

INDIANA GROUND-WATER QUALITY

By Konrad J. Banaszak

U.S. Geological Survey Open-File Report 87-0724

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, *Secretary*

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, *Director*

For additional information:

Chief Hydrologist
U.S. Geological Survey
407 National Center
Reston, VA 22092

For sale by:

U.S. Geological Survey
Books and Open-File Reports Section
Federal Center
Box 25425
Denver, Colorado 80225

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

FOREWORD

This report contains summary information on ground-water quality in one of the 50 States, Puerto Rico, the Virgin Islands, or the Trust Territories of the Pacific Islands, Saipan, Guam, and American Samoa. The material is extracted from the manuscript of the *1986 National Water Summary*, and with the exception of the illustrations, which will be reproduced in multi-color in the *1986 National Water Summary*, the format and content of this report is identical to the State ground-water-quality descriptions to be published in the *1986 National Water Summary*. Release of this information before formal publication in the *1986 National Water Summary* permits the earliest access by the public.

Contents

| | |
|--|---|
| Ground-Water Quality | 1 |
| Water-Quality in Principal Aquifers | 1 |
| Background Water Quality | 1 |
| Glaciofluvial and Glacial Aquifers | 1 |
| Glaciofluvial aquifers | 1 |
| Glacial-Outwash aquifers | 1 |
| Wisconsin Till aquifers | 2 |
| Carbonate Bedrock Aquifers | 2 |
| Mississippian aquifers | 2 |
| Silurian-Devonian aquifers | 2 |
| Other Aquifers | 2 |
| Effects of Land Use on Water Quality | 2 |
| Waste Disposal and Spills | 2 |
| Agriculture | 3 |
| Potential for Water-Quality Changes | 3 |
| Ground-Water-Quality Management | 3 |
| Selected References | 3 |

Illustrations

| | |
|--|---|
| Figure 1.--Selected geographic feature and 1985 population distribution in Indiana. | 5 |
| Figure 2.--Principal aquifers and related water-quality data in Indiana. | 6 |
| Figure 3.--Selected waste sites and ground-water quality information in Indiana. | 7 |
| Figure 4.--Public water-supply wells with one or more detectable volatile organic compounds | 8 |

INDIANA

Ground-Water Quality

Ground water provides drinking water for nearly 60 percent of the population in Indiana (fig. 1B); of this percentage, about one-half get their water from domestic wells (Indiana Department of Environmental Management, 1986, p. 152). Five principal aquifers have been identified in the State; of these five, the glaciofluvial and the glacial-outwash aquifers are the most productive (fig. 2A). Some ground water is obtained from other less-productive aquifers in areas where the principal aquifers are not present.

Ground water in Indiana is usually very hard—with hardness concentrations greater than 180 mg/L (milligrams per liter) as calcium carbonate—and has an average median dissolved-solids concentration of about 465 mg/L. Large concentrations of iron are common. However, most ground water in the State is potable. Water from 67 percent of the public water-supply wells has been analyzed for organic compounds, and water from about 8 percent of those wells contained at least one detectable organic compound (Indiana Department of Environmental Management, 1986).

The U.S. Environmental Protection Agency (1986c) has identified 23 hazardous-waste sites in Indiana (fig. 3A) for inclusion on the National Priorities List (NPL), or “Superfund”, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. The Interagency Groundwater Task Force (1986, p. 52) has estimated that as many as 50 of the 853 sites now undergoing evaluation for inclusion on the NPL will be listed. The U.S. Department of Defense (DOD) has identified 32 hazardous-waste sites at 3 facilities as having potential for contamination. Six sites at two facilities (fig. 3A) present a hazard significant enough to warrant response action in accordance with CERCLA. Hazardous wastes are disposed of at 28 Resources Conservation and Recovery Act (RCRA) sites. Indiana has 113 solid-waste landfills that are permitted by the State (fig. 3C) and 687 abandoned landfills. Ninety-six of the 1,774 public water-supply wells (serving more than 25 people) have water with detectable concentrations of volatile organic compounds (fig. 4).

