Water Quality in the Eastern Iowa Basins

Iowa and Minnesota, 1996–98

U.S. Department of the Interior
U.S. Geological Survey

Circular 1210

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Front cover: Aerial view of the Old Mans Creek basin showing pattern of wooded riparian buffers and cropland typical of the Southern Iowa Drift Plain landform in Iowa. *(Photograph by Doug Schnoebelen, USGS.)*

Back cover: Left, study unit biologist measuring water transparency *(photograph by Stephen Porter, USGS)*; center, study unit staff collecting aquatic organisms from woody debris *(photograph by Stephen Porter);* right, scientists measuring water temperature and dissolved oxygen in Old Mans Creek in preparation for sample collection (*photograph by Debra Sneck-Fahrer, USGS*).

Water Quality in the Eastern Iowa Basins, Iowa and Minnesota, 1996–98

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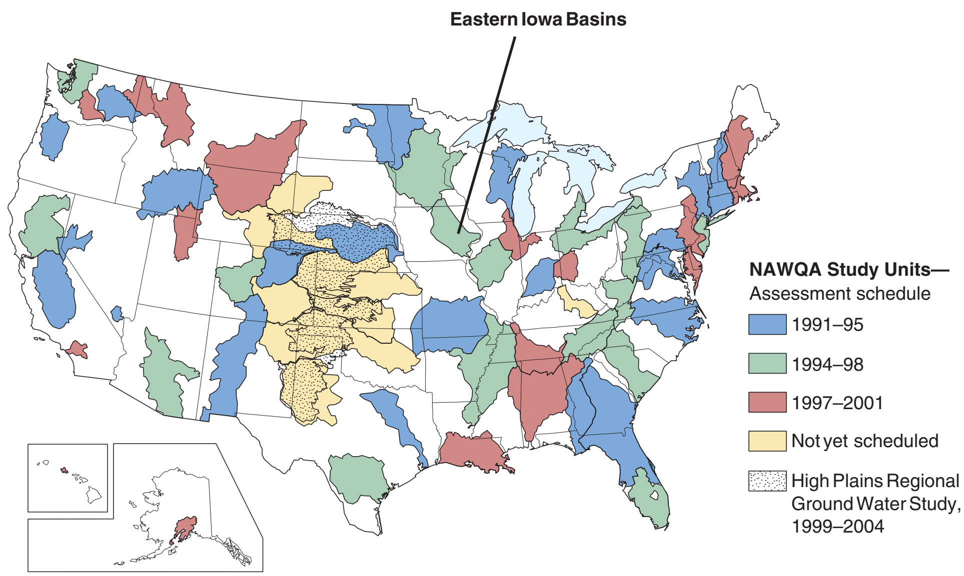
CONTENTS

