	.01	< .01	< .01	.01
	Natural	--	--	--	--	--	--
	Contaminated	10	7	.01	.30	< .01	.41

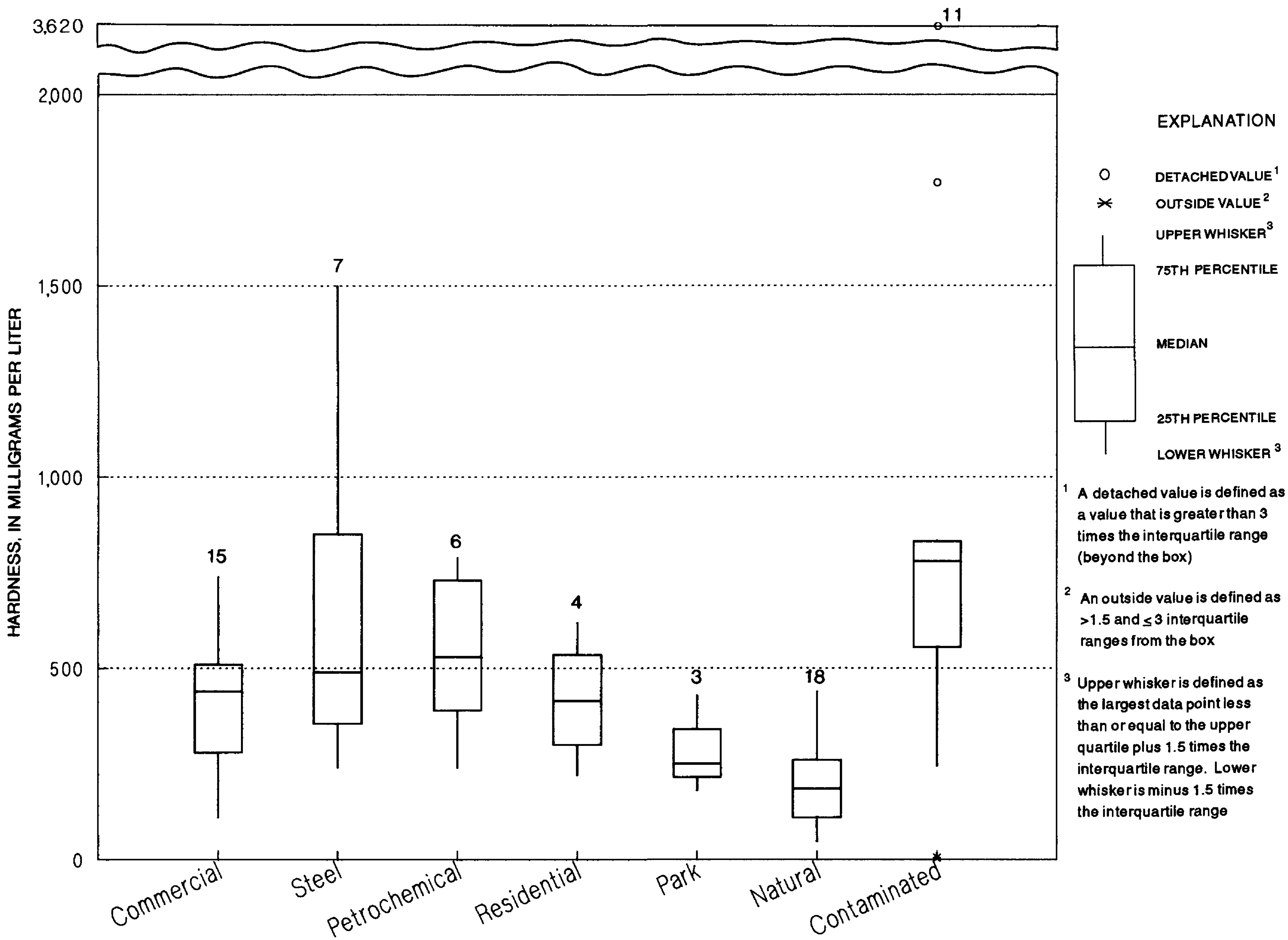

Figure 21. Box plots of hardness among seven data sets. (Soft water is generally considered to contain less than 60 milligrams per liter of hardness as $CaCO_3$ and very hard water greater than 180 milligrams per liter. The number of measurements is shown at the top of each plot.)

Chloride

The Secondary Maximum Contaminant Level (SMCL) for chloride of 250 mg/L (U.S. Environmental Protection Agency, 1986) was exceeded in 7 of the 35 study samples (fig. 22). Of these seven samples, four were from the steel land-use data set, two were from the petrochemical land-use data set, and one was from the commercial land-use data set. Median chloride concentrations ranged from 11 mg/L in the park land-use data set to 300 mg/L in the steel land-use data set. A potential source of some of the high chloride concentrations in the steel land-use data set could be pickling liquors (hydrochloric and sulfuric acids) that are used to process strips of steel. The median chloride concentrations of the five land-use data sets are much greater than those of the "natural" group in which the median concentration was about 8 mg/L. Although the median chloride concentration for the "contaminated" data set was also well below the SMCL, three of the eight "contaminated" samples had chloride concentrations that exceeded the SMCL. The "contaminated" data set also included two of the four highest concentrations among all the groups.

Sulfate

The SMCL for sulfate, 250 mg/L (U.S. Environmental Protection Agency, 1986), was exceeded in 8 of the 35 samples from the sampling network. Four of the samples were from the steel land-use data set, three were from the commercial land-use data set, and one was from the residential land-use data set (fig. 23). As with chloride, only the median concentration from the steel land-use data set exceeded the SMCL. Median concentrations of the samples from the land-use data sets ranged from 30 mg/L for the petrochemical land-use data set to 370 mg/L for the steel land-use data set. This relation of sulfate concentrations to land use is not surprising; the petrochemical industry produces mostly organic compounds, whereas the steel industry uses sulfate in steel production. The "natural" data set had a sample distribution similar to the petrochemical land-use data set and a median concentration of 30 mg/L. Sulfate concentrations in four of the eight samples from the "contaminated" data set exceeded the SMCL, yet the median concentration, 185 mg/L, was below the SMCL.

Fluoride

The Maximum Contaminant Level (MCL) for fluoride is 4 mg/L and the SMCL is 2 mg/L. The SMCL was exceeded in 5 of the 35 samples from the sampling network. Two of the samples were from the petrochemical land-use data set, two were from the commercial land-use data set, and one was from the steel land-use data set. The highest fluoride concentration in the steel land-use data set, 10 mg/L, was the only concentration to exceed the MCL. Four of the 12 samples from the "contaminated" data set exceeded the SMCL.

Nutriente

Analyses for three nutrients—nitrate plus nitrite, ammonia, and orthophosphate—were done and results were compared for differences in concentrations between the shallow and the deep wells. Median concentrations of ammonia and orthophosphate were lower in water samples from the shallow wells than in samples from the deep wells, and 9 of the 10 lowest ammonia concentrations recorded were in the samples from the shallow wells. The median concentration of nitrate plus nitrite in water samples from the shallow wells was higher than those in samples from the deep wells. Samples from the shallow wells had 8 of the 10 highest nitrate plus nitrite concentrations. Among the four paired wells that were sampled for nutrients, water samples from three shallow wells had lower ammonia concentrations and higher nitrate plus nitrite concentrations than did samples from the paired deep well.

A statistical summary by land-use for the three nutrients is given in table 36. Data for the "contaminated" and "natural" sites were available for ammonia and nitrate plus nitrite only. In general, nutrient concentrations in all the land-use data sets were low. The petrochemical and steel land-use data sets had the highest median concentrations for ammonia and orthophosphate and the lowest median concentrations for nitrate plus nitrite, respectively.

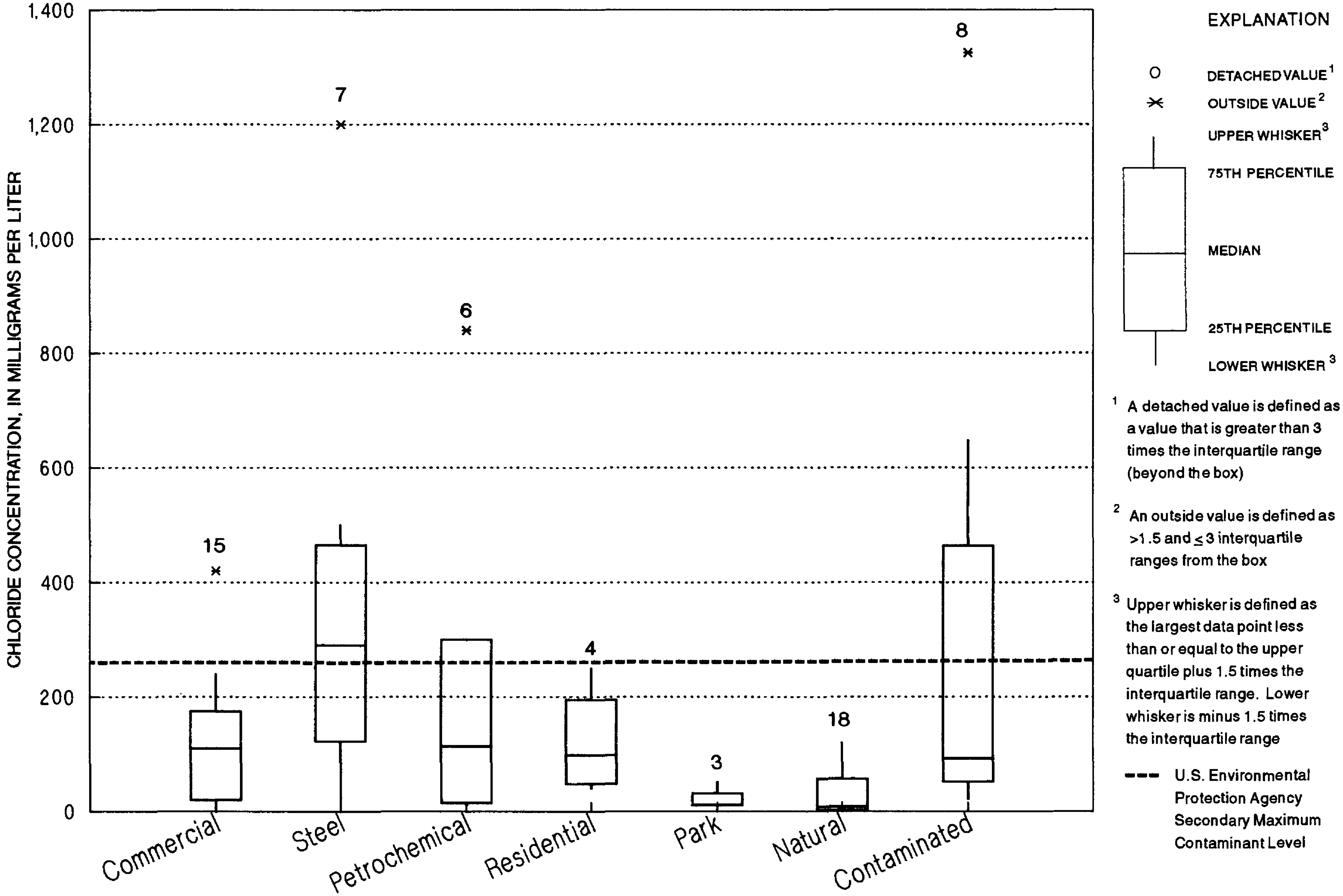

Figure 22. Box plots of chloride concentrations among seven data sets. (The number of measurements is shown at the top of each plot.)

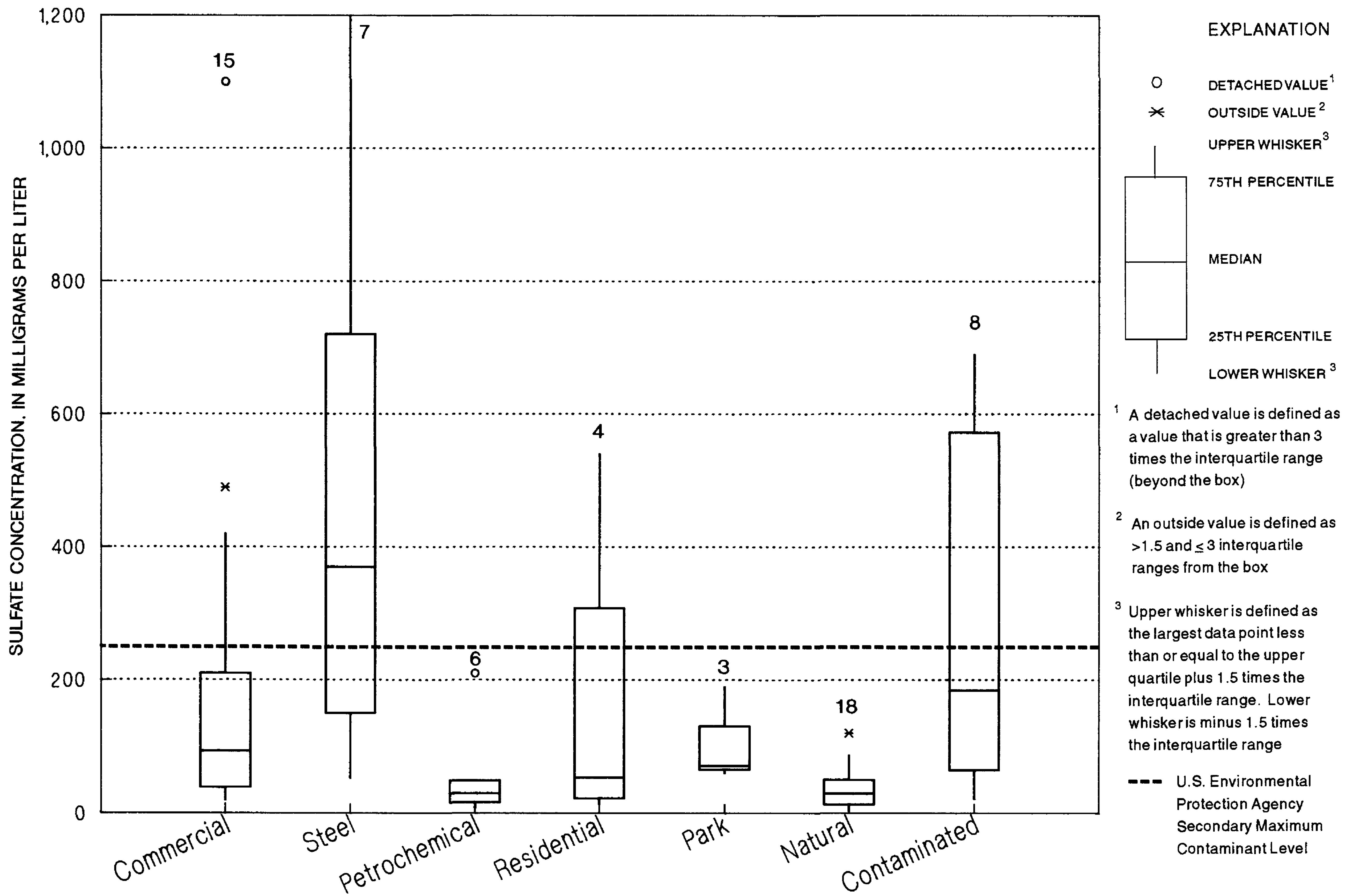

Figure 23. Box plots of sulfate concentrations among seven data sets. (The number of measurements is shown at the top of each plot.)

Although concentrations of all three nutrients were generally low, extreme concentrations were found for ammonia and nitrate plus nitrite. The maximum concentration of ammonia, 640 mg/L, was found in the steel land-use data set. The median concentrations of nitrate plus nitrite for all data sets were low, ranging from about 1 to less than 0.01 mg/L. The highest concentration of nitrate plus nitrite in any of the land-use data sets was about one-half the MCL for nitrate (10 mg/L, as N). Nitrate plus nitrite was detected in all 8 samples from the "natural" data set but, overall, was detected in less than half of the 28 samples analyzed for this study. Although the "contaminated" data set also had a low median concentration of nitrate plus nitrite, it was the only data set to have concentrations that exceeded the MCL for nitrate.

Selected Metals and Arsenic

Concentrations of 10 metals and arsenic were statistically summarized by land-use, "contaminated," and "natural" data sets (table 37). Within the five land-use data sets, the steel land-use data set tended to have the highest median concentrations for the metals. The residential and park land-use data sets contained most of the lowest median concentrations.

The "contaminated" group had higher maximum concentrations than any of the land-use data sets for 9 of the 11 elements listed in table 37; lead and mercury were the exceptions. Among the land-use data sets, the commercial, petrochemical, steel, and residential land-use data sets had 4, 3, 2, and 1 of the maximum concentrations, respectively, of the elements listed in table 37 (excluding

Table 36. Statistical summary of three nutrients for seven data sets

[Samples for the residential, commercial, steel, petrochemical, and park data sets were collected in 1987, and samples for the natural and contaminated data sets were collected from 1980 through 1988; mg/L, milligram per liter; <, less than; leaders (--), constituent not sampled]

Constituent	Data set	Number of samples	Number above detection	Detection limit(s)	Median	Minimum	Maximum
Ammonia, as nitrogen (mg/L)	Residential	3	3	0.01	0.09	0.05	4.5
	Commercial	12	12	.01	.78	.01	6.8
	Steel	7	7	.01	2.3	.18	640
	Petrochemical	3	3	.01	8.5	.87	13
	Park	2	2	.01		.05	0.20
	Natural	8	8	.01	.25	.04	.89
	Contaminated	7	3	.2	<.2	<.2	173
Nitrate plus nitrite, as nitrogen (mg/L)	Residential	3	2	.01	1.2	<.01	5.5
	Commercial	12	6	.01	.16	<.01	2.0
	Steel	7	3	.01	<.01	<.01	2.6
	Petrochemical	3	0	.01	<.01	<.01	<.01
	Park	3	1	.01	<.01	<.01	.02
	Natural	8	8	.01	.06	.02	.96
	Contaminated	12	10	.02, 0.1	.12	<.02	240
Orthophosphate, as phosphorus (mg/L)	Residential	3	1	.01	<.01	<.01	.01
	Commercial	13	3	.01	<.01	<.01	.14
	Steel	6	4	.01	.05	<.01	.15
	Petrochemical	3	2	.01	.12	<.01	.26
	Park	2	1	.01		<.01	.01
	Natural	8	2	.01	<.01	<.01	.08
	Contaminated	--	--	--	--	--	--

Table 37. Statistical summary of selected metals and arsenic for seven data sets

[Samples for the residential, commercial, steel, petrochemical, and park data sets were collected in 1987, and samples for the natural and contaminated data sets were collected from 1980 through 1988; µg/L, microgram per liter; <, less than; ≤, less than or equal; ?, detection limit unknown; leaders (--), constituent not sampled]

Constituent	Data set	Number of samples	Number above detection	Detection limit	Median	Minimum	Maximum
Aluminum (µg/L)	Residential	4	0	10	<10	<10	<10
	Commercial	15	8	10	10	<10	1,100
	Steel	7	4	10	20	<10	620
	Petrochemical	6	2	10	<10	<10	40
	Park	3	1	10	<10	<10	20
	Natural	--	--	--	--	--	--
	Contaminated	10	7	[1]170–360	<360	≤170	7,400
Arsenic (µg/L)	Residential	4	1	1	<1	<1	4
	Commercial	15	11	1	2	<1	55
	Steel	7	5	1	6	<1	17
	Petrochemical	6	6	1	3	3	76
	Park	3	3	1	1	1	3
	Natural	--	--	--	--	--	--
	Contaminated	15	7	[1]5–20	<10	<5	178
Barium (µg/L)	Residential	4	4	5	51	8	180
	Commercial	14	13	5–100	100	≤7	600
	Steel	7	6	5–100	100	≤19	1,000
	Petrochemical	3	2	5–100	<100	≤34	100
	Park	3	3	5	60	38	100
	Natural	--	--	--	--	--	--
	Contaminated	13	7	[1]50–500	<500	<50	1,300
Cadmium (µg/L)	Residential	4	0	1	<1	<1	<1
	Commercial	15	0	1–10	<1	<1	<10
	Steel	7	1	1	<1	<1	1
	Petrochemical	6	0	1–4	<1	<1	<4
	Park	3	1	1	<1	<1	2
	Natural	--	--	--	--	--	--
	Contaminated	14	3	[1]3–50	<20	<3	125
Chromium (µg/L)	Residential	4	1	10	<10	<10	10
	Commercial	15	3	10	<10	<10	40
	Steel	7	4	10	10	<10	100
	Petrochemical	6	4	10	15	<10	20
	Park	3	0	10	<10	<10	<10
	Natural	--	--	--	--	--	--
	Contaminated	15	4	[1]6–100	<60	<6	120

Table 37.--Statistical summary of selected metals and arsenic for seven data sets--Continued

Constituent	Dsta set	Number of samples	Number above detection	Detection limit	Medisn	Minimum	Maximum
Copper (µg/L)	Residential	4	3	1	2	<1	3
	Commercial	15	7	1	<1	<1	70
	Steel	7	3	1	<1	<1	64
	Petrochemical	6	0	1	<1	<1	<1
	Park	3	0	1	<1	<1	<1
	Natural	--	--	--	--	--	--
	Contaminated	10	4	[1]5–200	<40	≤5	1,300
Iron (µg/L)	Residential	4	3	3	10	<3	5,700
	Commercial	13	12	3	2,700	<3	24,000
	Steel	7	5	3–10	50	<3	9,300
	Petrochemical	3	3	3	2,800	1,600	66,000
	Park	3	3	3	81	8	420
	Natural	8	8	3	840	20	8,200
	Contaminated	16	15	30	830	<30	87,000
Lead (µg/L)	Residential	4	1	5	<5	<5	6
	Commercial	15	2	5	<5	<5	200
	Steel	7	0	5	<5	<5	<5
	Petrochemical	6	1	5	<5	<5	6
	Park	3	0	5	<5	<5	<5
	Natural	--	--	--	--	--	--
	Contaminated	16	8	[1]4–100	<40	<4	65
Manganese (µg/L)	Residential	4	3	1	62	<1	2,100
	Commercial	14	11	1	135	<1	910
	Steel	7	6	10	250	<10	1,100
	Petrochemical	3	3	1	690	250	1,700
	Park	3	3	1	120	110	430
	Natural	8	8	1	170	20	350
	Contaminated	15	14	50	335	<50	4,500
Mercury (µg/L)	Residential	4	4	.1	.35	.2	.4
	Commercial	15	12	.1	.2	< .1	.5
	Steel	7	5	.1	.2	< .1	.7
	Petrochemical	6	5	.1	.15	< .1	3.9
	Park	3	3	.1	.2	.2	.2
	Natural	--	--	--	--	--	--
	Contaminated	14	3	[1].2–.5	< .2	< .2	.99
Zinc (µg/L)	Residential	4	2	3	4	<3	15
	Commercial	15	13	3–10	9	<3	130
	Steel	7	6	3–10	10	≤4	20
	Petrochemical	6	5	3	8	<3	23
	Park	3	3	3	9	5	11
	Natural	--	--	--	--	--	--
	Contaminated	11	11	?	110	30	10,100

[1]The range in detection limiis in the "contaminated" data set reflects analysis by different water-quality laboratories.

cadmium). The park land-use data set had or shared the lowest concentration for all constituents but cadmium. Aluminum, cadmium, chromium, copper, and lead were detected in fewer than half of the samples collected for the study.

Median concentrations of arsenic, barium, iron, and manganese were generally higher in the samples from the deep wells than from the shallow wells in the sampling network. Of the five sets of paired wells in which both were sampled for iron, samples from the deeper of the two wells had iron concentrations that were 30 to more than 1,000 times greater than those from the shallow well. Of the seven paired wells that were sampled for copper, five of the seven samples from the shallow wells were higher. Most of the other metals differed little in concentration between the shallow and deep paired wells.

Concentrations of copper and zinc did not exceed the SMCL's in any of the land-use data set samples, whereas SMCL's for copper and zinc were each exceeded once in the "contaminated" data set. The SMCL for manganese was exceeded in 21 of the 30 samples collected for this study, 14 of the 15 samples in the "contaminated" data set, and 6 of the 8 samples in the "natural" data set. The SMCL for iron was exceeded in 16 of the 30 samples collected for this study, 13 of the 16 samples in the "contaminated" data set, and 6 of the 8 samples in the "natural" data set (fig. 24).

The MCL's for the metals and arsenic were rarely exceeded. Within the land-use data sets, mercury concentrations exceeded the MCL (0.002 mg/L) in one water sample from the petrochemical land-use data set, lead concentrations exceeded the MCL (0.05 mg/L) in one sample from the commercial land-use data set, and chromium concentrations exceeded the MCL (0.05 mg/L) in two water samples from the steel land-use data set. The MCL for arsenic (0.05 mg/L) was exceeded in two samples, one from the petrochemical land-use data set and the other from the same commercial land-use water sample that exceeded the MCL for lead. In the "contaminated" data set, the MCL's for arsenic and chromium were exceeded twice, and the MCL for lead was exceeded once. The MCL for cadmium (0.01 mg/L) was exceeded twice, and the MCL for barium (1.0 mg/L) was exceeded three times only in the "contaminated" data set.

Organic Compounds

Water samples collected for this study were analyzed for 88 organic compounds. These compounds, which are on the USEPA list of organic "priority pollutants," include acid-extractable, base/neutral-extractable, and volatile organic compounds but exclude pesticides and polychlorinated biphenyls (PCB's).

Acid-Extractable and Base/Neutral-Extractable Organic Compounds

The 52 acid-extractable and base/neutral-extractable organic compounds that were sampled for this study are listed in table 4. Of those, 45 were not found in concentrations that exceeded their detection limits in any of the study samples. Four compounds, bis(2-ethylhexyl)-phthalate, di-n-butyl phthalate, phenol, and total phenols, were detected in three or more water samples. A statistical summary of the seven compounds detected is given in table 38.

Acid-extractable and base/neutral-extractable organic compounds were detected in so few water samples that few comparisons can be made between those compounds that were found in shallow wells and those found in deep wells. In the 7 sets of paired wells, there were 12 detections of the compounds in the shallow wells and 11 detections in the deep wells. Most of the detections were of total phenols, which were found in higher concentrations in water samples from shallow wells than in samples from deep wells at five of the seven paired-well sites.

Five of the seven compounds that were detected in the study sample group (table 38) were found in three water samples or fewer. Acenaphthene and 2-4-dimethylphenol were detected in only one sample, from the steel land-use data set. Naphthalene was detected in the same steel land-use

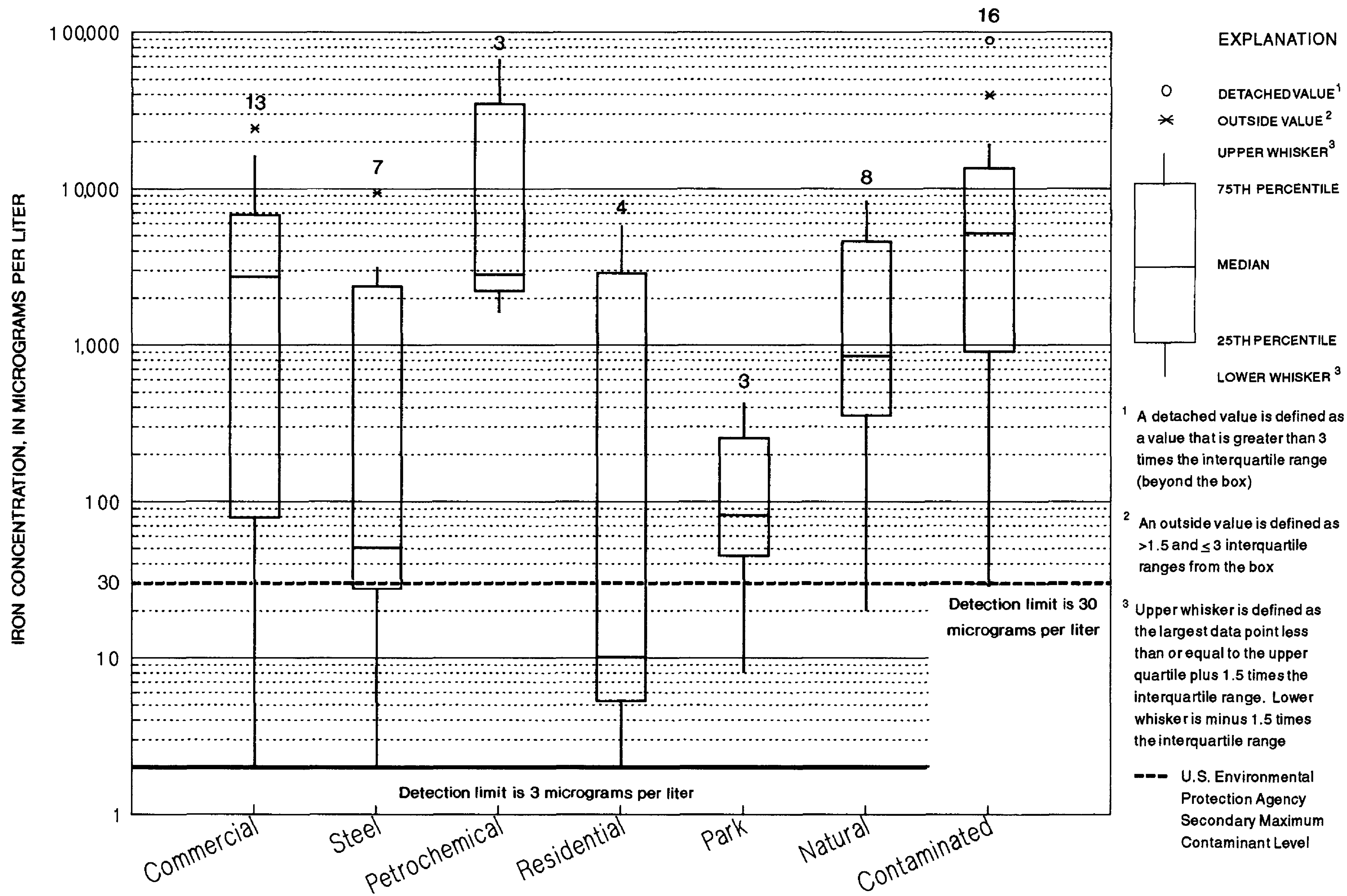

Figure 24. Box plots of iron concentrations among seven data sets. (The number of measurements is shown at the top of each plot.)

Table 38. Statistical summary of acid-extractable and base/neutral-extractable compounds detected in July 1987
[Numbers are concentrations in micrograms per liter]

Chemical	Number of samples	Number above detection	Detection limit	Median	Minimum	Maximum
Acenaphthene	35	1	5	<5	<5	33
Bis(2-ethylhexyl)phthalate	35	20	5	8	<5	100
2-4-Dimethylphenol	35	1	5-6	<5	<5	86
Di-n-butyl phthalate	35	3	5	<5	<5	220
Naphthalene	35	1	5	<5	<5	16
Phenol	35	3	5	<5	<5	73
Phenols, total	35	35	1	3	1	310

water sample and in a sample from the petrochemical land-use data set. Both of these water samples and a sample from the commercial land-use data set contained detectable phenol. Di-n-butyl phthalate was detected in three water samples from the commercial land-use data set.

Of the seven compounds that were detected in the study sample group, only two were not found in at least one of the "contaminated" water samples. One was di-n-octyl phthalate; the other was phenol, for which water samples were not collected in the "contaminated" data set. Six other compounds—bis(2-chloroethyl) ether; bis(2-chloroisopropyl) ether; diethyl phthalate; phenanthrene; 2,4-dinitrotoluene; and 4-nitrophenol—also were detected in the "contaminated" data set, but not more than twice.

Detections and concentrations of phenols and bis(2-ethylhexyl)phthalate are statistically summarized by the land-use, "natural," and "contaminated" data sets in table 39. Although the USEPA has not established a regulation for phenols, Canada has set a maximum acceptable concentration of phenols at 2 µg/L (Sayre, 1988). Of the 35 samples analyzed, 71 percent or 25 samples contained phenols in concentrations that exceeded 2 µg/L, and three contained greater than 20 µg/L. Samples from all 13 wells in the steel and petrochemical land-use data sets exceeded the Canadian guideline, and they include the four highest phenol concentrations detected. Slightly more than one-half of the water samples in the commercial, residential, and park land-use data sets exceeded the Canadian guideline. The significance of phenols in the "contaminated" data-set samples is less clear; although phenols were detected in only three samples (exceeding the Canadian guideline in each sample), the detection limit was 10 µg/L—five times the Canadian guideline.

Of the 35 samples, 20 contained detectable concentrations of bis(2-ethylhexyl)phthalate. Phthalate esters, of which bis(2-ethylhexyl)-phthalate is one of the most common, are widely used as plasticizers to produce plastics for home construction, automobiles, furnishings, tubing, food containers, and plastic bags. They also are used in pesticides, oils, and insect repellant (Smith and others, 1987). Although bis(2-ethyl-hexyl)phthalate was detected in water samples from wells in all five land-use groups, it was detected most often in samples from residential, park, and steel land-use data sets. Only 1 of the 15 water samples from the "contaminated" data set contained more than 10 µg/L of bis(2-ethyl-hexyl)phthalate, whereas 15 of the 35 study samples had concentrations greater than 10 µg/L.

Because bis(2-ethylhexyl)phthalate is used so extensively in production of common materials, water samples can easily be contaminated with bis(2-ethylhexyl)phthalate from sampling equipment (Smith and others, 1987). Sample water from this study may have been contaminated with bis(2-ethylhexyl)phthlate while in contact with the

Table 39. Statistical summary of bis(2-ethylhexyl)phthalate and total phenols for seven data sets

[Samples for the residential, commercial, steel, petrochemical, and park data sets were collected in 1987, and samples for the natural and contaminated data sets were collected from 1980 through 1988; µg/L, microgram per liter; <, less than; ≤, less than or equal; leaders (--), constituent not sampled]

Constituent	Data set	Number of samples	Number above detection	Detection limit	Median	Minimum	Maximum
Bis(2-ethylhexyl)-phthalate (µg/L)	Residential	4	4	5	10	8	25
	Commercial	15	7	5	<5	<5	100
	Steel	6	5	5	13	<5	19
	Petrochemical	6	2	5	<5	<5	11
	Park	3	2	5	14	<5	19
	Natural	--	--	--	--	--	--
	Contaminated	11	1	[1]3–10	<10	<10	≤3
Phenols (µg/L)	Residential	4	4	1	2.5	1	4
	Commercial	15	15	1	3	1	14
	Steel	7	7	1	6	3	190
	Petrochemical	6	6	1	9	3	310
	Park	3	3	1	3	2	5
	Natural	--	--	--	--	--	--
	Contaminated	15	3	[1]3–10	<10	≤3	110

[1]The range in detection limits in the "contaminated" data set reflects analysis by different water-quality laboratories.

Tygon intake tube and the silicon rubber tubing in the peristaltic pump. Low concentrations of bis(2-ethylhexyl)phthalate (less than 20 µg/L) are generally not considered indications of environmental contamination but rather are accepted as artifacts of the sampling procedure (Karyl Schmidt, Indiana Department of Environmental Management, oral commun., 1988; Mark Hardy, U.S. Geological Survey, oral commun., 1988). Four samples had concentrations greater than 20 µg/L—three in the commercial and one in the residential land-use data sets.

Volatile Organic Compounds

Of the 36 volatile organic compounds that were analyzed for in water samples, a total of 17 different compounds were detected—13 in 1987 and 14 in 1988 (table 5). The statistical summary for nine volatile organic compounds that were detected in at least three samples during one of the sampling periods is given in table 40. These nine compounds include benzene, chloroform, dichlorodifluoromethane, ethylbenzene, tetrachloroethylene, trichloroethylene, trichlorofluoromethane, toluene, and xylenes.

There is little evidence to suggest a relation of volatile organic compound concentration to depth. The number of occurrences of volatile organic compounds with higher concentrations in a sample from a shallow well as compared to a sample from the corresponding deep well was examined for each paired-well site. In 1987, there were 10 occurrences in which the concentrations were higher in the shallow wells and 9 in which concentrations were lower; in 1988, there were 9 occurrences in which the concentrations were higher in the shallow wells and 6 in which concentrations were lower.

MCL's have been established for only eight volatile organic compounds (table 32). Of these eight, carbontetrachloride, 1,2-dichloroethane, 1,1,1-trichloroethane, and para-1,4-dichlorobenzene were not detected in water samples

Table 40. Statistical summary of volatile organic compounds that were detected three or more times

Chemical	Year sampled	Number of samples	Number above detection limit	Concentration, in micrograms per liter	
				Detection limit	Maximum
Benzene	1987	31	18	0.2	1,900
	1988	34	23	.2	1,400
Chloroform	1987	31	5	.2	12
Dichlorodifluoromethane	1988	34	4	.2	5.0
Ethylbenzene	1987	31	4	.2	19
Tetrachloroethylene	1988	34	4	.2	11
Trichloroethylene	1988	34	5	.2	0.4
Trichlorofluoromethane	1988	34	4	.2	22
Toluene	1987	31	11	.2	1.5
	1988	34	3	.2	.7
Xylenes	1987	31	5	.2	19
	1988	34	5	.2	1.9

collected in 1987 or in 1988. Trichloroethylene and 1,1-dichloroethylene were detected at concentrations less than their MCL's. Only benzene and vinyl chloride were detected at concentrations exceeding their MCL's. Vinyl chloride was detected in only one water sample in 1988, and the concentration exceeded the MCL of 2 μg/L. Benzene concentrations in two water samples collected in 1987 and 5 samples collected in 1988 exceeded the MCL of 5 μg/L (fig. 25). The two samples collected in 1987 contained benzene in concentrations of 1,000 μg/L or greater. All samples that contained benzene concentrations that exceeded the MCL were from wells in the petrochemical or steel land-use areas.

Detections and concentrations of benzene, toluene, and xylenes are statistically summarized by the land-use, "natural," and "contaminated" data sets in table 41. Benzene was detected in 18 of the 31 samples in 1987, and 23 of the 34 samples in 1988. Benzene was detected in samples from all five land-use groups; however, it was most common in the steel, petrochemical, and commercial land-use data sets. Although benzene was detected most frequently in samples from the steel land-use area, samples from the petrochemical land-use area tended to have the highest concentrations. In figure 25, the "contaminated" data set is difficult to compare with other data sets because the detection limit was 25 times greater (5 μg/L) for the "contaminated" data set than for the other data sets. The "contaminated" data set did, however, include some extreme concentrations; 3 samples exceeded the MCL by a factor of 10.