WATER QUALITY IN PRINCIPAL AQUIFERS

Indiana has five principal aquifers (fig. 2A). In order from youngest to oldest, they are the glaciofluvial, glacial-outwash, Wisconsin till, Mississippian, and Silurian-Devonian aquifers. These five principal aquifers are of two principal types—glaciofluvial and glacial deposits, and carbonate bedrock. Water is stored and transmitted through interconnected pores in the glaciofluvial and glacial deposits and through fractures and solution openings in the carbonate bedrock (U.S. Geological Survey, 1985, p. 207). Parts of the State are underlain by less-productive aquifers of limited extent, which are shown in figures 2A and 2B as “other aquifer.” Small, but locally significant, withdrawals are made from these other aquifers.

In some areas of Indiana, large concentrations of iron [as much as 3,000 µg/L (micrograms per liter)] and manganese (as much as 1,000 µg/L) are present in the ground water (Clark, 1980, v. I, p. 80). The only other commonly occurring constituent of some concern is sulfate, which exceeds the 250-mg/L drinking-water standard (U.S. Environmental Protection Agency, 1986b) in some less productive aquifers in the coal-producing area of southwestern Indiana.

BACKGROUND WATER QUALITY

A graphic summary of selected water-quality variables compiled from (1) the U.S. Geological Survey’s National Water Data Storage and Retrieval System (WATSTORE), (2) unpublished data from the Indiana Department of Natural Resources (IDNR) for the St. Joseph River and Whitewater River basins Division of Water and (3) 1984 data from the Indiana State Board of Health (ISBH) for 169 public water-supply wells is presented in figure 2C. The summary is based on analyses of dissolved-solids, hardness (as calcium carbonate), nitrate (as nitrogen), chloride, and iron in water samples collected from aquifer units in Indiana. Percentiles of these variables (except hardness) are compared to national standards that specify the maximum concentration or level of a constituent in a drinking-water supply as established by the U.S. Environmental Protection Agency (1986a,b). The primary maximum contaminant level standards are health related and are legally enforceable. The secondary maximum contaminant level standards apply to esthetic qualities and are recommended guidelines. The primary drinking-water standards include a maximum concentration of 10 mg/L nitrate (as nitrogen), and the secondary drinking-water standards include maximum concentrations of 500 mg/L dissolved solids, 250 mg/L chloride, and 300 µg/L iron.

Differences in water quality of the principal aquifers occur throughout Indiana and are related to the mineral characteristics of the aquifers. Most of the State’s ground water is potable but very hard with median hardness ranging from 286 to 340 mg/L as calcium carbonate. Although not shown in figure 2C, the median calcium concentration ranged only from 77 to 88 mg/L for all aquifer units. The average median dissolved-solids concentration was about 465 mg/L, which is less than secondary drinking-water standards of 500 mg/L (U.S. Environmental Protection Agency, 1986b).

Glaciofluvial and Glacial Aquifers

GLACIOFLUVIAL AQUIFERS

Glaciofluvial aquifers are the most productive in the State. They consist of sand-and-gravel deposits in glacial channels and along river systems (fig. 2A, aquifer 1). These aquifers typically are unconfined. The depth to water is commonly from 10 to 25 feet, and usually wells are constructed 20 to 60 feet in depth. Median concentrations of 546 mg/L dissolved solids and 340 mg/L hardness (as calcium carbonate) were found in water from the glaciofluvial aquifers. Of the aquifers represented in figure 2C, water in the glaciofluvial aquifers had the largest median nitrate concentration (1.4 mg/L as nitrogen), the largest median chloride concentration (16 mg/L of the glaciofluvial and glacial aquifers), and the smallest median iron concentration (100 µg/L). Large chloride concentrations may reflect road-salting and waste-disposal activities. The small iron concentrations may result from oxidizing conditions typical of these aquifers.

GLACIAL-OUTWASH AQUIFERS

The glacial-outwash aquifers consist of sand and gravel that are more areally extensive than the glaciofluvial aquifers (fig. 2A, aquifer 2). These aquifers are generally unconfined, although units of small permeability, such as till, commonly restrict vertical flow between the permeable parts of these aquifers. The depth to water

is commonly 10 to 25 feet below land surface, and most wells are from 20 to 100 feet deep.