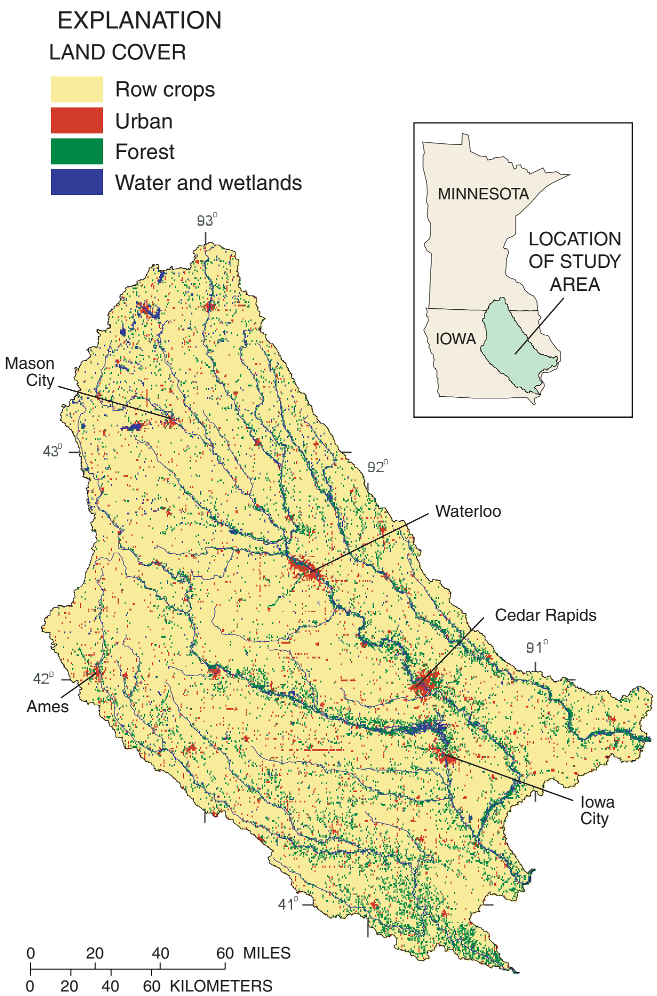
THIS REPORT summarizes major findings about water quality in the Eastern Iowa Basins that emerged from an assessment conducted between 1996 and 1998 by the U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Program. Water quality is discussed in terms of local and regional issues and compared to conditions found in all 36 NAWQA study areas, called Study Units, assessed to date. Findings also are explained in the context of selected national benchmarks, such as those for drinking-water quality and the protection of aquatic organisms. The NAWQA Program was not intended to assess the quality of the Nation's drinking water, such as by monitoring water from household taps. Rather, the assessments focus on the quality of the resource itself, thereby complementing many ongoing Federal, State, and local drinking-water monitoring programs. The comparisons made in this report to drinking-water standards and guidelines are only in the context of the available untreated resource. Finally, this report includes information about the status of aquatic communities and the condition of in-stream habitats as elements of a complete water-quality assessment.

Many topics covered in this report reflect the concerns of officials of State and Federal agencies, water-resource managers, and members of stakeholder groups who provided advice and input during the Eastern Iowa Basins assessment. Basin residents who wish to know more about water quality in the areas where they live will find this report informative as well.



THE NAWQA PROGRAM seeks to improve scientific and public understanding of water quality in the Nation's major river basins and ground-water systems. Better understanding facilitates effective resource management, accurate identification of water-quality priorities, and successful development of strategies that protect and restore water quality. Guided by a nationally consistent study design and shaped by ongoing communication with local, State, and Federal agencies, NAWQA assessments support the investigation of local issues and trends while providing a firm foundation for understanding water quality at regional and national scales. The ability to integrate local and national scales of data collection and analysis is a unique feature of the USGS NAWQA Program.

The Eastern Iowa Basins is one of 51 water-quality assessments initiated since 1991, when the U.S. Congress appropriated funds for the USGS to begin the NAWQA Program. As indicated on the map, 36 assessments have been completed, and 15 more assessments will conclude in 2001. Collectively, these assessments cover about one-half of the land area of the United States and include water resources that are available to more than 60 percent of the U.S. population.



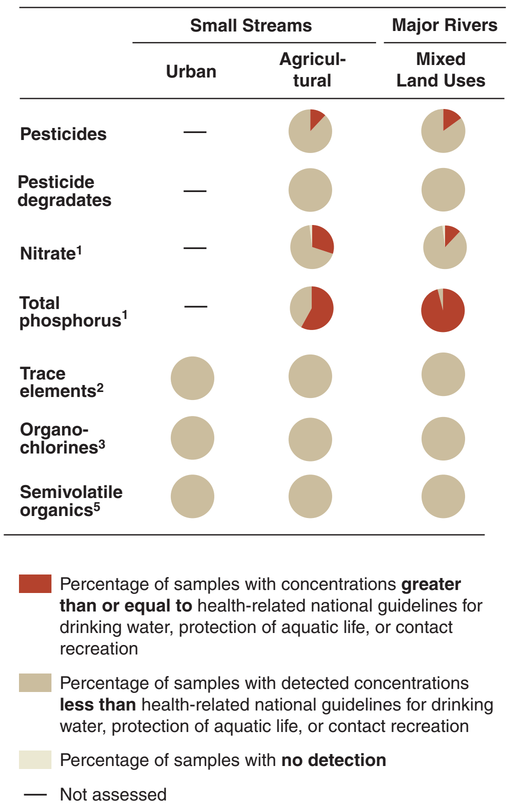
The Eastern Iowa Basins Study Unit encompasses the Wapsipinicon, the Cedar, the Iowa, and the Skunk River Basins and covers about 19,500 mi^2 in eastern Iowa and southern Minnesota. In 1990, about 40 percent of the more than 1 million people in the Study Unit were concentrated in cities with populations of greater than 20,000 people. Cedar Rapids is the only city with a population greater than 100,000. Ground water is the major source for municipal, industrial, and domestic supplies. During the study, Iowa City was the largest municipal user of surface water. Over 90 percent of the land in the Study Unit is used for agricultural purposes. Forested areas account for only 4 percent of the land. Data from Eros Data Center, 1994.

