AVAILABILITY AND QUALITY OF WATER FROM THE ALLUVIAL, GLACIAL-DRIFT, AND DAKOTA AQUIFERS AND WATER USE IN SOUTHWEST IOWA

by R.E. Hansen, C.A. Thompson, and P.E. VanDorpe

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Multiply	*By*	*To obtain*
inch (in.)	25.40	millimeter (mm)
inch per month (in/mo)	25.40	millimeter per month (mm/mo)
inch per year (in/yr)	25.40	millimeter per year (mm/yr)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
acre	0.4047	hectare
square mile (mi^2)	2.590	square kilometer (km^2)
gallon (gal)	3.785	liter (L)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
gallon per day (gal/d)	0.003785	cubic meter per day (m^3/d)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

$$°C = 5/9 \times (°F - 32).$$

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

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ABSTRACT

A ground-water resources investigation was conducted in southwest Iowa to describe the availability, quality, and use of water from the alluvial, glacial-drift, and Dakota aquifers in a nine-county area. Historical water quality was examined for each aquifer, and water samples were collected for major ions, trace metals, radionuclides, and selected pesticides. Selected aspects of surface-water resources in the study area also were examined to more fully evaluate alluvial aquifers. The flood plain of the Missouri River valley was not included except for the accounting of the water use in the area.

Four principal alluvial aquifers consisting of sand and gravel deposits in the valleys of the Nishnabotna, Tarkio, Nodaway, and One Hundred and Two Rivers are present. Yields to wells have been reported as large as 2,000 gallons per minute; however, most yields are less than 100 gallons per minute. Nitrate concentrations greater than the drinking-water regulation and agricultural herbicides have been detected in 6 of 27 samples from municipal water supplies.

Four types of glacial-drift aquifers are present--loess, inter-till sand and gravel, basal sand and gravel, and buried-channel aquifers. The glacial-drift aquifers are most commonly used by rural water users or users that do not have access to alluvial aquifers. These aquifers are discontinuous and unpredictable in location. Hydraulic and water-quality data generally are unavailable for these aquifers. Wells completed in loess commonly yield less than 10 gallons per minute, although there are reports of yields as large as 20 gallons per minute. Yields of 10 to 120 gallons per minute appear to be possible for inter-till and basal sand and gravel aquifers. Yields of more than 150 gallons per minute are possible from some buried-channel aquifers.

The Dakota aquifer is comprised of bedrock of Cretaceous age and is present as erosional remnants and outliers in several counties, mainly Cass and Montgomery. Yields of more than 150 gallons per minute to wells completed in the Dakota aquifer have been reported, although yields of 20 gallons per minute or less are more typical. The drinking-water regulation for nitrate has been exceeded in some samples from the Dakota aquifer.

The quantity of water withdrawn for municipal, rural-domestic, livestock, and other permitted water users was determined for each of the three principal aquifer types. The total water use within the study area was about 91.8 million gallons per day; 35.3 percent was from alluvial ground-water sources. Alluvial aquifers supplied most of the water from ground-water sources. The largest use of water is for permitted irrigation purposes, mostly from the Missouri River alluvial aquifer.

INTRODUCTION

Many residents of southwest Iowa, a predominantly agricultural region, depend on ground water for municipal and domestic water supplies. The quality of water from deep bedrock aquifers limits the use of water from these aquifers for most purposes; however, water of acceptable quality is available from shallow aquifers. Although geographically widespread, the shallow aquifers are not found in all locations. The need for an improved understanding of the occurrence and availability of shallow ground-water resources of southwest Iowa has resulted in the hydrologic study of a nine-county area: Adair, Adams, Cass, Fremont, Mills, Montgomery, Page, Pottawattamie, and Taylor Counties (fig. 1). The study is the last of nine regional areal appraisals describing