The water in these aquifers is suitable for most uses and had median concentrations of 440 mg/L dissolved solids; 286 mg/L hardness (as calcium carbonate) and iron, 900 $\mu\text{g/L}$. Concentrations of some constituents were small, however, such as median concentrations of 0.1 mg/L for nitrate (as nitrogen), and 10 mg/L for chloride.

WISCONSIN TILL AQUIFERS

The Wisconsin till aquifers (fig. 2A, aquifer 3) consist of isolated sand and gravel lenses that are usually enclosed by silty clay and clay till; therefore, the aquifers tend to be confined. From 5 to 100 feet of confining material may overlie the water-bearing zone.

Wells are commonly 20 to 100 feet deep. Water in Wisconsin till aquifers had median concentrations of 358 mg/L dissolved solids and 320 mg/L hardness (as calcium carbonate). Nitrate concentrations were small with a median of 0.2 mg/L as nitrogen. The water in till aquifers had a median chloride concentration of 9 mg/L, which is similar to that of precipitation. Water from the Wisconsin till aquifers however, contained the largest median iron concentration (1,900 $\mu\text{g/L}$). This may be due to the abundance of iron-rich materials in the aquifers and to the thick confining materials in which reducing conditions may prevail and through which water must flow.

Carbonate Bedrock Aquifers

MISSISSIPPIAN AQUIFERS

The Mississippian aquifers (fig. 2A) are fractured limestones characterized by solution channels that enhance permeability. Most wells drilled into these aquifers are shallow (from 20 to 150 feet deep). Unfortunately, data from only four water-quality sites (all public-supply wells) are available. For water samples from these four wells, the maximum concentrations were 640 mg/L hardness (as calcium carbonate), 1.2 mg/L nitrate (as nitrogen), 28 mg/L chloride, and 530 $\mu\text{g/L}$ iron. No dissolved-solids data were available.

SILURIAN-DEVONIAN AQUIFERS

The Silurian-Devonian aquifers consist of fractured limestone not known to contain solution channels. These aquifers (fig. 2A, aquifer 4) usually are confined by overlying glacial till. Where the limestones are unconfined (in the southeastern part of the State), well yields are small (Greeman, 1981). Wells completed in these aquifers are 50 to 200 feet deep. The general water quality is similar to that in the overlying Wisconsin till aquifers with median concentrations of 513 mg/L dissolved solids and 333 mg/L hardness (as calcium carbonate). The median dissolved-solids concentration in these aquifers was much larger than for water in the Wisconsin till. However, the median chloride concentration, 16 mg/L, was the largest for any of the carbonate bedrock aquifers. The large chloride concentration may reflect the depth of wells in this principal aquifer. Nitrate and iron concentrations in the Silurian-Devonian aquifers were smaller than for water in the Wisconsin till, with medians of 0.1 mg/L and 1,100 $\mu\text{g/L}$, respectively.

Other Aquifers

Other aquifers (fig. 2A, aquifer 5) include pre-Wisconsin till and loess, Pennsylvanian coal-bearing rocks, Mississippian clastic rocks, and Devonian shale. In general, these aquifers are not areally extensive and cannot support large withdrawals. Quality of water from these aquifers, statewide, generally is similar to that of the more extensive aquifers, with median concentrations of 314 mg/L hardness and 12 mg/L chloride. The median nitrate concentration (as nitrogen) was 0.5 mg/L, or about one-third of the median for

water from glaciofluvial aquifers. However, the median iron concentration was 1,800 $\mu\text{g/L}$, which was only 100 $\mu\text{g/L}$ below the largest median concentration (which occurred in the Wisconsin till aquifers). The coal-bearing rocks and the Devonian shale contain significant amounts of iron. Analysis of the data suggests that these rocks are the probable sources for the large iron concentrations in these other aquifers.

EFFECTS OF LAND USE ON WATER QUALITY

The quality of Indiana's ground water is degraded mainly by the handling, storage, spillage, and eventual disposal of hazardous materials. In addition, mining, production of brines associated with oil and gas drilling (Shedlock, 1980), and agriculture probably have degraded ground-water quality to some extent.