Benzene, toluene, and xylenes were the only volatile organic compounds detected three or more times in both 1987 and 1988. In 1988, every water sample in which either toluene or xylenes were detected also contained benzene. This is not surprising because benzene is commonly associated with toluene and xylenes. Toluene was most often detected in the petrochemical, residential, and steel land-use groups, where it was in 4 of the 12, 2 of the 6, and 3 of the 13 water samples, respectively (table 41). Toluene was also in 3 of the 11 water samples (at a higher detection limit) in the "contaminated" data set, in which the maximum concentration was 3,300 μg/L. Xylenes were most commonly detected in the petrochemical and steel land-use groups, where they were found in 4 of the 12 and 3 of the 13 water samples (table 41). As with toluene, xylenes were detected in 3 of the 11 "contaminated" data set samples (at a higher detection limit); maximum concentration was 6,300 μg/L.

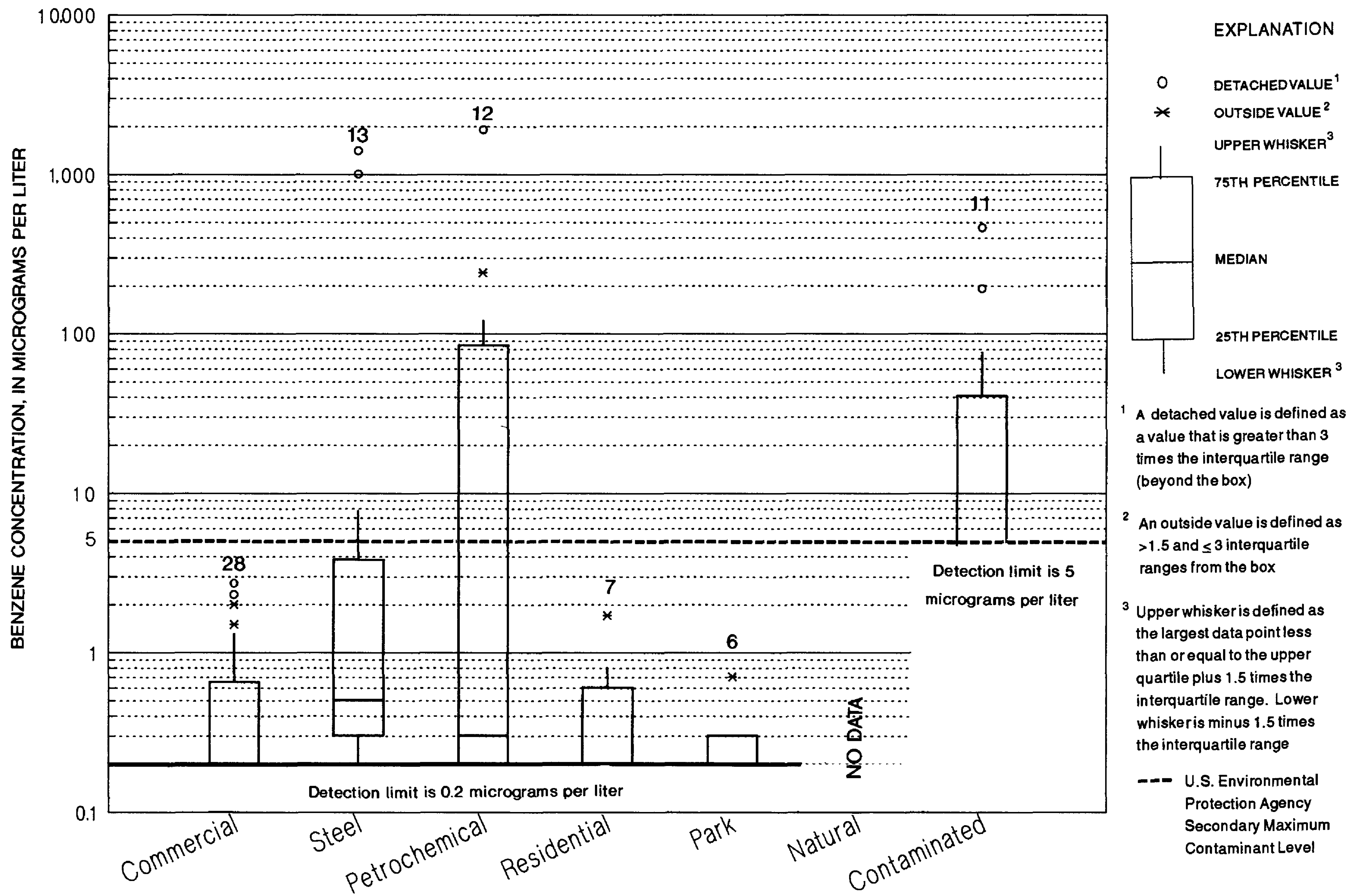

Figure 25. Box plots of benzene concentrations among seven data sets. (The number of measurements is shown at the top of each plot.)

Quality Assurance-Quality Control

In August 1988, three blanks of deionized water were submitted to the USGS National Water-Quality Laboratory for analyses of volatile organic compounds. No detectable compounds were found in one blank, four were detected in the second blank, and five were detected in the third blank (table 31, in the "Supplemental Data" section at the back of the report). The nine compounds found were all different.

Most of the volatile organic compounds detected in the blanks were not commonly found in the water samples. Three of the nine compounds were not detected in any of the August 1988 samples, and three were detected only once. The only compounds whose concentrations exceeded or were equal to 1 µg/L in the blanks were chloroform and dichlorobromomethane. These compounds are common in chlorinated drinking water, which was used as the source of the deionized water used for the blanks (Thomas Imbrigiotta, U.S. Geological Survey, written commun., 1991). Because of this and because the compounds detected in the blanks were generally not detected in the water samples, it is probable that

Table 41. Statistical summary of three volatile organic compounds for seven data sets

[Samples for the residential, commercial, steel, petrochemical, and park data sets were collected in 1987, and samples for the natural and contaminated data sets were collected from 1980 through 1988; µg/L, microgram per liter; <, less than; ≤, less than or equal; leaders (--), constituent not sampled]

Constituent	Data set	Number of samples	Number above detection	Detection limit	Median	Minimum	Maximum
Benzene (µg/L)	Residential	6	3	0.2	0.3	<0.2	1.7
	Commercial	28	17	.2	.2	<.2	2.7
	Steel	13	11	.2	.5	<.2	1,400
	Petrochemical	12	8	.2	.3	<.2	1,900
	Park	6	2	.2	<.2	<.2	.7
	Natural	--	--	--	--	--	--
	Contaminated	11	3	[1]5–10	<5	<5	460
Toluene (µg/L)	Residential	6	2	.2	<.2	<.2	.3
	Commercial	28	4	.2	<.2	<.2	.3
	Steel	13	3	.2–10	<.2	<.2	.9
	Petrochemical	12	4	.2	<.2	<.2	1.5
	Park	6	1	.2	<.2	<.2	.2
	Natural	--	--	--	--	--	--
	Contaminated	11	3	[1]1–10	<5	≤1	3,300
Xylenes (µg/L)	Residential	6	0	.2	<.2	<.2	<.2
	Commercial	28	2	.2	<.2	<.2	2.2
	Steel	13	3	.2–10	<.2	<.2	3.2
	Petrochemical	12	4	.2	<.2	<.2	19
	Park	6	1	.2	<.2	<.2	.3
	Natural	--	--	--	--	--	--
	Contaminated	11	3	[1]5–10	<5	<5	6,300

[1]The range in detection limits in the "contaminated" data set reflects analysis by different water-quality laboratories.

the deionized water used for the blanks was contaminated.[4] It is also possible that contamination occurred during sampling or laboratory analyses.

Five sample duplicates were collected in August 1988 for analyses of volatile organic compounds (table 31, in the "Supplemental Data" section at the back of the report). A volatile organic compound was detected in a water sample and not in the duplicate in only nine instances. In eight of these instances, the concentrations were less than or equal to 0.8 µg/L.

Of the wells that were sampled for volatile organic compounds in 1987 and 1988, a total of 103 volatile compounds were detected (50 in 1987 and 53 in 1988). Of the 50 compounds detected in 1987, 25 were not detected in the same well in 1988. Of the 53 compounds detected in 1988, 28 were not detected in the same well in 1987. Changes in detection of the compounds between years may indicate changes in the ground-water quality caused by changes in flow paths; however, many of the differences (especially at concentrations near the detection limit) could be caused by problems with repeatability of results because of differences in sampling and(or) laboratory procedures.

Five blanks were submitted for cyanide analysis in May 1988. Four of the five blanks contained no detectable cyanide, whereas one water sample had a concentration that was just above the detection limit (table 30, in the "Supplemental Data" section at the back of the report). Four duplicate water samples were collected for cyanide analysis. Concentrations for all four samples were the same as the concentrations for the sample they were duplicating (table 30, in the "Supplemental Data" section at the back of the report).

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[4]A water sample taken directly from the same water-purifying system used to make the deionized water for this study was analyzed for volatile organic compounds in 1992. Eight compounds (not present in a sample of the office tap water) were found in the deionized water sample at concentrations from 0.2 to 1.5 µg/L. The compounds were unintentionally introduced into the deionized water by the water-purifying system.

Chemical Loads in Discharge from the Calumet Aquifer

Several investigators have monitored the chemical mass discharges (loads) in the Grand Calumet River (Crawford and Wangsness, 1987; HydroQual, Inc., 1984) and have found that chemical loads measured in effluent from industrial and municipal discharges did not account for all instream chemical loads. HydroQual, Inc. (1984) determined that instream loads of chloride, ammonia, iron, lead, mercury, and sulfate could not be accounted for by the known sources to the river. Crawford and Wangsness (1987) determined that known sources could not account for all the chloride, ammonia, iron, lead, sulfate, dissolved solids, chromium, zinc, nitrate, and copper in the river. In both studies, the unaccounted for chemical loads were attributed to several possible sources, including measurement error and unmeasured chemical loads from sources such as combined and separate sewers, wastewater lagoons, landfills, nonpermitted outfalls, and ground water. An estimate of the loads contributed by ground water is described in the following sections.

Ground-water chemical loads to the Grand Calumet River were calculated by use of the following equation:

$$\text{Chemical load} = \text{concentration} \times \text{discharge} \times 5.395, \quad (1)$$

where chemical load is in pound per day,
concentration is in milligram per liter,
discharge is in cubic foot per second,
and 5.395 is the factor that converts milligram per liter multiplied by cubic foot per second to pound per day.

Concentrations used in the equation were determined from the average constituent concentrations in water samples from wells that were intercepting ground water that was expected to be discharging to the Grand Calumet River. Water samples with constituent concentrations below the detection limit were assigned a concentration of one-half the detection limit. The wells used are shown in table 42. The average concentration of a constituent

Table 42. Wells used to characterize ground-water quality for calculations of chemical loads to major ground-water sinks
[See figure 4 for well locations]

Discharge area	Well names
Grand Calumet River	A3, A4, B3, B7, B8, B10, C10, C12, C18, C20, D66, D67, D68, E10
East branch of Grand Calumet River, and Indiana Harbor Canal	A3, A4, B3, B7, B8, B10, C10, C12, C18, C20, D20, D21, D30, D31, D40, D60, D66, D67, D68, E6, E7
Lake Michigan	A2, A6, B2, C1, C2, C3, C4, D10, D11, E2
Bedrock	A2, A4, B2, B3, B8, C2, C3, C12, C18, D11, D21, D31, D66, D68, E3, E6
Sewers	A20, B10, C20, D21, D40, E20

among these wells was then assigned to the ground-water discharge for the entire river reach by use of equation 1. Discharges are based on an estimate of ground-water discharge calculated from the ground-water-flow model that incorporated a horizontal hydraulic conductivity of 50 ft/d for the aquifer.

The estimates of chemical loads to the discharge areas may be in error by large amounts (which are not estimated) because of the uncertainty of the concentration and discharge values used in equation 1. The average concentration of a constituent in the wells listed in table 42 was assumed to represent the quality of the water flowing to a particular discharge area. This average concentration is based on a limited number of wells which only approximates the true constituent concentration of the discharge water. The discharge values were obtained from the uncalibrated model and, as such, are only the best estimate of ground-water discharge, given the uncertainty of many of the modeling parameters (see "Model Evaluation and Limitations" section). Because of the uncertainty of the concentration and discharge values, the calculated chemical loads are considered to be a first approximation of chemical loads to the discharge areas.

Chemical Loads to the Grand Calumet River

Calculated ground-water chemical loads from data collected in this study, estimates of the municipal and industrial chemical loads (Crawford and Wangsness, 1987), and unaccounted for or unknown chemical loads to the Grand Calumet River in 1984 (Crawford and Wangsness, 1987) are summarized in table 43. The unaccounted for or unknown chemical loads were calculated by subtracting synchronous measurements of the municipal and industrial chemical loads from the total chemical loads measured in the Grand Calumet River. The reach of the Grand Calumet River included in all chemical-load measurements shown in table 43 extends from the headwaters of the river in Gary to about 1 mi west of the Indiana-Illinois State line and includes the southern 0.2 mi of the Indiana Harbor Canal—a total distance of 14.4 river miles.

Chemical loads in ground water that discharged to the Grand Calumet River in 1987 could be somewhat less than loads in 1984 because ground-water discharge decreased in response to high Lake Michigan levels in 1987 that raised the level of the Grand Calumet River near the Indiana Harbor Canal. The increased river level reduced the ground-water gradient to the river and, thus, reduced ground-water discharge. Given the change in gradient and the amount of river affected, however, the change in discharge to the Grand Calumet River is probably less than 10 percent. For study purposes, this decrease in ground-water discharge was considered insignificant, and comparisons were made between the unknown 1984 chemical loads and the calculated 1987 ground-water chemical loads.

Ground water could be a contributing source of some of the unaccounted for chemical loads determined by Crawford and Wangsness (1987). Estimated ground-water loads of ammonia could account for the entire unaccounted for load; sulfate and dissolved solids could account for 25 to 50 percent of the unaccounted for load; chloride, chromium, copper, iron and lead could account for

Table 43. Estimates of chemical loads[1] of selected constituents to and within the Grand Calumet River
[lb/d, pound per day; --, load is not statistically significant]

Constituent	Direct industrial and municipal load to Grand Calumet River,[2] 1984 (lb/d)	Unaccounted for or unknown load to Grand Calumet River,[2] 1984 (lb/d)	Calculated ground-water load to Grand Calumet River, 1987 (lb/d)
Dissolved solids	870,000	91,000	36,000
Chloride	180,000	39,000	5,200
Sulfate	160,000	22,000	9,400
Fluoride	2,100	--	62
Hardness, as $CaCO_3$	420,000	--	14,000
Ammonia, as nitrogen	2,200	1,500	2,500
Nitrate plus nitrite, as nitrogen	4,700	1,400	24
Chromium	2.8	4	0.74
Copper	5.8	4.2	.42
Iron	1,800	1,800	200
Lead	7.1	14	.73
Mercury	2.1	--	.01
Zinc	96	56	.68
Phenols	74	--	.63
Cyanide	110	--	25

[1]Loads are estimated over a 14.4 mile reach of the Grand Calumet River within the study area.
[2]Loadings from Crawford and Wangsness (1987).

about 5 to 20 percent of their unaccounted for loads; and nitrate plus nitrite and zinc could account for only 1 to 2 percent of the unaccounted for loads.

If ground water is a major contributor of many of these constituents to the Grand Calumet River, the constituents probably enter the river in one or more localized discharges of highly contaminated ground water. For example, ammonia and cyanide data show that a relatively small area of highly contaminated water has the potential to add a large chemical load to the river. About 800 lb/d of unaccounted for ammonia loading and 12 lb/d of unaccounted for cyanide entered the upper reach of the Grand Calumet River (Crawford and Wangsness, 1987) near a steel mill coke plant. Water from a nearby monitoring well contained the highest ammonia and cyanide concentrations (640 mg/L and 8.4 mg/L, respectively) detected in any of the wells sampled in this study (table 30, in the "Supplemental Data" section at the back of the report). Calculation of ammonia and cyanide loads in the upper reach of the Grand Calumet River with equation 1 required an estimate of ground-water discharge. The model-generated discharge of ground water to a 2,000-ft-long river cell on the upper reach of the Grand Calumet River is about 0.5 ft^3/s. If one-half of the flow comes from each side of the river, the discharge rate along the 2,000-ft reach of river on the north side of the Grand Calumet River would be about 0.25 ft^3/s. It is reasonable to assume that shallow ground water adjacent to this 2,000-ft reach of river could have concentrations of ammonia and cyanide similar to those found at the monitoring well. Therefore, on the basis of these values and use of equation 1, the estimated loads of ammonia (800 lb/d) and cyanide, (12 lb/d) to this 2,000-ft river reach from shallow ground-water discharge are shown to be possible.

Calculated chemical loads from ground-water are probably conservative because the calculations were based on the ground-water quality in wells from the sampling network (fig. 4), which may be biased toward noncontaminated areas. Because the wells were sited so as not to duplicate studies at hazardous-waste sites and because they were intentionally placed outside known contaminated areas, the calculated chemical loads may not reflect some of the localized chemical loading from hazardous-waste sites near the river. Previous sections of this report have shown that some of the hazardous-waste sites overlie ground water that is more contaminated than any sampled from the network.

In terms of ground-water contributions to the total chemical load in the Grand Calumet River, probably less than 1 percent of the total load in the

Grand Calumet River of nitrate plus nitrite, mercury, phenols, and zinc is from ground water; however, ground water probably contributes 2 to 6 percent of the total load to the Grand Calumet River of dissolved solids, chloride, sulfate, fluoride, hardness, copper, iron, and lead, and more than 10 percent of the ammonia, chromium, and cyanide. In comparison, 1 to 3 percent of the average flow of 550 ft^3/s of the Grand Calumet River (as measured for the east and west branches by Crawford and Wangsness, 1987) comes from ground-water flow.

Chemical Loads to Four Major Ground-Water Sinks

Chemical loads in ground water were calculated for four major ground-water sinks by use of equation 1. The sinks are the east branch of the Grand Calumet River including the Indiana Harbor Canal, Lake Michigan, the carbonate bedrock beneath the Calumet aquifer, and municipal sewers (table 44). Discharge values calculated by the ground-water-flow model, assuming a horizontal hydraulic conductivity of 50 ft/d (table 26), were used to calculate the loads. Concentrations of constituents in ground water that discharged to each of the four sinks also were calculated to compute the loads. This was done with the simulated water-table map to determine the likely direction of ground-water flow near each well. In some cases, ground water near a well was considered to have more than one potential sink. Once discharge areas were determined, an average constituent concentration in the ground water flowing to a sink was calculated by averaging constituent concentrations from all sampled wells that intercepted water flowing toward the sink. Water samples with constituent concentrations below the detection limit were assigned a concentration of one-half the detection limit. Wells used for calculations of constituent concentrations for each sink are shown in table 42. It was assumed that the water samples from these wells represented the quality of the water flowing to a particular discharge area.

East Branch of the Grand Calumet River and the Indiana Harbor Canal

A ground-water chemical load was calculated for the east branch of the Grand Calumet River and the Indiana Harbor Canal. In addition, the estimate of chemical loading accounted for ground water that discharges to the Grand Calumet River one-half mile west of the Indiana Harbor Canal, ditches that discharge to the east branch of the Grand Calumet River, the Lake George Canal, and ditches that discharge to the Lake George Canal.

Of the four ground-water sinks analyzed, the east branch of the Grand Calumet River and the Indiana Harbor Canal contained the largest calculated chemical loads from ground-water for about one-half of the analyzed constituents because of two factors. First, rates of ground-water discharge to the east branch of the Grand Calumet River and the Indiana Harbor Canal were fairly high—only the rate of ground-water discharge to the sewers was greater. Second, the highest average constituent concentrations in ground water for two-thirds of the analyzed constituents were in ground water that discharges to the east branch of the Grand Calumet River and the Indiana Harbor Canal. Loads of ammonia, arsenic, benzene, bromide, cyanide, iron, and phenols to the east branch of the Grand Calumet River and the Indiana Harbor Canal were more than twice the loads to any of the other three discharge areas shown in table 44. Estimated loads of some constituents, such as benzene, cyanide, and ammonia, were affected by extremely high chemical concentrations in one or two wells; thus, resultant calculated loads may be slightly high for the entire discharge area. The estimated mercury load was the only chemical load that was lower to the east branch of the Grand Calumet River and the Indiana Harbor Canal than it was to the other three sinks.

Lake Michigan

Chemical loads to Lake Michigan from the discharge of ground water in the study area were determined from water samples from 10 wells near the Lake Michigan shoreline (table 42). Three-quarters of the chemical loads to Lake Michigan were the lowest for any of the four

Table 44. Estimates of chemical loads to four major ground-water sinks in 1987
[Chemical loads are in pounds per day]

Constituent	East Branch of the Grand Calumet River and the Indiana Harbor Canal[1]	Lake Michigan	Silurian bedrock	Municipal sewers
Alkalinity, as $CaCO_3$	18,000	7,200	11,000	21,000
Aluminum	6.2	2.4	4.7	.94
Ammonia, as nitrogen	2,200	27	110	230
Arsenic	.60	.094	.29	.24
Barium	6.3	4.7	7.9	5.4
Benzene	6.1	.017	.15	1.6
Boron	16	6.1	16	18
Bromide	25	.88	12	4.4
Cadmium	.086	.022	.057	.13
Calcium	7,300	3,900	5,600	8,200
Chloride	7,800	6,200	7,100	6,000
Chromium	.88	.45	.61	.80
Copper	.41	.026	.30	.11
Cyanide	50	2.0	14	.91
Dissolved solids	55,000	15,000	33,000	41,000
Fluoride	81	23	33	84
Hardness	24,000	12,000	17,000	27,000
Iron	410	19	180	140
Lead	.77	.11	.56	.42
Magnesium	1,500	540	840	1,700
Manganese	22	1.6	10	47
Mercury	.011	.014	.017	.018
Nitrate plus nitrite, as nitrogen	25	14	8.3	89
Orthophosphate, as phosphorus	2.7	.71	1.8	6.6
Phenols	1.5	.25	.16	.28
Potassium	520	990	960	380
Silica	1,300	420	760	1,600
Sodium	6,400	2,100	4,500	3,800
Sulfate	15,000	3,800	8,300	6,000
Zinc	.66	.22	.60	.79

[1]Includes chemical loads to ditches that discharge to the Grand Calumet River and Indiana Harbor Canal

ground-water sinks (table 44). Loads were generally low because the amount of ground water that discharges to Lake Michigan is less than that which discharges to the three other areas, and the average concentrations of constituents near the lake were relatively low. Loads of ammonia, benzene, bromide, copper, iron, and manganese to Lake Michigan were less than one-quarter of the load to any of the other ground-water sinks, whereas the potassium load was the only chemical load to Lake Michigan that was higher than the potassium load to the other three sinks.

Bedrock

The average concentrations of ground-water constituents in all wells screened in the middle or bottom of the aquifer were used to calculate loads through the clay into the underlying bedrock (table 42). With the exception of barium, the chemical loads to the bedrock were lower than chemical loads to the east branch of the Grand Calumet River and the Indiana Harbor Canal and, with the exception of nitrate plus nitrite, phenols, and potassium, chemical loads to the bedrock were higher than chemical loads to Lake Michigan.

Sewers

Six wells that were adjacent to or within sewered areas were used to calculate chemical loads to the sewers. Although the rate of ground-water discharge to the sewers was the highest of the four ground-water sinks, chemical loads to the sewers were higher than loads to any of the sinks for only about one-half of the constituents (table 44). Chemical loads of four constituents to sewers—aluminum, chloride, cyanide, and potassium—were lower than loads to the other three sinks.

SUMMARY AND CONCLUSIONS

The geohydrology of and water quality in the Calumet aquifer in the vicinity of the Grand Calumet River/Indiana Harbor Canal in Lake County, Ind., was characterized. This study included an assessment of the potential for ground-water contaminants to migrate to Lake Michigan and to the Grand Calumet River/Indiana Harbor Canal.

The water-table configuration reflects the complexity of the aquifer system. This complexity is exemplified in the sewered areas by large depressions in the water table that interrupt the broad ground-water divides between rivers. Aquifer/stream interactions on the Grand Calumet River/Indiana Harbor Canal are directly related to Lake Michigan water levels because of the direct hydraulic connection of the Grand Calumet River/Indiana Harbor Canal to the lake. Fluctuations in lake levels, evapotranspiration, and precipitation cause local reversals in ground-water gradients near the stream that can last from several minutes to several months. The reversals in ground-water gradients extend farther from the stream and last longer during periods of high water levels in Lake Michigan than during periods when the lake level is low or near normal.

A finite-difference mathematical-numerical model was used to examine the ground-water system in the study area and to estimate the amount of ground water that discharges to the four major ground-water sinks. Model simulations indicate that the sewers are the largest ground-water sink; the approximate ground-water discharge rate is 15 ft^3/s. The Grand Calumet River/Indiana Harbor Canal receives about 10 ft^3/s of ground water, and the northern side of the Little Calumet River receives about 8 ft^3/s. The rest of the discharged ground water flows into Lake Michigan and the underlying bedrock. The lake receives only about 4 ft^3/s along a 25-mile section of shoreline. The bedrock probably receives about 6 ft^3/s, but this amount could range from 0 to 10 ft^3/s depending on the actual head distribution in the bedrock and the distribution of vertical hydraulic conductivity of the overlying clay unit.

Water-quality data were compared by depth in the aquifer and by land use in the vicinity of the well site. Water-quality data from wells in five land-use types—steel industry, petrochemical industry, commercial and light industry, residential, and parks—were compared. Water from wells in the steel and petrochemical land-use areas generally had the highest median concentrations of the inorganic ions and the most detections of the organic compounds. Water from wells in the commercial and light industrial land-use areas generally had median chemical concentrations that were lower than those in water from wells in the steel and petrochemical land-use areas and greater than those in water from wells in the residential and park land-use areas. Concentrations of organic compounds were generally low; 7 of 52 acid-extractable and base/neutral-extractable organic compounds and 17 of 36 volatile organic compounds were detected in at least 1 sample. Four of the 88 organic compounds—phenols, bis(2-ethylhexyl)phthalate, benzene, and toluene—were detected in more than 5 samples from the 35 wells.

A comparison of data from wells in the land-use groups to data from "contaminated" sites and data from "natural" areas showed that, for most constituents and chemicals, water from the land-use groups had higher median concentrations than water from the "natural" area but lower median concentrations than water from the "contaminated" sites.

Some of the documented but unaccounted for chemical loads in the Grand Calumet River are from ground-water discharge. Ground water may contribute more than 10 percent of the total chemical load of ammonia, chromium, and cyanide; 2 to 6 percent of the dissolved solids, chloride, sulfate, fluoride, hardness, copper, iron, and lead; and less than 1 percent of the nitrate plus nitrite, mercury, phenols, and zinc in the Grand Calumet River. In comparison, the Grand Calumet River receives about 1 to 3 percent of its water from ground-water discharge. Ground-water loads may actually be higher than those calculated for this study because of the discharge of localized but highly contaminated ground water to the Grand Calumet River that was not sampled. Of the four major ground-water sinks in the aquifer, the east branch of the Grand Calumet River and the Indiana Harbor Canal generally receive the greatest chemical loads from ground water, Lake Michigan generally received the smallest loads, and the sewers and the carbonate bedrock generally received intermediate loads.

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GLOSSARY OF SELECTED MODELING TERMS

Constant-head node. A node that is set at a specified head and remains constant throughout a simulation.

Drain node. A head-dependent sink in which the flow of water from a cell into a drain is dependent on the average head difference between the cell node and the elevation of the drain and the conductance of the drain. If the head in the node is equal to or less than the head in the drain, no water will flow into the drain; that is, drains are one-way conduits—ground water can seep into them and thus be removed from the model.

General-head boundary. A head-dependent flow boundary in which the flow of water between a cell and a known head outside the model is based on the conductance of the material and the difference in heads between the cell node and the outside head.

Hydraulic conductance. The ability of a material to transmit water. Conductance is dependent on the hydraulic conductivity of the material, the area through which water is transmitted, and the distance the water is moved.

Recharge boundary. A constant-flow boundary in which a specified volume of water per unit time is added per unit area.

River boundary. A head-dependent boundary in which the flow of water between a river and a cell containing the river (river node) is dependent on the head difference between the river level and the cell node and on the conductance of the riverbed material. If the head in the node falls below the riverbed bottom, the elevation of the riverbed bottom is used instead of the head in the node to calculate seepage from the river. Ground water can flow into a river node (as ground-water discharge) or out of the river node (as recharge to the underlying aquifer).

SUPPLEMENTAL DATA

Table 1. Characteristics of observation wells completed in the Calumet aquifer
[USGS, U.S. Geological Survey; i.d., identification; n.a., not applicable; ?, not known; CA, screened in the Calumet aquifer; GAA, Gary Airport Authority; USX, USX Corporation; Auger, hollow stem auger]

Well name	Well owner	Latitude/longitude	USGS site i.d. number	Date drilled (month/year)	Method of installation	Land surface in feet above sea level	Screened interval in feet below land surface	Screen and casing stainless-steel type	Relative vertical position of screen in aquifer
A1	USGS	413647/871919	413647087191901	07/85	Auger	604	18-21	304	Top
A2	USGS	413706/871818	413706087181800	06/87	Auger	603	34-39	316L	Middle
A3	USGS	413631/871820	413631087182000	06/87	Hand driven	590	3-6	316L	Top
A4	USGS	413630/871821	413630087182100	06/87	Auger	603	18-23	316L	Middle
A5	USGS	413629/871921	413629087192102	12/85	Auger	601	18-21	304	Top
A6	USGS	413706/871701	413706087170101	06/87	Hand driven	588	4-7	316L	Top
A10	USGS	413626/871919	413626087191901	07/85	Hand driven	590	12-15	304	Top
A15	USGS	413617/871912	413617087191201	07/85	Hand driven	591	2-5	304	Top
A20	USGS	413503/871935	413503087193501	12/85	Auger	614	21-24	304	Top
B1	USGS	413637/872343	413637087234301	08/85	Hand driven	585	9-12	304	Top
B2	USGS	413752/872235	413752087223500	06/87	Auger	608	43-48	316L	Middle
B3	USGS	413633/872220	413633087222000	06/87	Auger	594	18-23	316L	Middle
B5	USGS	413632/872340	413632087234001	08/85	Hand driven	589	8-11	304	Top
B7	USGS	413617/872252	413617087225202	06/87	Hand driven	596	8-11	316L	Top
B8	USGS	413617/872252	413617087225201	06/87	Auger	596	32-37	316L	Bottom
B10	USGS	413544/872337	413544087233700	12/85	Auger	607	17-20	304	Top
C1	USGS	413830/872600	413830087260001	12/85	Auger	587	4-7	304	Top
C2	USGS	414031/872450	414031087245000	06/87	Auger	594	22-27	316L	Middle
C3	USGS	413828/872513	413828087251301	06/87	Auger	589	23-28	316L	Middle
C4	USGS	413828/872513	413828087251302	06/87	Auger	589	8-13	316L	Top
C5	USGS	413655/872620	413655087275202	07/85	Hand driven	584	2-5	304	Top
C10	USGS	413650/872620	413652087274901	07/85	Hand driven	584	1-4	304	Top
C12	USGS	413650/872620	413650087262000	06/87	Auger	584	13-18	316L	Middle
C15	USGS	413648/872620	413650087274802	07/85	Hand driven	583	1-4	304	Top
[1]C17	USGS	413559/872703	413559087270301	07/86	Mud rotary	592	18-23	n.a.	Bottom

Table 1. Characteristics of observation wells completed in the Calumet aquifer--Continued

Well name	Well owner	Latitude/longitude	USGS site i.d. number	Date drilled (month/year)	Method of installation	Land surface in feet above sea level	Screened interval in feet below land snrface	Screen and casing stainless-steel type	Relative vertical position of screen in aqnifer
C18	USGS	413607/872522	413607087252200	06/87	Auger	595	17-22	316L	Bottom
C19	USGS	413617/872620	413617087262001	12/86	Hand driven	591	2-5	304	Top
C20	USGS	413557/872611	413557087283901	07/85	Hand driven	593	3-6	304	Top
C25	USGS	413527/872543	413527087254301	07/85	Hand driven	599	2-5	304	Top
CGA3	GAA	413722/872513	n.a.	pre-1985	?	590	CA	n.a.	?
CGA4	GAA	413719/872519	n.a.	pre-1985	?	591	CA	n.a.	?
CGA5	GAA	413733/872520	n.a.	pre-1985	?	594	CA	n.a.	?
D1	USGS	414052/872912	414052087291201	07/85	Hand driven	590	8-11	304	Top
D5	USGS	414043/872908	414043087290802	07/85	Hand driven	588	2-7	304	Top
D10	USGS	414043/872908	414043087290802	07/85	Hand driven	588	7-10	304	Top
D11	USGS	414043/872908	414043087290801	06/87	Auger	588	17-22	316L	Middle
D20	USGS	413941/872900	413941087290000	07/85	Hand	588	6-9	304	Top
D21	USGS	413941/872926	413941087292600	06/87	Auger	584	13-18	316L	Middle
D25	USGS	413909/872803	413804087291102	07/85	Hand driven	588	5-8	304	Top
D30	USGS	413907/872758	413758087290702	07/85	Hand driven	586	6-9	304	Top
D31	USGS	413907/872758	413907087275901	06/87	Auger	586	12-17	316L	Middle
D35	USGS	413906/872757	413757087290601	07/85	Hand driven	586	4-7	304	Top
D40	USGS	413835/872851	413835087245101	07/85	Hand driven	584	4-7	304	Top
D45	USGS	413812/872702	413812087270201	07/85	Hand driven	586	6-9	304	Top
D50	USGS	413800/872854	413800087285401	12/85	Hand driven	585	9-12	304	Top

Table 1. Characteristics of observation wells completed in the Calumet aquifer--Continued

Well name	Well owner	Latitude/longitude	USGS site i.d. number	Date drilled (month/year)	Method of installation	Land surface in feet above sea level	Screened interval in feet below land surface	Screen and casing stainless-steel type	Relative vertical position of screen in aquifer
D55	USGS	413758/872814	413758087281401	07/85	Hand driven	585	5-8	304	Top
D60	USGS	413758/872810	413758087281001	07/85	Hand driven	587	5-8	304	Top
D65	USGS	413759/872801	413759087280101	07/85	Hand driven	584	1-4	304	Top
D66	USGS	413654/872740	413654087274000	06/87	Auger	587	17-22	316L	Middle
D67	USGS	413647/872825	413647087282502	06/87	Hand driven	589	4-7	316L	Top
D68	USGS	413647/872825	413647087282501	06/87	Auger	589	18-23	316L	Middle
D70	USGS	413515/872914	413515087291401	07/85	Hand driven	603	6-9	304	Top
D75	USGS	413435/872919	413435087291901	07/85	Hand driven	601	5-8	304	Top
E1	USGS	413844/873104	413844087310401	07/85	Hand driven	582	5-8	304	Top
E2	USGS	414105/872939	414105087293900	06/87	Hand driven	585	3-6	316L	Top
E3	USGS	414013/873033	414013087303300	06/87	Auger	585	7-12	316L	Middle
E5	USGS	413810/873052	413810087305201	07/85	Hand driven	587	9-12	304	Top
E6	USGS	413938/873043	413938087304301	06/87	Auger	586	17-22	316L	Bottom
E7	USGS	413938/873043	413938087304302	06/87	Hand driven	586	3-6	316L	Top
E10	USGS	413722/873041	413722087304101	07/85	Hand driven	586	6-9	304	Top
E15	USGS	413720/873042	413720087304201	07/85	Hand driven	584	11-14	304	Top
E17	USGS	413719/873045	413719087304501	07/85	Hand driven	584	5-8	304	Top
E20	USGS	413627/873105	413627087310500	07/85	Hand driven	592	5-8	304	Top
HWT2-9	USX	413752/872235	n.a.	04/84	Auger	608	50-70	n.a.	Bottom
HWT2-10	USX	413732/872322	n.a.	04/84	Auger	589	24-44	n.a.	Bottom
HWT14-5	USX	413722/872255	n.a.	04/84	Auger	589	27-47	n.a.	Bottom
P4	USX	413744/872239	n.a.	04/84	Auger	603	25-35	n.a.	Top
P7	USX	413738/872248	n.a.	04/84	Auger	601	20-30	n.a.	Top
P11	USX	413734/872251	n.a.	04/84	Auger	596	15-25	n.a.	Top

[1]Continuous recording water-level well (LK 13) operated by the USGS as part of a State ground-water data network. Water levels are published in the USGS annual data report for Indiana, water years 1986-92.

Table 2. Description of surface-water sites in the study area

[USGS, U.S. Geological Survey; i.d., identification; n.a., not assigned; S, stage only; C, continuous gage]

Site designation[1]	USGS site i.d. number	Site type	Abbreviated location description
A11S	n.a.	S	Grand Calumet River near Tennessee St. at Gary, Ind.
C16S	413648087283502	C	Grand Calumet River at Cline Ave. at East Chicago, Ind.
D36S	413756087290602	C	Indiana Harbor Canal beneath Cline Ave. overpass at East Chicago, Ind.
D54S	413759087281502	C	Indiana Harbor Canal 0.25 mile north of Chicago Ave. at East Chicago, Ind.
E16S	413719087304302	C	Grand Calumet River near Calumet Ave. at Hammond, Ind.
S1	n.a.	S	Wolf Lake at Hammond, Ind.
S2	n.a.	S	Lake George at Hammond, Ind.
S3	n.a.	S	Unnamed ditch, east side of Calumet Ave., 0.1 mile north of 129th St. at Hammond, Ind.
S4	n.a.	S	Ditch on southeast corner of Calumet Ave. and 129th St. at Hammond, Ind.
S6	n.a.	S	Indiana Harbor Canal at Columbus Ave. at East Chicago, Ind.
S7	n.a.	S	Grand Calumet River at Indianapolis Blvd. at East Chicago, Ind.
S8	n.a.	S	Sewer grate at Washington Park at East Chicago, Ind.
S9	n.a.	S	Unnamed lake southwest of Buffington Harbor at Gary, Ind.
S10	n.a.	S	Unnamed ditch on southwest end of Gary Airport at Gary, Ind.
S11	n.a.	S	Unnamed ditch on north side of Hwy 20, 0.3 mile west of Cline Ave. at Gary, Ind.
S12	n.a.	S	Grand Calumet River at Hwy 12 at Gary, Ind.
S13	n.a.	S	Grand Calumet River at Bridge St. at Gary, Ind.
S14	n.a.	S	Lake Michigan at south end of Gary Harbor at Gary, Ind.
S15	n.a.	S	West Grand Calumet Lagoon at Gary, Ind.
S16	n.a.	S	East Grand Calumet Lagoon at Gary, Ind.