Stream And River Highlights

Nitrogen and phosphorus concentrations in streams in the Eastern Iowa Basins Study Unit rank as some of the highest in the Corn Belt (see map, p. 8) as well as the Nation and were higher than the drinking-water standard in many samples. These conditions reflect intensive use of the land for growing crops and dense populations of livestock in some basins.

- Nitrate concentrations in 22 percent of the stream samples exceeded the U.S. Environmental Protection Agency (USEPA) drinking-water standard of 10 mg/L (milligrams per liter). The standard was most frequently exceeded during June, soon after spring fertilizer application. Although many of the streams sampled are not currently used for drinking-water supplies, the Cedar and Iowa Rivers are the direct or indirect source for Cedar Rapids and Iowa City—two of the largest cities in the study area.
- The highest nitrate concentrations occurred in medium-sized streams draining basins with the most intensive row-crop agriculture and in a stream draining a basin with both intensive row-crop agriculture and dense concentrations of large-scale animal feeding operations. Nitrate concentrations in these streams exceeded 10 mg/L in almost 50 percent of the samples. Conversely, nitrate concentrations were lowest in basins that had greater percentages of pasture, grassland, and forest.
- Total phosphorus concentrations frequently (75 percent of the samples) exceeded the 0.1-mg/L USEPA-recommended goal to minimize algal growth in rivers. Total phosphorus concentrations were greatest in streams and rivers that drain basins with more highly erodible soils and in large river basins that contain the largest cities and towns in the Study Unit.
- The large amounts of nitrogen and phosphorus that are transported to the Mississippi River from the Study Unit represent an economic loss to farmers and a potential environmental threat to downstream waters. The estimated annual loss of 17 to 41 lb/acre (pounds per acre) of nitrogen and 1.2 to 1.5 lb/acre of phosphorus represents a potential loss in crop yield or the cost of additional fertilizer needed to compensate for that flushed from the fields. Nutrients transported to the Mississippi River likely reach the Gulf of Mexico where they contribute to eutrophication and hypoxia.
- Although the use of herbicides and insecticides in the Study Unit is among the most intense nationwide, herbicide concentrations in streams were not among the highest 25 percent nationally, and insecticide concentrations were in the lowest 25 percent nationally. Breakdown compounds (degradates), whose widespread occurrence has only recently been discovered and about which little is known of the human and environmental effects, generally accounted for the majority of the pesticide compounds present in rivers and streams.
- The most commonly used herbicides were the most frequently detected and were generally present in the greatest concentrations. Atrazine and metolachlor were detected in all stream samples. Concentrations generally ranged from 0.1 to 1.0 µg/L (microgram per liter). Atrazine concentrations exceeded the USEPA 3.0-µg/L drinking-water standard in about 10 percent of the samples; exceedances occurred mainly during late-spring runoff.
- Acetochlor, a conditionally registered herbicide that is intended to replace several other commonly used herbicides, was frequently detected, but concentrations were less than 0.1 µg/L in 75 percent of the samples. Mean annual acetochlor concentrations did not exceed the 2.0-µg/L USEPA registration requirement at any site, but concentrations did exceed that level in about 3 percent of the individual samples. The maximum concentration measured during the study (10.6 µg/L) exceeded the level that would require biweekly sampling by water-supply systems.
- Alachlor, metolachlor, and acetochlor degradates are present in relatively high concentrations throughout the year, indicating that they are more persistent than their parent compounds.
- Carbofuran and chlorpyrifos, insecticides that have been identified as posing a high risk to aquatic insects and mussels, were present in as much as 60 percent of the monthly samples during the summer when these insecticides are normally applied.
- Riparian buffer zones influence the quality of water in streams and rivers. Biological communities respond to tree density in riparian buffer zones. Invertebrate taxa indicative of good stream quality increased with increased numbers of trees. In contrast, streams that were not shaded by trees contained large algal growths considered indicative of eutrophication.