Waste Disposal and Spills

The Indiana Department of Environmental Management (IDEM) has identified 146 sites and three areas where ground-water contamination has occurred (fig. 3B). Contamination is defined as "concentrations of chemicals in excess of public drinking-water standards, proposed standards or health protection guidance from the EPA" (Indiana Department of Environmental Management, 1986, p. 159). Of these sites, 29 have no confirmed source of contamination. Of the 117 remaining sites, about one-third were affected by spills of hazardous materials. After spills, the sources of contamination in order of declining importance are leaks from underground storage tanks; solid- and hazardous-waste disposal; leaks from above-ground storage; and disposal pits, ponds, and lagoons (Indiana Department of Environmental Management, 1986, p. 161). Of the 146 sites, 48 percent contained detectable volatile organic compounds, about 25 percent contained petroleum or petroleum-related products, and 27 percent of the sites contained metals, trace metals, chloride, and nitrate (Indiana Department of Environmental Management, 1986, p. 162).

The IDEM and the EPA have identified 23 CERCLA (Superfund) sites (fig. 3A). Ground-water contamination has been detected at 16 of the sites. An additional five sites have been proposed for inclusion on the EPA's NPL. Hazardous wastes are disposed at 28 RCRA sites (fig. 3A). Eight class-I injection wells (fig. 3A) currently are regulated by the Underground Injection Control (UIC) Program (U.S. Environmental Protection Agency, 1984). The EPA administers the UIC program in Indiana. Seven of the eight injection wells are located in Lake and Porter Counties in the far northwest corner of the State. The other well is located in Elkhart County.

As of September 1985, 32 hazardous-waste sites at 3 facilities in Indiana have been identified by the DOD as part of their Installation Restoration Program (IRP) as having potential for contamination. The IRP, established in 1976, parallels the EPA Superfund program under CERCLA. The EPA presently ranks these sites under a hazardous-ranking system and may include them in the NPL. Of the 32 sites evaluated under the program, 6 sites contained contaminants, but they did not present a hazard to people or to the environment. Six sites at two facilities (fig. 3A) were considered to present a hazard significant enough to warrant response action in accordance with CERCLA. The remaining sites were scheduled for confirmation studies to determine if remedial action is required.

Indiana has 113 operating county or municipal solid-waste landfills permitted by the State (fig. 3C) and 687 abandoned landfills (Indiana Department of Environmental Management, 1986).

The EPA has been assessing the 1,774 public water-supply wells in Indiana that serve more than 25 people for the possible presence of 26 volatile organic compounds. As of March 31, 1986, the EPA reported that 96 of the 1,198 wells sampled had detectable levels of at least one volatile organic compound (Indiana Department of Environmental Management, 1986, p. 157). Seventy-

nine of these well locations, which include multiple wells at some locations, are shown in figure 4. As a result of the survey, fifteen of the 96 wells were abandoned permanently or temporarily and four water-supply systems are now using treatment systems. In order to reduce the concentrations of volatile organic compounds in the water, some water suppliers are mixing uncontaminated water with contaminated water.

Agriculture

The effects of agricultural chemicals on the quality of ground water in Indiana are not well understood. The occurrence of some large nitrate concentrations in water from glaciofluvial aquifers may be related to agricultural activity. IDEM (1986) has identified 12 sites throughout the State with known nitrate contamination, 10 are located near fertilizer storage or manufacturing or are near known spills of fertilizer. Two sites have no identified contamination source.

POTENTIAL FOR WATER-QUALITY CHANGES

Three of the five principal aquifers have a relatively significant potential for contamination—the glaciofluvial aquifers, the glacial-outwash aquifers, and the Mississippian aquifers. The glaciofluvial and glacial-outwash aquifers are the most important water-supply aquifers for the State. However, water from these two aquifers had the largest 90th-percentile nitrate concentration of the five principal aquifers (fig. 2A, aquifers 1 and 2), indicating that they are contaminated more easily than the others. Furthermore, the glaciofluvial and glacial-outwash aquifers underlie the majority of the contamination sites, as evidenced by the fact that most of the public-supply wells that yield water with detectable concentrations of volatile organic compounds (fig. 4) tap these aquifers. Additionally, much of the population (fig. 1B) resides above or near these aquifers. Ground-water flow paths in the limestones of the Mississippian aquifers are short, which reduces the time available for adsorption of contaminants by aquifer materials. The Wisconsin till and Silurian-Devonian aquifers are protected in direct proportion to the thickness of the overlying confining units.