[1]Because of the short duration of this study, the sites listed herein were assigned arbitrary designations rather than downstream-order numbers.

Table 7. Ground-water levels in wells in the water-level network, August 1985 through August 1988

[Water level, in feet above sea level]

Well name	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
A1	10/24/85	586.85	12/17/85	587.46	02/06/86	586.72	02/18/86	586.66	03/17/86	586.58	03/31/86	586.60
	05/16/86	586.80	06/09/86	587.15	07/24/86	587.72	09/22/86	587.10	11/25/86	587.32	02/25/87	586.77
	08/04/87	587.30	03/31/88	586.58	07/06/88	586.49	10/13/88	586.41	01/25/89	586.46	04/19/89	586.42
	08/03/89	587.12										
A2	06/26/87	587.14	07/08/87	587.02	08/04/87	586.90	03/31/88	586.96	07/06/88	587.49	10/13/88	586.93
	01/25/89	587.01	04/19/89	586.88	08/03/89	587.14						
A3	06/25/87	588.52	06/26/87	588.48	07/09/87	588.43	08/04/87	588.53	03/31/88	588.48	07/06/88	588.44
	10/13/88	588.32	01/25/89	588.50	04/19/89	588.43	08/03/89	588.52				
A4	06/26/87	588.69	07/15/87	588.61	08/05/87	588.52	03/31/88	588.64	07/06/88	588.60	10/13/88	588.48
	01/25/89	588.70	04/19/89	588.72	08/03/89	588.67						
A5	12/17/85	586.40	02/06/86	585.60	03/17/86	585.67	03/31/86	585.65	05/16/86	586.00	09/22/86	585.71
	11/25/86	585.85	02/26/87	585.42	06/26/87	586.42	08/04/87	585.95	03/31/88	585.41	07/06/88	585.33
	10/13/88	585.39	01/25/89	585.44	04/19/89	585.45	08/03/89	586.20				
A6	07/14/87	585.57	08/05/87	585.19	03/30/88	585.32	07/07/88	584.61	10/12/88	584.58	01/24/89	585.23
	04/20/89	585.33	08/03/89	585.34								
A10	10/24/85	585.95	12/17/85	585.88	02/06/86	585.64	03/17/86	585.59	03/31/86	585.59	05/15/86	585.86
	09/22/86	585.85	11/25/86	585.66	02/26/87	585.39	06/26/87	586.21	08/04/87	586.08	03/31/88	585.47
	07/06/88	585.98	10/13/88	585.56	01/25/89	585.40	04/19/89	585.48	08/03/89	586.05		
A15	10/24/85	589.54	12/10/85	591.15	03/06/86	589.74	03/20/86	589.79	03/31/86	589.84	05/09/86	589.69
	06/09/86	589.99	07/24/86	590.43	08/04/86	590.23	08/19/86	589.90	09/25/86	589.58	12/30/86	590.03
	02/25/87	589.52	08/04/87	589.92	03/31/88	589.97	07/05/88	589.28	10/13/88	589.30	01/25/89	589.84
	04/19/89	590.11	08/03/89	589.94								
A20	01/03/86	595.41	02/03/86	595.29	02/07/86	595.15	02/17/86	595.13	03/06/86	595.06	03/20/86	595.18
	03/31/86	595.10	05/16/86	595.21	08/13/86	595.46	08/27/86	595.37	11/25/86	595.40	02/24/87	595.38
	07/06/87	595.95	08/05/87	595.72	12/17/87	595.61	04/01/88	595.81	07/07/88	595.78	10/12/88	595.59
	01/25/89	595.80	04/19/89	595.96	08/03/89	595.91						

Table 7. Ground-water levels in wells in the water-level network, August 1985 through August 1988--Continued

Well name	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
B1	10/24/85	580.49	11/11/85	580.93	11/27/85	581.95	12/04/85	582.04	12/17/85	581.76	01/03/86	581.23
	02/03/86	580.69	02/17/86	580.71	03/06/86	580.85	03/20/86	581.20	03/31/86	581.06	05/09/86	580.67
	06/09/86	581.11	07/24/86	581.33	08/04/86	581.06	08/19/86	580.72	09/25/86	580.42	12/30/86	582.40
	02/26/87	580.57	08/04/87	580.61	04/01/88	584.18	07/05/88	580.23	10/11/88	580.63	01/26/89	580.82
	04/20/89	581.60	08/01/89	581.89								
B2	06/25/87	581.62	07/08/87	581.39	08/04/87	581.14	03/31/88	580.24	07/06/88	580.17	10/13/88	579.86
	01/25/89	579.56	04/19/89	579.46	08/03/89	580.13						
B3	07/14/87	584.48	08/04/87	584.30	03/31/88	584.54	07/06/88	583.90	10/11/88	583.85	01/24/89	584.10
	04/20/89	584.39	08/03/89	584.53								
B5	10/24/85	582.36	11/11/85	582.52	11/27/85	583.55	12/04/85	583.52	12/17/85	583.37	01/03/86	582.88
	02/03/86	582.42	02/17/86	582.41	03/06/86	582.52	03/20/86	583.57	03/31/86	582.80	05/09/86	582.48
	06/09/86	582.78	07/24/86	583.07	08/04/86	582.84	08/19/86	582.53	09/25/86	582.23	12/30/86	582.67
	02/26/87	582.24	04/01/88	582.53	07/05/88	581.92	10/11/88	581.69	01/26/89	582.43	04/20/89	582.85
	08/01/89	583.09										
B7	06/22/87	587.94	08/04/87	587.33	03/31/88	587.50	07/07/88	586.84	10/11/88	586.75	01/26/89	587.46
	04/20/89	587.77	08/03/89	587.73								
B8	07/14/87	587.56	08/04/87	587.31	03/31/88	587.48	07/07/88	586.83	10/11/88	586.73	01/26/89	587.43
	04/20/89	587.74	08/03/89	587.74								
B10	12/10/85	593.67	01/03/86	593.23	02/03/86	592.74	02/17/86	592.69	03/06/86	592.99	03/20/86	593.28
	03/31/86	593.40	05/09/86	592.97	06/09/86	593.23	07/24/86	593.25	08/04/86	592.99	08/19/86	592.60
	09/25/86	591.88	12/30/86	594.30	02/25/87	592.77	07/13/87	593.63	08/05/87	592.96	04/01/88	593.64
	07/05/88	592.58	10/11/88	591.83	01/24/89	593.42	04/19/89	593.99	08/03/89	593.39		
HWT2-9	12/10/85	582.21	02/06/86	581.93	02/18/86	581.64	03/17/86	581.77	03/31/86	581.80	05/09/86	581.91
	06/09/86	582.35	07/24/86	582.44	11/25/86	581.89	02/26/87	581.60	06/25/87	581.68	03/31/88	580.28
	07/06/88	580.26	10/13/88	579.90	01/25/89	579.69	04/19/89	579.55	08/03/89	580.28		

Table 7. Ground-water levels in wells in the water-level network, August 1985 through August 1988--Continued

Well name	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
HWT2-10	12/10/85	588.66	02/06/86	588.08	02/18/86	585.55	03/17/86	588.27	03/31/86	587.91	05/09/86	587.30
	06/09/86	588.15	07/24/86	587.73	09/22/86	586.79	11/25/86	587.94	02/26/87	587.50	08/04/87	587.12
	03/31/88	588.57	07/06/88	586.36	10/13/88	586.16	01/25/89	587.83	04/19/89	588.01	08/03/89	587.56
HWT14-5	12/10/85	584.84	02/06/86	584.55	02/18/86	584.57	03/17/86	584.61	03/31/86	584.57	05/09/86	584.09
	06/09/86	584.71	07/24/86	584.61	09/22/86	583.08	11/25/86	584.53	02/26/87	585.44	08/04/87	584.39
	03/31/88	585.17	07/06/88	584.07	10/13/88	583.94	01/25/89	584.57	04/19/89	584.59	08/03/89	584.59
P4	12/10/85	583.86	02/06/86	583.93	02/18/86	584.26	03/17/86	583.86	03/31/86	583.80	05/09/86	583.23
	06/09/86	584.12	07/24/86	583.96	09/22/86	583.56	11/25/86	583.28	02/26/87	584.01	08/04/87	582.96
	03/31/88	583.38	07/06/88	582.32	10/13/88	581.97	01/25/89	582.75	04/19/89	582.47	08/03/89	583.06
P7	12/10/85	585.71	02/06/86	584.74	02/18/86	584.71	03/17/86	584.83	03/31/86	584.88	05/09/86	584.84
	06/09/86	585.04	07/24/86	585.36	09/22/86	584.70	11/25/86	584.94	02/26/87	585.99	08/04/87	584.57
	03/31/88	584.14	07/06/88	584.27	10/13/88	584.31	01/25/89	584.28	04/19/89	584.23	08/03/89	584.63
P11	12/10/85	586.89	02/06/86	585.51	02/18/86	585.44	03/17/86	585.71	03/31/86	585.49	05/09/86	585.28
	06/09/86	585.84	07/24/86	586.10	09/22/86	585.06	11/25/86	585.57	02/26/87	585.87	08/04/87	585.38
	03/31/88	585.41	07/06/88	584.81	10/13/88	584.96	01/25/89	585.36	04/19/89	585.34	08/03/89	585.63
C1	12/09/85	583.45	01/06/86	582.75	02/03/86	582.46	02/17/86	582.65	03/08/86	582.91	03/20/86	583.26
	03/31/86	582.94	05/09/86	582.50	06/09/86	583.23	07/24/86	582.94	08/04/86	582.64	08/19/86	582.27
	09/25/86	582.57	12/30/86	584.38	02/27/87	582.80	06/24/87	583.26	08/04/87	582.68	03/31/88	583.64
	07/05/88	582.14	10/11/88	581.68	01/24/89	582.71	04/18/89	582.98	08/01/89	582.91		
C2	07/07/87	583.55	08/04/87	583.47	08/04/87	583.44	12/07/88	583.98	01/24/89	584.99	04/18/89	584.73
	08/01/89	584.96										
C3	06/24/87	581.87	07/09/87	581.63	08/04/87	581.56	03/31/88	580.85	07/05/88	580.56	10/11/88	580.29
	01/24/89	580.08	04/18/89	580.56	08/01/89	580.72						
C4	06/24/87	581.87	08/04/87	581.56	03/31/88	580.87	07/05/88	580.58	10/11/88	580.38	01/24/89	580.01
	04/18/89	580.61	08/01/89	580.77								

Table 7. Ground-water levels in wells in the water-level network, August 1985 through August 1988--Continued

Well name	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
C5	10/25/85	583.58	11/27/85	584.66	12/06/85	584.59	02/20/86	585.39	03/21/86	584.51	04/01/86	583.69
	05/15/86	583.98	08/13/86	583.13	12/16/86	584.26	02/24/87	583.99	07/21/87	583.04	08/05/87	582.74
	12/17/87	585.17	03/30/88	584.74	03/31/88	584.81	07/06/88	582.36	01/25/89	583.61	04/19/89	584.10
	08/04/89	582.99										
C10	10/25/85	582.96	11/27/85	584.19	12/06/85	583.41	12/18/85	583.26	01/08/86	583.17	02/04/86	583.68
	02/20/86	583.49	03/07/86	583.40	03/21/86	583.32	04/01/86	583.30	05/15/86	583.21	08/13/86	582.80
	12/16/86	583.29	02/24/87	583.12	07/21/87	582.35	08/05/87	582.22	12/17/87	583.20	03/30/88	583.53
	07/06/88	581.37	10/13/88	581.32	01/25/89	582.87	04/19/89	583.01	08/04/89	582.15		
C12	08/05/87	582.25	03/31/88	583.42	07/06/88	581.28	10/13/88	581.28	01/25/89	582.76	04/19/89	582.93
	08/04/89	582.10										
C15	10/25/85	582.51	11/27/85	582.82	12/06/85	582.95	02/04/86	582.91	03/21/86	582.53	05/15/86	582.87
	08/13/86	582.93	12/17/86	582.64	02/24/87	582.55	08/05/87	582.37	12/17/87	582.54	03/30/88	582.58
	07/06/88	580.97	10/13/88	581.20	01/25/89	582.24	04/19/89	582.26	08/04/89	581.82		
C17	08/05/87	587.59	03/31/88	590.99	07/07/88	587.72	10/12/88	587.01	01/26/89	590.32	04/19/89	590.54
	08/04/89	588.74										
C18	06/24/87	591.45	07/14/87	590.95	08/04/87	590.29	04/01/88	591.08	07/07/88	590.10	10/12/88	589.62
	01/24/89	591.42	04/19/89	590.75								
C19	12/15/86	590.06	02/27/87	589.98	08/04/87	588.90	04/01/88	590.25	07/07/88	588.58	10/12/88	588.39
	01/26/89	590.15	04/18/89	590.00	08/04/89	589.57						
C20	12/05/85	593.69	02/04/86	592.62	02/19/86	588.64	03/04/86	587.60	03/21/86	588.94	04/01/86	590.57
	05/10/86	592.01	06/10/86	592.81	08/05/86	591.84	08/20/86	591.37	09/26/86	591.45	12/31/86	593.28
	02/25/87	593.53	07/16/87	592.63	08/04/87	591.73	03/31/88	594.03	07/07/88	591.60	10/12/88	590.98
	01/26/89	593.59	04/19/89	593.83	08/04/89	592.88						

Table 7. Ground-water levels in wells in the water-level network, August 1985 through August 1988--Continued

Well name	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
C25	12/05/85	597.62	01/03/86	596.37	02/04/86	596.84	02/19/86	597.65	03/04/86	597.08	03/21/86	597.41
	04/03/86	596.88	05/12/86	596.15	06/10/86	597.81	08/05/86	596.12	08/20/86	596.13	09/26/86	596.05
	12/31/86	596.73	02/27/87	596.40	08/04/87	595.84	03/31/88	597.93	07/07/88	595.10	10/12/88	595.76
	01/24/89	597.08	04/20/89	597.10	08/04/89	596.62						
CGA3	10/24/85	584.81	12/05/85	585.15	02/03/86	584.88	02/17/86	584.98	03/06/86	584.98	03/20/86	584.47
	03/31/86	584.98	05/09/86	584.80	06/09/86	585.00	07/24/86	584.81	08/04/86	584.73	08/19/86	584.70
	09/25/86	584.77	12/30/86	585.02	02/27/87	585.04	08/04/87	584.71	04/01/88	585.56	07/05/88	584.77
	10/11/88	584.63	01/26/89	585.25	04/20/89	585.36	08/01/89	585.14				
CGA4	10/24/85	584.16	12/05/85	584.83	02/03/86	584.51	02/17/86	584.75	03/06/86	584.72	03/20/86	584.83
	03/31/86	584.66	05/09/86	584.44	06/09/86	584.78	07/24/86	584.57	08/04/86	584.45	08/19/86	584.30
	09/25/86	584.34	12/30/86	584.84	08/04/87	584.49	04/01/88	585.41	07/05/88	584.57	10/11/88	584.19
	01/26/89	585.08	04/20/89	585.20	08/01/89	584.94						
CGA5	10/24/85	586.36	12/05/85	588.16	02/07/86	587.29	03/06/86	587.56	03/20/86	587.51	03/31/86	587.62
D1	08/25/85	583.48	10/24/85	582.74	01/06/86	582.67	02/03/86	582.54	02/19/86	582.66	03/04/86	582.58
	03/21/86	582.91	04/03/86	582.76	05/09/86	582.73	06/10/86	583.16	07/24/86	583.30	08/04/86	583.12
	08/19/86	583.08	09/25/86	583.10	12/30/86	582.94	02/25/87	582.89	02/27/87	582.93	08/04/87	582.39
	10/13/87	582.18	11/04/87	581.83	03/31/88	581.76	07/05/88	581.56	10/11/88	581.40	01/25/89	581.35
	04/18/89	581.55	08/02/89	581.77								
D5	10/24/85	583.50	12/11/85	584.12	01/06/86	583.31	02/04/86	583.19	02/19/86	583.32	03/04/86	583.41
	03/21/86	583.56	04/03/86	583.52	05/09/86	583.34	06/10/86	583.88	07/24/86	584.06	08/04/86	583.80
	08/19/86	583.49	09/25/86	583.51	12/30/86	583.34	02/25/87	583.51	06/10/87	584.09	06/11/87	584.08
	08/04/87	583.51	10/13/87	583.27	03/31/88	583.15						
D10	10/24/85	583.46	12/11/85	583.97	01/06/86	583.23	02/04/86	583.15	02/16/86	583.23	03/04/86	583.44
	03/21/86	583.43	04/03/86	583.40	05/09/86	583.27	06/10/86	583.75	07/24/86	583.87	08/04/86	583.69
	08/19/86	583.40	09/25/86	583.47	12/30/86	583.26	02/25/87	583.41	06/11/87	583.99	08/04/87	583.42
	10/13/87	583.19	11/04/87	582.87	03/31/88	583.11	07/05/88	582.56	10/11/88	582.66	01/25/89	582.86
	04/18/89	583.00	06/15/89	583.95	08/02/89	583.29						

Table 7. Ground-water levels in wells in the water-level network, August 1985 through August 1988--Continued

Well name	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
D11	06/11/87	584.01	08/04/87	583.45	10/13/87	583.22	11/04/87	582.88	03/31/88	583.16	07/05/88	582.61
	10/11/88	582.71	01/25/89	582.91	04/18/89	583.05	06/15/89	584.01	08/02/89	583.33		
D20	10/24/85	584.02	12/05/85	584.47	01/06/86	583.63	02/03/86	583.57	02/19/86	584.36	03/04/86	584.42
	03/21/86	584.24	04/03/86	584.04	05/09/86	584.61	06/10/86	584.81	07/24/86	584.68	08/04/86	584.34
	08/19/86	584.04	09/25/86	584.25	12/30/86	583.55	02/25/87	583.14	08/04/87	583.72	10/13/87	583.55
	11/04/87	583.48	03/31/88	583.07	07/05/88	583.11	10/11/88	581.80	01/24/89	582.04	04/18/89	581.99
	08/02/89	583.03										
D21	08/04/87	580.89	10/13/87	581.04	11/04/87	581.08	03/31/88	582.07	07/05/88	580.61	10/11/88	580.84
	01/24/89	581.37	04/18/89	581.08	08/02/89	581.10						
D25	12/05/85	584.65	01/07/86	583.41	01/23/86	583.37	02/17/86	583.41	03/08/86	583.65	03/22/86	583.77
	03/31/86	583.44	05/15/86	583.27	08/13/86	583.62	01/14/87	583.74	02/23/87	583.41	08/04/87	583.22
	10/13/87	583.35	11/04/87	583.04	12/17/87	583.38	03/31/88	583.10	07/05/88	582.51	10/11/88	582.39
	01/24/89	582.77	04/18/89	582.76	08/02/89	583.02						
D30	12/05/85	583.24	01/06/86	582.45	01/23/86	582.49	02/17/86	582.44	03/08/86	582.43	03/22/86	581.43
	05/15/86	582.81	08/13/86	583.04	11/24/86	582.97	02/23/87	582.44	07/16/87	582.37	08/04/87	582.21
	10/13/87	581.58	11/04/87	581.43	12/17/87	581.72	03/31/88	581.43	07/05/88	581.10	01/24/89	580.93
	04/18/89	581.00	08/02/89	581.30								
D31	08/04/87	582.24	10/13/87	581.64	11/04/87	581.51	03/31/88	581.48	07/05/88	581.15	10/11/88	580.77
	01/24/89	580.82	04/18/89	580.87	08/02/89	581.19						
D35	12/05/85	582.82	01/06/86	582.48	01/23/86	582.20	02/17/86	582.47	03/08/86	581.93	03/22/86	581.74
	03/31/86	582.40	05/15/86	582.58	08/13/86	582.92	11/25/86	582.63	02/23/87	582.16	08/04/87	582.23
	11/04/87	580.95	03/31/88	580.77	07/05/88	580.78	10/11/88	580.35	01/24/89	580.37	04/18/89	580.33
	08/02/89	580.56										
D40	10/24/85	582.44	12/05/85	583.52	01/06/86	582.42	02/03/86	582.59	02/19/86	583.27	03/04/86	582.94
	03/21/86	583.12	04/03/86	582.67	05/10/86	582.63	06/10/86	583.39	07/24/86	583.07	08/04/86	582.89
	08/19/86	582.84	09/25/86	583.13	12/30/86	582.89	02/26/87	582.46	08/04/87	582.29	03/30/88	583.46
	07/06/88	582.16	10/11/88	581.52	01/24/89	582.53	04/18/89	582.58	08/02/89	582.37		

Table 7. Ground-water levels in wells in the water-level network, August 1985 through August 1988--Continued

Well name	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
D45	10/24/85	580.44	12/13/85	581.20	01/06/86	580.69	01/15/86	580.58	02/03/86	580.38	03/07/86	580.72
	03/20/86	580.95	03/31/86	580.84	05/09/86	580.47	06/09/86	580.61	07/24/86	580.59	08/04/86	580.31
	08/19/86	580.18	09/25/86	580.31	12/30/86	579.73	02/26/87	580.58	08/05/87	580.37	03/31/88	581.26
	07/06/88	580.48	10/12/88	580.36	01/24/89	580.90	04/18/89	580.03	08/01/89	580.87		
D50	12/13/85	578.22	03/22/86	578.61	04/03/86	578.42	05/10/86	578.11	06/10/86	578.25	08/05/86	577.95
	08/20/86	577.84	09/26/86	577.76	12/31/86	578.26	02/25/87	577.79	08/04/87	577.79	03/30/88	578.03
	07/06/88	577.72	10/11/88	577.54	01/24/89	577.81	04/18/89	578.03	08/02/89	577.93		
D55	10/24/85	582.27	10/29/85	582.34	11/05/85	582.64	11/12/85	582.88	11/27/85	582.73	12/05/85	582.60
	12/12/85	582.54	01/06/86	582.20	02/05/86	582.66	02/19/86	582.28	03/07/86	582.45	03/21/86	582.27
	04/03/86	582.58	05/15/86	582.70	08/14/86	582.65	11/25/86	582.61	02/24/87	582.16	08/05/87	582.01
	12/17/87	581.28	03/30/88	580.88	07/06/88	580.68	10/12/88	580.23	01/24/89	580.33	04/19/89	580.43
	08/04/89	580.59										
D60	10/29/85	582.76	11/05/85	582.99	11/11/85	583.49	11/27/85	583.78	12/05/85	583.62	01/06/86	583.00
	02/05/86	583.19	02/19/86	583.16	03/21/86	583.40	04/03/86	583.22	05/15/86	583.18	08/14/86	582.99
	12/16/86	583.46	02/24/87	583.05	07/22/87	582.57	08/05/87	582.36	12/17/87	582.85	03/31/88	582.62
	07/06/88	581.17	10/12/88	580.70	01/24/89	581.90	04/19/89	582.11	08/04/89	581.81		
D65	10/24/85	583.50	10/29/85	583.93	11/11/85	584.27	11/27/85	584.24	03/21/86	584.32	04/03/86	584.23
	05/15/86	584.02	08/14/86	583.55	11/25/86	584.22	02/24/87	584.19	08/05/87	583.21	12/17/87	584.69
	03/30/88	584.45	07/06/88	581.74								
D66	08/05/87	582.24	03/30/88	581.74	07/05/88	581.41	10/13/88	581.26	01/25/89	581.75	04/19/89	581.66
	08/04/89	581.76										
D67	08/05/87	584.52	03/31/88	586.24	07/07/88	584.05	10/12/88	583.49	01/25/89	585.49	04/18/89	585.63
	08/04/89	585.18										
D68	08/05/87	584.52	03/31/88	586.24	07/07/88	584.03	10/12/88	583.49	01/25/89	585.49	04/18/89	585.64
	08/04/89	585.17										

Table 7. Ground-water levels in wells in the water-level network, August 1985 through August 1988--Continued

Well name	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
D70	01/07/86	599.27	02/04/86	599.57	02/20/86	600.26	03/04/86	599.77	03/22/86	600.12	04/01/86	599.70
	05/10/86	599.16	06/09/86	599.38	08/05/86	598.82	08/20/86	598.53	09/26/86	598.71	12/31/86	599.60
	02/25/87	599.46	08/04/87	598.87	03/31/88	600.65	07/06/88	598.81	10/12/88	598.48	01/25/89	599.72
	04/18/89	599.90	08/02/89	599.48								
D75	01/07/86	595.98	01/24/86	596.09	02/04/86	596.09	02/20/86	596.49	03/04/86	596.39	03/22/86	596.60
	04/01/86	596.44	05/10/86	596.22	06/09/86	596.70	08/05/86	596.31	08/20/86	596.12	09/26/86	596.43
	12/31/86	596.30	02/25/87	596.18	02/26/87	596.19	08/04/87	596.27	03/31/88	596.94	07/06/88	596.15
	10/12/88	596.20	01/25/89	596.30	04/18/89	596.46	08/02/89	596.62				
E1	12/13/85	579.09	01/06/86	578.61	02/04/86	579.22	02/19/86	579.45	03/04/86	579.17	03/21/86	579.39
	04/03/86	579.05	05/09/86	578.49	06/10/86	578.94	07/24/86	578.46	08/04/86	578.48	08/19/86	578.39
	09/25/86	577.87	12/30/86	578.83	02/27/87	578.93	08/04/87	577.89	10/13/87	577.89	03/31/88	578.90
	07/06/88	577.79	10/12/88	577.62	01/25/89	578.52	04/17/89	578.34	08/02/89	577.91		
E2	06/09/87	582.49	07/14/87	582.14	08/04/87	581.73	10/13/87	581.46	11/03/87	581.05	03/31/88	580.99
	07/05/88	580.81	10/11/88	580.61	01/25/89	580.29	08/02/89	580.74				
E3	06/22/87	582.54	07/13/87	582.58	08/04/87	582.05	10/13/87	582.39	11/04/87	582.70	03/31/88	583.98
	07/05/88	581.71	10/11/88	582.30	01/25/89	582.94	04/17/89	582.84	08/02/89	582.77		
E5	10/25/85	580.76	12/13/85	581.66	01/06/86	580.96	02/04/86	580.86	02/19/86	581.22	03/04/86	581.12
	03/22/86	581.46	04/03/86	581.39	05/09/86	581.02	06/10/86	581.21	08/04/86	580.95	08/19/86	580.73
	09/25/86	580.56	12/30/86	581.11	02/25/87	580.88	08/04/87	580.98	03/31/88	581.58	07/06/88	580.71
	10/12/88	580.62	01/25/89	581.24	04/17/89	581.39	08/02/89	581.30				
E6	06/22/87	584.72	07/15/87	584.85	08/04/87	583.83	10/13/87	584.22	11/04/87	584.48	03/31/88	585.29
	07/05/88	583.07	10/11/88	584.25	01/25/89	584.62	04/17/89	584.42	08/02/89	584.30		
E7	06/22/87	584.70	07/15/87	584.92	08/04/87	583.86	10/13/87	584.24	11/04/87	584.51	03/31/88	585.33
	07/05/88	583.06	10/11/88	584.16	01/25/89	584.67	04/17/89	584.45	08/02/89	584.31		

Table 7. Ground-water levels in wells in the water-level network, August 1985 through August 1988--Continued

Well name	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
E10	10/30/85	581.10	11/05/85	581.31	11/11/85	581.81	12/19/85	582.48	01/06/86	581.92	02/06/86	581.99
	02/20/86	581.92	02/26/86	582.16	04/03/86	582.42	05/16/86	581.91	08/14/86	581.38	11/24/86	582.46
	12/15/86	582.72	01/14/87	582.25	02/23/87	582.05	06/26/87	582.28	07/16/87	581.90	08/04/87	581.45
	03/31/88	582.79	07/06/88	580.96	10/11/88	580.39	01/25/89	582.09	04/17/89	582.23	08/02/89	581.51
E15	10/30/85	581.14	11/05/85	581.42	11/11/85	581.89	12/19/85	582.20	01/06/86	581.73	02/06/86	581.84
	02/20/86	581.79	03/22/86	582.15	04/03/86	582.16	05/16/86	581.71	08/14/86	581.29	11/24/86	582.18
	02/23/87	581.85	08/04/87	581.24	03/31/88	582.45	07/06/88	580.81	01/25/89	581.80	08/02/89	581.11
E17	10/25/85	581.31	11/27/85	581.88	01/06/86	581.50	02/20/86	581.67	03/08/86	581.42	03/22/86	581.45
	04/03/86	581.52	05/09/86	581.61	06/10/86	581.71	08/04/86	581.67	08/19/86	581.52	09/26/86	581.97
	12/31/86	581.60	02/25/87	581.34	08/04/87	580.93	03/31/88	581.23	:			
E20	10/25/85	587.44	12/06/85	588.67	01/08/86	587.66	02/04/86	587.80	02/20/86	588.10	03/08/86	588.03
	03/22/86	588.41	04/03/86	588.13	05/09/86	587.66	06/10/86	588.10	08/04/86	587.26	08/20/86	586.79
	09/26/86	587.37	12/31/86	588.03	02/25/87	587.84	07/15/87	587.72	08/04/87	587.16	03/31/88	588.94
	07/06/88	586.98	10/11/88	586.79	01/25/89	588.26	04/17/89	588.56	08/02/89	587.79		

Table 8. Surface-water levels at sites in the water-level network, September 1985 through August 1988

[Water level, in feet above sea level]

Well name	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
A11S	12/17/85	585.66	02/06/86	585.60	02/18/86	585.58	03/17/86	585.58	03/31/86	585.62	05/16/86	585.62
	09/22/86	585.82	11/25/86	585.53	02/26/87	585.50	06/26/87	586.28	08/04/87	586.39	03/31/88	585.57
	07/06/88	586.51	10/13/88	585.65	01/25/89	585.45	04/19/89	585.57	08/03/89	586.25		
C16S	12/18/85	582.47	01/08/86	582.25	02/04/86	582.89	02/20/86	582.51	03/07/86	582.69	03/21/86	582.35
	04/01/86	582.55	05/15/86	582.87	08/13/86	583.42	12/17/86	582.47	02/24/87	582.33	08/05/87	582.37
	12/17/87	582.28	03/30/88	582.25	07/06/88	580.97	10/13/88	581.22	01/25/89	581.90	04/19/89	581.98
	08/04/89	581.68										
D36S	01/23/86	582.03	03/08/86	581.63	03/22/86	581.59	03/31/86	582.61	05/15/86	583.05	08/13/86	582.80
	11/24/86	582.39	11/25/86	582.44	02/26/87	582.23	03/26/87	581.66	08/04/87	581.95	10/13/87	580.90
	07/05/88	580.86	10/11/88	579.90	01/24/89	580.38	04/18/89	579.64	08/02/89	580.66		
D54S	12/12/85	582.47	02/05/86	582.55	03/07/86	582.27	04/03/86	582.28	05/15/86	582.49	08/14/86	582.83
	11/25/86	582.47	12/16/86	582.46	10/12/88	580.20	01/24/89	580.05	04/19/89	580.16		
E16S	12/19/85	581.04	01/06/86	581.16	02/06/86	581.59	03/08/86	580.93	03/22/86	580.83	04/03/86	581.58
	05/16/86	581.60	08/14/86	581.21	11/24/86	581.42	02/23/87	581.30	03/26/87	581.02	08/04/87	581.00
	03/31/88	580.99	07/06/88	580.50	10/11/88	579.41	01/25/89	580.32	04/17/89	580.28	08/02/89	579.99
S1	03/04/86	583.01	03/21/86	582.93	04/03/86	582.96	05/09/86	583.18	06/03/86	583.22	06/10/86	583.31
	07/24/86	583.28	08/04/86	583.23	08/19/86	583.15	09/25/86	583.27	12/30/86	583.21	02/25/87	583.19
	06/22/87	583.12	08/04/87	583.03	10/13/87	583.00	11/04/87	583.14	03/31/88	583.51	07/05/88	582.82
	10/11/88	583.11	01/25/89	583.23	04/17/89	583.06	08/02/89	583.08				
S2	05/09/86	582.32	06/03/86	582.64	06/10/86	582.81	08/04/86	582.79	08/19/86	582.62		
	09/25/86	582.69	12/30/86	582.50	02/25/87	582.15	08/04/87	581.74	08/06/87	581.68	10/13/87	582.05
	11/04/87	582.08	03/31/88	582.41	07/05/88	581.20	10/11/88	581.12	01/25/89	582.33	04/17/89	582.93
	08/02/89	582.47										
S3	06/04/86	582.66	08/04/87	581.99	10/13/87	582.00	03/31/88	582.37	07/05/88	582.02	10/11/88	581.95
	01/25/89	582.08										
S4	06/04/86	582.65	08/04/87	581.99	10/13/87	582.00	11/04/87	582.04	03/31/88	582.32	07/05/88	582.02
	10/11/88	581.94	01/25/89	582.07								

Table 8. Surface-water levels at sites in the water-level network, September 1985 through August 1988--Continued

Well name	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level	Date	Water level
S6	12/05/85	581.33	01/06/86	580.27	02/03/86	580.90	02/19/86	581.10	03/07/86	580.96	03/21/86	580.84
	04/03/86	581.35	05/09/86	581.65	06/03/86	581.60	06/09/86	581.90	07/24/86	581.83	08/04/86	581.75
	08/19/86	582.11	09/25/86	581.87	12/30/86	581.54						
S7	12/06/85	582.75	01/07/86	582.18	02/03/86	582.28	02/17/86	582.33	03/04/86	582.10	03/22/86	581.38
	04/01/86	582.20	05/09/86	582.85	06/09/86	583.07	08/05/86	582.77	08/19/86	583.11	09/26/86	583.23
	12/31/86	582.06										
S8	01/14/86	579.62	02/03/86	579.75	02/17/86	579.12	03/06/86	579.31	03/20/86	579.43	05/09/86	579.41
	06/09/86	579.39	09/25/86	579.31	12/30/86	579.57	08/05/87	579.80	03/31/88	580.12	07/06/88	579.89
	10/12/88	579.99										
S9	08/04/87	585.79	03/31/88	586.03	07/07/88	585.01	10/11/88	584.05	01/24/89	585.13	04/18/89	585.85
	08/01/89	585.72										
S10	11/27/85	581.96	12/04/85	582.75	01/03/86	582.84	02/04/86	582.92	02/17/86	582.62	03/06/86	582.68
	03/20/86	582.96	03/31/86	582.51	05/09/86	583.13	06/09/86	583.09	07/24/86	583.13	08/04/86	583.04
	08/19/86	583.17	09/25/86	583.10	12/30/86	582.74	08/04/87	582.49	04/01/88	581.63	07/05/88	581.46
	10/11/88	581.45	01/26/89	581.90	04/20/89	581.54	08/01/89	582.17				
S11	08/05/87	589.97	04/01/88	590.19	07/07/88	589.83	10/12/88	589.99	01/24/89	590.24	04/19/89	590.24
	08/04/89	590.07										
S12	11/27/85	583.21	12/04/85	582.89	12/12/85	581.69	01/03/86	582.96	02/03/86	582.53	02/17/86	582.87
	03/06/86	582.67	03/20/86	583.04	03/31/86	582.65	05/09/86	583.16	06/09/86	583.17	07/24/86	583.36
	08/04/86	583.11	08/19/86	583.09	09/25/86	583.10	12/30/86	582.71	02/26/87	582.28	08/04/87	582.89
	04/01/88	582.44	07/05/88	582.39	10/12/88	581.91	01/26/89	581.74	04/20/87	581.79	08/01/89	582.94
S13	10/12/88	582.74	01/24/89	582.62	04/20/89	582.60	08/03/89	583.38				
S14	09/10/85	581.85	05/16/86	582.56	06/09/86	582.81	07/24/86	582.64	02/26/87	581.87	08/04/87	581.86
	08/06/87	581.45	03/31/88	580.96	07/06/88	580.33	10/13/88	580.39	01/25/89	578.71	04/19/89	579.47
	08/03/89	579.37										
S15	08/06/87	586.9	09/15/87	587.0	03/31/88	587.2	07/06/88	587.0	10/13/88	586.9	01/25/89	587.1
	04/19/89	587.0	08/03/89	586.8								
S16	08/07/87	589.24	07/07/88	588.76								

Table 9. Ground-water levels in well A20, February 7, 1986, through July 7, 1988

[Dashes (--) indicate no data collected]

DAY	Mean water levels in feet above sea level, water year October 1985 through September 1986											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	--	--	--	--	--	595.28	595.44	595.50	--
2	--	--	--	--	--	--	--	--	595.25	595.44	595.50	--
3	--	--	--	--	--	--	--	--	595.26	595.43	595.49	--
4	--	--	--	--	--	--	--	--	595.27	595.44	595.49	--
5	--	--	--	--	--	--	--	--	595.28	595.44	595.49	--
6	--	--	--	--	--	--	--	--	595.28	595.43	595.49	--
7	--	--	--	--	595.14	--	--	--	595.30	595.42	595.49	--
8	--	--	--	--	595.13	--	--	--	595.29	595.43	595.49	--
9	--	--	--	--	595.13	--	--	--	595.30	595.44	595.48	--
10	--	--	--	--	595.13	--	--	--	595.32	595.45	595.48	--
11	--	--	--	--	595.13	--	--	--	595.35	595.45	595.46	--
12	--	--	--	--	595.12	--	--	--	595.36	595.46	595.46	--
13	--	--	--	--	595.12	--	--	--	595.34	595.46	595.46	--
14	--	--	--	--	595.14	--	--	--	595.34	595.46	595.47	595.29
15	--	--	--	--	595.11	--	--	--	595.36	595.46	595.48	595.30
16	--	--	--	--	595.13	--	--	595.21	595.38	595.47	595.46	595.27
17	--	--	--	--	595.14	--	--	595.23	595.37	595.48	595.45	595.30
18	--	--	--	--	--	--	--	595.24	595.39	595.48	595.43	595.32
19	--	--	--	--	--	--	--	595.23	595.41	595.49	595.42	595.31
20	--	--	--	--	--	--	--	595.22	595.41	595.49	595.41	595.29
21	--	--	--	--	--	--	--	595.23	595.42	595.49	595.40	595.28
22	--	--	--	--	--	--	--	595.24	595.43	595.49	595.41	595.30
23	--	--	--	--	--	--	--	595.25	595.44	595.49	595.41	595.31
24	--	--	--	--	--	--	--	595.25	595.43	595.49	595.40	595.31
25	--	--	--	--	--	--	--	595.25	595.43	595.50	595.40	595.31
26	--	--	--	--	--	--	--	595.25	595.44	595.50	595.41	595.30
27	--	--	--	--	--	--	--	595.27	595.44	595.51	595.52	595.29
28	--	--	--	--	--	--	--	595.26	595.45	595.52	--	595.29
29	--	--	--	--	--	--	--	595.26	595.45	595.51	--	595.30
30	--	--	--	--	--	--	--	595.27	595.44	595.50	--	595.30
31	--	--	--	--	--	--	--	595.28	--	595.51	--	--
MEAN	--	--	--	--	--	--	--	--	595.36	595.47	--	--
MAXIMUM	--	--	--	--	--	--	--	--	595.45	595.52	--	--
MINIMUM	--	--	--	--	--	--	--	--	595.25	595.42	--	--