Selected Indicators of Stream-Water Quality



Major influences on streams and rivers

- Agricultural storm runoff
- Animal feeding operations
- Tile-line drainage
- Urban areas

Ground-Water Highlights

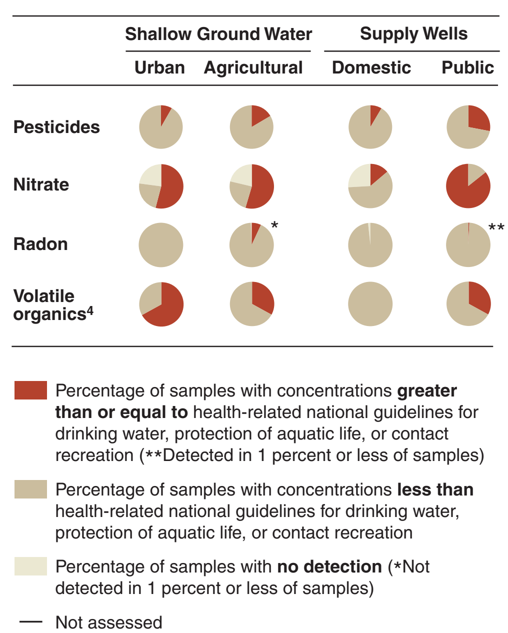
Compared to surface water, ground water in the Eastern Iowa Basins had substantially lower nutrient concentrations and less frequent detections. Land use, however, had a substantial effect on the quality of water in alluvial aquifers. Pesticide degradates were some of the most commonly detected constituents in these aquifers. Nitrate and methyl *tert*-butyl ether (MTBE) exceeded the USEPA standard or advisory in some of the samples. In contrast, bedrock aquifers, which are generally protected by clay and shale layers, typically had low nitrate concentrations and low frequency of pesticide detections.

- Nitrate concentrations generally decreased with depth in the alluvial aquifers. Biological denitrification may result in decreased nitrate concentration with depth, but it is also possible that the deeper water infiltrated during past years when less fertilizer was used for crops.
- Nutrients move from ground water to streams by natural drainage and tile lines. Nitrate concentrations in 24 of 25 medium-sized streams exceeded 10 mg/L during the sampling period in May 1998 when streamflow originated primarily from ground-water discharge. Nitrate concentrations consistently exceeded 10 mg/L in water from a selected tile line draining to the Iowa River.
- Pesticides were detected in alluvial aquifers underlying both agricultural and urban areas, but shallow ground water in agricultural areas contained greater concentrations than urban areas. A greater variety of pesticide compounds was detected in urban areas than agricultural areas, reflecting a more diverse usage.
- Pesticides most commonly detected in the alluvial aquifers underlying urban areas were atrazine, prometon, and metolachlor. Pesticide concentrations did not exceed established drinking-water standards.
- With the exception of atrazine and metolachlor and prometon in urban areas, pesticides were infrequently detected in alluvial aquifers. Pesticide degradates generally were more commonly detected in the alluvial aquifers than their parent compounds. The greater presence of degradates indicates that many pesticides break down in the soil and that the resulting pesticide degradates are transported to the shallow aquifers.
- MTBE, a common gasoline additive used to increase the octane content or ensure cleaner burning, was detected in 23 percent of samples from alluvial aquifers in urban areas. Concentrations exceeded the USEPA drinking-water advisory in samples from 6 percent of the wells.

Major influences on ground water

- Lawn, garden, and agricultural fertilizers
- Agricultural and urban pesticides
- Leaking underground fuel-storage tanks

Selected Indicators of Ground-Water Quality



[1] Phosphorus and nitrogen, sampled in water.
[2] Arsenic, mercury, and metals, sampled in sediment, fish tissue, and water.
[3] DDT and PCBs, sampled in sediment and fish tissue.
[4] Solvents, refrigerants, fumigants, and gasoline compounds, sampled in water.
[5] By-products of fossil-fuel combustion; components of coal and crude oil, sampled in sediment and fish tissue.