Recognizing the potential for contamination of ground water and the ranking of that potential for the various aquifers, the State is developing a program to protect ground-water quality. These steps and greater public awareness should reduce the likelihood of ground-water contamination in the future.

GROUND-WATER QUALITY MANAGEMENT

Three agencies have primary responsibility for ground water. The Indiana Department of Natural Resources (IDNR) has responsibility for protecting the quantity of ground water by (1) registering facilities capable of withdrawing 100,000 gallons per day or more; (2) assessing the availability of water; and (3) planning for the development, conservation, and use of water for beneficial uses. The IDNR derives its authority from the Water Resources Management Act (IC 13-2-6.1), which makes no distinction between ground and surface water. The Indiana State Board of Health (ISBH) has responsibility for monitoring water quality of public-water supplies for selected inorganic constituents and derives its authority from the Water Sanitary Regulation (320 IAC 3) and the Environmental Management Act (IC 13-7-7-5). The Indiana Department of Environmental Management (IDEM) has responsibility for the quality of ground water and can set standards specifying maximum permissible concentrations of contaminants. The IDEM derives its authority from the Environmental Management Act (IC 13-7-7-5) and from the Stream Pollution Control Law (IC 13-1-3-7), which applies both to surface and ground water.

The IDNR Division of Reclamation has responsibility for the effects of mining on ground-water quality under the Surface Mining

Reclamation Act (IC-13-4). The Office of the State Fire Marshall and the Office of the State Chemist have responsibility for regulating the storage and handling of flammable liquids and agricultural chemicals. Local authorities also have the power to protect ground water. Several local governments, notably the City of Elkhart and Elkhart County, and Indianapolis and Marion County, have been actively delineating ground-water contamination areas.

The inadequacy of existing ground-water data bases has been recognized as a major issue in the Draft Strategy for Ground Water (Interagency Groundwater Task Force, 1986, p. 18-20.) The U.S. Geological Survey and the IDNR Division of Water maintain the only significant computerized data bases within the State. The Interagency Groundwater Task Force (1986) lists several alternatives for improving the ground-water data bases for the State.

SELECTED REFERENCES

- Aten, R.E., Melhorn, W.N., Bassett, J.L., Keith, J.H., and Powell, R.L., 1982, Hydrologic atlas of Indiana: Bloomington, Geoscience Research Association, Inc., scale of 1:1,000,000, 31 plates.
- Bailey, Z.C., and Imbrigiotta, T.E., 1982, Ground-water resources of the glacial outwash along White River, Johnson and Morgan Counties, Indiana: U.S. Geological Survey Water-Resources Investigations Report 82-4016, 87 p.
- Clark, G.D., ed., 1980, The Indiana water resource: Indianapolis, Indiana Department of Natural Resources, v. I, 508 p; v. II, 94 p.
- Greeman, T.K., 1981, Lineaments and fracture traces, Jennings County and Jefferson Proving Ground, Indiana: U.S. Geological Survey Open-File Report 81-1120, 17 p.
- Imbrigiotta, T.E., and Martin, A., Jr., 1981, Hydrologic and chemical evaluation of the ground-water resources of northwest Elkhart County, Indiana: U.S. Geological Survey Water-Resources Investigations Report 81-53, 149 p.
- Indiana Department of Environmental Management, 1986, The 1984-85 305(b) Report: Indianapolis, 172 p.
- Indiana State Board of Health, 1984, Data on Indiana public water supplies (revised 1984): Indianapolis, Indiana State Board of Health Bulletin PWS 3, 89 p.
- Interagency Groundwater Task Force, 1986, Draft Indiana ground water protection and management strategy: Indianapolis, Indiana Department of Environmental Management, 85 p.
- Meyer, William, Reussow, J.P., and Gillies, D.C., 1975, Availability of ground water in Marion County, Indiana: U.S. Geological Survey Open-File Report 75-312, 87 p.
- Shedlock, R.J., 1980, Saline water at the base of the glacial-outwash aquifer near Vincennes, Knox County, Indiana: U.S. Geological Survey Water-Resources Investigations Report 80-65, 54 p.
- Smith, B.S., 1983, Availability of water from the outwash aquifer, Marion County, Indiana: U.S. Geological Survey Water-Resources Investigations Report 83-4144, 70 p.
- Smith, B.S., Hardy, M.A., and Crompton, E.J., 1985, Water resources of Wildcat Creek and Deer Creek basins, Howard and parts of adjacent counties, Indiana, 1979-82: U.S. Geological Survey Water-Resources Investigations Report 85-4076, 92 p.
- U.S. Department of Defense, 1986, Status of the Department of Defense Installation Restoration Program—Information Paper: Washington, D.C., U.S. Department of Defense, Office of the Assistant Secretary of Defense (Acquisition and Logistics), Environmental Policy Directorate, February, 35 p.
- U.S. Environmental Protection Agency, 1984, Classification of injection wells (section 146.5 of subpart A of part 146, Underground injection control program: criteria and standards): U.S. Code of Federal Regulations, Title 40, Part 146, July 1, 1984, p. 371-372.
- 1986a, Maximum contaminant levels (subpart B of part 141, national interim primary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, Parts 100 to 149, revised as of July 1, 1986, p. 524-528.
- 1986b, Secondary maximum contaminant levels (section 143.3 of part 143, national secondary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, Parts 100-149, revised as of July 1, 1986, p. 587-590.