Table 9. Ground-water levels in well A20, February 7, 1986, through July 7, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1986 through September 1987											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	595.31	595.54	595.46	595.56	595.57	595.48	595.42	595.51	596.14	596.05	595.75	--
2	595.32	595.52	595.50	595.57	595.60	595.40	595.40	595.53	596.16	596.05	595.75	--
3	595.37	595.54	595.50	595.55	595.58	595.36	595.37	595.51	596.18	596.04	595.74	--
4	595.43	595.53	595.48	595.54	595.53	595.36	595.37	595.48	596.19	596.01	595.73	--
5	595.47	595.53	595.45	595.55	595.50	595.39	595.38	595.48	596.21	596.00	595.72	--
6	595.49	595.53	595.47	595.59	595.49	595.38	595.38	595.51	596.24	595.98	595.72	--
7	595.53	595.52	595.49	595.55	595.50	595.39	595.39	595.52	596.27	595.93	--	--
8	595.55	595.53	595.51	595.54	595.48	595.42	595.39	595.52	596.30	595.91	--	--
9	595.56	595.50	595.52	595.56	595.44	595.40	595.39	595.53	596.31	595.91	--	--
10	595.57	595.47	595.50	595.58	595.45	595.37	595.40	595.54	596.32	595.89	--	--
11	595.59	595.47	595.52	595.55	595.46	595.37	595.42	595.54	596.34	595.88	--	--
12	595.61	595.47	595.51	595.55	595.47	595.37	595.40	595.51	596.35	595.87	--	--
13	595.62	595.44	595.48	595.54	595.46	595.39	595.37	595.52	596.36	595.86	--	--
14	595.62	595.46	595.52	595.54	595.47	595.43	595.41	595.54	596.36	595.84	--	--
15	595.63	595.48	595.52	595.52	595.43	595.41	595.42	595.52	596.34	595.84	--	--
16	595.63	595.49	595.52	595.49	595.43	595.38	595.42	595.54	596.32	595.83	--	--
17	595.62	595.49	595.54	595.50	595.43	595.38	595.43	595.56	596.30	595.82	--	--
18	595.61	595.47	595.56	595.53	595.43	595.41	595.42	595.57	596.28	595.82	--	--
19	595.61	595.44	595.56	595.54	595.42	595.42	595.42	595.63	596.28	595.82	--	--
20	595.62	595.47	595.55	595.51	595.41	595.41	595.44	595.68	596.27	595.81	--	--
21	595.63	595.43	595.53	595.52	595.42	595.41	595.46	595.72	596.26	595.80	--	--
22	595.63	595.43	595.53	595.54	595.43	595.41	595.48	595.77	596.24	595.79	--	--
23	595.63	595.44	595.56	595.52	595.42	595.41	595.49	595.81	596.21	595.78	--	--
24	595.62	595.41	595.58	595.50	595.38	595.42	595.47	595.86	596.17	595.78	--	--
25	595.62	595.40	595.58	595.49	595.37	595.43	595.46	595.92	596.16	595.78	--	--
26	595.63	595.42	595.55	595.49	595.37	595.42	595.47	595.96	596.15	595.77	--	--
27	595.62	595.39	595.55	595.50	595.41	595.40	595.50	596.01	596.12	595.77	--	--
28	595.59	595.42	595.55	595.51	595.45	595.39	595.50	596.07	596.10	595.77	--	--
29	595.58	595.43	595.57	595.53	--	595.41	595.54	596.10	596.09	595.77	--	--
30	595.55	595.43	595.57	595.54	--	595.40	595.50	596.12	596.06	595.76	--	--
31	595.55	--	595.56	595.50	--	595.40	--	596.13	--	595.75	--	--
MEAN	595.56	595.47	595.53	595.53	595.46	595.40	595.43	595.68	596.24	595.86	--	--
MAXIMUM	595.63	595.54	595.58	595.59	595.60	595.48	595.54	596.13	596.36	596.05	--	--
MINIMUM	595.31	595.39	595.45	595.49	595.37	595.36	595.37	595.48	596.06	595.75	--	--

Table 9. Ground-water levels in well A20, February 7, 1986, through July 7, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1987 through September 1988											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	595.77	595.64	595.59	595.70	595.84	595.82	595.81	595.98	595.84	595.78	--	--
2	595.75	595.64	595.56	595.71	595.82	595.82	595.84	595.98	595.83	595.79	--	--
3	595.70	595.65	595.58	595.74	595.82	595.82	595.87	595.99	595.82	595.78	--	--
4	595.72	595.66	595.55	595.75	595.82	595.83	595.86	595.99	595.82	595.78	--	--
5	595.75	595.63	595.54	595.74	595.82	595.82	595.86	595.94	595.82	595.78	--	--
6	595.75	595.63	595.54	595.74	595.81	595.82	595.86	595.89	595.82	595.78	--	--
7	595.72	595.63	595.54	595.77	595.82	595.83	595.84	595.89	595.82	595.78	--	--
8	595.69	595.64	595.56	595.79	595.81	595.83	595.83	595.89	595.83	--	--	--
9	595.69	595.61	595.58	595.80	595.82	595.84	595.83	595.90	595.82	--	--	--
10	595.68	595.61	595.56	595.79	595.81	595.83	595.85	595.90	595.82	--	--	--
11	595.68	595.61	595.59	595.81	595.81	595.84	595.86	595.89	595.82	--	--	--
12	595.69	595.63	595.58	595.83	595.81	595.87	595.88	595.89	595.82	--	--	--
13	595.69	595.64	595.54	595.79	595.81	595.85	595.89	595.89	595.82	--	--	--
14	595.68	595.61	595.53	595.78	595.84	595.84	595.90	595.89	595.82	--	--	--
15	595.68	595.60	595.62	595.81	595.83	595.83	595.90	595.89	595.82	--	--	--
16	595.68	595.61	595.53	595.83	595.81	595.81	595.90	595.89	595.81	--	--	--
17	595.68	595.65	595.50	595.83	595.81	595.81	595.94	595.88	595.81	--	--	--
18	595.68	595.59	595.52	595.82	595.81	595.82	595.96	595.87	595.81	--	--	--
19	595.68	595.59	595.55	595.84	595.84	595.82	595.96	595.87	595.81	--	--	--
20	595.68	595.59	595.56	595.86	595.84	595.82	595.96	595.86	595.81	--	--	--
21	595.67	595.57	595.53	595.81	595.81	595.81	595.97	595.85	595.81	--	--	--
22	595.68	595.59	595.58	595.81	595.85	595.82	595.97	595.84	595.81	--	--	--
23	595.67	595.59	595.57	595.84	595.81	595.84	595.97	595.84	595.80	--	--	--
24	595.66	595.57	595.62	595.84	595.80	595.84	595.96	595.84	595.80	--	--	--
25	595.65	595.58	595.60	595.83	595.81	595.85	595.96	595.84	595.80	--	--	--
26	595.68	595.56	595.60	595.82	595.83	595.84	595.98	595.84	595.80	--	--	--
27	595.69	595.56	595.63	595.81	595.82	595.81	595.99	595.84	595.79	--	--	--
28	595.67	595.60	595.67	595.81	595.82	595.81	595.97	595.84	595.79	--	--	--
29	595.67	595.61	595.64	595.83	595.82	595.82	595.97	595.84	595.80	--	--	--
30	595.67	595.60	595.69	595.84	--	595.80	595.97	595.84	595.79	--	--	--
31	595.64	--	595.73	595.84	--	595.79	--	595.84	--	--	--	--
MEAN	595.69	595.61	595.58	595.80	595.82	595.83	595.91	595.88	595.81	--	--	--
MAXIMUM	595.77	595.66	595.73	595.86	595.85	595.87	595.99	595.99	595.84	--	--	--
MINIMUM	595.64	595.56	595.50	595.70	595.80	595.79	595.81	595.84	595.79	--	--	--

Table 11. Surface-water levels at site C16S, December 18, 1985, through September 8, 1986

[Dashes (--) indicate no data collected]

DAY	Mean water levels in feet above sea level, water year October 1985 through September 1986											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	582.18	582.42	582.19	582.65	582.80	583.47	583.63	583.51	583.31
2	--	--	--	582.39	582.42	582.21	582.68	582.66	583.62	583.58	583.47	583.40
3	--	--	--	582.82	582.43	582.45	582.84	582.67	583.32	583.46	583.48	583.36
4	--	--	--	582.63	582.75	582.29	582.99	582.40	583.20	583.22	583.39	583.28
5	--	--	--	582.52	582.77	582.22	582.90	582.44	583.54	583.25	583.36	583.26
6	--	--	--	582.37	582.84	582.79	582.83	582.75	583.54	583.33	583.50	583.33
7	--	--	--	582.52	582.88	582.68	582.62	582.85	583.53	583.43	583.57	583.32
8	--	--	--	582.20	582.56	582.00	582.67	583.04	583.32	583.47	583.44	583.01
9	--	--	--	581.57	582.35	582.27	582.78	583.05	583.36	583.79	583.36	--
10	--	--	--	582.09	582.34	582.50	582.70	582.99	583.50	583.63	583.48	--
11	--	--	--	582.02	582.43	582.59	582.60	582.93	583.46	583.75	583.46	--
12	--	--	--	582.22	582.27	582.68	582.89	582.95	583.60	583.74	583.37	--
13	--	--	--	582.57	582.05	582.77	582.91	582.93	583.37	583.67	583.35	--
14	--	--	--	582.68	582.24	582.56	582.91	582.95	583.41	583.65	583.31	--
15	--	--	--	582.31	582.18	582.41	583.02	582.93	583.65	583.63	583.40	--
16	--	--	--	582.23	582.34	582.44	583.14	582.97	583.44	583.79	583.42	--
17	--	--	--	582.18	582.53	582.43	583.03	583.35	583.38	583.63	583.63	--
18	--	--	582.22	582.18	582.54	582.52	582.89	583.67	583.39	583.57	583.76	--
19	--	--	582.18	582.59	582.57	582.91	582.76	583.78	583.42	583.69	583.68	--
20	--	--	582.45	582.35	582.75	582.85	582.73	583.56	583.59	583.78	583.57	--
21	--	--	582.30	582.19	582.92	582.34	583.22	583.32	583.48	583.79	583.71	--
22	--	--	582.05	582.53	582.40	581.90	583.05	583.35	583.40	583.69	583.65	--
23	--	--	582.25	582.29	582.44	582.31	582.71	583.35	583.33	583.59	583.61	--
24	--	--	583.07	582.25	582.46	582.43	582.68	583.31	583.64	583.46	583.41	--
25	--	--	582.51	582.29	582.33	582.26	582.91	583.39	583.44	583.74	583.33	--
26	--	--	581.90	582.66	582.46	582.46	583.05	583.45	583.35	583.74	583.62	--
27	--	--	582.25	582.94	582.90	582.49	582.89	583.51	583.41	583.67	583.83	--
28	--	--	581.86	582.27	582.41	582.25	582.76	583.39	583.51	583.74	583.56	--
29	--	--	581.93	582.40	--	582.33	582.68	583.31	583.48	583.66	583.28	--
30	--	--	581.83	582.28	--	582.46	582.80	583.21	583.67	583.60	583.19	--
31	--	--	582.18	582.30	--	582.49	--	583.25	--	583.55	583.28	--
MEAN	--	--	--	582.36	582.50	582.43	582.84	583.11	583.46	583.61	583.48	--
MAXIMUM	--	--	--	582.94	582.92	582.91	583.22	583.78	583.67	583.79	583.83	--
MINIMUM	--	--	--	581.57	582.05	581.90	582.60	582.40	583.20	583.22	583.19	--

Table 12. Ground-water levels in well C15, February 4, 1986, through July 6, 1988

[Dashes (--) indicate no data collected]

	Mean water levels in feet above sea level, water year October 1985 through September 1986											
DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	--	--	582.64	582.73	582.82	583.22	583.25	583.11	582.81
2	--	--	--	--	--	582.63	582.72	582.71	583.25	583.19	583.07	582.89
3	--	--	--	--	--	582.65	582.83	582.70	582.96	583.08	583.08	582.88
4	--	--	--	--	582.93	582.65	583.00	582.62	582.84	582.86	583.00	582.81
5	--	--	--	--	582.84	582.66	582.91	582.55	583.23	582.85	582.97	582.77
6	--	--	--	--	582.90	582.86	582.86	582.72	583.19	582.92	583.12	582.85
7	--	--	--	--	583.02	583.24	582.70	582.81	583.19	583.03	583.18	582.88
8	--	--	--	--	582.71	582.91	582.71	582.99	582.98	583.08	583.05	582.62
9	--	--	--	--	582.62	582.65	582.79	583.02	583.02	583.43	582.97	582.58
10	--	--	--	--	--	582.75	582.73	582.96	583.16	583.26	583.10	582.59
11	--	--	--	--	--	582.77	582.67	582.90	583.12	583.36	583.07	582.92
12	--	--	--	--	--	582.76	582.86	582.92	583.25	583.35	582.98	583.13
13	--	--	--	--	--	582.84	582.92	582.89	583.02	583.27	582.94	582.94
14	--	--	--	--	--	582.73	582.91	582.93	583.08	583.25	582.85	583.06
15	--	--	--	--	--	582.68	583.04	582.94	583.30	583.24	582.91	583.30
16	--	--	--	--	--	582.66	583.12	582.85	583.09	583.39	582.93	583.29
17	--	--	--	--	582.69	582.65	583.05	582.99	583.03	583.21	583.15	582.97
18	--	--	--	--	582.74	582.68	582.90	583.34	583.03	583.15	583.27	583.08
19	--	--	--	--	582.77	582.94	582.78	583.43	583.06	583.28	583.18	583.15
20	--	--	--	--	582.90	583.13	582.74	583.22	583.23	583.37	583.09	583.30
21	--	--	--	--	583.17	582.72	583.19	582.99	583.10	583.37	583.22	583.15
22	--	--	--	--	582.73	582.61	583.05	583.01	583.02	583.28	583.18	583.17
23	--	--	--	--	582.68	582.62	582.75	583.00	582.95	583.18	583.14	583.18
24	--	--	--	--	582.68	582.66	582.69	582.94	583.27	583.05	582.94	583.12
25	--	--	--	--	582.69	582.59	582.88	583.03	583.07	583.33	582.85	583.23
26	--	--	--	--	582.70	582.62	583.02	583.09	582.98	583.33	583.15	583.30
27	--	--	--	--	582.97	582.66	582.89	583.16	583.05	583.26	583.34	583.36
28	--	--	--	--	582.82	582.59	582.78	583.03	583.14	583.33	583.10	583.34
29	--	--	--	--	--	582.54	582.70	582.96	583.10	583.25	582.83	583.32
30	--	--	--	--	--	582.60	582.84	582.85	583.30	583.19	582.72	583.44
31	--	--	--	--	--	582.62	--	582.89	--	583.15	582.78	--
MEAN	--	--	--	--	--	582.72	582.86	582.94	583.11	583.21	583.04	583.05
MAXIMUM	--	--	--	--	--	583.24	583.19	583.43	583.30	583.43	583.34	583.44
MINIMUM	--	--	--	--	--	582.54	582.67	582.55	582.84	582.85	582.72	582.58

Table 12. Ground-water levels in well C15, February 4, 1986, through July 6, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1986 through September 1987											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	583.49	583.27	583.27	582.62	582.63	--	--	--	--	--	--	582.47
2	583.46	583.22	583.10	582.72	582.68	--	--	--	--	--	--	582.44
3	583.75	582.96	582.79	582.66	582.67	--	--	--	--	--	--	582.41
4	583.91	583.29	582.68	582.62	582.65	--	--	--	--	--	--	582.36
5	583.53	583.16	582.64	582.61	582.62	--	--	--	--	--	582.27	582.33
6	583.39	582.94	582.62	582.61	582.59	--	--	--	--	--	582.18	582.31
7	583.06	583.02	582.74	582.67	582.60	--	--	--	--	--	582.06	582.32
8	583.23	582.89	582.92	582.62	583.67	--	--	--	--	--	582.10	582.35
9	583.82	582.71	583.01	582.58	583.86	--	--	--	--	--	582.22	582.35
10	583.48	582.70	582.87	582.91	583.59	--	--	--	--	--	582.33	582.31
11	583.33	582.97	582.76	582.86	583.59	--	--	--	--	--	582.18	582.27
12	583.27	582.88	582.61	582.62	583.64	--	--	--	--	--	582.06	582.42
13	583.34	583.10	582.63	582.61	583.64	--	--	--	--	--	582.08	582.42
14	583.29	582.88	582.61	582.65	583.85	--	--	--	--	--	582.62	582.34
15	583.37	582.61	582.58	582.71	583.96	--	--	--	--	--	582.46	582.30
16	583.32	582.73	582.64	582.66	583.95	--	--	--	--	--	582.58	582.46
17	583.63	582.77	582.66	582.64	584.03	--	--	--	--	--	583.05	582.57
18	583.38	583.26	582.73	582.63	584.02	--	--	--	--	--	582.67	582.56
19	583.26	582.93	582.65	582.65	583.96	--	--	--	--	--	582.60	582.50
20	583.11	583.01	582.69	582.64	583.96	--	--	--	--	--	582.53	582.44
21	583.20	582.92	582.66	582.58	583.96	--	--	--	--	--	582.62	582.50
22	583.15	582.70	582.60	582.65	583.97	--	--	--	--	--	582.61	582.75
23	583.23	582.79	582.59	582.71	583.98	--	--	--	--	--	582.55	582.62
24	583.53	582.75	582.69	--	583.98	--	--	--	--	--	582.49	582.59
25	583.65	582.68	582.69	--	--	--	--	--	--	--	582.57	582.55
26	583.58	583.31	582.64	--	--	--	--	--	--	--	582.84	582.49
27	583.38	582.81	582.64	--	--	--	--	--	--	--	582.73	582.43
28	583.08	582.70	582.60	--	--	--	--	--	--	--	582.68	582.41
29	583.39	582.79	582.58	--	--	--	--	--	--	--	582.64	582.61
30	583.29	583.10	582.74	--	--	--	--	--	--	--	582.57	582.55
31	583.01	--	582.65	--	--	--	--	--	--	--	582.51	--
MEAN	583.38	582.93	582.72	--	--	--	--	--	--	--	--	582.45
MAXIMUM	583.91	583.31	583.27	--	--	--	--	--	--	--	--	582.75
MINIMUM	583.01	582.61	582.58	--	--	--	--	--	--	--	--	582.27

Table 12. Ground-water levels in well C15, February 4, 1986, through July 6, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1987 through September 1988											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	582.49	582.43	582.57	--	--	--	582.55	582.44	581.86	581.51	--	--
2	582.45	582.52	582.51	--	--	--	582.57	582.41	581.86	581.38	--	--
3	582.58	582.48	582.51	--	--	--	582.62	582.39	581.85	581.25	--	--
4	582.50	582.44	582.53	--	--	--	582.57	582.36	581.79	581.14	--	--
5	582.44	582.42	582.48	--	--	--	582.54	582.32	581.72	581.08	--	--
6	582.42	582.38	582.47	--	--	--	582.79	582.29	581.64	581.09	--	--
7	582.42	582.36	582.56	--	--	--	582.62	582.28	581.60	--	--	--
8	582.41	582.37	582.59	--	--	--	582.57	582.29	581.65	--	--	--
9	582.40	582.39	582.56	--	--	582.62	582.56	582.41	581.69	--	--	--
10	582.43	582.39	582.52	--	--	582.56	582.55	582.38	581.63	--	--	--
11	582.53	582.37	582.50	--	--	582.53	582.54	582.35	581.56	--	--	--
12	582.48	582.33	582.50	--	--	582.53	582.53	582.30	581.48	--	--	--
13	582.43	582.33	582.48	--	--	582.50	582.51	582.26	581.41	--	--	--
14	582.38	582.32	582.45	--	--	582.50	582.50	582.23	581.34	--	--	--
15	582.35	582.32	582.62	--	--	582.50	582.50	582.24	581.29	--	--	--
16	582.34	582.33	582.60	--	--	582.50	582.49	582.26	581.29	--	--	--
17	582.50	582.38	582.54	--	--	582.48	582.47	582.23	581.32	--	--	--
18	582.43	582.33	582.52	--	--	582.43	582.47	582.22	581.28	--	--	--
19	582.42	582.26	582.58	--	--	582.42	582.46	582.18	581.19	--	--	--
20	582.55	582.24	582.74	--	--	582.41	582.45	582.15	581.38	--	--	--
21	582.49	582.24	582.64	--	--	582.38	582.45	582.12	582.07	--	--	--
22	582.46	582.24	582.62	--	--	582.37	582.45	582.11	581.78	--	--	--
23	582.44	582.28	--	--	--	582.39	582.52	582.36	581.61	--	--	--
24	582.56	582.29	--	--	--	582.51	582.49	582.57	581.52	--	--	--
25	582.53	582.57	--	--	--	582.49	582.46	582.46	581.36	--	--	--
26	582.50	582.52	--	--	--	582.42	582.46	582.39	581.28	--	--	--
27	582.49	582.48	--	--	--	582.38	582.54	582.30	581.23	--	--	--
28	582.48	582.55	--	--	--	582.52	582.53	582.19	581.17	--	--	--
29	582.47	582.55	--	--	--	582.60	582.48	582.08	581.80	--	--	--
30	582.45	582.53	--	--	--	582.63	582.46	581.99	581.70	--	--	--
31	582.43	--	--	--	--	582.57	--	581.92	--	--	--	--
MEAN	582.46	582.39	--	--	--	--	582.52	582.27	581.54	--	--	--
MAXIMUM	582.58	582.57	--	--	--	--	582.79	582.57	582.07	--	--	--
MINIMUM	582.34	582.24	--	--	--	--	582.45	581.92	581.17	--	--	--

Table 13. Ground-water levels in well C10, December 18, 1985, through May 4, 1988

[Dashes (--) indicate no data collected]

DAY	Mean water levels in feet above sea level, water year October 1985 through September 1986											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	583.18	--	583.37	583.18	583.28	583.27	583.39	583.03	582.68
2	--	--	--	583.20	--	583.36	583.16	583.18	583.34	583.32	582.98	582.70
3		--	--	583.25	--	583.36	583.13	583.12	583.17	583.18	582.99	582.77
4	--	--	--	--	583.62	583.36	583.16	583.06	583.12	583.03	582.92	582.74
5	--	--	--	--	583.52	583.40	583.16	582.98	583.38	582.93	582.88	582.64
6	--	--	--	--	583.45	583.44	583.15	582.96	583.34	582.90	583.01	582.64
7	--	--	--	--	583.43	583.38	583.11	583.01	583.57	582.96	583.08	582.70
8	--	--	--	--	583.39	583.31	583.08	583.05	583.37	583.15	582.98	582.61
9	--	--	--	--	583.34	583.40	583.09	583.10	583.26	583.61	582.88	582.51
10	--	--	--	--	583.32	583.49	583.09	583.07	583.49	583.50	583.00	582.43
11	--	--	--	--	583.30	583.41	583.07	583.03	583.40	583.57	582.99	582.81
12	--	-	--	--	583.27	583.37	583.10	583.03	583.40	583.53	582.88	583.06
13	--	--	--	--	583.24	583.39	583.16	583.03	583.28	583.40	582.83	582.94
14	--	--	--	--	583.21	583.35	583.23	583.13	583.35	583.33	582.82	582.91
15	--	--	--	--	583.18	583.32	583.30	583.24	583.69	583.30	582.81	583.05
16	--	--	--	--	583.20	583.29	583.30	583.26	583.44	583.34	582.81	583.19
17	--	--	--	--	583.34	583.27	583.28	583.28	583.32	583.22	582.91	583.00
18	--	--	583.24	--	583.50	583.36	583.21	583.58	583.25	583.12	583.05	582.97
19	--	--	583.23	--	583.55	583.42	583.14	583.71	583.21	583.21	582.99	583.13
20	--	--	583.23	--	583.50	583.38	583.13	583.53	583.28	583.30	582.92	583.29
21	--	--	583.23	--	583.53	583.30	583.26	583.37	583.19	583.27	582.95	583.17
22	--	--	583.23	--	583.45	583.27	583.26	583.31	583.11	583.22	583.00	583.12
23	--	--	583.24	--	583.42	583.25	583.15	583.28	583.05	583.11	582.97	583.31
24	--	--	583.44	--	583.39	583.23	583.07	583.22	583.22	583.02	582.86	583.24
25	--	--	583.29	--	583.38	583.19	583.04	583.21	583.11	583.35	582.76	583.23
26	--	--	583.23	--	583.39	583.20	583.09	583.35	583.01	583.30	583.03	583.34
27	--	--	583.22	--	583.42	583.18	583.07	583.54	583.20	583.19	583.26	583.35
28	--	--	583.21	--	583.40	583.15	583.09	583.39	583.27	583.33	583.18	583.35
29	--	--	583.19	--	--	583.11	583.06	583.38	583.17	583.21	582.95	583.44
30	--	--	583.18	--	--	583.09	583.37	583.24	583.46	583.11	582.79	583.58
31	--	--	583.18	--	--	583.08	--	583.15	--	583.06	582.69	--
MEAN	--	--	--	--	--	583.31	583.16	583.23	583.29	583.24	582.94	583.00
MAXIMUM	--	--	--	--	--	583.49	583.37	583.71	583.69	583.61	583.26	583.58
MINIMUM	--	--	--	--	--	583.08	583.04	582.96	583.01	582.90	582.69	582.43

Table 13. Ground-water levels in well C10, December 18, 1985, through May 4, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1986 through September 1987											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	583.61	583.38	583.53	583.19	583.32	583.45	583.05	583.09	583.53	582.74	582.44	582.97
2	583.57	583.42	583.56	583.18	583.39	583.35	583.07	583.27	583.44	582.70	582.29	582.91
3	584.02	583.29	583.43	583.18	583.37	583.27	583.05	583.33	583.36	582.59	582.18	582.87
4	584.06	583.38	583.37	583.16	583.32	583.23	583.05	583.25	583.22	582.51	582.14	582.81
5	583.84	583.35	583.32	583.15	583.28	583.21	583.05	583.18	583.13	582.53	582.14	582.74
6	583.68	583.26	583.31	583.15	583.26	583.19	583.05	583.12	583.04	582.57	582.10	582.69
7	583.52	583.21	583.45	583.15	583.25	583.17	583.03	583.07	582.95	582.85	582.04	582.68
8	583.45	583.21	583.53	583.15	583.69	583.15	583.01	583.05	582.90	582.69	582.09	582.71
9	583.79	583.16	583.51	583.14	583.72	583.42	583.00	583.00	582.94	582.60	582.17	582.70
10	583.64	583.12	583.39	583.16	583.32	583.30	582.99	582.93	582.86	582.74	582.12	582.65
11	583.51	583.15	583.33	583.23	583.28	583.20	583.25	582.97	582.91	582.80	582.05	582.60
12	583.45	583.14	583.31	583.17	583.26	583.16	583.25	583.20	583.19	582.62	582.00	582.74
13	583.46	583.12	583.29	583.18	583.23	583.14	583.16	583.08	582.97	582.54	582.04	582.74
14	583.45	583.09	583.27	583.29	583.22	583.16	583.46	583.00	582.84	582.52	582.69	582.66
15	583.45	583.09	583.27	583.38	583.21	583.21	583.51	582.95	582.77	582.69	582.57	582.61
16	583.43	583.09	583.27	583.32	583.17	583.16	583.42	582.89	582.72	582.69	582.81	582.79
17	583.61	583.09	583.28	583.27	583.17	583.12	583.35	582.86	582.66	582.50	583.65	582.97
18	583.51	583.51	583.28	583.25	583.16	583.12	583.29	583.47	582.59	582.38	583.30	582.99
19	583.43	583.52	583.26	583.24	583.14	583.16	583.24	583.74	582.56	582.30	583.13	582.92
20	583.35	583.41	583.24	583.22	583.13	583.12	583.19	583.51	582.69	582.26	583.00	582.85
21	583.30	583.39	583.24	583.19	583.13	583.11	583.17	583.35	583.02	582.46	583.12	582.91
22	583.29	583.30	583.21	583.18	583.13	583.09	583.41	583.39	582.93	582.30	583.04	583.40
23	583.30	583.34	583.20	583.17	583.12	583.07	583.47	583.31	582.87	582.21	582.93	583.25
24	583.54	583.29	583.20	583.14	583.11	583.07	583.35	583.29	582.75	582.16	582.85	583.15
25	583.75	583.25	583.19	583.12	583.12	583.13	583.29	583.35	582.87	582.12	582.99	583.07
26	583.77	583.86	583.19	583.12	583.11	583.10	583.23	583.34	582.88	582.27	583.64	583.00
27	583.63	583.68	583.19	583.11	583.11	583.09	583.19	583.19	582.73	582.48	583.49	582.92
28	583.44	583.50	583.17	583.11	583.27	583.07	583.16	583.10	582.59	582.47	583.33	582.88
29	583.49	583.44	583.16	583.15	--	583.06	583.12	583.02	582.59	582.33	583.22	583.14
30	583.47	583.44	583.20	583.24	--	583.05	583.10	583.15	582.69	582.24	583.12	583.05
31	583.35	--	583.21	583.23	--	583.05	--	583.31	--	582.45	583.04	--
MEAN	583.55	583.32	583.30	583.19	583.25	583.17	583.20	583.19	582.91	582.49	582.70	582.88
MAXIMUM	584.06	583.86	583.56	583.38	583.72	583.45	583.51	583.74	583.53	582.85	583.65	583.40
MINIMUM	583.29	583.09	583.16	583.11	583.11	583.05	582.99	582.86	582.56	582.12	582.00	582.60

Table 13. Ground-water levels in well C10, December 18, 1985, through May 4, 1988--Continued

	Mean water levels in feet above sea level, water year October 1987 through September 1988											
DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	582.97	582.89	--	583.28	583.43	583.31	583.37	583.15	--	--	--	--
2	582.90	583.00	--	583.26	583.37	583.30	583.39	583.13	--	--	--	--
3	582.94	582.96	--	583.25	583.33	583.27	583.48	583.10	--	--	--	--
4	582.91	582.93	--	583.24	583.31	583.25	583.42	583.09	--	--	--	--
5	582.87	582.89	--	583.20	583.29	583.22	583.38	--	--	--	--	--
6	582.85	582.87	--	583.17	583.29	583.20	583.83	--	--	--	--	--
7	582.84	582.85	--	583.16	583.28	583.19	583.61	--	--	--	--	--
8	582.83	582.84	--	583.15	583.27	583.19	583.49	--	--	--	--	--
9	582.83	582.85	--	583.13	583.27	583.24	583.41	--	--	--	--	--
10	582.85	582.85	--	583.11	583.27	583.21	583.38	--	--	--	--	--
11	582.94	582.84	--	583.08	583.27	583.19	583.36	--	--	--	--	--
12	582.91	582.82	--	583.07	583.27	583.19	583.34	--	--	--	--	--
13	582.87	582.80	--	583.07	583.27	583.18	583.32	--	--	--	--	--
14	582.83	582.79	--	583.07	583.30	583.16	583.31	--	--	--	--	--
15	582.78	582.77	--	583.05	583.54	583.15	583.29	--	--	--	--	--
16	582.74	582.77	--	583.04	583.43	583.14	583.27	--	--	--	--	--
17	582.92	582.84	583.20	583.21	583.42	583.13	583.26	--	--	--	--	--
18	582.87	582.81	583.19	583.43	583.49	583.11	583.26	--	--	--	--	--
19	582.86	582.77	583.27	583.50	583.49	583.10	583.24	--	--	--	--	--
20	583.03	582.75	583.67	583.64	583.46	583.10	583.23	--	--	--	--	--
21	582.96	582.74	583.49	583.51	583.41	583.08	583.23	--	--	--	--	--
22	582.92	582.73	583.40	583.43	583.42	583.07	583.22	--	--	--	--	--
23	582.90	582.74	583.36	583.39	583.46	583.07	583.26	--	--	--	--	--
24	583.05	582.78	583.34	583.37	583.41	583.17	583.22	--	--	--	--	--
25	583.03	583.09	583.34	583.35	583.37	583.19	583.20	--	--	--	--	--
26	583.00	583.05	583.32	583.34	583.34	583.13	583.19	--				
27	582.99	583.02	583.30	583.33	583.33	583.10	583.28	--	--	--	--	--
28	582.97	583.11	583.39	583.31	583.33	583.28	583.26	--	--	--	--	--
29	582.94	583.11	583.40	583.33	583.33	583.44	583.21	--	--	--	--	--
30	582.92	583.09	583.35	583.38	--	583.58	583.18	--	--	--	--	--
31	582.90	--	583.32	583.49	--	583.45	--	--	--	--	--	--
MEAN	582.91	582.88	--	583.27	583.36	583.21	583.33	--	--	--	--	--
MAXIMUM	583.05	583.11	--	583.64	583.54	583.58	583.83	--	--	--	--	--
MINIMUM	582.74	582.73	--	583.04	583.27	583.07	583.18	--	--	--	--	--

Table 14. Ground-water levels in well C5, May 15, 1986, through June 29, 1988
[Dashes (--) indicate no data collected]

DAY	Mean water levels in feet above sea level, water year October 1985 through September 1986											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	--	--	--	--	--	584.03	584.04	583.41	582.92
2	--	--	--	--	--	--	--	--	583.99	583.98	583.38	582.90
3	--	--	--	--	--	--	--	--	583.96	583.87	583.37	582.89
4	--	--	--	--	--	--	--	--	583.94	583.74	583.32	582.89
5	--	--	--	--	--	--	--	--	584.08	583.65	583.29	582.84
6	--	--	--	--	--	--	--	--	584.05	583.60	583.30	582.82
7	--	--	--	--	--	--	--	--	584.42	583.57	583.33	582.80
8	--	--	--	--	--	--	--	--	584.35	583.62	583.31	582.79
9	--	--	--	--	--	--	--	--	584.19	584.34	583.24	582.77
10	--	--	--	--	--	--	--	--	584.33	584.20	583.28	582.75
11	--	--	--	--	--	--	--	--	584.37	584.30	583.25	582.90
12	--	--	--	--	--	--	--	--	584.26	584.25	583.18	583.02
13	--	--	--	--	--	--	--	--	584.17	584.12	583.15	582.98
14	--	--	--	--	--	--	--	--	584.17	584.00	583.14	582.95
15	--	--	--	--	--	--	--	584.48	584.64	583.93	583.13	582.91
16	--	--	--	--	--	--	--	584.13	584.47	583.84	583.11	582.91
17	--	--	--	--	--	--	--	584.09	584.35	583.74	583.09	582.93
18	--	--	--	--	--	--	--	584.31	584.24	583.67	583.07	582.94
19	--	--	--	--	--	--	--	584.73	584.13	583.61	583.05	583.04
20	--	--	--	--	--	--	--	584.45	584.07	583.66	583.03	583.22
21	--	--	--	--	--	--	--	584.38	584.00	583.56	583.01	583.21
22	--	--	--	--	--	--	--	584.30	583.92	583.54	583.01	583.17
23	--	--	--	--	--	--	--	584.23	583.84	583.50	583.00	583.31
24	--	--	--	--	--	--	--	584.16	583.78	583.47	582.98	583.33
25	--	--	--	--	--	--	--	584.10	583.76	583.70	582.96	583.33
26	--	--	--	--	--	--	--	584.17	583.71	583.64	583.10	583.38
27	--	--	--	--	--	--	--	584.46	583.85	583.54	583.16	583.43
28	--	--	--	--	--	--	--	584.38	583.98	583.63	583.20	583.41
29	--	--	--	--	--	--	--	584.37	583.85	583.54	583.13	583.50
30	--	--	--	--	--	--	--	584.25	584.06	583.47	583.04	583.65
31	--	--	--	--	--	--	--	584.12	--	583.43	582.96	--
MEAN	--	--	--	--	--	--	--	--	584.10	583.77	583.16	583.06
MAXIMUM	--	--	--	--	--	--	--	--	584.64	584.34	583.41	583.65
MINIMUM	--	--	--	--	--	--	--	--	583.71	583.43	582.96	582.75

Table 14. Ground-water levels in well C5, May 15, 1986, through June 29, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1986 through September 1987											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	583.70	583.95	584.56	584.09	584.15	584.43	583.90	584.12	--	--	--	--
2	583.69	583.94	584.62	584.09	584.19	584.31	583.89	584.29	--	--	--	--
3	584.45	583.93	584.54	584.07	584.30	584.23	583.88	584.37	--	--	--	--
4	584.62	583.90	584.45	584.04	584.35	584.17	583.87	584.29	--	--	--	--
5	584.58	583.89	584.40	584.02	--	584.15	583.86	584.22	--	--	--	--
6	584.47	583.87	584.37	584.02	--	584.12	583.86	584.17	--	--	--	--
7	584.36	583.84	584.50	584.02	--	584.10	583.85	584.10	--	--	--	--
8	584.23	583.83	584.61	584.01	584.34	584.08	583.84	584.07	--	--	--	--
9	584.16	583.81	584.58	584.00	584.33	584.06	583.83	584.03	--	--	--	--
10	584.14	583.78	584.56	584.00	584.29	584.04	583.82	583.98	--	--	--	--
11	584.09	583.77	584.50	584.00	584.26	584.02	584.01	584.02	--	--	--	--
12	584.06	583.76	584.39	584.00	584.23	584.00	584.08	584.19	--	--	--	--
13	584.03	583.74	584.39	584.01	584.19	584.00	584.02	584.07	--	--	--	--
14	584.01	583.72	584.34	584.08	584.17	584.02	584.34	584.00	--	--	--	--
15	583.98	583.72	584.27	584.25	584.15	584.06	584.54	583.94	--	--	--	--
16	583.96	583.72	584.26	584.24	584.13	584.02	584.51	583.90	--	--	--	--
17	583.94	583.71	584.27	584.19	584.09	583.99	584.46	583.87	--	--	--	--
18	583.93	584.01	584.29	584.17	584.05	583.99	584.41	584.44	--	--	--	--
19	583.91	584.17	584.26	584.16	584.03	584.03	584.36	584.93	--	--	--	--
20	583.88	584.15	584.23	584.14	584.00	583.98	584.30	584.86	--	--	--	--
21	583.86	584.13	584.20	--	584.00	583.97	584.25	584.79	--	--	--	--
22	583.82	584.08	584.18	--	584.02	583.96	584.45	584.82	--	--	--	--
23	583.81	584.13	584.17	--	584.02	583.95	584.63	584.72	--	--	--	--
24	583.87	584.09	584.17	--	583.99	583.95	584.50	584.63	--	--	--	--
25	584.16	584.05	584.16	--	583.98	583.99	584.41	584.63	--	--	--	--
26	584.26	584.66	584.13	--	583.97	583.96	584.34	584.71	--	--	--	--
27	584.19	584.74	584.11	--	583.97	583.94	584.29	584.53	--	--	--	--
28	584.12	584.71	584.09	--	584.13	583.93	584.24	584.36	--	--	--	--
29	584.05	584.66	584.09	--	--	583.92	584.20	584.22	--	--	--	--
30	584.02	584.59	584.11	--	--	583.91	584.15	584.18	--	--	--	--
31	583.99	--	584.11	--	--	583.90	--	584.26	--	--	--	--
MEAN	584.08	584.03	584.32	--	--	584.04	584.17	584.31	--	--	--	--
MAXIMUM	584.62	584.74	584.62	--	--	584.43	584.63	584.93	--	--	--	--
MINIMUM	583.69	583.71	584.09	--	--	583.90	583.82	583.87	--	--	--	--