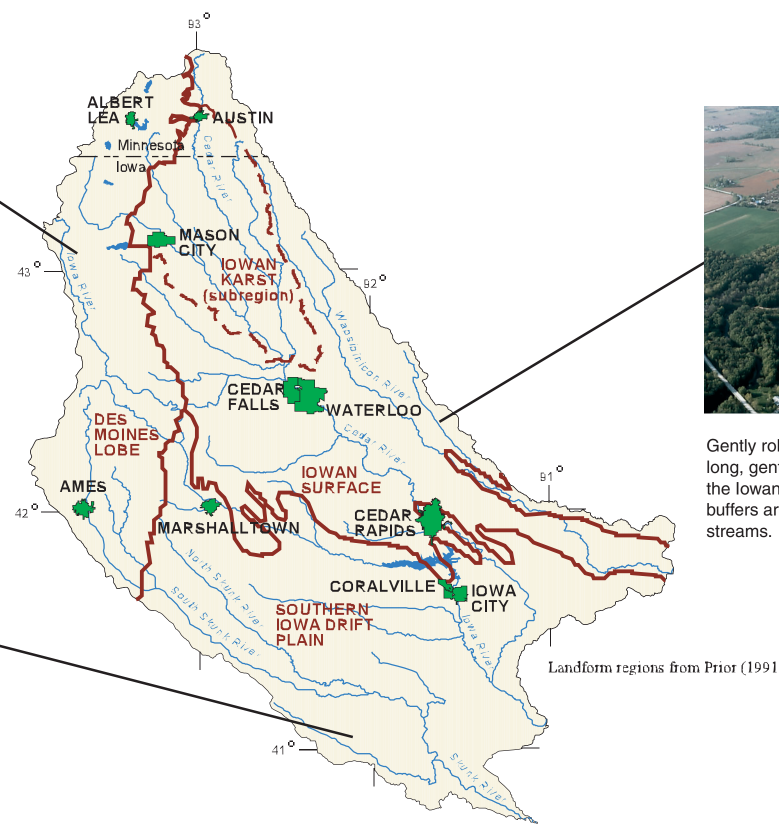
The Eastern Iowa Basins Study Unit encompasses the Wapsipinicon, the Cedar, the Iowa, and the Skunk River Basins and encompasses about 19,500 mi^2 (square miles) in eastern Iowa and southern Minnesota (fig. 1). The four major rivers in the Study Unit generally flow in a southeasterly direction and empty into the Mississippi River. The basins of these four major rivers are relatively long and narrow. The Wapsipinicon River originates in southeastern Minnesota and extends about 225 mi (miles) to its confluence with the Mississippi River. The Wapsipinicon River Basin has a drainage area of 2,540 mi^2. The Cedar River originates in southern Minnesota and joins the Iowa River about 30 mi upstream from the mouth of the Iowa River. The Iowa River originates in north-central Iowa. The Iowa and the Cedar River Basins cover 12,640 mi^2, more than 90 percent of which is in Iowa. The Skunk River originates in central Iowa and drains about 4,350 mi^2.

Geology

Glaciers created a land surface with three distinct regions in the Eastern Iowa Basins Study Unit: the Des Moines Lobe, the Iowan Surface, and the Southern Iowa Drift Plain (fig. 1). The Des Moines Lobe is characterized by low relief with some distinct ridges near the eastern boundary and occasional depressions that form lakes, ponds, and swamps. Glacial till is the dominant surficial material, and alluvium is present along the streams. Poorly drained soils have developed on the tills. The Iowan Surface has gently rolling topography with long slopes, low relief, and a mature drainage pattern. The surficial material is primarily glacial drift with thin layers of windblown loess on the ridges and alluvium near the streams. A subregion of the Iowan Surface (Iowan Karst) was defined for this study in an area where bedrock is close to the land surface. In the Southern Iowa Drift Plain, streams have eroded deeply into the glacial drift and loess mantle to produce a steeply rolling terrain with broad, flat drainage divides. Moderately well-drained soils have developed on the loess.

The Des Moines Lobe is characterized by flat topography and fertile soils; conditions ideal for growing corn and soybeans.