____ 1986c, Amendment to National Oil and Hazardous Substances Contingency Plan; national priorities list, final rule and proposed rule: Federal Register, v. 51, no. 111, June 10, 1986, p. 21053-21112.

U.S. Geological Survey, 1985, National water summary 1984—Hydrologic events, related water-quality trends, and ground-water resources: U.S. Geological Survey Water-Supply Paper 2275, 467 p.

Prepared by Konrad J. Banaszak

FOR ADDITIONAL INFORMATION: District Chief, U.S. Geological Survey, 6023 Guion Road, Indianapolis, IN 46254

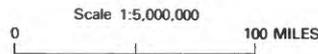


Figure 1. Selected geographic features and 1985 population distribution in Indiana. *A*, Counties, selected cities, and major drainages. *B*, Population distribution, 1985, each dot on the map represents 1,000 people. (Source: *B*, Data from U.S. Bureau of the Census 1980 decennial census files, adjusted to the 1985 U.S. Bureau of the Census data for county populations.)

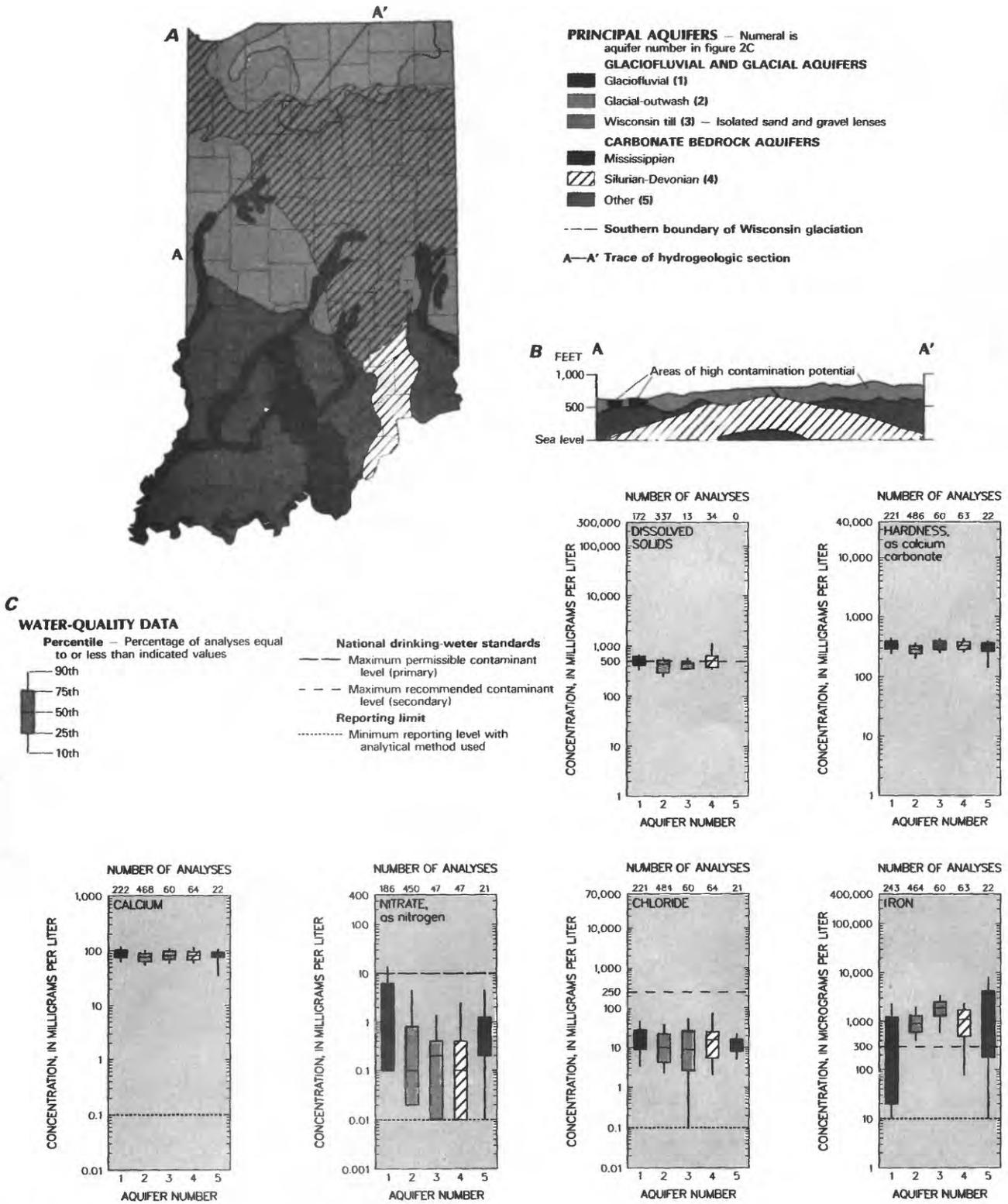


Figure 2. Principal aquifers and related water-quality data in Indiana. *A*, Principal aquifers. *B*, Generalized hydrogeologic section. *C*, Selected water-quality constituents and properties, as of 1986. (Sources: *A* and *B*, Aten and others, 1982; U.S. Geological Survey, 1985; Indiana Department of Environmental Management, 1986. *C*, Analyses compiled from Indiana State Board of Health, 1984, unpublished data from the Division of Water of the Indiana Department of Natural Resources; and from U.S. Geological Survey files; national drinking-water standards from U.S. Environmental Protection Agency, 1986a,b.)