Table 14. Ground-water levels in well C5, May 15, 1986, through June 29, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1987 through September 1988											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	--	--	--	584.71	584.31	583.64	--	--	--
2	--	--	--	--	--	--	584.72	584.28	583.60	--	--	--
3	--	--	--	--	--	--	584.81	584.26	583.57	--	--	--
4	--	--	--	--	--	--	584.83	584.23	583.53	--	--	--
5	--	--	--	--	--	--	584.78	584.21	583.48	--	--	--
6	--	--	--	--	--	--	585.12	584.18	583.42	--	--	--
7	--	--	--	--	--	--	585.13	584.16	583.36	--	--	--
8	--	--	--	--	--	--	585.09	584.16	583.33	--	--	--
9	--	--	--	--	--	--	585.04	584.22	583.31	--	--	--
10	--	--	--	--	--	--	584.99	584.16	583.27	--	--	--
11	--	--	--	--	--	--	584.92	584.12	583.23	--	--	--
12	--	--	--	--	--	--	584.85	584.11	583.18	--	--	--
13	--	--	--	--	--	--	584.80	584.09	583.12	--	--	--
14	--	--	--	--	--	--	584.74	584.06	583.08	--	--	--
15	--	--	--	--	--	--	584.67	584.04	583.04	--	--	--
16	--	--	--	--	--	--	584.62	584.01	583.01	--	--	--
17	--	--	585.17	--	--	--	584.59	584.00	582.98	--	--	--
18	--	--	585.16	--	--	--	584.56	583.97	582.95	--	--	--
19	--	--	585.23	--	--	--	584.51	583.93	582.90	--	--	--
20	--	--	585.48	--	--	--	584.48	583.90	582.96	--	--	--
21	--	--	585.49	--	--	--	584.46	583.87	583.13	--	--	--
22	--	--	585.49	--	--	--	584.43	583.84	583.03	--	--	--
23	--	--	585.50	--	--	--	584.46	584.05	582.94	--	--	--
24	--	--	585.51	--	--	--	584.41	584.43	582.86	--	--	--
25	--	--	585.50	--	--	--	584.38	584.27	582.81	--	--	--
26	--	--	585.49	--	--	--	584.37	584.18	582.74	--	--	--
27	--	--	585.49	--	--	--	584.46	584.07	582.73	--	--	--
28	--	--	--	--	--	--	584.44	583.97	582.72	--	--	--
29	--	--	--	--	--	--	584.37	583.86	582.82	--	--	--
30	--	--	--	--	--	--	584.33	583.76	--	--	--	--
31	--	--	--	--	--	584.73	--	583.69	--	--	--	--
MEAN	--	--	--	--	--	--	584.67	584.08	--	--	--	--
MAXIMUM	--	--	--	--	--	--	585.13	584.43	--	--	--	--
MINIMUM	--	--	--	--	--	--	584.33	583.69	--	--	--	--

Table 15. Surface-water levels at site E16S, December 19, 1985, through April 5, 1987

[Dashes (--) indicate no data collected]

DAY	Mean water levels in feet above sea level, water year October 1985 through September 1986											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	581.07	581.31	581.17	581.46	581.54	581.69	581.74	581.75	581.29
2	--	--	--	581.24	581.35	581.17	581.49	581.49	581.79	581.72	581.59	581.40
3	--	--	--	581.60	581.35	581.37	581.61	581.50	581.59	581.60	581.65	581.48
4	--	--	--	581.47	581.65	581.23	581.73	581.34	581.48	581.39	581.56	581.31
5	--	--	--	581.37	581.63	581.17	581.65	581.27	581.72	581.39	581.53	581.27
6	--	--	--	581.29	581.66	581.51	581.60	581.48	581.72	581.49	581.65	581.33
7	--	--	--	581.43	581.69	581.54	581.43	581.57	581.73	581.60	581.71	581.44
8	--	--	--	581.22	581.45	581.08	581.46	581.69	581.61	581.71	581.53	581.12
9	--	--	--	580.73	581.30	581.16	581.56	581.73	581.63	582.29	581.40	581.12
10	--	--	--	581.04	581.28	581.32	581.51	581.69	581.77	582.00	581.42	581.07
11	--	--	--	581.02	581.33	581.50	581.42	581.64	581.67	582.15	581.53	581.59
12	--	--	--	581.03	581.24	581.55	581.61	581.66	581.72	582.18	581.36	581.79
13	--	--	--	581.46	581.11	581.63	581.66	581.63	581.61	582.10	581.34	581.51
14	--	--	--	581.51	581.13	581.46	581.64	581.68	581.63	582.17	581.24	581.70
15	--	--	--	581.28	581.20	581.34	581.71	581.66	581.81	582.21	581.35	581.88
16	--	--	--	581.21	581.27	581.38	581.77	581.59	581.61	582.11	581.42	581.97
17	--	--	--	581.14	581.44	581.36	581.75	581.67	581.59	581.97	581.44	581.50
18	--	--	--	581.11	581.44	581.45	581.64	581.92	581.55	581.91	581.67	581.71
19	--	--	581.10	581.44	581.43	581.56	581.51	581.98	581.55	582.01	581.60	581.90
20	--	--	581.29	581.28	581.48	581.65	581.48	581.80	581.69	582.20	581.50	581.95
21	--	--	581.27	581.13	581.74	581.27	581.79	581.66	581.64	582.19	581.55	581.80
22	--	--	581.03	581.38	581.34	580.98	581.74	581.68	581.56	582.13	581.60	581.84
23	--	--	581.07	581.25	581.36	581.11	581.50	581.66	581.50	582.02	581.55	582.03
24	--	--	581.67	581.22	581.36	581.36	581.45	581.63	581.67	581.88	581.33	581.96
25	--	--	581.45	581.17	581.29	581.17	581.61	581.67	581.59	582.12	581.26	582.02
26	--	--	581.33	581.44	581.34	581.24	581.68	581.72	581.52	582.06	581.61	582.43
27	--	--	581.08	--	581.69	581.37	581.61	581.79	581.60	581.97	581.80	582.51
28	--	--	580.86	--	581.34	581.16	581.50	581.69	581.67	582.14	581.66	582.55
29	--	--	580.85	--	--	581.21	581.44	581.65	581.60	581.94	581.27	582.65
30	--	--	580.86	--	--	581.29	581.60	581.53	581.85	581.72	581.08	582.84
31	--	--	581.00	--	--	581.35	--	581.56	--	581.74	581.16	--
MEAN	--	--	--	--	581.40	581.33	581.59	581.64	581.65	581.93	581.49	581.77
MAXIMUM	--	--	--	--	581.74	581.65	581.79	581.98	581.85	582.29	581.80	582.84
MINIMUM	--	--	--	-	581.11	580.98	581.42	581.27	581.48	581.39	581.08	581.07

Table 15. Surface-water levels at site E16S, December 19, 1985, through April 5, 1987--Continued

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	Mean water levels in feet above sea level, water year October 1986 through September 1987											
1	582.92	581.98	582.11	--	--	581.66	581.07	--	--	--	--	--
2	582.86	581.97	581.98	--	--	581.31	581.74	--	--	--	--	--
3	583.33	581.70	581.57	--	--	581.19	581.41	--	--	--	--	--
4	583.34	582.04	581.32	--	--	581.16	581.59	--	--	--	--	--
5	583.08	581.97	581.35	--	--	581.33	581.78	--	--	--	--	--
6	582.98	581.78	581.27	--	--	581.24	--	--	--	--	--	--
7	582.67	581.86	581.61	--	--	581.02	--	--	--	--	--	--
8	582.78	581.68	581.85	--	--	581.20	--	--	--	--	--	--
9	583.28	581.31	581.89	--	--	582.22	--	--	--	--	--	--
10	582.96	581.43	581.73	--	--	581.80	--	--	--	--	--	--
11	582.83	581.82	581.67	--	--	581.36	--	--	--	--	--	--
12	582.89	581.68	--	--	--	581.24	--	--	--	--	--	--
13	583.02	581.70	--	--	--	581.21	--	--	--	--	--	--
14	582.96	581.12	--	--	--	581.48	--	--	--	--	--	--
15	583.09	581.24	--	--	--	581.58	--	--	--	--	--	--
16	583.06	581.57	--	--	--	581.50	--	--	--	--	--	--
17	583.01	581.64	--	--	--	581.36	--	--	--	--	--	--
18	582.31	582.10	--	--	--	581.43	--	--	--	--	--	--
19	582.21	581.78	--	--	--	581.46	--	--	--	--	--	--
20	581.98	581.79	--	--	--	581.28	--	--	--	--	--	--
21	581.94	581.78	--	--	--	581.27	--	--	--	--	--	--
22	581.92	581.33	--	--	--	581.25	--	--	--	--	--	--
23	581.96	581.61	--	--	581.26	581.26	--	--	--	--	--	--
24	582.21	581.51	--	--	581.24	581.35	--	--	--	--	--	--
25	582.33	581.45	--	--	581.32	581.22	--	--	--	--	--	--
26	582.31	582.22	--	--	581.31	581.08	--	--	--	--	--	--
27	582.11	581.60	--	--	581.37	581.17	--	--	--	--	--	--
28	581.88	581.29	--	--	581.61	581.30	--	--	--	--	--	--
29	582.06	581.65	--	--	--	581.52	--	--	--	--	--	--
30	582.04	581.97	--	--	--	581.53	--	--	--	--	--	--
31	581.80	--	--	--	--	581.30	--	--	--	--	--	--
MEAN	582.58	581.69	--	--	--	581.36	--	--	--	--	--	--
MAXIMUM	583.34	582.22	--	--	--	582.22	--	--	--	--	--	--
MINIMUM	581.80	581.12	--	--	--	581.02	--	--	--	--	--	--

Table 16. Ground-water levels in well E15, February 6, 1986, through August 4, 1987

[Dashes (--) indicate no data collected]

	Mean water levels in feet above sea level, water year October 1985 through September 1986											
DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	--	--	581.79	582.13	581.92	--	--	--	581.04
2	--	--	--	--	--	581.82	582.13	581.87	--	--	--	581.03
3	--	--	--	--	--	581.84	582.15	581.85	--	--	--	581.03
4	--	--	--	--	--	581.83	582.16	581.85	--	--	--	581.01
5	--	--	--	--	--	581.85	582.14	581.86	--	--	--	580.97
6	--	--	--	--	581.86	581.92	582.12	581.86	--	--	--	580.95
7	--	--	--	--	581.86	581.88	582.08	581.83	--	--	--	580.94
8	--	--	--	--	581.81	581.83	582.06	581.82	--	--	--	580.90
9	--	--	--	--	581.78	581.90	582.05	581.81	--	--	--	580.86
10	--	--	--	--	581.76	581.99	582.04	581.81	--	--	--	580.84
11	--	--	--	--	581.77	582.02	582.02	581.81	--	--	--	580.94
12	--	--	--	--	581.74	582.10	582.01	581.79	--	--	--	581.00
13	--	--	--	--	581.70	582.18	582.00	581.78	--	--	--	580.93
14	--	--	--	--	581.74	582.18	582.02	581.81	--	--	581.29	580.95
15	--	--	--	--	581.69	582.17	582.04	581.81	--	--	581.29	580.98
16	--	--	--	--	581.71	582.15	582.02	581.80	--	--	581.28	580.98
17	--	--	--	--	581.77	582.15	581.99	--	--	--	581.25	580.92
18	--	--	--	--	581.80	582.21	581.97	--	--	--	581.26	580.94
19	--	--	--	--	581.83	582.31	581.95	--	--	--	581.24	580.99
20	--	--	--	--	581.87	582.27	581.97	--	--	--	581.22	581.09
21	--	--	--	--	581.87	582.23	581.98	--	--	--	581.20	581.09
22	--	--	--	--	581.83	582.19	581.92	--	--	--	581.20	581.11
23	--	--	--	--	581.82	582.20	581.88	--	--	--	581.19	581.23
24	--	--	--	--	581.81	582.19	581.88	--	--	--	581.14	581.24
25	--	--	--	--	581.80	582.20	581.91	--	--	--	581.11	581.29
26	--	--	--	--	581.88	582.19	581.90	--	--	--	581.16	581.44
27	--	--	--	--	581.88	582.17	581.88	--	--	--	581.19	581.61
28	--	--	--	--	581.81	582.15	581.87	--	--	--	581.16	581.65
29	--	--	--	--	--	582.15	581.82	--	--	--	581.09	581.75
30	--	--	--	--	--	582.13	581.91	--	--	--	581.05	581.99
31	--	--	--	--	--	582.12	--	--	--	--	581.03	--
MEAN	--	--	--	--	--	582.07	582.00	--	--	--	--	581.12
MAXIMUM	--	--	--	--	--	582.31	582.16	--	--	--	--	581.99
MINIMUM	--	--	--	--	--	581.79	581.82	--	--	--	--	580.84

Table 16. Ground-water levels in well E15, February 6, 1986, through August 4, 1987--Continued

DAY	Mean water levels in feet above sea level, water year October 1986 through September 1987											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	582.11	582.31	582.69	582.10	581.95	582.09	581.72	582.08	582.36	581.83	581.34	--
2	582.15	582.28	582.73	582.13	581.97	582.00	581.77	582.09	582.39	581.82	581.31	--
3	582.67	582.25	582.69	582.08	582.01	581.95	581.72	582.12	582.43	581.79	581.27	--
4	582.99	582.26	582.54	582.05	582.01	581.95	581.72	582.09	582.38	581.75	581.26	--
5	582.91	582.26	582.49	582.03	582.00	581.99	581.76	582.07	582.32	581.75	--	--
6	582.82	582.20	582.44	582.06	582.02	581.95	581.73	582.05	582.30	581.74	--	--
7	582.75	582.18	582.52	582.03	582.07	581.93	581.72	582.03	582.24	581.70	--	--
8	582.71	582.15	582.74	581.97	582.21	581.97	581.71	582.00	582.19	581.68	--	--
9	582.75	582.04	582.82	582.01	582.05	582.08	581.69	581.95	582.15	581.66	--	--
10	582.71	582.03	582.70	582.10	582.03	581.96	581.68	581.95	582.09	581.70	--	--
11	582.68	582.08	582.58	581.99	582.06	581.91	581.74	581.96	582.10	581.72	--	--
12	582.67	582.04	582.52	581.97	582.04	581.88	581.78	581.98	582.19	581.69	--	--
13	582.67	581.96	582.44	581.96	582.00	581.87	581.76	581.97	582.15	581.68	--	--
14	582.67	581.93	582.36	582.00	582.07	581.92	581.91	581.95	582.11	581.66	--	--
15	582.65	581.97	582.36	582.03	582.02	581.89	582.06	581.90	582.07	581.65	--	--
16	582.65	582.00	582.36	582.03	582.01	581.85	582.08	581.89	582.03	581.66	--	--
17	582.60	581.98	582.36	582.08	582.02	581.83	582.08	581.88	581.97	581.61	--	--
18	582.43	582.06	582.36	582.11	581.95	581.87	582.04	582.10	581.93	581.56	--	--
19	582.40	582.13	582.31	582.14	581.90	581.86	582.04	582.41	581.90	581.53	--	--
20	582.38	582.22	582.30	582.07	581.88	581.83	582.02	582.41	581.96	581.51	--	--
21	582.34	582.22	582.27	582.01	581.89	581.83	582.05	582.37	582.06	581.50	--	--
22	582.32	582.18	582.21	582.08	581.90	581.82	582.13	582.34	582.01	581.48	--	--
23	582.28	582.22	582.20	582.01	581.86	581.82	582.26	582.30	581.94	581.45	--	--
24	582.27	582.19	582.28	581.92	581.83	581.84	582.23	582.27	581.91	581.39	--	--
25	582.40	582.18	582.26	581.89	581.83	581.82	582.20	582.27	581.98	581.39	--	--
26	582.55	582.63	582.19	581.90	581.82	581.76	582.19	582.27	581.97	581.37	--	--
27	582.53	582.77	582.18	581.86	581.85	581.75	582.18	582.22	581.93	581.39	--	--
28	582.46	582.69	582.12	581.85	581.94	581.75	582.11	582.20	581.87	581.39	--	--
29	582.43	582.68	582.14	581.90	--	581.79	582.12	582.15	581.85	581.36	--	--
30	582.38	582.68	582.16	581.95	--	581.78	582.09	582.16	581.83	581.34	--	--
31	582.32	--	582.10	581.91	--	581.74	--	582.22	--	581.35	--	--
MEAN	582.54	582.23	582.40	582.01	581.97	581.88	581.94	582.12	582.09	581.58	--	--
MAXIMUM	582.99	582.77	582.82	582.14	582.21	582.09	582.26	582.41	582.43	581.83	--	--
MINIMUM	582.11	581.93	582.10	581.85	581.82	581.74	581.68	581.88	581.83	581.34	--	--

Table 17. Ground-water levels in well E10, October 30, 1985, through April 28, 1987

[Dashes (--) indicate no data collected]

DAY	Mean water levels in feet above sea level, water year October 1985 through September 1986											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	581.15	582.99	582.11	581.82	582.03	582.41	582.07	582.20	--	--	--
2	--	581.23	583.02	582.12	581.80	582.09	582.40	582.02	582.14	--	--	--
3	--	581.24	582.96	582.08	581.80	582.07	582.40	582.00	582.13	--	--	--
4	--	581.26	582.96	582.10	581.92	582.07	582.39	582.03	582.13	--	--	--
5	--	581.30	582.95	582.07	582.02	582.12	582.38	582.06	582.13	--	--	--
6	--	581.33	582.89	582.04	582.01	582.16	582.36	582.02	582.11	--	--	--
7	--	581.34	582.88	581.98	582.03	582.12	582.34	581.97	582.12	--	--	--
8	--	581.33	582.87	581.96	582.02	582.13	582.31	581.95	582.10	--	--	--
9	--	581.40	582.82	582.00	582.01	582.19	582.28	581.93	582.05	--	--	--
10	--	581.70	582.85	581.97	582.01	582.30	582.27	581.92	582.10	--	--	--
11	--	581.78	583.00	581.97	582.01	582.33	582.25	581.92	582.14	--	--	--
12	--	581.84	583.00	581.96	582.01	582.40	582.21	581.90	582.12	--	--	--
13	--	581.87	582.93	581.92	581.99	582.45	582.18	581.89	582.05	--	--	--
14	--	581.91	582.83	581.94	581.98	582.47	582.20	581.90	582.04	--	581.37	--
15	--	581.97	582.77	581.90	581.94	582.49	582.20	581.89	582.15	--	581.36	--
16	--	582.26	582.70	581.90	581.94	582.46	582.17	581.90	582.17	--	581.33	--
17	--	582.28	582.65	581.94	581.95	582.45	582.14	581.92	582.13	--	581.29	--
18	--	582.39	582.52	581.94	581.97	582.54	582.14	581.97	582.12	--	--	--
19	--	582.86	582.49	581.93	582.05	582.60	582.14	582.13	582.13	--	--	--
20	--	582.86	582.47	581.91	582.17	582.53	582.16	582.13	582.10	--	--	--
21	--	582.82	582.43	581.93	--	582.53	582.13	582.13	582.08	--	--	--
22	--	582.83	582.48	581.86	--	582.58	582.07	582.13	--	--	--	--
23	--	582.80	582.44	581.84	--	582.58	582.05	582.13	--	--	--	--
24	--	582.75	582.35	581.89	--	582.52	582.06	582.13	--	--	--	--
25	--	582.76	582.31	581.94	--	582.56	582.06	582.13	--	--	--	--
26	--	582.80	582.34	581.93	582.70	582.54	582.05	582.12	--	--	--	--
27	--	582.76	582.23	581.92	582.06	582.48	582.03	582.16	--	--	--	--
28	--	582.77	582.19	581.92	582.03	582.49	582.03	582.17	--	--	--	--
29	--	582.76	582.18	581.88	--	582.50	581.98	582.19	--	--	--	--
30	581.09	582.76	582.17	581.83	--	582.45	582.05	582.20	--	--	--	--
31	581.11	--	582.14	581.82	--	582.42	--	582.21	--	--	--	--
MEAN	--	582.10	582.64	581.95	--	582.38	582.19	582.04	--	--	--	--
MAXIMUM	--	582.86	583.02	582.12	--	582.60	582.41	582.21	--	--	--	--
MINIMUM	--	581.15	582.14	581.82	--	582.03	581.98	581.89	--	--	--	--

Table 17. Ground-water levels in well E10, October 30, through April 28, 1987--Continued

	Mean water levels in feet above sea level, water year October 1986 through September 1987											
DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	--	582.18	582.25	581.94	--	--	--	--	--
2	--	--	--	--	582.25	582.23	581.90	--	--	--	--	--
3	--	--	--	--	582.30	582.21	581.88	--	--	--	--	--
4	--	--	--	--	582.30	582.22	581.86	--	--	--	--	--
5	--	--	--	--	582.30	582.25	581.87	--	--	--	--	--
6	--	--	--	--	582.33	582.22	581.86	--	--	--	--	--
7	--	--	--	--	582.37	582.22	581.86	--	--	--	--	--
8	--	--	--	--	582.34	582.24	581.85	--	--	--	--	--
9	--	--	--	--	582.29	582.19	581.84	--	--	--	--	--
10	--	--	--	--	582.31	582.14	581.84	--	--	--	--	--
11	--	--	--	--	582.30	582.14	581.89	--	--	--	--	--
12	--	--	--	--	582.28	582.11	581.91	--	--	--	--	--
13	--	--	--	--	582.26	582.10	581.89	--	--	--	--	--
14	--	--	--	582.26	582.27	582.12	582.02	--	--	--	--	--
15	--	--	--	582.26	582.20	582.08	582.23	--	--	--	--	--
16	--	--	--	582.31	582.19	582.05	582.25	--	--	--	--	--
17	--	--	--	582.37	582.20	582.03	582.29	--	--	--	--	--
18	--	--	--	582.41	582.16	582.06	582.29	--	--	--	--	--
19	--	--	--	582.41	582.12	582.05	582.28	--	--	--	--	--
20	--	--	--	582.35	582.09	582.03	582.28	--	--	--	--	--
21	--	--	--	582.35	582.09	582.03	582.27	--	--	--	--	--
22	--	--	--	582.34	582.10	582.02	582.29	--	--	--	--	--
23	--	--	--	582.27	582.06	582.02	582.47	--	--	--	--	--
24	--	--	--	582.20	582.04	582.03	582.45	--	--	--	--	--
25	--	--	--	582.17	582.03	582.03	582.45	--	--	--	--	--
26	--	--	--	582.14	582.02	581.99	582.46	--	--	--	--	--
27	--	--	--	582.13	582.04	581.98	582.47	--	--	--	--	--
28	--	--	--	582.09	582.12	581.95	582.44	--	--	--	--	--
29	--	--	--	582.14	--	581.96	--	--	--	--	--	--
30	--	--	--	582.13	--	581.94	--	--	--	--	--	--
31	--	--	--	582.11	--	581.93	--	--	--	--	--	--
MEAN	--	--	--	--	582.20	582.09	--	--	--	--	--	--
MAXIMUM	--	--	--	--	582.37	582.25	--	--	--	--	--	--
MINIMUM	--	--	--	--	582.02	581.93	--	--	--	--	--	--

Table 18. Surface-water levels at site D54S, December 12, 1985, through February 7, 1987

[Dashes (--) indicate no data collected]

DAY	Mean water levels in feet above sea level, water year October 1985 through September 1986											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	582.11	582.09	--	--	--	582.95	583.02	583.15	582.90
2	--	--	--	582.24	582.11	--	--	--	582.94	582.97	583.12	582.99
3	--	--	--	582.60	582.09	--	--	--	582.64	582.87	583.11	582.97
4	--	--	--	582.47	582.39	--	--	--	582.53	582.56	583.06	582.89
5	--	--	--	582.33	582.48	--	--	--	582.94	582.62	583.04	582.87
6	--	--	--	582.19	582.56	--	--	--	582.91	582.79	583.18	583.00
7	--	--	--	582.33	582.54	--	--	--	582.78	582.88	583.21	583.01
8	--	--	--	582.15	582.21	--	--	--	582.65	582.90	583.11	582.74
9	--	--	--	581.99	582.07	--	--	--	582.77	583.07	583.05	582.65
10	--	--	--	582.02	582.11	--	--	--	582.82	583.03	583.18	582.79
11	--	--	--	582.01	582.11	--	--	--	582.78	583.10	583.14	582.71
12	--	--	582.38	582.16	582.06	--	--	--	582.92	583.15	583.11	--
13	--	--	582.53	582.24	582.00	--	--	--	582.71	583.09	583.03	--
14	--	--	582.42	582.37	582.06	--	--	--	582.81	583.07	582.83	--
15	--	--	582.24	582.12	582.08	--	--	582.47	582.90	583.08	582.89	--
16	--	--	582.26	582.01	582.08	--	--	582.43	582.74	583.16	582.93	--
17	--	--	582.29	581.99	582.16	--	--	582.63	582.73	583.01	583.13	--
18	--	--	583.00	582.02	582.14	--	--	582.96	582.75	582.99	583.24	--
19	--	--	582.58	582.29	582.17	--	--	583.04	582.76	583.07	583.19	--
20	--	--	582.38	582.13	582.35	--	--	582.85	582.93	583.20	583.06	--
21	--	--	582.30	582.07	--	--	--	582.62	582.83	583.25	583.23	--
22	--	--	582.20	582.22	--	--	--	582.69	582.76	583.14	583.13	--
23	--	--	582.27	582.06	--	--	--	582.65	582.68	583.08	583.09	--
24	--	--	582.88	582.04	--	--	--	582.65	583.00	582.94	582.91	--
25	--	--	582.46	582.02	--	--	--	582.73	582.81	583.11	582.81	--
26	--	--	582.19	582.35	--	--	--	582.78	582.70	583.20	583.08	--
27	--	--	582.17	582.80	--	--	--	582.81	582.72	583.15	583.29	--
28	--	--	582.12	582.81	--	--	--	582.69	582.86	583.16	583.03	--
29	--	--	582.12	582.49	--	--	--	582.59	582.92	583.14	582.77	--
30	--	--	582.09	582.00	--	--	--	582.50	583.03	583.12	582.70	--
31	--	--	582.11	581.99	--	--	--	582.61	--	583.14	582.84	--
MEAN	--	--	--	582.21	--	--	--	--	582.81	583.03	583.05	--
MAXIMUM	--	--	--	582.81	--	--	--	--	583.03	583.25	583.29	--
MINIMUM	--	--	--	581.99	--	--	--	--	582.53	582.56	582.70	--

Table 18. Surface-water levels at site D54S, December 12, 1985, through February 7, 1987--Continued

DAY	Mean water levels in feet above sea level, water year October 1986 through September 1987											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	582.31	582.05	--	--	--	--	--	--	--
2	--	--	--	582.56	582.04	--	--	--	--	--	--	--
3	--	--	--	582.35	582.26	--	--	--	--	--	--	--
4	--	--	--	582.32	582.10	--	--	--	--	--	--	--
5	--	--	--	582.19	582.09	--	--	--	--	--	--	--
6	--	--	--	582.17	582.08	--	--	--	--	--	--	--
7	--	--	--	582.37	582.08	--	--	--	--	--	--	--
8	--	--	--	582.07	--	--	--	--	--	--	--	--
9	--	--	--	582.16	--	--	--	--	--	--	--	--
10	--	--	--	582.81	--	--	--	--	--	--	--	--
11	--	--	--	582.30	--	--	--	--	--	--	--	--
12	--	--	--	582.11	--	--	--	--	--	--	--	--
13	--	--	--	582.06	--	--	--	--	--	--	--	--
14	--	--	--	582.17	--	--	--	--	--	--	--	--
15	--	--	--	582.40	--	--	--	--	--	--	--	--
16	--	--	582.40	582.26	--	--	--	--	--	--	--	--
17	--	--	582.35	582.21	--	--	--	--	--	--	--	--
18	--	--	582.44	582.24	--	--	--	--	--	--	--	--
19	--	--	582.17	582.38	--	--	--	--	--	--	--	--
20	--	--	582.53	582.32	--	--	--	--	--	--	--	--
21	--	--	582.38	582.11	--	--	--	--	--	--	--	--
22	--	--	582.04	582.31	--	--	--	--	--	--	--	--
23	--	--	582.11	582.77	--	--	--	--	--	--	--	--
24	--	--	582.54	582.77	--	--	--	--	--	--	--	--
25	--	582.43	582.39	582.77	--	--	--	--	--	--	--	--
26	--	582.93	582.35	582.77	--	--	--	--	--	--	--	--
27	--	--	582.31	582.77	--	--	--	--	--	--	--	--
28	--	--	582.02	582.51	--	--	--	--	--	--	--	--
29	--	--	582.21	582.10	--	--	--	--	--	--	--	--
30	--	--	582.57	582.42	--	--	--	--	--	--	--	--
31	--	--	582.14	582.12	--	--	--	--	--	--	--	--
MEAN	--	--	--	582.36	--	--	--	--	--	--	--	--
MAXIMUM	--	--	--	582.81	--	--	--	--	--	--	--	--
MINIMUM	--	--	--	582.06	--	--	--	--	--	--	--	--

Table 19. Ground-water levels in well D55, October 29, 1985, through July 6, 1988

[Dashes (--) indicate no data collected]

	Mean water levels in feet above sea level, water year October 1985 through September 1986											
DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	582.58	582.69	582.11	582.27	582.22	582.45	582.60	--	--	--	582.75
2	--	582.74	583.00	582.25	582.29	582.18	582.50	582.53	--	--	--	582.81
3	--	582.59	582.63	582.58	582.30	582.37	582.63	582.54	--	--	--	582.79
4	--	582.65	582.55	582.52	582.52	582.27	582.82	582.42	--	--	--	582.70
5	--	582.73	582.69	582.40	582.61	582.20	582.78	582.36	--	--	--	582.68
6	--	582.37	582.81	582.28	582.68	582.53	582.73	582.52	--	--	--	582.73
7	--	582.39	582.37	582.40	582.73	582.58	582.55	582.59	--	--	--	582.77
8	--	582.26	582.49	582.19	582.49	582.10	582.55	582.74	--	--	--	582.53
9	--	582.58	582.71	581.69	582.31	582.17	582.65	582.80	--	--	--	582.53
10	--	583.20	582.76	581.97	582.29	582.31	582.62	582.78	--	--	--	582.47
11	--	582.91	582.87	581.97	582.34	582.46	582.51	582.74	--	--	--	582.68
12	--	582.72	582.60	581.98	582.23	582.51	582.71	582.76	--	--	--	582.93
13	--	582.63	582.58	582.37	582.06	582.57	582.79	582.73	--	--	--	582.82
14	--	582.66	582.36	582.45	582.09	582.48	582.75	582.72	--	--	582.74	582.94
15	--	582.71	582.19	582.24	582.11	582.37	582.85	582.69	--	--	582.66	583.12
16	--	582.63	582.27	582.16	582.19	582.39	582.94	582.54	--	--	582.85	583.14
17	--	582.51	582.27	582.11	582.33	582.38	582.92	582.67	--	--	582.99	582.87
18	--	582.48	582.36	582.08	582.31	582.40	582.82	--	--	--	583.12	582.95
19	--	582.73	582.22	582.40	582.37	582.59	582.70	--	--	--	583.08	583.00
20	--	582.37	582.40	582.27	582.49	582.67	582.65	--	--	--	582.99	583.15
21	--	582.50	582.33	582.11	582.75	582.38	583.00	--	--	--	583.09	583.05
22	--	582.72	582.08	582.32	582.39	582.04	582.94	--	--	--	583.07	583.04
23	--	582.63	582.21	582.19	582.39	582.15	582.66	--	--	--	583.01	583.07
24	--	582.53	582.78	582.16	582.39	582.36	582.59	--	--	--	582.86	583.06
25	--	582.56	582.48	582.15	582.32	582.23	582.75	--	--	--	582.77	583.16
26	--	582.77	582.04	582.42	582.36	582.30	582.86	--	--	--	582.97	583.23
27	--	582.81	582.17	582.72	582.74	582.41	582.79	--	--	--	583.16	583.33
28	--	582.67	581.92	582.25	582.42	582.24	582.67	--	--	--	582.99	583.33
29	582.27	582.74	581.90	582.26	--	582.27	582.56	--	--	--	582.77	583.29
30	582.36	582.69	581.86	582.20	--	582.33	582.56	--	--	--	582.67	583.42
31	582.47	--	582.04	582.18	--	582.39	--	--	--	--	582.73	--
MEAN	--	582.64	582.41	582.24	582.38	582.35	582.71	--	--	--	--	582.94
MAXIMUM	--	583.20	583.00	582.72	582.75	582.67	583.00	--	--	--	--	583.42
MINIMUM	--	582.26	581.86	581.69	582.06	582.04	582.45	--	--	--	--	582.47

Table 19. Ground-water levels in well D55, October 29, 1985, through July 6, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1986 through September 1987											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	583.49	583.26	--	--	--	582.59	582.01	582.14	582.14	582.16	581.86	581.77
2	583.47	583.23	--	--	--	582.33	582.50	582.26	582.16	582.13	581.82	581.91
3	583.71	583.00	--	--	--	582.17	582.25	582.41	582.17	582.04	581.74	581.86
4	583.92	583.27	--	--	--	582.12	582.40	582.35	582.16	582.02	581.93	581.77
5	583.63	583.19	--	--	--	582.24	582.55	582.25	582.12	582.09	582.01	581.72
6	583.48	583.00	--	--	--	582.18	582.41	582.13	582.14	582.10	581.84	581.71
7	583.21	583.06	--	--	--	582.01	582.26	582.12	582.05	582.00	581.74	581.75
8	583.28	582.89	--	--	--	582.15	582.26	582.12	582.07	581.97	581.77	581.75
9	583.75	582.64	--	--	--	583.03	582.10	581.91	582.26	581.93	581.88	581.70
10	583.51	582.68	--	--	--	582.66	582.08	581.99	582.18	581.91	581.97	581.70
11	583.38	582.96	--	--	--	582.33	582.19	582.08	582.07	581.90	581.87	581.71
12	583.32	582.87	--	--	--	582.20	582.23	582.22	582.02	581.91	581.85	581.67
13	583.35	582.76	--	--	--	582.13	582.18	582.19	582.07	581.99	581.80	581.61
14	583.29	582.41	--	--	--	582.32	582.44	582.11	582.08	581.99	581.85	581.58
15	583.36	582.46	--	--	--	582.41	582.53	582.12	582.17	582.00	581.75	581.57
16	583.33	582.68	--	--	--	582.35	582.45	582.05	582.15	582.05	581.76	581.58
17	583.58	582.74	--	--	--	582.22	582.36	581.99	582.14	581.81	582.33	581.66
18	583.40	583.11	--	--	--	582.26	582.27	582.24	582.12	581.75	582.10	581.85
19	583.30	582.91	--	--	--	582.31	582.30	582.53	582.08	581.76	582.04	581.67
20	583.18	582.96	--	--	--	582.18	582.26	582.50	582.18	581.83	581.98	581.64
21	583.23	582.91	--	--	--	582.16	582.47	582.37	582.24	581.80	581.88	581.79
22	583.19	582.55	--	--	--	582.14	582.62	582.31	582.22	581.80	582.03	582.02
23	583.26	582.72	--	--	--	582.15	582.52	582.33	582.15	581.73	581.94	581.75
24	583.50	582.64	--	--	582.19	582.22	582.51	582.31	582.10	581.69	581.86	581.81
25	583.63	582.53	--	--	582.20	582.12	582.42	582.37	582.12	581.80	581.78	581.73
26	583.60	--	--	--	582.22	582.01	582.34	582.34	582.08	581.87	582.10	581.55
27	583.43	--	--	--	582.27	582.05	582.26	582.23	582.09	581.85	582.26	581.57
28	583.17	--	--	--	582.44	582.14	582.12	582.18	581.97	581.81	582.16	581.51
29	583.38	--	--	--	--	582.34	582.12	582.16	581.98	581.80	582.01	581.52
30	583.32	--	--	--	--	582.38	582.19	582.14	582.09	581.81	581.80	581.66
31	583.08	--	--	--	--	582.17	--	582.09	--	581.88	581.85	--
MEAN	583.41	--	--	--	--	582.26	582.32	582.21	582.12	581.91	581.92	581.70
MAXIMUM	583.92	--	--	--	--	583.03	582.62	582.53	582.26	582.16	582.33	582.02
MINIMUM	583.08	--	--	--	--	582.01	582.01	581.91	581.97	581.69	581.74	581.51