The more steeply rolling terrain of the Southern Iowa Drift Plain is extensively farmed but has relatively more forests, pastures, and grassland than the other landform regions.



Gently rolling topography with long, gentle slopes characterize the Iowan Surface. Wooded buffers are present along many streams.

Figure 1. Glacial deposits formed three major landforms with characteristic soils and topography in the Eastern Iowa Basins.

Climate

Water originates as rainfall in late spring through late fall and as snow during winter and early spring. Average annual precipitation in the basins ranges from about 30 inches in the northwestern part of the Study Unit to about 36 inches in the southeast. The greatest rainfall typically occurs during the growing season in spring and summer. The mean April-to-October precipitation is about 25 inches. The most intense 24-hour rainfall (5-year recurrence interval) can be more than 4 inches. Snowfall has been recorded from September to May. The greatest 24-hour snowfall seldom (less than 25 percent of the years) exceeds 10 inches. Yearly rainfall during the study period ranged from below average in 1996 to about average in 1997 and above average in 1998.

Land Use

Because water flows over the land surface or infiltrates the soil, human activities may have a substantial effect on the quality of ground and surface water. The production of row crops, such as corn, and cover crops, such as alfalfa and small grains, constitutes the major land use in the Study Unit. Land near the streams and rivers has a combination of crops and forests. About 40 percent of the more than 1 million people in the Study Unit are concentrated in cities with populations greater than 20,000.

Water Use

Water used for household, municipal, commercial, industrial, and agriculture purposes originates primarily from ground water. Surface water, although an important supply for several larger cities including Cedar Rapids and Iowa City, is used primarily for cooling water in the generation of electric power.

Water that infiltrates through the soil into underlying sand and gravel deposits and ultimately into the underlying bedrock formations is used as a water supply for about 94 percent of the population in the Eastern Iowa Basins Study Unit. Rivers and streams are the source of public-water supplies for about 6 percent of the population (fig. 2).

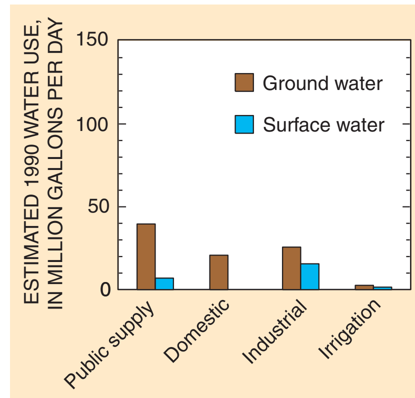


Figure 2. An abundant ground-water resource provides water to municipalities, homes, and industry. Ground water is used by more than 90 percent of the population in the Study Unit.

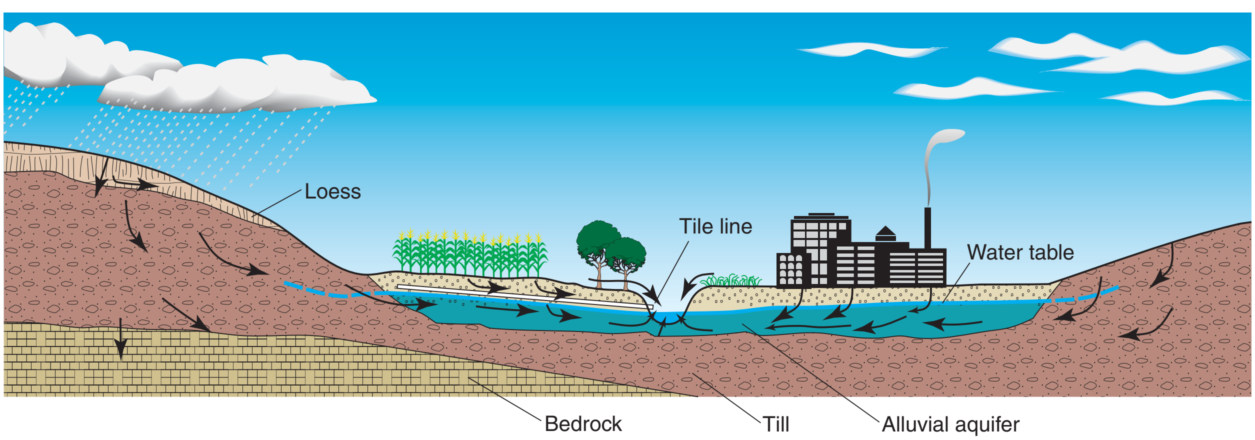


Figure 3. In the Eastern Iowa Basins, water originating from precipitation flows overland or through loess, till, and alluvial deposits to nearby streams. Areas with high water tables and poor natural drainage have commonly been artificially drained with tile lines. (Graphic created by Suzanne Roberts, U.S. Geological Survey.)