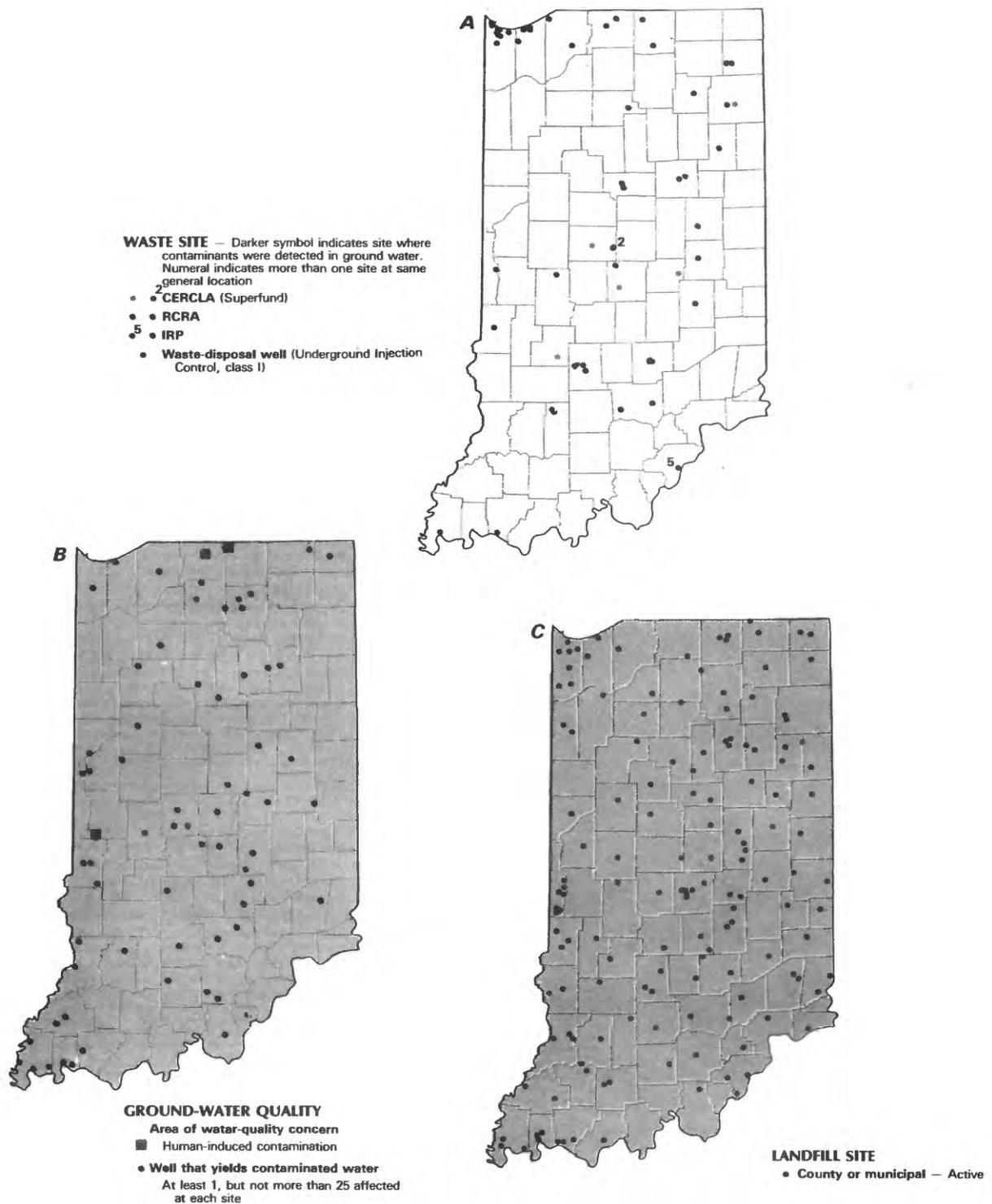


Figure 3. Selected waste sites and ground-water-quality information in Indiana. *A*, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites, as of 1986; Resource Conservation and Recovery Act (RCRA) sites, as of 1986, Department of Defense Installation Restoration Program (IRP) sites, as of 1986, and other selected waste sites, as of 1986. *B*, Areas of human induced contamination and distribution of wells that yield contaminated water, as