Table 19. Ground-water levels in well D55, October 29, 1985, through July 6, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1987 through September 1988											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	581.41	581.30	581.37	580.88	581.02	580.78	581.09	581.10	580.91	580.81	--	--
2	581.73	581.28	581.11	580.78	581.21	580.82	581.09	581.13	581.12	580.69	--	--
3	581.81	581.12	581.12	580.74	581.11	580.92	581.08	581.18	581.12	580.66	--	--
4	581.44	581.07	581.31	580.82	581.18	580.94	581.00	581.16	580.99	580.68	--	--
5	581.27	581.14	581.13	580.71	581.04	580.74	581.03	581.09	580.88	580.70	--	--
6	581.44	581.04	581.08	580.73	580.88	580.61	581.57	581.08	580.85	580.68	--	--
7	581.74	580.96	581.04	580.87	580.68	580.65	581.41	581.10	580.88	--	--	--
8	581.53	581.08	581.06	580.87	580.81	580.67	581.31	581.03	581.17	--	--	--
9	581.26	581.28	580.97	580.89	580.88	580.74	581.29	580.94	581.22	--	--	--
10	581.36	581.33	580.97	580.79	580.96	580.71	581.37	581.02	581.04	--	--	--
11	581.46	581.18	580.90	580.57	581.13	580.74	581.47	581.06	580.85	--	--	--
12	581.28	580.96	580.98	580.50	581.16	580.84	581.38	581.08	580.79	--	--	--
13	581.20	580.98	580.96	580.95	580.88	580.99	581.23	581.08	580.77	--	--	--
14	581.08	581.07	581.01	580.85	580.68	580.96	581.24	581.08	580.76	--	--	--
15	581.15	581.12	581.47	580.56	581.03	580.90	581.14	581.05	580.74	--	--	--
16	581.20	581.11	581.53	580.46	580.81	580.79	581.09	581.11	580.81	--	--	--
17	581.18	580.94	581.30	580.69	580.81	580.73	581.02	581.25	580.88	--	--	--
18	581.07	580.93	581.07	580.90	580.75	580.70	581.06	581.17	580.83	--	--	--
19	581.23	580.76	581.00	580.97	580.79	580.68	580.96	581.13	580.71	--	--	--
20	581.25	581.06	581.20	581.11	580.99	580.87	580.99	581.11	580.70	--	--	--
21	581.27	581.09	581.05	581.18	580.79	580.77	581.04	581.09	580.75	--	--	--
22	581.10	580.81	581.07	580.97	580.46	580.69	581.13	581.16	580.77	--	--	--
23	581.28	580.77	581.23	580.87	580.72	580.67	581.34	581.26	580.87	--	--	--
24	581.34	580.91	581.28	580.96	580.69	580.73	581.19	581.36	580.76	--	--	--
25	581.25	581.26	581.42	580.90	580.76	580.65	580.99	581.21	580.67	--	--	--
26	581.06	581.33	581.39	581.18	580.60	580.59	581.11	580.95	580.80	--	--	--
27	581.16	581.23	581.23	580.98	580.92	580.61	581.20	580.89	580.77	--	--	--
28	581.13	581.32	581.44	580.88	580.75	580.60	581.28	580.95	580.72	--	--	--
29	581.19	581.28	581.57	580.83	580.73	580.83	581.09	580.99	580.84	--	--	--
30	581.10	581.20	581.20	580.74	--	580.91	581.07	580.94	580.87	--	--	--
31	581.21	--	580.93	580.70	--	580.95	--	580.91	--	--	--	--
MEAN	581.30	581.10	581.17	580.83	580.87	580.77	581.18	581.09	580.86	--	--	--
MAXIMUM	581.81	581.33	581.57	581.18	581.21	580.99	581.57	581.36	581.22	--	--	--
MINIMUM	581.06	580.76	580.90	580.46	580.46	580.59	580.96	580.89	580.67	--	--	--

Table 20. Ground-water levels in well D60, October 29, 1985, through July 6, 1988

[Dashes (--) indicate no data collected]

	Mean water levels in feet above sea level, water year October 1985 through September 1986											
DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	582.80	583.68	583.02	582.96	583.36	583.22	583.24	583.49	583.29	583.16	582.80
2	--	582.85	583.76	583.02	582.95	583.34	583.22	583.24	583.48	583.31	583.15	582.78
3	--	582.90	583.75	583.02	582.95	583.32	583.24	583.24	583.48	583.31	583.14	582.78
4	--	582.95	583.69	583.05	582.99	583.32	583.26	583.23	583.43	583.27	583.12	582.76
5	--	582.99	583.64	583.06	583.15	583.32	583.29	583.19	583.40	583.19	583.09	582.74
6	--	582.99	583.61	583.05	583.24	583.31	583.30	583.15	583.41	583.14	583.08	582.73
7	--	582.99	583.58	583.03	583.28	--	583.30	583.15	583.42	583.11	583.08	582.72
8	--	582.97	583.53	583.02	583.29	--	583.29	583.15	583.42	583.10	583.08	582.70
9	--	582.97	583.51	582.98	583.29	--	583.28	583.15	583.40	583.28	583.06	582.67
10	--	583.15	583.51	582.93	583.27	--	583.27	583.16	583.39	583.41	583.04	582.64
11	--	583.41	583.55	582.92	583.25	583.36	583.26	583.17	583.39	583.50	583.04	582.62
12	--	583.52	583.57	582.90	583.23	583.37	583.24	583.17	583.39	583.54	583.03	582.64
13	--	583.54	583.54	582.90	583.19	583.39	583.24	583.17	583.39	583.55	583.01	582.66
14	--	583.54	583.49	582.91	583.14	583.40	583.25	583.17	583.38	583.55	582.99	582.69
15	--	583.54	583.42	582.92	583.12	583.41	583.28	583.17	583.45	583.54	582.97	582.72
16	--	583.64	583.37	582.92	583.11	583.40	583.30	583.18	583.54	583.51	582.95	582.76
17	--	583.70	583.34	582.90	583.11	583.38	583.32	583.18	583.55	583.45	582.94	582.76
18	--	583.72	583.32	582.89	583.11	583.38	583.33	583.22	583.53	583.37	582.94	582.76
19	--	583.98	583.29	582.90	583.17	583.38	583.33	583.40	583.48	583.31	582.94	582.77
20	--	584.07	583.28	582.94	583.25	583.40	583.33	583.53	583.44	583.29	582.93	582.83
21	--	584.05	583.27	582.94	583.34	583.41	583.32	583.54	583.41	583.29	582.92	582.89
22	--	584.00	583.24	582.94	583.37	583.39	583.32	583.54	583.36	583.29	582.92	582.90
23	--	583.93	583.21	582.94	583.37	583.32	583.32	583.53	583.29	583.26	582.90	582.97
24	--	583.84	583.20	582.95	583.37	583.31	583.30	583.51	583.25	583.22	582.88	583.08
25	--	583.77	583.20	582.96	583.37	583.30	583.29	583.49	583.24	583.18	582.85	583.17
26	--	583.74	583.19	582.96	583.37	583.28	583.28	583.48	583.21	583.20	582.83	583.25
27	--	583.70	583.15	583.02	583.37	583.27	583.28	583.50	583.16	583.21	582.85	583.51
28	--	583.67	583.12	583.05	583.37	583.26	583.27	583.55	583.17	583.20	582.87	583.61
29	582.79	583.65	583.09	583.02	--	583.24	583.23	583.57	583.18	583.20	582.86	583.65
30	582.77	583.63	583.06	582.99	--	583.22	583.21	583.57	583.20	583.19	582.83	583.80
31	582.78	--	583.04	582.96	--	583.22	--	583.53	--	583.17	582.81	--
MEAN	--	583.47	583.39	582.97	583.21	--	583.28	583.32	583.38	583.30	582.98	582.91
MAXIMUM	--	584.07	583.76	583.06	583.37	--	583.33	583.57	583.55	583.55	583.16	583.80
MINIMUM	--	582.80	583.04	582.89	582.95	--	583.21	583.15	583.16	583.10	582.81	582.62

Table 20. Ground-water levels in well D60, October 29, 1985, through July 6, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1986 through September 1987											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	583.90	--	--	--	--	583.16	582.98	583.23	583.13	582.76	582.47	583.34
2	583.93	--	--	--	--	583.19	582.97	583.19	583.15	582.76	582.46	583.27
3	584.33	--	--	--	--	583.18	582.97	583.19	583.21	582.75	582.43	583.22
4	584.70	--	--	--	--	583.15	582.97	583.19	583.21	582.74	582.41	583.16
5	584.68	--	--	--	--	583.14	582.99	583.19	583.19	582.73	582.39	583.09
6	584.56	--	--	--	--	583.13	583.00	583.18	583.14	582.73	582.37	583.05
7	584.41	--	--	--	--	583.09	583.00	583.14	583.07	582.72	582.36	583.02
8	584.25	--	--	--	--	583.07	583.00	583.11	583.01	582.70	582.35	583.00
9	584.19	--	--	--	--	583.09	582.98	583.06	582.99	582.67	582.39	582.98
10	584.15	--	--	--	--	583.15	582.96	583.00	582.98	582.67	582.46	582.94
11	584.07	--	--	--	--	583.16	582.96	582.97	582.96	582.67	582.49	582.92
12	584.01	--	--	--	--	583.13	582.96	582.98	582.94	582.66	582.50	582.90
13	583.97	--	--	--	--	583.10	582.96	583.00	582.94	582.66	582.50	582.88
14	583.96	--	--	--	--	583.07	583.04	583.00	582.92	582.66	582.50	582.86
15	--	--	--	--	--	583.07	583.38	582.98	582.91	582.66	582.53	582.84
16	--	--	--	--	--	583.07	583.47	582.97	582.89	582.69	582.54	582.82
17	--	--	--	--	--	583.07	583.49	582.94	582.88	582.68	583.32	582.82
18	--	--	--	--	--	583.07	583.48	582.96	582.84	582.65	583.54	582.82
19	--	--	--	--	--	583.07	583.46	583.29	582.81	582.63	583.52	582.83
20	--	--	--	--	--	583.06	583.43	583.51	582.81	582.60	583.44	582.82
21	--	--	--	--	--	583.05	583.39	583.53	582.81	582.58	583.34	582.81
22	--	--	--	--	--	583.04	583.38	583.51	582.82	582.57	583.28	582.89
23	--	--	--	--	--	583.03	583.47	583.49	582.82	582.56	583.23	583.06
24	--	--	--	--	583.04	583.03	583.49	583.44	582.81	582.53	583.16	583.05
25	--	--	--	--	583.04	583.03	583.49	583.41	582.79	582.53	583.11	583.03
26	--	--	--	--	583.04	583.01	583.47	583.40	582.79	582.51	583.38	582.97
27	--	--	--	--	583.04	583.00	583.43	583.35	582.79	582.50	583.73	582.89
28	--	--	--	--	583.05	582.98	583.37	583.27	582.78	582.50	583.76	582.84
29	--	--	--	--	--	582.98	583.31	583.19	582.76	582.49	583.72	582.82
30	--	--	--	--	--	582.98	583.26	583.12	582.76	582.47	583.59	582.81
31	--	--	--	--	--	582.99	--	583.08	--	582.47	583.45	--
MEAN	--	--	--	--	--	583.08	583.22	583.19	582.93	582.63	582.93	582.96
MAXIMUM	--	--	--	--	--	583.19	583.49	583.53	583.21	582.76	583.76	583.34
MINIMUM	--	--	--	--	--	582.98	582.96	582.94	582.76	582.47	582.35	582.81

Table 20. Ground-water levels in well D60, October 29, 1985, through July 6, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1987 through September 1988											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	582.81	582.50	582.63	582.89	--	--	--	--	582.00	581.33	--	--
2	582.78	582.50	582.66	582.83	--	--	--	--	581.97	581.30	--	--
3	582.78	582.50	582.66	582.77	--	--	--	--	581.97	581.28	--	--
4	582.78	582.50	582.67	582.74	--	--	--	--	581.95	581.25	--	--
5	582.76	582.50	582.68	582.72	--	--	--	--	581.90	581.22	--	--
6	582.74	582.50	582.68	582.69	--	--	--	--	581.86	581.20	--	--
7	582.74	582.50	582.68	582.67	--	--	--	--	581.82	--	--	--
8	582.74	582.49	582.68	582.64	--	--	--	--	581.80	--	--	--
9	582.72	582.49	582.70	582.59	--	--	--	--	581.81	--	--	--
10	582.68	582.49	582.71	582.56	--	--	--	582.30	581.79	--	--	--
11	582.67	582.51	582.71	582.51	--	--	--	582.30	581.76	--	--	--
12	582.66	582.51	582.71	582.49	--	--	--	582.30	581.73	--	--	--
13	582.63	582.50	582.71	--	--	--	--	582.30	581.69	--	--	--
14	582.60	582.49	582.71	--	--	--	--	582.29	581.66	--	--	--
15	582.57	582.49	582.74	--	--	--	--	582.27	581.62	--	--	--
16	582.56	582.49	582.82	--	--	--	--	582.23	581.60	--	--	--
17	582.55	582.49	582.84	--	--	--	--	582.23	581.58	--	--	--
18	582.54	582.47	582.84	--	--	--	--	582.22	581.55	--	--	--
19	582.52	582.46	582.82	--	--	--	--	582.22	581.52	--	--	--
20	582.52	582.45	582.87	--	--	--	--	582.21	581.48	--	--	--
21	582.52	582.44	583.03	--	--	--	--	582.19	581.45	--	--	--
22	582.52	582.44	583.07	--	--	--	--	582.16	581.45	--	--	--
23	582.52	582.42	583.09	--	--	--	--	582.14	581.45	--	--	--
24	582.53	582.41	583.10	--	--	--	--	582.16	581.45	--	--	--
25	582.54	582.42	583.10	--	--	--	--	582.19	581.41	--	--	--
26	582.54	582.48	583.10	--	--	--	--	582.18	581.38	--	--	--
27	582.52	582.49	583.06	--	--	--	--	582.14	581.37	--	--	--
28	582.50	582.52	583.03	--	--	--	--	582.11	581.35	--	--	--
29	582.50	582.58	583.03	--	--	--	--	582.07	581.32	--	--	--
30	582.50	582.59	583.04	--	--	--	--	582.05	581.33	--	--	--
31	582.50	--	582.97	--	--	--	--	582.04	--	--	--	--
MEAN	582.61	582.49	582.84	--	--	--	--	--	581.63	--	--	--
MAXIMUM	582.81	582.59	583.10	--	--	--	--	--	582.00	--	--	--
MINIMUM	582.50	582.41	582.63	--	--	--	--	--	581.32	--	--	--

Table 21. Ground-water levels in well D65, November 5, 1985, through April 8, 1988

[Dashes (--) indicate no data collected]

	Mean water levels in feet above sea level, water year October 1985 through September 1986											
DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	584.31	--	--	--	584.26	584.19	584.15	584.14	583.95	583.07
2	--	--	584.36	--	--	--	584.26	584.19	584.13	584.14	583.92	583.01
3	--	--	584.36	--	--	--	584.26	584.19	584.10	584.13	583.87	582.99
4	--	--	584.31	--	--	--	584.25	584.18	584.08	584.08	583.83	583.00
5	--	576.33	584.27	--	--	--	584.25	584.15	584.07	584.04	583.78	582.95
6	--	583.75	584.27	--	--	--	584.25	584.13	584.07	584.01	583.76	582.90
7	--	583.78	584.27	--	--	--	584.24	584.12	584.11	583.97	583.76	582.87
8	--	583.79	584.26	--	--	--	584.22	584.10	584.14	583.94	583.73	582.83
9	--	583.87	584.26	--	--	--	584.22	584.08	584.14	584.24	583.69	582.79
10	--	584.30	584.25	--	--	--	584.21	584.07	584.15	584.27	583.67	582.74
11	--	584.28	584.28	--	--	--	584.20	584.05	584.18	584.26	583.67	582.93
12	--	584.25	584.28	--	--	--	584.19	584.05	584.18	584.26	583.64	583.11
13	--	584.24	584.28	--	--	--	584.18	584.04	584.18	584.25	583.60	583.10
14	--	584.23	584.28	--	--	584.40	584.17	584.03	584.16	584.23	583.56	583.08
15	--	584.23	584.25	--	--	584.36	584.18	584.03	584.27	584.20	583.52	583.05
16	--	584.37	--	--	--	584.34	584.19	584.05	584.29	584.17	583.48	583.02
17	--	584.33	--	--	--	584.31	584.20	584.05	584.24	584.13	583.44	582.99
18	--	584.34	--	--	--	584.32	584.20	584.08	584.20	584.09	583.39	582.98
19	--	584.58	--	--	--	584.37	584.20	584.25	584.17	584.04	583.34	583.12
20	--	584.50	--	--	--	584.35	584.19	584.27	584.14	584.06	583.28	583.34
21	--	584.39	--	--	--	584.31	584.18	584.24	584.11	584.07	583.23	583.34
22	--	584.33	--	--	--	584.30	584.17	584.22	584.07	584.06	583.20	583.35
23	--	584.30	--	--	--	584.31	584.17	584.20	584.03	584.03	583.16	583.59
24	--	584.28	--	--	--	584.31	584.14	584.18	583.99	584.00	583.10	583.81
25	--	584.27	--	--	--	584.31	584.13	584.16	583.97	583.99	583.06	583.95
26	--	584.27	--	--	--	584.31	584.11	584.14	583.93	584.02	583.18	584.08
27	--	584.26	--	--	--	584.31	584.10	584.20	583.90	584.02	583.27	584.34
28	--	584.25	--	--	--	584.30	584.09	584.24	583.98	584.02	583.29	584.31
29	--	584.25	--	--	--	584.29	584.08	584.24	583.99	584.02	583.25	584.31
30	--	584.25	--	--	--	584.28	584.12	584.23	584.06	584.00	583.20	584.48
31	--	--	--	--	--	584.27	--	584.19	--	583.97	583.14	--
MEAN	--	--	--	--	--	--	584.19	584.15	584.11	584.09	583.48	583.31
MAXIMUM	--	--	--	--	--	--	584.26	584.27	584.29	584.27	583.95	584.48
MINIMUM	--	--	--	--	--	--	584.08	584.03	583.90	583.94	583.06	582.74

Table 21. Ground-water levels in well D65, November 5, 1985, through April 8, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1986 through September 1987											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	584.46	584.23	584.35	584.22	584.37	584.32	584.10	584.14	584.40	584.04	583.54	584.50
2	584.38	584.23	584.35	584.22	584.41	584.33	584.10	584.14	584.38	584.04	583.49	584.50
3	584.67	584.21	584.39	584.22	584.43	584.32	584.08	584.18	584.38	584.01	583.39	584.47
4	584.77	584.20	584.42	584.21	584.43	584.29	584.07	584.19	584.33	583.96	583.30	584.45
5	584.64	584.18	584.41	584.21	584.42	584.28	584.05	584.19	584.27	583.93	583.21	584.42
6	584.50	584.18	584.38	584.21	584.41	584.27	584.04	584.18	584.23	583.91	583.24	584.37
7	584.43	584.17	584.39	584.21	584.41	584.26	584.02	584.17	584.19	583.90	583.93	584.32
8	584.37	584.17	584.41	584.21	584.42	584.24	584.01	584.15	584.16	583.88	584.20	584.32
9	584.34	584.16	584.41	584.21	584.40	584.21	584.00	584.13	584.13	583.85	584.31	584.39
10	584.32	584.15	584.41	584.19	584.34	584.20	583.98	584.10	584.09	583.98	584.34	584.44
11	584.29	584.14	584.36	584.19	584.30	584.18	584.00	584.09	584.07	584.11	584.31	584.45
12	584.29	584.13	584.28	584.20	584.27	584.17	584.05	584.21	584.22	584.12	584.27	584.45
13	584.29	584.12	584.28	584.20	584.26	584.16	584.06	584.22	584.23	584.11	584.25	584.45
14	584.29	584.09	584.27	584.22	584.25	584.16	584.15	584.20	584.18	584.10	584.33	584.45
15	584.28	584.09	584.26	584.25	584.25	584.16	584.34	584.17	584.14	584.09	584.38	584.45
16	584.27	584.09	584.26	584.26	584.25	584.16	584.32	584.14	584.09	584.10	584.46	584.48
17	584.26	584.09	584.28	584.25	584.24	584.16	584.28	584.10	584.05	584.10	584.92	584.50
18	584.25	584.15	584.28	584.25	584.23	584.16	584.26	584.22	583.99	584.07	584.74	584.50
19	584.24	584.26	584.26	584.25	584.23	584.16	584.23	584.46	583.94	584.01	584.59	584.47
20	584.23	584.26	584.24	584.25	584.22	584.16	584.21	584.43	583.90	583.94	584.49	584.40
21	584.22	584.26	584.24	584.25	584.20	584.16	584.19	584.35	584.00	583.90	584.51	584.41
22	584.21	584.25	584.24	584.25	584.20	584.15	584.19	584.30	584.04	583.85	584.51	584.57
23	584.20	584.25	584.24	584.25	584.20	584.14	584.29	584.28	584.04	583.79	584.43	584.65
24	584.18	584.25	584.23	584.25	584.19	584.13	584.28	584.26	584.03	583.72	584.41	584.53
25	584.22	584.23	584.23	584.25	584.19	584.12	584.26	584.24	584.04	583.66	584.45	584.45
26	584.29	584.43	584.23	584.25	584.19	584.12	584.23	584.26	584.14	583.62	584.72	584.42
27	584.29	584.54	584.22	584.25	584.19	584.12	584.21	584.26	584.13	583.62	584.76	584.37
28	584.29	584.46	584.22	584.25	584.21	584.12	584.19	584.23	584.09	583.61	584.65	584.35
29	584.27	584.41	584.22	584.25	--	584.12	584.18	584.19	584.05	583.55	584.58	584.38
30	584.26	584.38	584.22	584.26	--	584.11	584.16	584.17	584.04	583.50	584.49	584.40
31	584.25	--	584.22	584.30	--	584.11	--	584.23	--	583.55	584.46	--
MEAN	584.33	584.23	584.30	584.23	584.29	584.19	584.15	584.21	584.13	583.89	584.25	584.44
MAXIMUM	584.77	584.54	584.42	584.30	584.43	584.33	584.34	584.46	584.40	584.12	584.92	584.65
MINIMUM	584.18	584.09	584.22	584.19	584.19	584.11	583.98	584.09	583.90	583.50	583.21	584.32

Table 21. Ground-water levels in well D65, November 5, 1985, through April 8, 1988--Continued

	Mean water levels in feet above sea level, water year October 1987 through September 1988											
DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	584.39	584.33	584.56	584.44	584.54	584.35	584.42	--	--	--	--	--
2	584.37	584.31	584.56	584.41	584.53	584.37	584.40	--	--	--	--	--
3	584.35	584.31	584.60	584.43	584.53	584.37	584.40	--	--	--	--	--
4	584.32	584.38	584.62	584.59	584.48	584.33	584.40	--	--	--	--	--
5	584.28	584.40	584.55	584.59	584.43	584.30	584.40	--	--	--	--	--
6	584.27	584.40	584.51	584.59	584.43	584.30	584.54	--	--	--	--	--
7	584.24	584.40	584.53	584.59	584.43	584.30	584.51	--	--	--	--	--
8	584.22	584.41	584.57	584.59	584.42	584.30	584.46	--	--	--	--	--
9	584.20	584.46	584.57	584.59	584.38	584.30	--	--	--	--	--	--
10	584.18	584.46	584.55	584.59	584.36	584.30	--	--	--	--	--	--
11	584.17	584.46	584.54	584.59	584.35	584.30	--	--	--	--	--	--
12	584.17	584.46	584.52	584.63	584.34	584.30	--	--	--	--	--	--
13	584.16	584.46	584.49	584.74	584.32	584.29	--	--	--	--	--	--
14	584.14	584.47	584.51	584.77	584.30	584.29	--	--	--	--	--	--
15	584.15	584.47	584.60	584.77	584.43	584.27	--	--	--	--	--	--
16	584.20	584.47	584.69	584.89	584.47	584.25	--	--	--	--	--	--
17	584.23	584.47	584.69	585.08	584.48	584.24	--	--	--	--	--	--
18	584.23	584.47	584.69	584.80	584.48	584.24	--	--	--	--	--	--
19	584.25	584.47	584.69	584.70	584.48	584.24	--	--	--	--	--	--
20	584.40	584.47	584.80	584.76	584.47	584.23	--	--	--	--	--	--
21	584.43	584.46	584.78	584.69	584.44	584.21	--	--	--	--	--	--
22	584.51	584.46	584.74	584.65	584.42	584.19	--	--	--	--	--	--
23	584.53	584.46	584.71	584.63	584.45	584.18	--	--	--	--	--	--
24	584.46	584.46	584.59	584.61	584.42	584.17	--	--	--	--	--	--
25	584.38	584.46	584.51	584.60	584.39	584.20	--	--	--	--	--	--
26	584.35	584.46	584.46	584.60	584.37	584.21	--	--	--	--	--	--
27	584.37	584.46	584.43	584.60	584.38	584.20	--	--	--	--	--	--
28	584.39	584.46	584.43	584.61	584.37	584.20	--	--	--	--	--	--
29	584.39	584.46	584.45	584.60	584.37	584.31	--	--	--	--	--	--
30	584.39	584.47	584.45	584.57	--	584.44	--	--	--	--	--	--
31	584.37	--	584.44	584.57	--	584.44	--	--	--	--	--	--
MEAN	584.31	584.44	584.58	584.64	584.42	584.28	--	--	--	--	--	--
MAXIMUM	584.53	584.47	584.80	585.08	584.54	584.44	--	--	--	--	--	--
MINIMUM	584.14	584.31	584.43	584.41	584.30	584.17	--	--	--	--	--	--

Table 22. Surface-water levels at site D36S, May 15, 1986, through August 17, 1987

[Dashes (--) indicate no data collected]

DAY	Mean water levels in feet above sea level, water year October 1985 through September 1986											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	--	--	--	--	--	582.92	582.88	--	--
2	--	--	--	--	--	--	--	--	582.90	--	--	--
3	--	--	--	--	--	--	--	--	582.60	--	--	--
4	--	--	--	--	--	--	--	--	582.50	--	--	--
5	--	--	--	--	--	--	--	--	582.88	--	--	--
6	--	--	--	--	--	--	--	--	582.85	--	--	--
7	--	--	--	--	--	--	--	--	582.70	--	--	--
8	--	--	--	--	--	--	--	--	582.59	--	--	--
9	--	--	--	--	--	--	--	--	582.70	--	--	--
10	--	--	--	--	--	--	--	--	582.74	--	--	--
11	--	--	--	--	--	--	--	--	582.71	--	--	--
12	--	--	--	--	--	--	--	--	582.84	--	--	--
13	--	--	--	--	--	--	--	--	582.62	--	582.84	--
14	--	--	--	--	--	--	--	--	582.74	--	582.68	--
15	--	--	--	--	--	--	--	582.50	582.81	--	--	--
16	--	--	--	--	--	--	--	582.44	582.65	--	--	--
17	--	--	--	--	--	--	--	582.62	582.64	--	--	--
18	--	--	--	--	--	--	--	582.95	582.65	--	--	--
19	--	--	--	--	--	--	--	583.04	582.68	--	--	--
20	--	--	--	--	--	--	--	582.83	582.85	--	--	--
21	--	--	--	--	--	--	--	582.63	582.72	--	--	--
22	--	--	--	--	--	--	--	582.69	582.66	--	--	--
23	--	--	--	--	--	--	--	582.64	582.59	--	--	--
24	--	--	--	--	--	--	--	582.64	582.88	--	--	--
25	--	--	--	--	--	--	--	582.71	582.70	--	--	--
26	--	--	--	--	--	--	--	582.76	582.61	--	--	--
27	--	--	--	--	--	--	--	582.79	582.61	--	--	--
28	--	--	--	--	--	--	--	582.67	582.72	--	--	--
29	--	--	--	--	--	--	--	582.58	582.79	--	--	--
30	--	--	--	--	--	--	--	582.49	582.88	--	--	--
31	--	--	--	--	--	--	--	582.59	--	--	--	--
MEAN	--	--	--	--	--	--	--	--	582.72	--	--	--
MAXIMUM	--	--	--	--	--	--	--	--	582.92	--	--	--
MINIMUM	--	--	--	--	--	--	--	--	582.50	--	--	--

Table 22. Surface-water levels at site D36S, May 15, 1986, through August 17, 1987--Continued

	Mean water levels in feet above sea level, water year October 1986 through September 1987											
DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	583.15	--	582.06	582.44	581.83	581.91	581.87	582.09	581.81	--
2	--	--	582.93	--	582.04	581.99	582.52	582.09	581.93	582.00	581.82	--
3	--	--	582.46	--	582.29	581.91	582.05	582.29	581.94	581.92	581.73	--
4	--	--	582.12	--	582.12	581.87	582.32	582.15	581.90	581.92	581.96	--
5	--	--	582.09	--	581.97	582.07	582.47	582.01	581.91	582.02	581.84	--
6	--	--	582.14	--	581.87	581.90	582.23	581.87	581.95	582.00	581.66	--
7	--	--	582.50	--	581.91	581.67	582.04	581.92	581.81	581.85	581.63	--
8	--	--	582.75	--	583.40	582.06	582.08	581.89	581.91	581.84	581.67	--
9	--	--	582.81	--	582.13	583.24	581.86	581.55	582.16	581.78	581.83	--
10	--	--	582.22	--	581.99	582.43	581.90	581.81	582.03	581.75	581.80	--
11	--	--	581.81	--	582.17	582.00	582.05	581.93	581.84	581.76	581.74	--
12	--	--	582.36	--	582.32	581.89	582.04	582.07	581.82	581.78	581.76	--
13	--	--	582.29	--	582.09	581.85	582.01	582.02	581.93	581.91	581.79	--
14	--	--	581.75	582.30	582.71	582.22	582.31	581.91	581.95	581.85	581.84	--
15	--	--	582.21	582.60	582.54	582.24	582.29	581.94	582.08	581.94	581.83	--
16	--	--	582.39	582.44	582.60	582.15	582.16	581.83	582.02	581.90	581.85	--
17	--	--	582.35	582.41	582.66	581.99	582.04	581.82	582.06	581.62	581.94	--
18	--	--	582.44	582.42	582.31	582.10	581.95	582.16	582.00	581.60	--	--
19	--	--	582.15	582.57	582.12	582.14	582.04	582.32	581.99	581.64	--	--
20	--	--	--	582.20	582.08	581.94	581.96	582.20	582.13	581.75	--	--
21	--	--	--	581.80	582.05	581.97	582.36	582.04	582.14	581.73	--	--
22	--	--	--	582.45	582.03	581.93	582.44	581.99	582.12	581.71	--	--
23	--	--	--	--	582.12	581.98	582.22	582.05	582.02	581.59	--	--
24	--	--	--	--	582.09	582.05	582.27	582.06	581.98	581.60	--	--
25	--	582.52	--	--	582.13	581.88	582.15	582.15	582.01	581.74	--	--
26	--	583.03	--	--	582.10	581.74	582.06	582.08	581.93	581.82	--	--
27	--	582.31	--	--	582.12	581.85	581.95	581.94	581.98	581.77	--	--
28	--	582.05	--	582.16	582.37	582.00	581.76	581.94	581.79	581.74	--	--
29	--	582.57	--	582.20	--	582.29	581.89	581.93	581.86	581.76	--	--
30	--	583.00	--	582.60	--	582.21	581.95	581.91	582.00	581.79	--	--
31	--	--	--	582.17	--	581.90	--	581.84	--	581.85	--	--
MEAN	--	--	--	--	582.23	582.06	582.11	581.99	581.97	581.81	--	--
MAXIMUM	--	--	--	--	583.40	583.24	582.52	582.32	582.16	582.09	--	--
MINIMUM	--	--	--	--	581.87	581.67	581.76	581.55	581.79	581.59	--	--

Table 23. Ground-water levels in well D35, January 23, 1986, through May 11, 1988

[Dashes (--) indicate no data collected]

DAY	Mean water levels in feet above sea level, water year October 1985 through September 1986											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	--	582.31	582.10	582.40	582.50	583.06	583.05	583.10	582.84
2	--	--	--	--	582.31	582.13	582.48	582.39	583.08	583.01	583.06	582.90
3	--	--	--	--	582.36	582.32	582.65	582.41	582.84	582.93	583.07	582.89
4	--	--	--	--	582.62	582.18	582.80	582.18	582.71	582.73	583.00	582.79
5	--	--	--	--	582.66	582.12	582.73	582.14	583.05	582.71	582.98	582.78
6	--	--	--	--	582.76	582.58	582.64	582.38	583.05	582.81	583.10	582.86
7	--	--	--	--	582.76	582.50	582.43	582.50	582.94	582.91	583.15	582.89
8	--	--	--	--	582.46	581.92	582.44	582.69	582.81	582.94	583.06	582.58
9	--	--	--	--	582.25	582.11	582.56	582.73	582.90	583.14	582.99	582.62
10	--	--	--	--	582.25	582.30	582.52	582.69	582.96	583.13	583.06	582.57
11	--	--	--	--	582.32	582.40	582.38	582.64	582.93	583.19	583.06	582.79
12	--	--	--	--	582.16	582.52	582.66	582.66	583.02	583.22	583.00	583.03
13	--	--	--	--	581.95	582.60	582.71	582.64	582.83	583.15	582.96	582.94
14	--	--	--	--	582.05	582.38	582.66	582.61	582.92	583.14	582.87	583.05
15	--	--	--	--	582.04	582.24	582.76	582.64	583.01	583.15	582.97	583.26
16	--	--	--	--	582.19	582.28	582.87	582.64	582.87	583.25	582.97	583.23
17	--	--	--	--	582.32	582.27	582.81	582.81	582.85	583.12	583.13	582.95
18	--	--	--	--	582.28	582.32	582.69	583.10	582.87	583.04	583.32	583.06
19	--	--	--	--	582.36	582.57	582.54	583.22	582.87	583.17	583.18	583.09
20	--	--	--	--	582.55	582.62	582.52	583.05	583.02	583.26	583.10	583.25
21	--	--	--	--	582.73	582.15	582.92	582.85	582.93	583.24	583.18	583.13
22	--	--	--	--	582.30	581.77	582.80	582.90	582.87	583.14	583.24	583.13
23	--	--	--	582.24	582.32	582.04	582.47	582.86	582.79	583.07	583.13	583.10
24	--	--	--	582.18	582.32	582.24	582.44	582.85	583.05	582.98	582.96	583.12
25	--	--	--	582.18	582.23	582.07	582.64	582.91	582.92	583.19	582.90	583.23
26	--	--	--	582.54	582.35	582.19	582.73	582.96	582.82	583.18	583.12	583.25
27	--	--	--	582.81	582.74	582.29	582.64	583.00	582.80	583.12	583.34	583.39
28	--	--	--	582.20	582.30	582.09	582.50	582.89	582.94	583.28	583.08	583.36
29	--	--	--	582.27	--	582.18	582.40	582.81	582.95	583.11	582.84	583.26
30	--	--	--	582.17	--	582.26	582.45	582.73	583.06	583.08	582.73	583.44
31	--	--	--	582.19	--	582.32	--	582.80	--	583.09	582.80	--
MEAN	--	--	--	--	582.37	582.26	582.61	582.72	582.92	583.08	583.05	583.03
MAXIMUM	--	--	--	--	582.76	582.62	582.92	583.22	583.08	583.28	583.34	583.44
MINIMUM	--	--	--	--	581.95	581.77	582.38	582.14	582.71	582.71	582.73	582.57

Table 23. Ground-water levels in well D35, January 23, 1986, through May 11, 1988--Continued

	Mean water levels in feet above sea level, water year October 1986 through September 1987											
DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	583.53	583.29	583.34	582.48	582.12	582.60	581.98	582.15	582.25	582.31	582.08	581.82
2	583.48	583.26	583.18	582.71	582.13	582.26	582.60	582.28	582.27	582.27	582.03	581.98
3	583.61	583.00	582.75	582.53	582.31	582.12	582.22	582.46	582.25	582.18	581.94	581.90
4	583.90	583.31	582.43	582.49	582.18	582.10	582.42	582.35	582.24	582.14	582.14	581.82
5	583.53	583.22	582.41	582.34	582.08	582.23	582.58	582.25	582.21	582.25	582.12	581.78
6	583.39	582.99	582.40	582.31	582.01	582.13	582.39	582.14	582.25	582.26	581.94	581.77
7	583.09	583.09	582.72	582.54	582.05	581.93	582.21	582.14	582.15	582.13	581.84	581.80
8	583.27	582.85	582.98	582.26	583.20	582.16	582.25	582.15	582.19	582.11	581.88	581.81
9	583.80	582.54	583.05	582.30	582.27	583.22	582.08	581.91	582.40	582.06	582.00	581.76
10	583.51	582.69	582.56	582.90	582.09	582.63	582.08	582.01	582.30	582.06	582.05	581.75
11	583.37	583.01	582.16	582.44	582.26	582.25	582.21	582.14	582.18	582.06	581.96	581.77
12	583.31	582.89	582.55	582.25	582.38	582.11	582.21	582.30	582.15	582.08	581.95	581.73
13	583.35	582.75	582.55	582.21	582.21	582.07	582.18	582.26	582.20	582.18	581.89	581.68
14	583.29	582.24	582.07	582.35	582.70	582.34	582.47	582.18	582.22	582.16	581.95	581.61
15	583.38	582.44	582.43	582.57	582.58	582.40	582.49	582.18	582.31	582.18	581.85	581.61
16	583.36	582.74	582.60	582.47	582.61	582.32	582.38	582.12	582.27	582.20	581.84	581.63
17	583.64	582.78	582.59	582.44	582.66	582.19	582.27	582.07	582.28	581.98	582.07	581.75
18	583.41	583.22	582.66	582.46	582.39	582.26	582.17	582.35	582.24	581.92	581.98	581.93
19	583.31	582.90	582.41	582.57	582.20	582.29	582.22	582.56	582.22	581.94	581.98	581.74
20	583.19	583.03	582.70	582.28	582.17	582.16	582.18	582.49	582.33	582.01	581.96	581.71
21	583.26	582.88	582.61	581.94	582.15	582.14	582.50	582.33	582.38	581.99	581.89	581.86
22	583.21	582.48	582.18	582.39	582.11	582.13	582.63	582.27	582.36	581.99	582.08	582.05
23	583.28	582.77	582.24	582.44	582.16	582.13	582.44	582.33	582.27	581.92	581.97	581.81
24	583.56	582.60	582.70	582.08	582.13	582.21	582.48	582.33	582.23	581.88	581.90	581.89
25	583.68	582.60	582.60	582.09	582.17	582.09	582.37	582.41	582.26	582.00	581.81	581.81
26	583.65	583.22	582.53	582.27	582.19	581.95	582.31	582.37	582.21	582.07	582.04	581.62
27	583.44	582.68	582.53	581.95	582.26	582.03	582.22	582.24	582.23	582.04	582.20	581.65
28	583.18	582.42	582.18	582.17	582.50	582.14	582.05	582.24	582.10	582.01	582.10	581.57
29	583.42	582.82	582.36	582.23	--	582.40	582.11	582.22	582.12	582.01	581.95	581.54
30	583.37	583.17	582.73	582.55	--	582.37	582.18	582.21	582.24	582.02	581.80	581.75
31	583.07	--	582.35	582.25	--	582.13	--	582.17	--	582.10	581.88	--
MEAN	583.41	582.86	582.57	582.36	582.30	582.24	582.30	582.25	582.24	582.08	581.97	581.76
MAXIMUM	583.90	583.31	583.34	582.90	583.20	583.22	582.63	582.56	582.40	582.31	582.20	582.05
MINIMUM	583.07	582.24	582.07	581.94	582.01	581.93	581.98	581.91	582.10	581.88	581.80	581.54