Surface Water

Excess precipitation that does not infiltrate into the soil or evaporate runs off to the streams (fig. 3). Generally, poorly permeable till soils typical of the Des Moines Lobe and steeper slopes typical of the Southern Iowa Drift Plain generate greater overland flow than the moderately well drained loess soils and gentle slopes typical of the Iowa Surface. Overland flow to streams is slowed or reduced by grass, perennials, shrubs, and trees (riparian buffers) where present near streambanks. Runoff to streams averages about 25 percent of the annual precipitation and ranges from less than 7 inches per year in the northern part of the Study Unit to about 9 inches per year in the southeastern part. Overland flow and ground-water discharge are the major sources of streamflow. However, tile lines may be an important source to streams during base flow in areas where they have been installed to remove standing water from surface depressions and to lower the water table.

Long-term yearly discharge from the Eastern Iowa Basins Study Unit averages about 9.2 million acre-feet. The overall increase in rainfall from 1996 to 1998 was reflected in the substantial increase in yearly stream discharge (fig. 4). Yearly discharge from the Eastern Iowa Basins increased from about 8.6 million acre-feet in 1996 to almost 13.8 million acre-feet in 1998. Yearly discharge was not uniform in the major basins. Discharge from the Wapsipinicon and Iowa River Basins increased in 1997 and 1998, and the discharge from the Skunk River Basin decreased from 1996 to 1998.

Ground Water

Water from rainfall infiltrates through the soil and, depending on whether permeable sand, gravel, and fractured bedrock are present, may continue to move to the deeper aquifers (fig. 3). If low-permeability clay or shale lies below the unconsolidated surficial materials, water may move laterally to a nearby stream.

Alluvial material that has been deposited by rivers and streams commonly consists of sand and gravel layers that store and transmit water readily. The alluvial aquifers (fig. 5) are the most frequently used source of ground water in the Eastern Iowa Basins because they are near land surface and can supply large amounts of water. The same properties (shallow depth and permeable material) that make alluvial aquifers excellent sources of water also make the alluvial aquifers susceptible to contamination from surface activities.

Two additional surficial deposits, not assessed during this study, provide water for domestic and municipal supplies. Sand and gravel deposits in low-permeability glacial till generally yield small quantities of water that are used mostly for rural domestic and stock supplies. Also, deep sand and

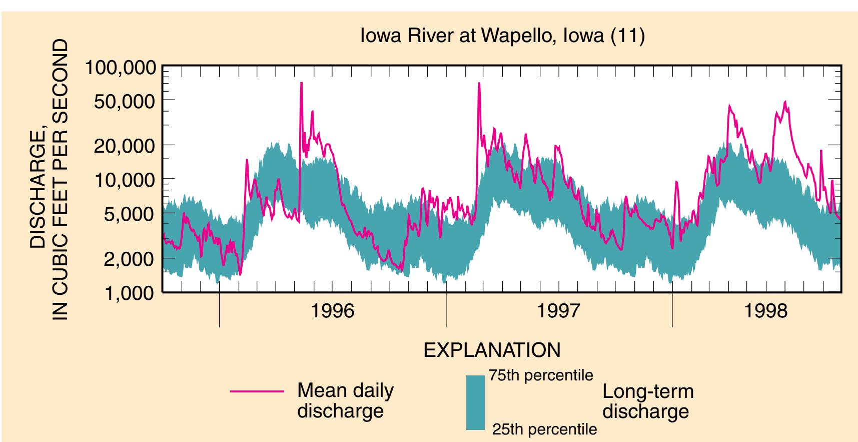


Figure 4. Stream discharge in the Eastern Iowa Basins ranged from below normal in 1996 to near normal in 1997 and above normal in 1998 (site number in parentheses; see site map in “Study Unit Design” section).