of 1986. *C*, County and municipal landfills, as of 1986. (Sources: *A*, Indiana Department of Environmental Management files. *B*, Indiana Department of Environmental Management, 1986. *C*, Indiana Department of Environmental Management, written communication, 1986.)

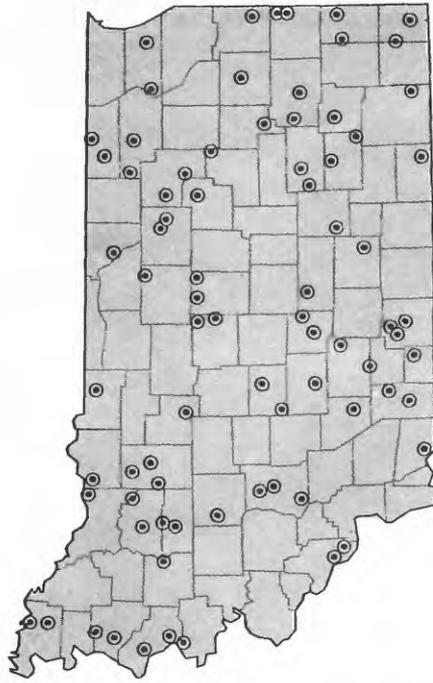


Figure 4. Public water-supply wells with one or more detectable volatile organic compounds. (Source: modified from Indiana Department of Environmental Management, 1986, p. 158.)