Table 23. Ground-water levels in well D35, January 23, 1986, through May 11, 1988--Continued

	Mean water levels in feet above sea level, water year October 1987 through September 1988											
DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	581.39	581.27	581.24	580.69	580.90	580.63	580.91	581.02	--	--	--	--
2	581.82	581.26	580.92	580.59	581.05	580.68	580.90	581.05	--	--	--	--
3	581.86	581.21	580.96	580.56	580.94	580.78	580.89	581.10	--	--	--	--
4	581.37	581.10	581.12	580.64	581.01	580.78	580.79	581.09	--	--	--	--
5	581.25	580.98	580.92	580.54	580.85	580.59	580.82	581.04	--	--	--	--
6	581.41	580.87	580.87	580.55	580.71	580.47	581.57	581.02	--	--	--	--
7	581.84	580.79	580.84	580.69	580.49	580.48	581.16	581.05	--	--	--	--
8	581.54	580.95	580.89	580.71	580.61	580.53	581.08	580.96	--	--	--	--
9	581.23	581.13	580.77	580.72	580.72	580.57	581.06	580.87	--	--	--	--
10	581.32	581.20	580.76	580.63	580.80	580.54	581.16	580.95	--	--	--	--
11	581.41	580.99	580.72	580.37	581.03	580.59	581.26	580.96	--	--	--	--
12	581.26	580.79	580.77	580.31	581.01	580.70	581.19	--	--	--	--	--
13	581.22	580.83	580.72	580.75	580.73	580.87	581.08	--	--	--	--	--
14	581.19	580.92	580.80	580.67	580.54	580.79	581.08	--	--	--	--	--
15	581.22	580.97	581.42	580.39	580.97	580.73	581.00	--	--	--	--	--
16	581.23	580.96	581.39	580.26	580.76	580.63	580.95	--	--	--	--	--
17	581.22	580.75	581.08	580.47	580.73	580.58	580.89	--	--	--	--	--
18	581.20	580.75	580.82	580.72	580.69	580.55	580.95	--	--	--	--	--
19	581.24	580.53	580.78	580.85	580.74	580.55	580.84	--	--	--	--	--
20	581.25	580.89	580.99	581.01	580.95	580.66	580.87	--	--	--	--	--
21	581.26	580.93	580.82	581.04	580.73	580.61	580.93	--	--	--	--	--
22	581.21	580.63	580.80	580.81	580.37	580.60	581.04	--	--	--	--	--
23	581.25	580.56	580.92	580.72	580.60	580.60	581.25	--	--	--	--	--
24	581.30	580.74	581.00	580.78	580.57	580.60	581.07	--	--	--	--	--
25	581.25	581.20	581.15	580.73	580.61	580.60	580.88	--	--	--	--	--
26	581.20	581.17	581.09	581.00	580.50	580.59	581.02	--	--	--	--	--
27	581.22	581.08	580.95	580.81	580.78	580.59	581.15	--	--	--	--	--
28	581.21	581.19	581.28	580.69	580.61	580.59	581.19	--	--	--	--	--
29	581.23	581.11	581.39	580.62	580.59	580.66	581.03	--	--	--	--	--
30	581.20	581.05	580.95	580.51	--	580.69	581.00	--	--	--	--	--
31	581.23	--	580.70	580.56	--	580.73	--	--	--	--	--	--
MEAN	581.32	580.96	580.96	580.66	580.74	580.63	581.03	--	--	--	--	--
MAXIMUM	581.86	581.27	581.42	581.04	581.05	580.87	581.57	--	--	--	--	--
MINIMUM	581.19	580.53	580.70	580.26	580.37	580.47	580.79	--	--	--	--	--

Table 24. Ground-water levels in well D30, January 23, 1986, through June 12, 1988

[Dashes (--) indicate no data collected]

DAY	Mean water levels in feet above sea level, water year October 1985 through September 1986											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	--	582.44	--	582.53	582.77	--	--	--	--
2	--	--	--	--	582.44	--	582.60	582.67	--	--	--	--
3	--	--	--	--	582.48	--	582.71	582.67	--	--	--	--
4	--	--	--	--	582.73	--	582.81	582.62	--	--	--	--
5	--	--	--	--	582.82	--	582.82	582.55	--	--	--	582.99
6	--	--	--	--	582.88	--	582.76	582.59	--	--	--	582.91
7	--	--	--	--	582.91	--	582.65	582.65	--	--	--	582.92
8	--	--	--	--	582.76	582.37	582.60	582.76	--	--	--	582.82
9	--	--	--	--	582.60	582.45	582.65	582.83	--	--	--	582.77
10	--	--	--	--	582.56	582.67	582.67	582.84	--	--	--	582.74
11	--	--	--	--	582.57	582.75	582.61	582.83	--	--	--	582.86
12	--	--	--	--	582.49	582.82	582.67	582.83	--	--	--	--
13	--	--	--	--	582.35	582.91	582.76	582.82	--	--	--	--
14	--	--	--	--	582.31	582.84	582.78	582.82	--	--	--	--
15	--	--	--	--	582.32	582.73	582.85	582.82	--	--	--	--
16	--	--	--	--	582.38	582.69	582.89	582.79	--	--	--	--
17	--	--	--	--	582.49	582.68	582.91	582.89	--	--	--	--
18	--	--	--	--	582.56	582.76	582.85	583.08	--	--	--	--
19	--	--	--	--	582.74	582.81	582.76	583.30	--	--	--	--
20	--	--	--	--	582.80	582.86	582.75	583.27	--	--	--	--
21	--	--	--	--	--	582.66	582.89	583.21	--	--	--	--
22	--	--	--	--	--	582.43	582.88	--	--	--	--	--
23	--	--	--	582.49	--	582.43	582.71	--	--	--	--	--
24	--	--	--	582.50	--	582.58	582.67	--	--	--	--	--
25	--	--	--	582.48	--	582.53	582.75	--	--	--	--	--
26	--	--	--	582.60	--	582.49	582.82	--	--	--	583.57	583.84
27	--	--	--	582.83	--	582.54	582.81	--	--	--	583.48	583.77
28	--	--	--	582.53	--	582.48	582.72	--	--	--	583.38	583.64
29	--	--	--	582.40	--	582.47	582.62	--	--	--	--	583.66
30	--	--	--	582.36	--	582.45	582.77	--	--	--	--	583.96
31	--	--	--	582.33	--	582.50	--	--	--	--	--	--
MEAN	--	--	--	--	--	--	582.74	--	--	--	--	--
MAXIMUM	--	--	--	--	--	--	582.91	--	--	--	--	--
MINIMUM	--	--	--	--	--	--	582.53	--	--	--	--	--

Table 24. Ground-water levels in well D30, January 23, 1986, through June 12, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1986 through September 1987											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	583.88	583.46	583.59	582.70	582.40	582.91	582.21	582.42	582.96	582.41	582.10	582.57
2	583.78	583.47	583.59	582.83	582.49	582.68	582.52	582.46	582.81	582.43	582.03	582.56
3	584.08	583.42	583.30	582.77	582.51	582.50	582.38	582.58	582.78	582.36	582.00	582.54
4	584.28	583.44	583.04	582.73	582.50	582.46	582.44	582.56	582.73	582.29	582.07	582.44
5	583.96	583.44	583.00	582.69	582.49	582.49	582.58	582.52	582.68	582.30	582.23	582.40
6	583.80	583.41	582.94	582.65	582.46	582.49	582.52	582.44	582.69	582.34	582.14	582.32
7	583.65	--	583.13	582.69	582.48	582.34	582.41	582.38	582.62	582.29	582.03	582.26
8	583.57	--	583.33	582.61	582.99	582.38	582.38	582.36	582.56	582.23	582.05	582.26
9	583.80	--	583.41	582.59	582.85	582.98	582.27	582.24	582.61	582.19	582.10	582.23
10	583.75	--	583.11	582.87	582.58	582.82	582.25	582.23	582.55	582.33	582.15	582.16
11	583.67	--	582.86	582.77	582.65	582.57	582.32	582.31	582.49	582.24	582.10	582.14
12	583.62	--	582.92	582.55	582.68	582.44	582.33	582.74	582.58	582.29	582.10	582.13
13	583.60	--	582.94	582.56	582.62	582.39	582.31	582.62	582.55	582.39	582.07	582.07
14	583.57	--	582.67	582.66	582.77	582.49	582.59	582.51	582.53	582.34	582.13	582.04
15	583.56	--	582.79	582.77	582.79	582.56	582.80	582.45	582.52	582.31	582.15	582.02
16	583.54	--	582.94	582.76	582.74	582.52	582.72	582.43	582.53	582.37	582.13	582.02
17	583.65	--	582.98	582.73	582.78	582.46	582.64	582.36	582.48	582.18	583.03	582.06
18	583.58	583.66	583.00	582.73	582.65	582.49	582.54	582.57	582.48	582.13	582.79	582.17
19	583.53	583.49	582.86	582.77	582.50	582.50	582.51	582.89	582.45	582.10	582.71	582.10
20	583.48	--	582.92	582.64	582.47	582.43	582.50	582.89	582.47	582.11	582.68	582.08
21	583.46	--	582.93	582.44	582.47	582.37	582.59	582.84	582.55	582.11	582.59	582.09
22	583.44	--	582.73	582.52	582.45	582.34	582.74	582.74	582.52	582.10	582.60	582.32
23	583.45	--	582.63	582.62	582.44	582.35	582.72	582.74	582.45	582.07	582.53	582.39
24	583.58	582.91	582.90	582.35	582.42	582.40	582.69	582.74	582.42	581.98	582.46	582.36
25	583.82	582.94	582.88	582.28	582.41	582.35	582.66	582.79	582.43	582.02	582.36	582.34
26	583.88	583.59	582.79	582.41	582.42	582.23	582.60	582.78	582.45	582.07	582.69	582.21
27	583.72	583.46	582.81	582.27	582.48	582.23	582.55	582.71	582.41	582.10	582.89	582.15
28	583.56	583.17	582.65	582.28	582.68	582.27	582.46	582.66	582.30	582.09	582.87	582.14
29	583.57	583.26	582.66	582.41	--	582.45	582.41	582.62	582.30	582.08	582.79	582.13
30	583.56	583.44	582.85	582.54	--	582.50	582.41	582.59	582.38	582.04	582.66	582.12
31	583.46	--	582.74	582.50	--	582.35	--	582.63	--	582.07	582.63	--
MEAN	583.67	--	582.96	582.60	582.58	582.48	582.50	582.57	582.54	582.21	582.38	582.23
MAXIMUM	584.28	--	583.59	582.87	582.99	582.98	582.80	582.89	582.96	582.43	583.03	582.57
MINIMUM	583.44	--	582.63	582.27	582.40	582.23	582.21	582.23	582.30	581.98	582.00	582.02

Table 24. Ground-water levels in well D30, January 23, 1986, through June 12, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1987 through September 1988											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	582.11	581.47	581.51	581.62	581.51	581.28	581.46	581.49	581.34	--	--	--
2	582.06	581.52	581.49	581.60	581.63	581.29	581.50	581.48	581.35	--	--	--
3	582.20	581.51	581.42	581.56	581.63	581.31	581.52	581.46	581.36	--	--	--
4	582.11	581.42	581.45	581.47	581.63	581.33	581.52	581.47	581.34	--	--	--
5	582.05	581.40	581.44	581.36	581.59	581.30	581.51	581.45	581.32	--	--	--
6	582.05	581.40	581.42	581.29	581.52	581.28	581.93	581.42	581.24	--	--	--
7	582.05	581.37	581.40	581.30	581.46	581.27	582.11	581.41	581.21	--	--	--
8	582.04	581.33	581.41	581.31	581.41	581.27	582.03	581.41	581.27	--	--	--
9	581.91	581.37	581.40	581.31	581.41	581.27	581.99	581.35	581.37	--	--	--
10	581.74	581.40	581.39	581.30	581.40	581.27	581.97	581.33	581.34	--	--	--
11	581.80	581.44	581.39	581.22	581.41	581.26	581.98	581.32	581.26	--	--	--
12	581.75	581.35	581.35	581.16	581.46	581.27	581.97	581.32	581.21	--	--	--
13	581.65	581.34	581.31	581.09	581.44	581.28	581.93	581.32	--	--	--	--
14	581.51	581.33	581.31	581.15	581.35	581.29	581.89	581.32	--	--	--	--
15	581.49	581.33	581.67	581.16	581.54	581.28	581.78	581.33	--	--	--	--
16	581.50	581.33	581.77	581.15	581.65	581.27	581.64	581.32	--	--	--	--
17	581.50	581.30	581.73	581.14	581.59	581.27	581.59	581.38	--	--	--	--
18	581.48	581.21	581.64	581.20	581.59	581.26	581.56	581.39	--	--	--	--
19	581.48	581.20	581.55	581.31	581.64	581.26	581.50	581.38	--	--	--	--
20	581.54	581.19	581.78	581.49	581.61	581.26	581.49	581.37	--	--	--	--
21	581.54	581.20	581.84	581.52	581.57	581.26	581.49	581.36	--	--	--	--
22	581.52	581.20	581.79	581.53	581.42	581.25	581.51	581.34	--	--	--	--
23	581.49	581.15	581.78	581.47	581.39	581.24	581.61	581.40	--	--	--	--
24	581.52	581.12	581.79	581.45	581.39	581.24	581.59	581.55	--	--	--	--
25	581.55	581.28	581.81	581.43	581.38	581.22	581.53	581.65	--	--	--	--
26	581.54	581.39	581.82	581.44	581.32	581.16	581.51	581.51	--	--	--	--
27	581.53	581.39	581.79	581.44	581.30	581.12	581.50	581.42	--	--	--	--
28	581.52	581.45	581.84	581.41	581.30	581.12	581.54	581.40	--	--	--	--
29	581.52	581.48	581.98	581.41	581.28	581.17	581.52	581.39	--	--	--	--
30	581.47	581.47	581.97	581.40	--	581.26	581.51	581.38	--	--	--	--
31	581.43	--	581.72	581.40	--	581.34	--	581.36	--	--	--	--
MEAN	581.70	581.34	581.61	581.36	581.48	581.26	581.67	581.40	--	--	--	--
MAXIMUM	582.20	581.52	581.98	581.62	581.65	581.34	582.11	581.65	--	--	--	--
MINIMUM	581.43	581.12	581.31	581.09	581.28	581.12	581.46	581.32	--	--	--	--

Table 25. Ground-water levels in well D25, January 23, 1986, through July 5, 1988

[Dashes (--) indicate no data collected]

DAY	Mean water levels in feet above sea level, water year October 1985 through September 1986											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	--	--	583.24	583.69	583.42	583.40	583.94	583.99	583.91	583.63
2	--	--	--	--	583.18	583.72	583.40	583.36	583.86	583.98	583.89	583.61
3	--	--	--	--	583.22	583.67	583.42	583.36	583.86	583.94	583.82	583.59
4	--	--	--	--	583.34	583.66	583.42	583.42	583.88	583.95	583.78	583.59
5	--	--	--	--	583.43	583.71	583.41	583.44	583.87	583.89	583.78	583.55
6	--	--	--	--	583.55	583.69	583.39	583.37	583.87	583.82	583.77	583.51
7	--	--	--	--	583.64	583.62	583.39	583.31	583.90	583.75	583.77	583.47
8	--	--	--	--	583.63	583.65	583.36	583.30	583.92	583.77	583.77	583.45
9	--	--	--	--	583.63	583.68	583.33	583.28	583.88	584.29	583.72	583.44
10	--	--	--	--	583.63	583.72	583.33	583.28	583.92	584.42	583.71	583.44
11	--	--	--	--	583.63	583.72	583.34	583.30	583.98	584.54	583.65	583.46
12	--	--	--	--	583.62	583.84	583.32	583.30	583.94	584.55	583.63	583.43
13	--	--	--	--	583.60	583.88	583.30	583.31	583.86	584.50	583.63	583.40
14	--	--	--	--	583.55	583.92	583.34	583.31	583.85	584.42	583.67	583.40
15	--	--	--	--	583.43	583.93	583.36	583.39	583.92	584.40	583.64	583.47
16	--	--	--	--	583.44	583.88	583.34	583.30	583.98	584.35	583.61	583.43
17	--	--	--	--	583.44	583.86	583.33	583.37	583.90	584.29	583.58	583.42
18	--	--	--	--	583.48	583.94	583.35	583.42	583.92	584.23	583.55	583.49
19	--	--	--	--	583.65	583.91	583.38	583.70	583.93	584.20	583.54	583.43
20	--	--	--	--	583.73	583.80	583.40	583.83	583.85	584.34	583.53	583.59
21	--	--	--	--	583.73	583.80	583.34	583.85	583.84	584.29	583.52	583.71
22	--	--	--	--	583.82	583.82	583.27	583.86	583.84	584.19	583.53	583.75
23	--	--	--	583.37	583.81	583.77	583.27	583.84	583.81	584.13	583.56	583.82
24	--	--	--	583.43	583.78	583.71	583.31	583.81	583.73	584.12	583.51	583.94
25	--	--	--	583.47	583.77	583.74	583.31	583.80	583.71	584.07	583.50	583.97
26	--	--	--	583.43	583.88	583.67	583.28	583.80	583.71	584.05	583.54	584.01
27	--	--	--	583.38	583.72	583.60	583.29	583.89	583.69	584.03	583.59	584.32
28	--	--	--	583.39	583.69	583.60	583.31	583.94	583.75	584.01	583.61	584.58
29	--	--	--	583.30	--	583.60	583.23	583.97	583.76	584.00	583.64	584.55
30	--	--	--	583.19	--	583.51	583.34	583.98	583.86	583.97	583.66	584.68
31	--	--	--	583.19	--	583.46	--	583.98	--	583.95	583.65	--
MEAN	--	--	--	--	583.58	583.73	583.34	583.56	583.86	584.14	583.65	583.70
MAXIMUM	--	--	--	--	583.88	583.94	583.42	583.98	583.98	584.55	583.91	584.68
MINIMUM	--	--	--	--	583.18	583.46	583.23	583.28	583.69	583.75	583.50	583.40

Table 25. Ground-water levels in well D25, January 23, 1986, through July 5, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1986 through September 1987											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	584.92	584.26	584.75	583.78	583.53	583.51	583.07	583.56	--	--	--	--
2	584.93	584.21	584.68	583.76	583.61	583.41	583.06	583.56	--	--	--	--
3	584.87	584.15	584.68	583.72	583.63	583.37	583.08	583.53	--	--	--	--
4	585.49	584.16	584.75	583.70	583.62	583.37	583.08	583.50	--	--	--	--
5	585.63	584.12	584.64	583.70	583.68	583.35	583.05	583.62	--	--	--	--
6	585.46	584.10	584.47	583.77	583.74	583.37	583.08	583.68	--	--	--	--
7	585.25	584.08	584.38	583.64	583.81	583.39	583.19	583.71	--	--	--	--
8	585.13	584.04	584.34	583.63	583.74	583.33	583.45	583.71	--	--	--	--
9	584.99	584.06	584.38	583.67	583.72	583.30	583.53	583.71	--	--	--	--
10	584.83	583.98	584.58	583.66	583.76	583.31	583.56	583.71	--	--	--	--
11	584.78	583.91	584.62	583.61	583.75	583.35	583.56	583.77	--	--	--	--
12	584.75	583.93	584.40	583.62	583.71	583.31	583.56	584.10	--	--	--	--
13	584.69	583.92	584.14	583.62	583.71	583.29	583.56	584.24	--	--	--	--
14	584.62	583.83	584.13	583.71	583.72	583.29	583.55	584.26	--	--	--	--
15	584.56	583.81	584.10	583.71	583.64	583.26	583.57	584.26	--	--	--	--
16	584.45	583.86	584.11	583.69	583.64	583.27	583.69	584.25	--	--	--	--
17	584.43	583.86	584.18	583.75	583.61	583.29	583.70	584.25	--	--	--	--
18	584.35	583.84	584.12	583.78	583.55	583.27	583.73	584.25	--	--	--	--
19	584.29	583.79	584.09	583.78	583.50	583.21	583.73	--	--	--	--	--
20	584.27	584.03	584.01	583.70	583.48	583.20	583.76	--	--	--	--	--
21	584.27	584.28	583.97	583.70	583.48	583.17	583.73	--	--	--	--	--
22	584.26	584.18	583.97	583.69	583.48	583.20	583.75	--	--	--	--	--
23	584.22	584.13	583.97	583.60	583.42	583.16	583.64	--	--	--	--	--
24	584.19	584.15	583.98	583.53	583.37	583.16	583.65	--	--	--	--	--
25	584.15	584.08	583.90	583.49	583.51	583.18	583.64	--	--	--	--	--
26	584.28	584.04	583.87	583.45	583.55	583.10	583.63	--	--	--	--	--
27	584.54	584.11	583.87	583.45	583.50	583.08	583.61	--	--	--	--	--
28	584.53	584.75	583.87	583.39	583.50	583.08	583.60	--	--	--	--	--
29	584.45	584.91	583.86	583.48	--	583.10	583.62	--	--	--	--	--
30	584.38	584.86	583.79	583.45	--	583.09	583.60	--	--	--	--	--
31	584.29	--	583.78	583.41	--	583.08	--	--	--	--	--	--
MEAN	584.65	584.11	584.21	583.63	583.61	583.25	583.50	--	--	--	--	--
MAXIMUM	585.63	584.91	584.75	583.78	583.81	583.51	583.76	--	--	--	--	--
MINIMUM	584.15	583.79	583.78	583.39	583.37	583.08	583.05	--	--	--	--	--

Table 25. Ground-water levels in well D25, January 23, 1986, through July 5, 1988--Continued

DAY	Mean water levels in feet above sea level, water year October 1987 through September 1988											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	--	--	582.98	--	--	--	583.11	--	582.73	582.61	--	--
2	--	--	582.99	--	--	--	583.15	--	582.68	582.60	--	--
3	--	--	583.06	--	--	--	583.18	--	582.63	582.58	--	--
4	--	583.01	582.97	--	--	--	--	--	582.61	582.54	--	--
5	--	582.94	582.99	--	--	--	--	--	582.60	582.51	--	--
6	--	582.94	583.00	--	--	--	--	--	582.59	--	--	--
7	--	582.95	583.02	--	--	--	--	--	582.59	--	--	--
8	--	582.92	583.12	--	--	--	--	--	582.56	--	--	--
9	--	582.85	583.22	--	--	--	--	--	582.49	--	--	--
10	--	582.85	583.23	--	--	--	--	--	582.49	--	--	--
11	--	582.87	583.33	--	--	--	--	582.70	582.50	--	--	--
12	--	582.91	583.27	--	--	--	--	582.72	582.49	--	--	--
13	--	582.89	583.19	--	--	--	--	582.66	582.47	--	--	--
14	--	582.82	583.19	--	--	--	--	582.68	582.46	--	--	--
15	--	582.79	583.36	--	--	--	--	582.70	582.45	--	--	--
16	--	582.85	583.33	--	--	--	--	582.62	582.44	--	--	--
17	--	582.85	583.34	--	--	--	--	582.60	582.42	--	--	--
18	--	582.71	--	--	--	--	--	582.59	582.41	--	--	--
19	--	582.78	--	--	--	--	--	582.59	582.40	--	--	--
20	--	582.72	--	--	--	--	--	582.58	582.39	--	--	--
21	--	582.71	--	--	--	--	--	582.56	582.59	--	--	--
22	--	582.75	--	--	--	--	--	582.55	582.69	--	--	--
23	--	582.71	--	--	--	--	--	582.55	582.65	--	--	--
24	--	582.66	--	--	--	--	--	582.69	582.69	--	--	--
25	--	582.71	--	--	--	--	--	582.79	582.69	--	--	--
26	--	582.73	--	--	--	--	--	582.85	582.61	--	--	--
27	--	582.80	--	--	--	--	--	582.86	582.60	--	--	--
28	--	582.89	--	--	--	--	--	582.84	582.59	--	--	--
29	--	582.95	--	--	--	--	--	582.81	582.58	--	--	--
30	--	582.98	--	--	--	--	--	582.77	582.61	--	--	--
31	--	--	--	--	--	583.10	--	582.73	--	--	--	--
MEAN	--	--	--	--	--	--	--	--	582.56	--	--	--
MAXIMUM	--	--	--	--	--	--	--	--	582.73	--	--	--
MINIMUM	--	--	--	--	--	--	--	--	582.39	--	--	--

Table 27. Physical characteristics and inorganic-constituent data, arranged by land use, from 35 wells sampled in July 1987

[μS/cm, microsiemen per centimeter at 25° Celsius; mg/L, milligram per liter; μg/L, microgram per liter; --, not determined; five-digit number in parentheses is WATSTORE (USGS) and STORET (USEPA) parameter code]

Well name	Land use	Date	Specific conductance (μS/cm) (00095)	pH, field (standard nnits) (00400)	Temperature (degree Celslns) (00010)	Oxygen, dissolved (mg/L) (00300)	Calcium, dissolved (mg/L as Ca) (00915)	Magnesinm, dissolved (mg/L as Mg) (00925)	Sodium, dissolved (mg/L as Na) (00930)	Potassium, dissolved (mg/L as K) (00935))	Alkalinity, field (mg/L as $CaCO_3$) (00410)	Alkalinity, lab (mg/L as $CaCO_3$) (90410)
A20	Residential	07-06-87	1430	7.2	19.5	6.3	110	26	150	4.2	246	231
B10	Residential	07-13-87	940	7.7	12.5	8.0	57	19	9.3	1.5	150	146
C1	Residential	07-07-87	1750	7.3	19.5	0.4	220	16	130	34	232	207
E20	Residential	07-15-87	956	7.1	17.0	1.0	150	18	26	4.2	430	423
B3	Commercial	07-14-87	1870	7.9	12.5	.9	130	49	200	8.2	554	547
B7	Commercial	07-14-87	428	7.4	17.5	6.1	63	13	6.8	1.8	180	169
B8	Commercial	07-14-87	2050	7.0	14.0	1.0	150	29	230	4.2	344	311
C3	Commercial	07-09-87	1080	7.3	14.0	.4	130	27	54	5.7	291	197
C4	Commercial	07-09-87	1280	7.2	19.5	.4	150	18	99	7.6	288	228
C10	Commercial	07-21-87	567	6.9	19.0	1.2	87	15	4.3	1.4	--	187
C12	Commercial	07-21-87	1780	6.8	13.5	<.1	240	27	91	5.3	251	231
C18	Commercial	07-14-87	1580	7.1	15.5	.5	120	22	190	5.9	490	398
D66	Commercial	07-15-87	--	7.7	--	--	130	27	860	5.5	--	2100
D67	Commercial	07-16-87	241	6.7	19.5	2.5	36	6.0	1.9	1.0	71	81
D68	Commercial	07-16-87	600	7.6	13.5	.5	94	11	16	3.5	182	183
E2	Commercial	07-14-87	390	7.6	16.0	5.1	52	15	6.3	2.3	142	152
E6	Commercial	07-15-87	1520	7.3	14.5	1.9	200	51	63	6.3	320	300
E7	Commercial	07-15-87	1280	11.3	19.5	3.6	140	94	58	12	200	133
E10	Commercial	07-16-87	1260	7.0	18.0	.3	150	21	62	6.5	335	314
A2	Steel	07-08-87	760	7.3	16.5	.4	120	20	12	3.3	280	183
A3	Steel	07-09-87	580	7.8	19.5	.3	140	35	100	19	935	880
A4	Steel	07-15-87	437	7.2	12.0	1.1	66	18	3.1	1.7	168	170
B2	Steel	07-08-87	5460	11.8	17.5	3.0	610	<.10	84	220	512	424
C2	Steel	07-07-87	2580	11.7	18.0	.3	130	<.10	120	110	355	380
D30	Steel	07-16-87	2310	9.7	15.5	4.1	330	<.10	170	48	28	57
D31	Steel	07-16-87	2740	7.0	13.0	<.1	270	50	170	41	260	261
D10	Petrochemical	07-23-87	3490	7.2	19.0	<.1	180	68	360	27	478	488
D11	Petrochemical	07-23-87	1260	7.2	16.0	<.1	130	38	77	6.7	445	440
D20	Petrochemical	07-16-87	2480	6.7	20.0	.8	250	39	190	14	975	870
D21	Petrochemical	07-22-87	1330	7.4	19.0	<.1	160	43	54	15	390	385
D40	Petrochemical	07-16-87	550	7.1	18.0	.8	77	12	25	1.5	237	220
D60	Petrochemical	07-22-87	775	7.0	19.0	.6	120	23	8.4	4.3	348	352
A6	Park	07-14-87	1130	7.3	16.5	.3	92	48	58	48	321	348
C20	Park	07-16-87	449	6.9	13.0	.1	59	8.0	21	1.6	148	129
E3	Park	07-13-87	674	8.0	15.5	2.0	95	3.3	15	32	242	249

Table 27. Physical characteristics and inorganic-constituent data, arranged by land use, from 35 wells sampled in July 1987--Continued

Well name	Land use	Sulfate, dissolved (mg/L as SO_4 (00945)	Chloride, dissolved (mg/L as Cl) (00940)	Fluoride, dissolved (mg/L as F) (00950)	Bromide, dissolved (mg/L as Br) (71870)	Silica, dissolved (mg/L as SiO_2) (00955)	Solids, sum of constituents, dissolved (mg/L) (70301)	Nitrogen, NO_2+NO_3, total (mg/L as N) (00630)	Nitrogen, ammonia, dissolved (mg/L as N) (00608))	Phosphorous ortho, dissolved (mg/L as P) (00671)	Aluminum, dissolved (µg/L as Al) (01106)	Arsenic, dissolved µg/L as As (01000)
A20	Residential	76	250	1.3	0.11	11	776	5.5	0.05	<0.01	<10	<1
B10	Residential	31	40	0.7	.02	8.3	257	--	--	--	<10	<1
C1	Residential	540	140	.5	.02	22	1240	1.2	.09	.01	<10	4
E20	Residential	13	56	1.3	.08	21	561	<0.01	4.5	<.01	<10	<1
B3	Commercial	42	170	.4	.07	31	975	<.01	5.0	.14	<10	5
B7	Commercial	34	11	1.1	.03	9.7	249	1.2	.02	.02	10	1
B8	Commercial	95	420	.1	.16	15	1170	<.01	2.0	<.01	20	14
C3	Commercial	120	110	.7	.08	24	654	<.01	.75	<.01	<10	23
C4	Commercial	170	150	.9	.05	35	804	1.6	.05	<.01	<10	<1
C10	Commercial	73	13	1.1	<.01	7.4	315	.32	.16	<.01	<10	<1
C12	Commercial	490	130	3.2	--	18	1160	--	--	--	10	1
C18	Commercial	93	240	.3	.13	19	986	<.01	.80	<.01	20	<1
D66	Commercial	1100	180	2.3	4.4	55	3650	--	--	--	1100	55
D67	Commercial	19	1.8	.9	<.01	9.6	119	2.0	.01	<.01	30	3
D68	Commercial	93	27	.8	.04	14	373	--	--	--	<10	4
E2	Commercial	35	9.8	.5	.03	12	218	1.7	.01	<.01	10	<1
E6	Commercial	420	95	.5	<.01	47	1090	<.01	6.8	<.01	<10	2
E7	Commercial	250	53	.9	<.01	23	756	1.4	2.6	<.01	1100	9
E10	Commercial	24	190	.8	<.01	20	688	<.01	1.7	.02	<10	1
A2	Steel	120	15	.8	.03	16	476	<.01	.34	.10	<10	6
A3	Steel	1200	500	10	3.3	39	3440	<.01	640	.15	<10	14
A4	Steel	52	4.6	.7	<.01	9.2	258	2.6	.18	<.01	<10	2
B2	Steel	370	1200	.9	<.01	12	2800	.07	5.9	.04	430	<1
C2	Steel	180	230	1.3	<.01	8.5	990	.08	2.3	.05	620	<1
D30	Steel	800	290	1.6	<.01	49	1700	<.01	3.6	<.01	20	17
D31	Steel	640	430	1.6	.17	23	1790	<.01	.82	--	20	12
D10	Petrochemical	7.2	840	2.7	--	34	1810	--	--	--	<10	3
D11	Petrochemical	24	150	.5	--	20	713	--	--	--	<10	3
D20	Petrochemical	16	300	.7	.06	37	1520	<.01	13	<.01	40	76
D21	Petrochemical	210	78	1.6	.03	38	847	<.01	8.5	.12	<10	11
D40	Petrochemical	49	11	1.0	<.01	24	348	<.01	.87	.26	10	3
D60	Petrochemical	35	15	2.3	--	19	436	--	--	--	<10	3
A6	Park	190	52	1.8	.10	13	696	<.01	.05	<.01	<10	1
C20	Park	71	11	.4	.08	17	279	.02	.20	.01	20	1
E3	Park	60	10	.8	<.01	26	389	<.01	--	--	<10	3

Table 27. Physical characteristics and inorganic-constituent data, arranged by land use, from 35 wells sampled in July 1987--Continued

Well name	Land use	Barium, dissolved (µg/L as Ba) (01005)	Boron, dissolved (µg/L as B) (01020)	Cadmium, dissolved (µg/L as Cd) (01025)	Chrominm, dissolved (µg/L as Cr) (01030)	Copper, dissolved (µg/L as Cu) (01040)	Iron, dissolved (µg/L as Fe) (01046)	Lead, dissolved (µg/L as Pb) (01049)	Manganese, dissolved (µg/L as Mn) (01056)	Mercury, dissolved (µg/L as Hg) (71890)	Mercury, total recoverable (µg/L as Hg) (71900)	Zinc, dissolved (µg/L as Zn) (01090)
A20	Residential	46	90	<1	<10	3	11	6	26	0.4	--	<3
B10	Residential	8	90	<1	10	<1	<3	<5	<1	.3	--	15
C1	Residential	57	590	<1	<10	2	9	<5	98	.2	--	<3
E20	Residential	180	170	<1	<10	1	5700	<5	2100	--	0.4	6
B3	Commercial	240	550	<1	<10	1	3700	<5	360	.3	--	15
B7	Commercial	17	90	<1	<10	2	<3	<5	<1	.3	--	<3
B8	Commercial	300	270	<1	<10	<1	16000	<5	410	.3	--	<10
C3	Commercial	200	370	<1	<10	<1	6700	<5	110	<.1	--	5
C4	Commercial	100	360	<1	10	2	90	<5	60	.3	--	10
C10	Commercial	<100	100	<1	<10	1	430	<5	20	<.1	--	9
C12	Commercial	--	--	<1	20	<1	--	<5	--	<.1	--	4
C18	Commercial	99	320	<1	<10	<1	--	<5	430	--	.2	16
D66	Commercial	600	230	<10	40	70	24000	200	540	.5	--	130
D67	Commercial	7	50	<1	<10	6	78	<5	71	--	.2	11
D68	Commercial	100	1900	<1	<10	<1	2700	<5	160	--	.2	9
E2	Commercial	12	90	<1	<10	<1	5	<5	<1	.3	--	23
E6	Commercial	200	470	<1	<10	2	4600	<5	160	--	.2	9
E7	Commercial	44	300	<1	<10	<1	6	<5	<1	--	.2	4
E10	Commercial	61	200	<1	<10	<1	9100	5	910	.4	--	6
A2	Steel	110	340	<1	<10	<1	<3	<5	250	<.1	--	11
A3	Steel	100	430	1	100	2	3100	<5	1100	<.1	--	10
A4	Steel	19	90	<1	<10	64	1600	<5	380	.2	--	4
B2	Steel	1000	20	<1	<10	<1	50	<5	10	.1	--	20
C2	Steel	200	60	<1	100	<1	<10	<5	<10	.7	--	<10
D30	Steel	100	510	<1	10	1	50	<5	10	--	.2	10
D31	Steel	<100	470	<1	10	<1	9300	<5	1000	.2	--	10
D10	Petrochemical	--	--	<1	20	<1	--	<5	--	<.1	--	5
D11	Petrochemical	--	--	<1	20	<1	--	<5	--	3.9	--	10
D20	Petrochemical	100	590	<1	10	<1	66000	<5	1700	--	.2	20
D21	Petrochemical	<100	580	<4	<10	<1	1600	<5	250	.1	--	23
D40	Petrochemical	34	190	<1	<10	<1	2800	<5	690	.1	--	<3
D60	Petrochemical	--	--	<1	20	<1	--	6	--	.2	--	7
A6	Park	60	460	<1	<10	<1	81	<5	110	--	.2	5
C20	Park	38	190	2	<10	<1	8	<5	430	.2	--	9
E3	Park	100	1200	<1	<10	<1	420	<5	120	.2	--	11

Table 28. Acid-extractable and base/neutral-extractable (methylene chloride-extractable) compound data, arranged by land use, from 35 wells sampled in July 1987
[µg/L, microgram per liter; --, not determined; E, estimated value; five-digit number in parentheses is WATSTORE (USGS) and STORET (USEPA) parameter code]