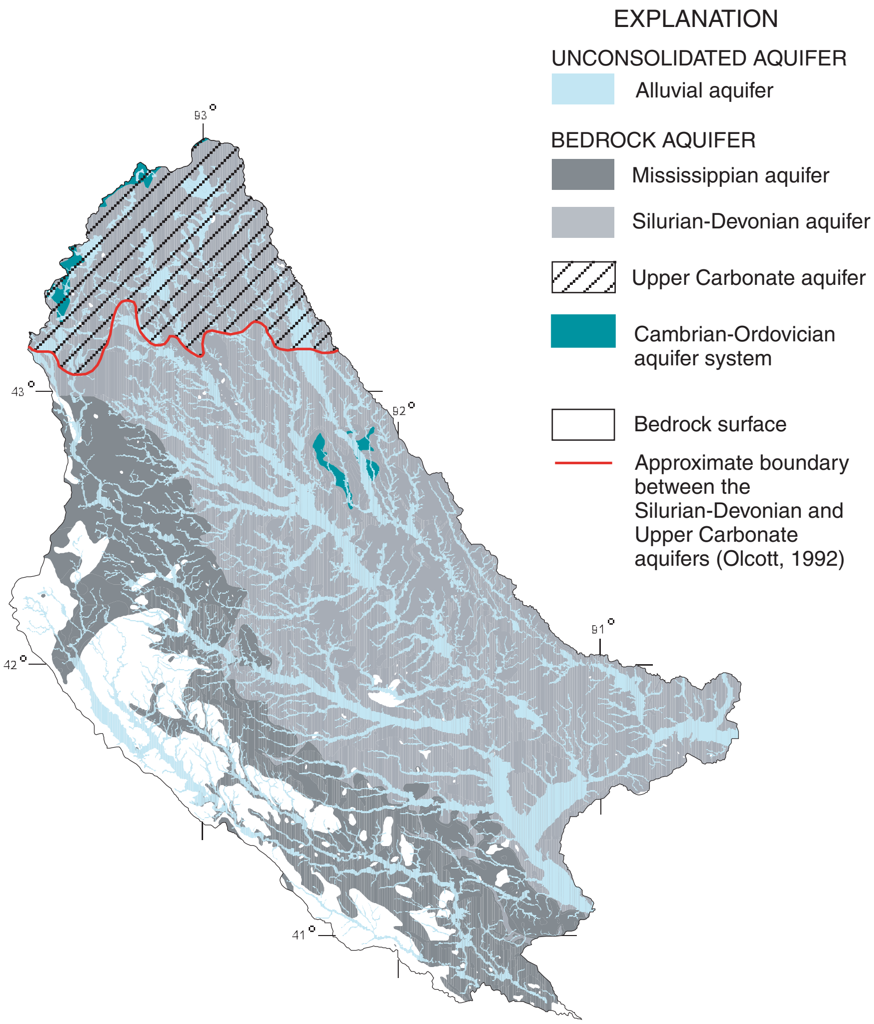


Figure 5. Several major bedrock and unconsolidated aquifers are used as sources of water for domestic, municipal, and industrial supplies. Only the most heavily used aquifers, the Silurian-Devonian and Upper Carbonate aquifers and the alluvial aquifers, were sampled.

gravel deposited in bedrock valleys before the last glacial advance is an important source of water in parts of the Eastern Iowa Basins.

Rock formations (bedrock) generally underlie the clay, silt, sand, and gravel surficial materials and can provide water for use. Bedrock aquifers are generally deep and are protected from surficial contamination. However, in areas such as the Iowan Karst, bedrock is exposed or is covered by very thin unconsolidated deposits and is susceptible to contamination from urban and agricultural land uses.

The most extensively used bedrock aquifers are the Silurian-Devonian and Upper Carbonate aquifers. The Silurian-Devonian and Upper Carbonate aquifers consist mainly of limestone and dolomite with locally interbedded shale and evaporite beds. Bedrock aquifers that are used as a source of water in the Study Unit but were not evaluated during this study are the Mississippian aquifer and the Cambrian-Ordovician aquifer system.