Well name	Land use	Date	Parachloro-metacresol, total (µg/L) (34452)	2-Chloro-phenol, total (µg/L) (34586)	2,4-Dichloro-phenol, total (µg/L) (34601)	2,4-Dimethyl-phenol, total (µg/L) (34606)	Dinitro-phenol, total (µg/L) (34616)	Dinitro-orthocresol, total (µg/L) (34657)	2-Nitrophenol, total (µg/L) 34591)	4-Nitrophenol, total (µg/L) (34646)	Pentachloro-phenol, total µg/L (39032)
A20	Residential	07-06-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
B10	Residential	07-13-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
C1	Residential	07-07-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
E20	Residential	07-15-87	<30	<6	<5	<6	<20	<30	<6	<30	<30
B3	Commercial	07-14-87	<30	<6	<5	<6	<20	<30	<6	<30	<30
B7	Commercial	07-14-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
B8	Commercial	07-14-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
C3	Commercial	07-09-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
C4	Commercial	07-09-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
C10	Commercial	07-21-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
C12	Commercial	07-21-87	<30	<5	<5	<5	--	<30	<5	<30	<30
C18	Commercial	07-14-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
D66	Commercial	07-15-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
D67	Commercial	07-16-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
D68	Commercial	07-16-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
E2	Commercial	07-14-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
E6	Commercial	07-15-87	<30	<6	<5	<6	<20	<30	<6	<30	<30
E7	Commercial	07-15-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
E10	Commercial	07-16-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
A2	Steel	07-08-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
A3	Steel	07-09-87	<30	<5	<5	86	<20	<30	<5	<30	<30
A4	Steel	08-05-87	<30	<5	<5	<5	--	<30	<5	<30	<30
B2	Steel	07-08-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
C2	Steel	07-07-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
D30	Steel	07-16-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
D31	Steel	07-16-87	<30	<6	<5	<6	<20	<30	<6	<30	<30
D10	Petrochemical	07-23-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
D11	Petrochemical	07-23-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
D20	Petrochemical	07-16-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
D21	Petrochemical	07-22-87	<30	<5	<5	<5	--	<30	<5	<30	<30
D40	Petrochemical	07-16-87	<30	<6	<5	<6	<20	<30	<6	<30	<30
D60	Petrochemical	07-22-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
A6	Park	07-14-87	<30	<5	<5	<5	<20	<30	<5	<30	<30
C20	Park	07-16-87	<30	<6	<5	<6	<20	<30	<6	<30	<30
E3	Park	07-13-87	<30	<5	<5	<5	<20	<30	<5	<30	<30

Table 28. Acid-extractable and base/neutral-extractable (methylene chloride-extractable) compound data, arranged by land use, from 35 wells sampled in July 1987--Continued

Well name	Land use	Phenol, total (µg/L) (34694)	Phenols, total (µg/L as phenol) (32730)	2,4,6-Trichloro-phenol, total (µg/L) (34621)	Acenaph-thene, total (µg/L) (34205)	Acenaph-thylene, total (µg/L) (34200)	Anthra-cene, total (µg/L) (34220)	Benzo(a)-anthracene (1,2-benzan-thracene), total (µg/L) (34526)	Benzo (b) fluoran-thene, total (µg/L) (34230)	Benzo (k) fluoran-thene, total (µg/L) (34242)	Benzo (g,h,i) perylene (1,12-benzo-perylene), total (µg/L) (34521)	Benzo (a) pyrene, total (µg/L) (34247)	4-Bromo-phenyl phenyl ether, total (µg/L) (34636)
A20	Residential	<5	2	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
B10	Residential	<5	1	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
C1	Residential	<5	4	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
E20	Residential	<6	3	<20	<5	<5	<5	<10	<10	<10	<10	<10	<5
B3	Commercial	<6	3	<20	<5	<5	<5	<10	<10	<10	<10	<10	<5
B7	Commercial	<5	2	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
B8	Commercial	<5	3	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
C3	Commercial	<5	2	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
C4	Commercial	<5	5	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
C10	Commercial	<5	8	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
C12	Commercial	<5	4	--	<5	<5	<5	<5	<10	<10	<10	<10	<5
C18	Commercial	<5	2	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
D66	Commercial	<5	9	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
D67	Commercial	<5	1	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
D68	Commercial	<5	2	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
E2	Commercial	<5	2	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
E6	Commercial	<6	2	<20	<5	<5	<5	<10	<10	<10	<10	<10	<5
E7	Commercial	7	14	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
E10	Commercial	<5	3	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
A2	Steel	<5	4	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
A3	Steel	73	190	<20	33	<5	<5	<5	<10	<10	<10	<10	<5
A4	Steel	<5	3	--	<5	<5	<5	<5	<10	<10	<10	<10	<5
B2	Steel	<5	15	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
C2	Steel	<5	6	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
D30	Steel	<5	7	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
D31	Steel	<6	3	<20	<5	<5	<5	<10	<10	<10	<10	<10	<5
D10	Petrochemical	<5	66	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
D11	Petrochemical	<5	9	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
D20	Petrochemical	18	310	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
D21	Petrochemical	<5	9	--	<5	<5	<5	<5	<10	<10	<10	<10	<5
D40	Petrochemical	<6	4	<20	<5	<5	<5	<10	<10	<10	<10	<10	<5
D60	Petrochemical	<5	3	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
A6	Park	<5	3	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5
C20	Park	<6	2	<20	<5	<5	<5	<10	<10	<10	<10	<10	<5
E3	Park	<5	5	<20	<5	<5	<5	<5	<10	<10	<10	<10	<5

Table 28. Acid-extractable and base/neutral-extractable (methylene chloride-extractable) compound data, arranged by land use, from 35 wells sampled in July 1987--Continued

Well name	Land use	N-Butyl benzyl phthalate, total (µg/L) (34292)	Bis (2-chloro-ethoxy) methane, total (µg/L) (34278)	Bis (2-chloro-ethyl) ether, total (µg/L) (34273)	Bis (2-chloro-isopropyl) ether, total (µg/L) (34283)	2-Chloro-naphthalene, total (µg/L) (34581)	4-Chloro-phenyl-phenyl-ether, total (µg/L) (34641)	Chrysene, total (µg/L) (34320)	1,2,5,6-Dibenz-anthracene, total (µg/L) (34556)	Diethyl phthalate, total (µg/L) (34336)	Dimethyl phthalate, total (µg/L) (34341)	Di-n-butyl phthalate, total (µg/L) (39110)
A20	Residential	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
B10	Residential	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
C1	Residential	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
E20	Residential	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
B3	Commercial	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
B7	Commercial	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	5
B8	Commercial	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	7
C3	Commercial	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
C4	Commercial	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
C10	Commercial	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
C12	Commercial	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
C18	Commercial	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
D66	Commercial	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
D67	Commercial	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	220
D68	Commercial	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
E2	Commercial	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
E6	Commercial	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
E7	Commercial	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
E10	Commercial	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
A2	Steel	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
A3	Steel	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
A4	Steel	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
B2	Steel	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
C2	Steel	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
D30	Steel	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
D31	Steel	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
D10	Petrochemical	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
D11	Petrochemical	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
D20	Petrochemical	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
D21	Petrochemical	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
D40	Petrochemical	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
D60	Petrochemical	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
A6	Park	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
C20	Park	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5
E3	Park	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<5

Table 28. Acid-extractable and base/neutral-extractable (methylene chloride-extractable) compound data, arranged by land use, from 35 wells sampled in July 1987--Continued

Well name	Land use	2,4-Dinitro-tolnene, total (µg/L) (34611)	2,6-Dinitro-toluene, total (µg/L) (34626)	Di-n-octyl phthalate, total (µg/L) (34596)	Bis (2-ethylhexyl)-phthalate, total (µg/L) (39100)	Fluoranthene, total (µg/L) (34376)	Fluorene, total (µg/L) (34381)	Hexachloro-benzene, total (µg/L) (39700)	Hexachloro-butadiene, total (µg/L) (39702	Hexachloro-cyclo-pentadiene total (µg/L) (34386)	Hexachloro-ethane, total (µg/L) (34396)
A20	Residential	<5	<5	<10	9	<5	<5	<5	<5	<5	<5
B10	Residential	<5	<5	<10	12	<5	<5	<5	<5	<5	<5
C1	Residential	<5	<5	<10	8	<5	<5	<5	<5	<5	<5
E20	Residential	<5	<5	<10	25	<5	<5	<5	<5	<5	<5
B3	Commercial	<5	<5	<10	13	<5	<5	<5	<5	<5	<5
B7	Commercial	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5
B8	Commercial	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5
C3	Commercial	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5
C4	Commercial	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5
C10	Commercial	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5
C12	Commercial	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5
C18	Commercial	<5	<5	<10	11	<5	<5	<5	<5	<5	<5
D66	Commercial	<5	<5	<10	9	<5	<5	<5	<5	<5	<5
D67	Commercial	<5	<5	<10	100	<5	<5	<5	<5	<5	<5
D68	Commercial	<5	<5	<10	43	<5	<5	<5	<5	<5	<5
E2	Commercial	<5	<5	<10	7	<5	<5	<5	<5	<5	<5
E6	Commercial	<5	<5	<10	32	<5	<5	<5	<5	<5	<5
E7	Commercial	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5
E10	Commercial	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5
A2	Steel	<5	<5	<10	11	<5	<5	<5	<5	<5	<5
A3	Steel	<5	<5	<10	11	<5	<5	<5	<5	<5	<5
A4	Steel	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5
B2	Steel	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5
C2	Steel	<5	<5	<10	17	<5	<5	<5	<5	<5	<5
D30	Steel	<5	<5	<10	16	<5	<5	<5	<5	<5	<5
D31	Steel	<5	<5	<10	19	<5	<5	<5	<5	<5	<5
D10	Petrochemical	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5
D11	Petrochemical	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5
D20	Petrochemical	<5	<5	<10	11	<5	<5	<5	<5	<5	<5
D21	Petrochemical	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5
D40	Petrochemical	<5	<5	<10	7	<5	<5	<5	<5	<5	<5
D60	Petrochemical	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5
A6	Park	<5	<5	<10	14	<5	<5	<5	<5	<5	<5
C20	Park	<5	<5	<10	<5	<5	<5	<5	<5	<5	<5
E3	Park	<5	<5	<10	19	<5	<5	<5	<5	<5	<5

Table 28. Acid-extractable and base/neutral-extractable (methylene chloride-extractable) compound data, arranged by land use, from 35 wells sampled in July 1987--Continued

Well name	Land use	Indeno (1,2,3-cd) pyrene, total (µg/L) (34403)	Isophorone, total (µg/L) (34408)	Naphthalene, total (µg/L) (34696)	Nitro-benzene, total (µg/L) (34447)	N-nitrosodi-methylamine total (µg/L) (34438)	N-nitrosodi-n-propylamine, total (µg/L) (34428)	N-nitrosodi-phenylamine, total (µg/L) (34433)	Phenan-threne, total (µg/L) (34461)	Pyrene, total (µg/L) (34469)	1,2,4-Trichloro-benzene, total (µg/L) (34551)
A20	Residential	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
B10	Residential	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
C1	Residential	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
E20	Residential	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
B3	Commercial	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
B7	Commercial	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
B8	Commercial	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
C3	Commercial	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
C4	Commercial	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
C10	Commercial	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
C12	Commercial	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
C18	Commercial	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
D66	Commercial	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
D67	Commercial	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
D68	Commercial	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
E2	Commercial	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
E6	Commercial	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
E7	Commercial	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
E10	Commercial	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
A2	Steel	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
A3	Steel	<10	<5	8	<5	<5	<5	<5	<5	<5	<5
A4	Steel	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
B2	Steel	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
C2	Steel	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
D30	Steel	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
D31	Steel	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
D10	Petrochemical	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
D11	Petrochemical	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
D20	Petrochemical	<10	<5	16	<5	<5	<5	<5	<5	<5	<5
D21	Petrochemical	1E	<5	<5	<5	<5	<5	<5	<5	<5	<5
D40	Petrochemical	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
D60	Petrochemical	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
A6	Park	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
C20	Park	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5
E3	Park	<10	<5	<5	<5	<5	<5	<5	<5	<5	<5

Table 29. Volatile organic compound data, arranged by land use, from 35 wells sampled in July 1987
[µg/L, microgram per liter; --, not determined; five-digit number in parentheses is WATSTORE (USGS) and STORET (USEPA) parameter code]

Well name	Land use	Date	Benzene, total (µg/L) (34030)	Bromoform, total (µg/L) (32104)	Carbontetra-chloride, total (µg/L) (32102)	Chloro-benzene, total (µg/L) (34301)	Chloro-ethane, total (µg/L) (34311)	2-Chloroethyl-vinylether, total (µg/L) (34576)	Chloroform, total (µg/L) (32106)	Methyl-chloride, total (µg/L) (34418)
A20	Residential	07-06-87	1.7	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
B10	Residential	07-13-87	--	--	--	--	--	--	--	--
C1	Residential	07-07-87	<0.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E20	Residential	07-15-87	--	--	--	--	--	--	--	--
B3	Commercial	07-14-87	.4	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B7	Commercial	07-14-87	.2	<.2	<.2	<.2	<.2	<.2	12	<.2
B8	Commercial	07-14-87	.3	<.2	<.2	<.2	<.2	<.2	.3	<.2
C3	Commercial	07-09-87	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C4	Commercial	07-09-87	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C10	Commercial	07-21-87	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C12	Commercial	07-21-87	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C18	Commercial	07-14-87	<.2	<.2	<.2	<.2	<.2	<.2	.8	<.2
D66	Commercial	07-15-87	--	--	--	--	--	--	--	--
D67	Commercial	07-16-87	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D68	Commercial	07-16-87	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E2	Commercial	07-14-87	.4	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E6	Commercial	07-15-87	.2	<.2	<.2	<.2	<.2	<.2	.2	<.2
E7	Commercial	07-15-87	--	--	--	--	--	--	--	--
E10	Commercial	07-16-87	<.2	<.2	<.2	<.2	<.2	<.2	.4	<.2
A2	Steel	07-08-87	.5	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A3	Steel	07-09-87	1000	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A4	Steel	07-15-87	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B2	Steel	07-08-87	.5	<.2	<.2	.2	<.2	<.2	<.2	<.2
C2	Steel	07-07-87	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D30	Steel	07-16-87	.8	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D31	Steel	07-16-87	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D10	Petrochemical	07-23-87	1.5	<.2	<.2	2.9	<.2	<.2	<.2	<.2
D11	Petrochemical	07-23-87	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D20	Petrochemical	07-16-87	1900	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D21	Petrochemical	07-22-87	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D40	Petrochemical	07-16-87	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D60	Petrochemical	07-22-87	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A6	Park	07-14-87	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C20	Park	07-16-87	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E3	Park	07-13-87	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 29. Volatile organic compound data, arranged by land use, from 35 wells sampled in July 1987--Continued

Well name	Land use	Chloro-dibromo-methane, total (µg/L) (32105)	Dichloro-bromo-methane total (µg/L) (32101)	1,2-Di-chloro-benzene, total (µg/L) (34536)	1,3-Di-chloro-benzene, total (µg/L) (34566)	1,4-Di-chloro-benzene, total (µg/L) (34571)	Dichloro-difluoro-methane, total (µg/L) (34668)	1,2-Dibromo-ethylene, total (µg/L) (39082)	1,1-Di-chloro-ethane, total (µg/L) (34496)	1,2-Di-chloro-ethane, total (µg/L) (32103)	1,1-Di-chloro-ethylene, total (µg/L) (34501)
A20	Residential	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
B10	Residential	--	--	<5	<5	<5	--	--	--	--	--
C1	Residential	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E20	Residential	--	--	<5	<5	<5	--	--	--	--	--
B3	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B7	Commercial	2.2	7.1	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B8	Commercial	<.2	<.2	<5	<5	<5	<.2	<.2	<.2	<.2	<.2
C3	Commercial	<.2	<.2	<5	<5	<5	<.2	<.2	<.2	<.2	<.2
C4	Commercial	<.2	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C10	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C12	Commercial	<.2	<.2	<5	<5	<5	4.2	<.2	<.2	<.2	<.2
C18	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D66	Commercial	--	--	<.2	<.2	<.2	--	--	--	--	--
D67	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D68	Commercial	<.2	<.2	<5	<5	<5	<.2	<.2	<.2	<.2	<.2
E2	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E6	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E7	Commercial	--	--	<.2	<.2	<.2	--	--	--	--	--
E10	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A2	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A3	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A4	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B2	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2	<.2
C2	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D30	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D31	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D10	Petrochemical	<.2	<.2	<5	<5	<5	<.2	<.2	<.2	<.2	<.2
D11	Petrochemical	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D20	Petrochemical	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D21	Petrochemical	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D40	Petrochemical	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D60	Petrochemical	<.2	<.2	<5	<5	<5	<.2	<.2	<.2	<.2	.3
A6	Park	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C20	Park	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E3	Park	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 29. Volatile organic compound data, arranged by land use, from 35 wells sampled in July 1987--Continued

Well name	Land use	1,2-Transdi-chloro-ethylene, total (µg/L) (34546)	1,2-Di-chloro-propane, total (µg/L) (34541)	Cis-1,3-di-chloro-propene, total (µg/L) (34704)	Trans-1,3-di-chloro-propene, total (µg/L) (34699)	1,3-Di-chloro-propene, total (µg/L) (34561)	Ethyl-benzene, total (µg/L) (34371)	Methyl-bromide, total (µg/L) (34413)	Styrene, total (µg/L) (77128)	Methylene chloride, total (µg/L) (34423)
A20	Residential	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
B10	Residential	--	--	--	--	--	--	--	--	--
C1	Residential	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E20	Residential	--	--	--	--	--	--	--	--	--
B3	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B7	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B8	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C3	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C4	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C10	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C12	Commercial	<.2	<.2	<.2	<.2	<.2	.5	<.2	.2	<.2
C18	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D66	Commercial	--	--	--	--	--	--	--	--	--
D67	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D68	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E2	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E6	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E7	Commercial	--	--	--	--	--	--	--	--	--
E10	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A2	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A3	Steel	<.2	<.2	<.2	<.2	<.2	1.0	<.2	<.2	<.2
A4	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B2	Steel	<.2	<.2	<.2	<.2	<.2	.2	<.2	<.2	<.2
C2	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D30	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D31	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D10	Petrochemical	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D11	Petrochemical	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D20	Petrochemical	<.2	<.2	<.2	<.2	<.2	19	<.2	<.2	<.2
D21	Petrochemical	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D40	Petrochemical	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D60	Petrochemical	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A6	Park	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C20	Park	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E3	Park	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 29. Volatile organic compound data, arranged by land use, from 35 wells sampled in July 1987--Continued

Well name	Land use	1,1,2,2-Tetra-chloro-ethane, total (µg/L) (34516)	Tetra-chloro-ethylene, total (µg/L) (34475)	Toluene, total (µg/L) (34010)	1,1,1-Trichloro-ethane, total (µg/L) (34506)	1,1,2-Trichloro-ethane, total (µg/L) (34511)	Trichloro-ethylene, total (µg/L) (39180)	Trichloro-fluoro-methane, total (µg/L) (34488)	Vinyl chloride, total (µg/L) (39175)	Xylenes, total (µg/L) (81551)
A20	Residential	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
B10	Residential	--	--	--	--	--	--	--	--	--
C1	Residential	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2	<.2
E20	Residential	--	--	--	--	--	--	--	--	--
B3	Commercial	<.2	<.2	.2	<.2	<.2	<.2	.2	<.2	<.2
B7	Commercial	<.2	4.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B8	Commercial	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2	<.2
C3	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C4	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C10	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C12	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	2.2
C18	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D66	Commercial	--	--	--	--	--	--	--	--	--
D67	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D68	Commercial	<.2	.2	.3	<.2	<.2	<.2	<.2	<.2	<.2
E2	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E6	Commercial	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2	<.2
E7	Commercial	--	--	--	--	--	--	--	--	--
E10	Commercial	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A2	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2
A3	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	3.2
A4	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B2	Steel	<.2	<.2	.7	<.2	<.2	<.2	<.2	<.2	1.5
C2	Steel	<.2	<.2	.9	<.2	<.2	<.2	<.2	<.2	<.2
D30	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D31	Steel	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2
D10	Petrochemical	<.2	<.2	.6	<.2	<.2	<.2	<.2	<.2	2.5
D11	Petrochemical	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D20	Petrochemical	<.2	<.2	1.5	<.2	<.2	<.2	<.2	<.2	19
D21	Petrochemical	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D40	Petrochemical	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D60	Petrochemical	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A6	Park	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C20	Park	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E3	Park	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 30. Physical characteristics and cyanide data from 34 wells sampled in May 1988, arranged by land use, and from 5 sample blanks
[µs/cm, microsiemen per centimeter at 25° Celsius; mg/L, milligram per liter; n.a., not applicable; --, not determined; five-digit number in parentheses is WATSTORE (USGS) and STORET (USEPA) parameter code]

Well name	Land use	Date	Specific condnctance (µs/cm) (00095)	pH, field (standard units) (00400)	Temperature water (degree Celsius) (00010)	Oxygen, dissolved (mg/L) (00300)	Cyanide, dissolved (mg/L as CN) (00723)
A20	Residential	05-05-88	994	7.3	16.0	0.4	<0.01
B10	Residential	05-04-88	470	7.8	10.5	7.1	<.01
C1	Residential	05-10-88	2760	7.4	10.0	1.2	<.01
C1 Duplicate	Residential	05-10-88	2760	7.4	10.0	1.2	<.01
E20	Residential	05-11-88	769	7.0	10.5	1.4	<.01
B3	Commercial	05-05-88	1510	7.8	12.5	.4	.02
B7	Commercial	05-05-88	758	6.9	10.5	3.4	<.01
B7 Duplicate	Commercial	05-05-88	758	6.9	10.5	3.4	<.01
B8	Commercial	05-05-88	1910	6.9	13.0	.4	<.01
C3	Commercial	05-02-88	1080	7.3	13.0	.7	<.01
C4	Commercial	05-02-88	1260	6.9	10.0	5.6	<.01
C10	Commercial	05-04-88	393	5.6	9.5	.7	<.01
C12	Commercial	05-04-88	1510	6.6	9.5	.6	<.01
C18	Commercial	05-04-88	1350	7.1	12.5	.5	<.01
D66	Commercial	05-04-88	--	8.0	--	--	--
D67	Commercial	05-05-88	275	6.5	10.5	.5	<.01
D68	Commercial	05-05-88	583	7.5	11.5	.5	<.01
E2	Commercial	05-03-88	612	7.4	10.0	4.2	<.01
E2 Duplicate	Commercial	05-03-88	612	7.4	10.0	4.2	<.01
E6	Commercial	05-03-88	1400	7.3	12.0	.5	8.2
E7	Commercial	05-03-88	2790	11.8	10.5	1.4	.19
E10	Commercial	05-09-88	941	6.3	11.0	.5	<.01
A2	Steel	05-11-88	843	7.3	15.0	.3	.02
A2 Duplicate	Steel	05-11-88	843	7.3	15.0	.3	.02
A3	Steel	05-10-88	4960	8.4	15.5	.3	8.3
A4	Steel	05-11-88	456	7.1	11.5	.5	<.01
B2	Steel	05-10-88	4490	11.7	15.0	3.9	.73
D30	Steel	05-02-88	2110	10.3	9.5	.5	.06
D31	Steel	05-02-88	2460	6.7	10.0	.5	.03

Table 30. Physical characteristics and cyanide data from 34 wells sampled in May 1988, arranged by land use, and from 5 sample blanks--Continued

Well name	Land use	Date	Specific conductance (µs/cm) (00095)	pH, field (standard units) (00400)	Temperature water (degree Celsius) (00010)	Oxygen, dissolved (mg/L) (00300)	Cyanide, dissolved (mg/L as CN) (00723)
D10	Petrochemical	05-03-88	1350	7.1	11.5	0.7	<0.01
D11	Petrochemical	05-03-88	1610	7.2	12.5	.4	.04
D20	Petrochemical	05-09-88	2520	6.9	11.5	.2	<.01
D21	Petrochemical	05-03-88	1200	7.7	12.5	.4	<.01
D40	Petrochemical	05-10-88	1720	7.3	8.5	.4	<.01
D60	Petrochemical	05-10-88	925	7.1	10.5	.8	<.01
A6	Park	05-12-88	758	7.2	11.5	2.6	.01
C20	Park	05-05-88	1120	6.8	11.0	.7	<.01
E3	Park	05-09-88	622	8.0	11.5	1.3	<.01
Blank	n.a.	05-02-88	--	--	--	--	<.01
Blank	n.a.	05-04-88	--	--	--	--	<.01
Blank	n.a.	05-05-88	--	--	--	--	<.01
Blank	n.a.	05-10-88	--	--	--	--	<.02
Blank	n.a.	05-10-88	--	--	--	--	<.10

Table 31. Physical characteristics and volatile organic compound data from 34 wells sampled in August 1988, arranged by land use, and from 3 sample blanks

[µs/cm, microsiemen per centimeter at 25° Celsius; n.a., not applicable; µg/L, microgram per liter; --, not determined; five-digit number in parentheses is WATSTORE (USGS) and STORET (USEPA) parameter code]

Well name	Land use	Date	Specific conductance (µs/cm) (00095)	pH (standard units) (00400)	Temperature water (degree Celsius) (00010)	Benzene, total (µg/L) (34030)	Bromo-form, total (µg/L) (32104)	Carbon-tetra-chloride, total (µg/L) (32102)	Chloro-benzene, total (µg/L) (34301)	Chloro-ethane, total (µg/L) (34311)	2-Chloro-ethylvinyl-ether, total (µg/L) (34576)
A20	Residential	08-04-88	1140	7.4	18.5	0.8	<0.2	<0.2	<0.2	<0.2	<0.2
B10	Residential	08-02-88	982	7.1	20.0	.4	<.2	<.2	<.2	<.2	<.2
B10 Duplicate	Residential	08-02-88	982	7.1	20.0	<.2	<.2	<.2	<.2	<.2	<.2
C1	Residential	08-03-88	2070	7.4	22.0	<.2	<.2	<.2	<.2	<.2	<.2
E20	Residential	08-02-88	801	7.1	19.0	<.2	<.2	<.2	<.2	<.2	<.2
B3	Commercial	08-03-88	1520	7.5	13.5	.6	<.2	<.2	<.2	<.2	<.2
B7	Commercial	08-02-88	906	6.9	18.5	1.3	<.2	<.2	<.2	<.2	<.2
B8	Commercial	08-02-88	1900	6.8	15.0	<.2	<.2	<.2	<.2	<.2	<.2
C3	Commercial	08-03-88	1040	7.3	13.5	2.7	<.2	<.2	<.2	<.2	<.2
C4	Commercial	08-03-88	850	7.0	17.0	.4	<.2	<.2	<.2	<.2	<.2
C10	Commercial	08-04-88	637	6.9	18.0	<.2	<.2	<.2	<.2	<.2	<.2
C12	Commercial	08-04-88	1650	6.7	13.0	<.2	<.2	<.2	<.2	<.2	<.2
C12 Duplicate	Commercial	08-04-88	1650	6.7	13.0	.6	<.2	<.2	<.2	<.2	<.2
C18	Commercial	08-03-88	1190	6.9	15.5	.3	<.2	<.2	<.2	<.2	<.2
D66	Commercial	08-04-88	3840	8.5	16.5	<.2	<.2	<.2	<.2	<.2	<.2
D67	Commercial	08-03-88	234	6.9	21.5	1.5	<.2	<.2	<.2	<.2	<.2
D68	Commercial	08-03-88	573	7.5	14.0	2.0	<.2	<.2	<.2	<.2	<.2
E2	Commercial	08-03-88	542	7.5	18.0	.7	<.2	<.2	<.2	<.2	<.2
E6	Commercial	08-02-88	1460	7.2	15.5	1.2	<.2	<.2	<.2	<.2	<.2
E6 Duplicate	Commercial	08-02-88	1460	7.2	15.5	1.0	<.2	<.2	<.2	<.2	<.2
E7	Commercial	08-02-88	--	--	--	2.3	<.2	<.2	<.2	<.2	<.2
E10	Commercial	08-02-88	982	7.1	20.0	.2	<.2	<.2	<.2	<.2	<.2
A2	Steel	08-16-88	1010	7.1	17.5	7.7	<.2	<.2	<.2	<.2	<.2
A3	Steel	08-16-88	--	--	--	1400	<10	<10	<10	<10	<10
A3 Duplicate	Steel	08-16-88	--	--	--	1600	<10	<10	<10	<10	<10
A4	Steel	08-17-88	492	6.9	15.0	<.2	<.2	<.2	<.2	<.2	<.2
B2	Steel	08-16-88	3930	11.9	18.0	.3	<.2	<.2	<.2	<.2	<.2
D30	Steel	08-03-88	2120	9.8	17.0	3.8	<.2	<.2	<.2	<.2	<.2
D31	Steel	08-03-88	2430	6.9	13.5	2.0	<.2	<.2	<.2	<.2	<.2

Table 31. Physical characteristics and volatile organic compound data from 34 wells sampled in August 1988, arranged by land use, and from 3 sample blanks--Continued

Well name	Land use	Date	Specific conductance (µs/cm) (00095)	pH (standard units) (00400)	Temperature water (degree Celsius) (00010)	Benzene, total (µg/L) (34030)	Bromo-form, total (µg/L) (32104)	Carbon-tetra-chloride, total (µg/L) (32102)	Chloro-benzene, total (µg/L) (34301)	Chloro-ethane, total (µg/L) (34311)	2-Chloro-ethylvinyl-ether, total (µg/L) (34576)
D10	Petrochemical	08-04-88	3490	7.0	21.0	0.3	<0.2	<0.2	<0.2	<0.2	<0.2
D11	Petrochemical	08-03-88	4390	7.0	17.5	<.2	<.2	<.2	<.2	<.2	<.2
D20	Petrochemical	08-03-88	1800	6.5	21.5		<.2	<.2	<.2	<.2	<.2
						48					
D21	Petrochemical	08-04-88	1360	7.4	19.5	24	<.2	<.2	<.2	<.2	<.2
						0					
D21 Duplicate	Petrochemical	08-04-88	1360	7.4	19.5	<.2	<.2	<.2	<.2	<.2	<.2
D40	Petrochemical	08-02-88	2070	6.9	19.0	12	<.2	<.2	<.2	<.2	<.2
						0					
D60	Petrochemical	08-04-88	1000	7.1	19.5	.3	<.2	<.2	<.2	<.2	<.2
A6	Park	08-03-88	1330	7.4	16.5	<.2	<.2	<.2	<.2	<.2	<.2
C20	Park	08-02-88	654	7.0	17.0	<.2	<.2	<.2	<.2	<.2	<.2
E3	Park	08-02-88	628	7.7	16.0	.7	<.2	<.2	<.2	<.2	<.2
Blank	n.a.	08-03-88	--	--	--	<.2	<.2	<.2	<.2	<.2	<.2
Blank	n.a.	08-17-88	--	--	--	.2	<.2	<.2	<.2	<.2	<.2
Blank	n.a.	08-03-88	--	--	--	<.2	<.2	<.2	<.2	<.2	<.2

Table 31. Physical characteristics and volatile organic compound data from 34 wells sampled in August 1988, arranged by land use, and from 3 sample blanks--Continued

Well name	Chloroform, total (µg/L) (32106)	Methyl-chloride, total (µg/L) (34418)	Chloro-dibromo-methane, total (µg/L) (32105)	Dichloro-bromo-methane (µg/L) (32101)	1,2-Di-chloro-benzene, total (µg/L) (34536)	1,3-Di-chloro-benzene, total (µg/L) (34566)	1,4-Di-chloro-benzene, total (µg/L) (34571)	Dichloro-difluoro-methane, total (µg/L) (34668)	1,2-Dibromo-ethylene, total (µg/L) (39082)	1,2-Dibromo-ethane, total (µg/L) (77651)	1,1-Di-chloro-ethane, total (µg/L) (34496)
A20	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	--	<0.2	<0.2
B10	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<0.2	--	<.2
B10 Duplicate	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2
C1	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
E20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2
B3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2
B7	.4	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	300	<.2
B8	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2
C3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2
C4	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2
C10	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
C12	<.2	<.2	<.2	<.2	<.2	<.2	<.2	5.0	--	<.2	<.2
C12 Duplicate	<.2	<.2	<.2	<.2	<.2	<.2	<.2	7.1	--	<.2	<.2
C18	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
D66	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
D67	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
D68	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
E2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
E6	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
E6 Duplicate	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
E7	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2
E10	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.5	<.2	--	<.2
A2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	2.1	--	<.2	<.2
A3	<10	<10	<10	<10	<10	<10	<10	<10	--	<10	12
A3 Duplicate	<10	<10	<10	<10	<10	<10	<10	<10	--	<10	11
A4	<.2	<.2	<.2	<.2	<.2	<.2	<.2	2.1	--	<.2	<.2
B2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
D30	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
D31	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2

Table 31. Physical characteristics and volatile organic compound data from 34 wells sampled in August 1988, arranged by land use, and from 3 sample blanks--Continued

Well name	Chloroform, total (µg/L) (32106)	Methyl-chloride, total (µg/L) (34418)	Chloro-dibromo-methane, total (µg/L) (32105)	Dichloro-bromo-methane (µg/L) (32101)	1,2-Di-chloro-benzene, total (µg/L) (34536)	1,3-Di-chloro-benzene, total (µg/L) (34566)	1,4-Di-chloro-benzene, total (µg/L) (34571)	Dichloro-difluoro-methane, total (µg/L) (34668)	1,2-Dibromo ethylene, total (µg/L) (39082)	1,2-Dibromo-ethane, water whole total (µg/L) (77651)	1,1-Di-chloro-ethane, total (µg/L) (34496)
D10	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	--	<0.2
D11	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<0.2	<.2
D20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
D21	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	.8	<.2
D21 Duplicate	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
D40	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2
D60	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	1.4
A6	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
C20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2
E3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2
Blank	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
Blank	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	--	<.2	<.2
Blank	5.6	<.2	.2	1.0	<.2	<.2	<.2	<.2	<.2	--	<.2

Table 31. Physical characteristics and volatile organic compound data from 34 wells sampled in August 1988, arranged by land use, and from 3 sample blanks--Continued

Well name	1,2-Di-chloro-ethane, total (μg/L) (32103)	1,1,-Di-chloro-ethylene, total (μg/L) (34501)	1,2-Transdi-chloroethylene, total (μg/L) (34546)	1,2-Di-chloro-propane, total (μg/L) (34541)	Cis-1,3-di-chloro-propene, total (μg/L) (34704)	Trans-1,3-di-chloro-propene, total (μg/L) (34699)	1,3-Di-chloro-propene, total (μg/L) (34561)	Ethyl-benzene, total (μg/L) (34371)	Methyl-bromide, total (μg/L) (34413)	Styrene, total (μg/L) (77128)
A20	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<02	<0.2	<0.2
B10	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B10 Duplicate	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C1	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B7	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B8	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C4	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C10	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C12	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C12 Duplicate	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C18	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D66	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D67	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D68	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E6	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2	<.2
E6 Duplicate	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.8	<.2	<.2
E7	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E10	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A3	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
A3 Duplicate	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
A4	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D30	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D31	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 31. Physical characteristics and volatile organic compound data from 34 wells sampled in August 1988, arranged by land use, and from 3 sample blanks--Continued

Well name	1,2-Di-chloro-ethane, total (µg/L) (32103)	1,1,-Di-chloro-ethylene, total (µg/L) (34501)	1,2-Transdi-chloroethylene, total (µg/L) (34546)	1,2-Di-chloro-propane, total (µg/L) (34541)	Cis-1,3-di-chloro-propene, total (µg/L) (34704)	Trans-1,3-di-chloro-propene, total (µg/L) (34699)	1,3-Di-chloro-propene, total (µg/L) (34561)	Ethyl-benzene, total (µg/L) (34371)	Methyl-bromide, total (µg/L) (34413)	Styrene, total (µg/L) (77128)
D10	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
D11	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D21	<.2	3.7	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D21 Duplicate	<.2	2.6	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D40	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D60	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A6	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C20	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Blank	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Blank	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Blank	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 31. Physical characteristics and volatile organic compound data from 34 wells sampled in August 1988, arranged by land use, and from 3 sample blanks--Continued

Well name	Methylene chloride, total (µg/L) (34423)	1,1,2,2-Tetrachloro-ethane, total (µg/L) (34516)	Tetra-chloro-ethylene, total (µg/L) (34475)	Toluene, total (µg/L) (34010)	1,1,1-Trichloro-ethane, total (µg/L) (34506)	1,1,2-Chloro-ethane, total (µg/L) (34511)	Tri-chloro-ethylene, total (µg/L) (39180)	Trichloro-fluoro-methane, total (µg/L) (34488)	Vinyl chloride, total (µg/L) (39175)	Xylenes, total (µg/L) (81551)
A20	<0.2	<0.2	0.4	<0.2	<0.2	<0.2	<0.2	22	<0.2	<0.2
B10	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<0.2	<.2	<.2
B10 Duplicate	<.4	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C1	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E20	<1.0	<.2	<.2	<.2	<.2	<.2	.4	.2	<.2	<.2
B3	<.4	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B7	<.2	<.2	11	<.2	<.2	<.2	<.2	<.2	<.2	<.2
B8	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C3	<.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C4	<.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C10	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C12	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C12 Duplicate	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C18	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D66	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D67	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D68	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E2	<.3	<.2	<.2	<.2	<.2	<.2	.3	<.2	<.2	<.2
E6	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	1.9
E6 Duplicate	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	5.0
E7	<.4	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E10	<1.0	<.2	<.2	<.2	<.2	<.2	<.2	.3	<.2	<.2
A2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A3	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
A3 Duplicate	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
A4	<.2	<.2	<.2	<.2	<.2	<.2	.4	<.2	<.2	<.2
B2	<.2	<.2	<.2	.3	<.2	<.2	<.2	<.2	<.2	.5
D30	<.2	<.2	<.2	<.2	<.2	<.2	<.2	3.3	<.2	<.2
D31	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table 31. Physical characteristics and volatile organic compound data from 34 wells sampled in August 1988, arranged by land use, and from 3 sample blanks--Continued

Well name	Methylene chloride, total (µg/L) (34423)	1,1,2,2-Tetrachloro-ethane, total (µg/L) (34516)	Tetra-chloro-ethylene, total (µg/L) (34475)	Toluene, total (µg/L) (34010)	1,1,1-Trichloro-ethane, total (µg/L) (34506)	1,1,2-Chloro-ethane, total (µg/L) (34511)	Tri-chloro-ethylene, total (µg/L) (39180)	Trichloro-fluoro-methane, total (µg/L) (34488)	Vinyl chloride, total (µg/L) (39175)	Xylenes, total (µg/L) (81551)
D10	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3
D11	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D20	<.2	<.2	<.2	.7	<.2	<.2	<.2	<.2	<.2	.9
D21	<.4	<.2	<.2	.5	<.2	<.2	.2	<.2	5.8	<.2
D21 Duplicate	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2	3.0	<.2
D40	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
D60	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
A6	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
C20	<.5	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
E3	<.4	<.2	<.2	<.2	<.2	<.2	.3	<.2	<.2	.3
Blank	<.2	<.2	<.4	<.2	<.2	<.2	.4	<.2	<.2	<.2
Blank	.7	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2	<.2
Blank	<.6	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2	<.2

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