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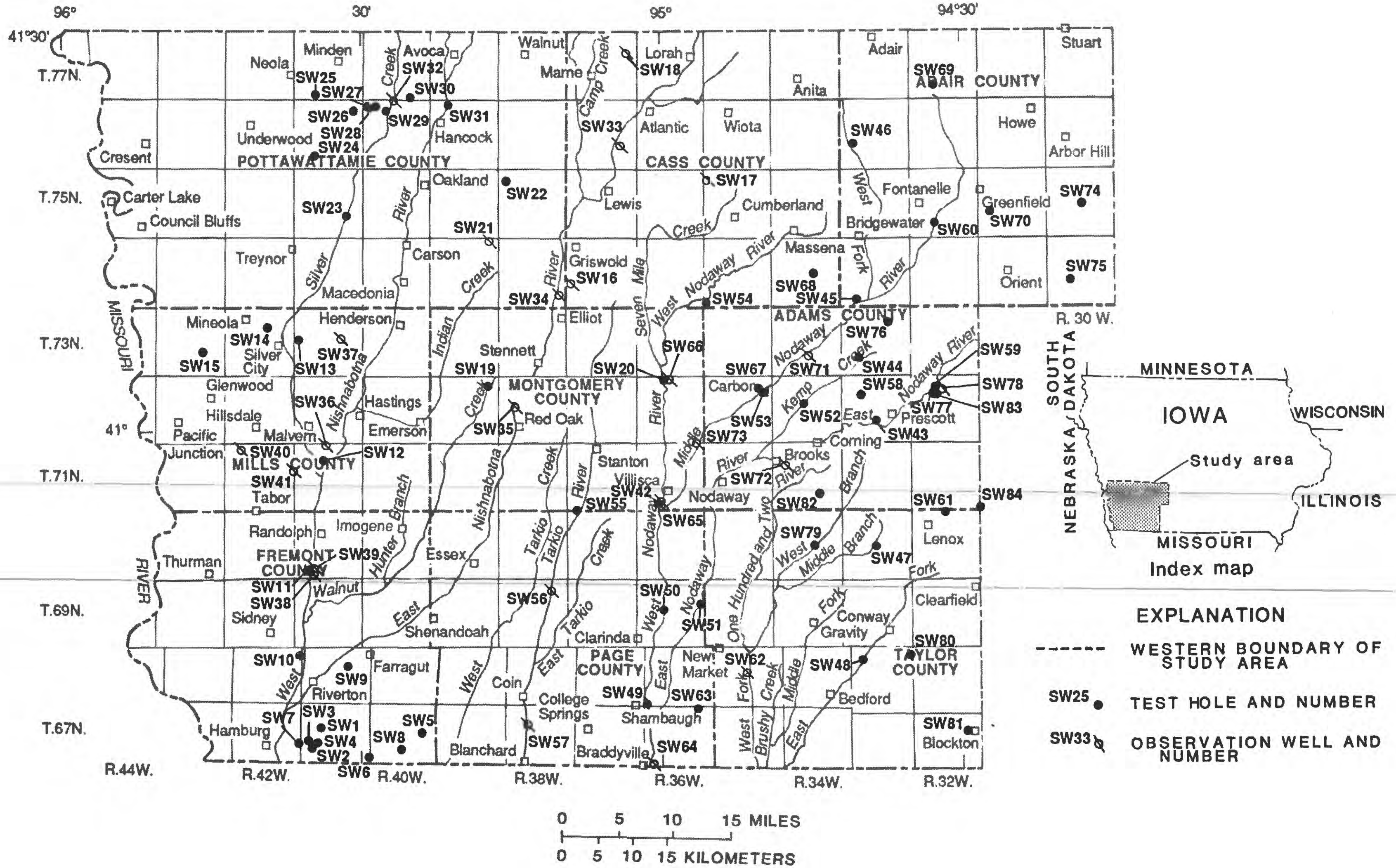


Figure 1. Location of test holes and observation wells drilled from 1985 to 1987.

ground-water resources in Iowa. The study is part of a cooperative program between the U.S. Geological Survey and the Geological Survey Bureau of the Iowa Department of Natural Resources. The stratigraphic nomenclature used throughout this report is that of the Iowa Department of Natural Resources, Geological Survey Bureau.

Purpose and Scope

This report describes the availability and quality of ground water from the alluvial, glacial-drift, and Dakota aquifers, and water use in southwest Iowa. Specifically, the report describes: (1) the location and areal extent of the aquifers, (2) the occurrence of ground water, (3) the chemical quality of the water in the aquifers, and (4) the quantity of water withdrawn from these aquifers and surface-water sources for various uses.

This report contains a general appraisal of the ground-water resources in southwest Iowa and is intended to provide background information to aid in the development of ground-water supplies. Selected aspects of surface-water resources in the area were included as a means of evaluating the alluvial aquifers. The Missouri River alluvial aquifer is not included in this study because of the relatively large quantity of water available from it that is adequate for most uses. In addition, the Missouri River alluvial aquifer is presently (1989) used by only about 10 percent of the water users in southwest Iowa. However, for some categories of water use it was not practical to determine or estimate quantities of water derived from outside the study area. Therefore, water use is summarized for each county within the study area.

Method of Investigation

Historical records were examined, and observation-well drilling was used to obtain data for specific aquifers in areas where little or no ground-water information was available. Logs of the test holes and observation wells, along with well-construction details, are in table 1 at the back of this report, and locations are shown in figure 1. Observation wells were constructed to monitor water-level changes and to obtain samples of ground water for chemical analysis. Surface-water samples also were collected at several sites for chemical analysis. Municipal water-use information was obtained from local water departments.

Water-quality data obtained from the University of Iowa Hygienic Laboratory, the U.S. Geological Survey, and the Iowa Department of Natural Resources were used to aid in the assessment of water quality in each of the aquifers. Water samples were collected during this study by U.S. Geological Survey personnel. All water samples were analyzed by the University of Iowa Hygienic Laboratory. Details of the analytical methods and quality-control procedures can be obtained from the laboratory.

Physiography and Climate

Three general landform regions are present in Iowa--the Southern Iowa Drift Plain, the Western Loess Hills, and the Missouri Alluvial Plain (Prior, 1976; fig. 2). The Western Loess Hills and the Missouri Alluvial Plain regions comprise about 20 percent of the land area in southwest Iowa. These narrow regions, about 3 to 10 mi and 6 to 15 mi wide, respectively, parallel the western side of the study area. Most of southwest Iowa lies within the Southern Iowa Drift Plain.

The Southern Iowa Drift Plain is a landscape of steeply rolling hills and incised valleys that has evolved since the end of the pre-Illinoian glaciation. Extensive erosion has removed many of the original glacial landforms and left a characteristic, multi-level, stepped-erosion landscape (Ruhe, 1969; Bettis and Littke, 1987). The Western Loess Hills region is characterized by a thick loess cover and sharply ridged terrain. The Missouri Alluvial Plain is a broad, low-lying, level region adjacent to the Missouri River.

The total area of southwest Iowa is 4,982 mi^2 or about 9 percent of the total area of the State. Maximum topographic relief is about 555 ft. The highest land-surface altitude is just over 1,460 ft, several miles north of Anita in Cass County, and the lowest altitude is about 905 ft in the Missouri River valley at the southwest corner of the State.

The climate of southwest Iowa is subhumid. The average precipitation for southwest Iowa is 33.11 in/yr and varies from 31 in. in the northwest to more than 35 in. in the southern

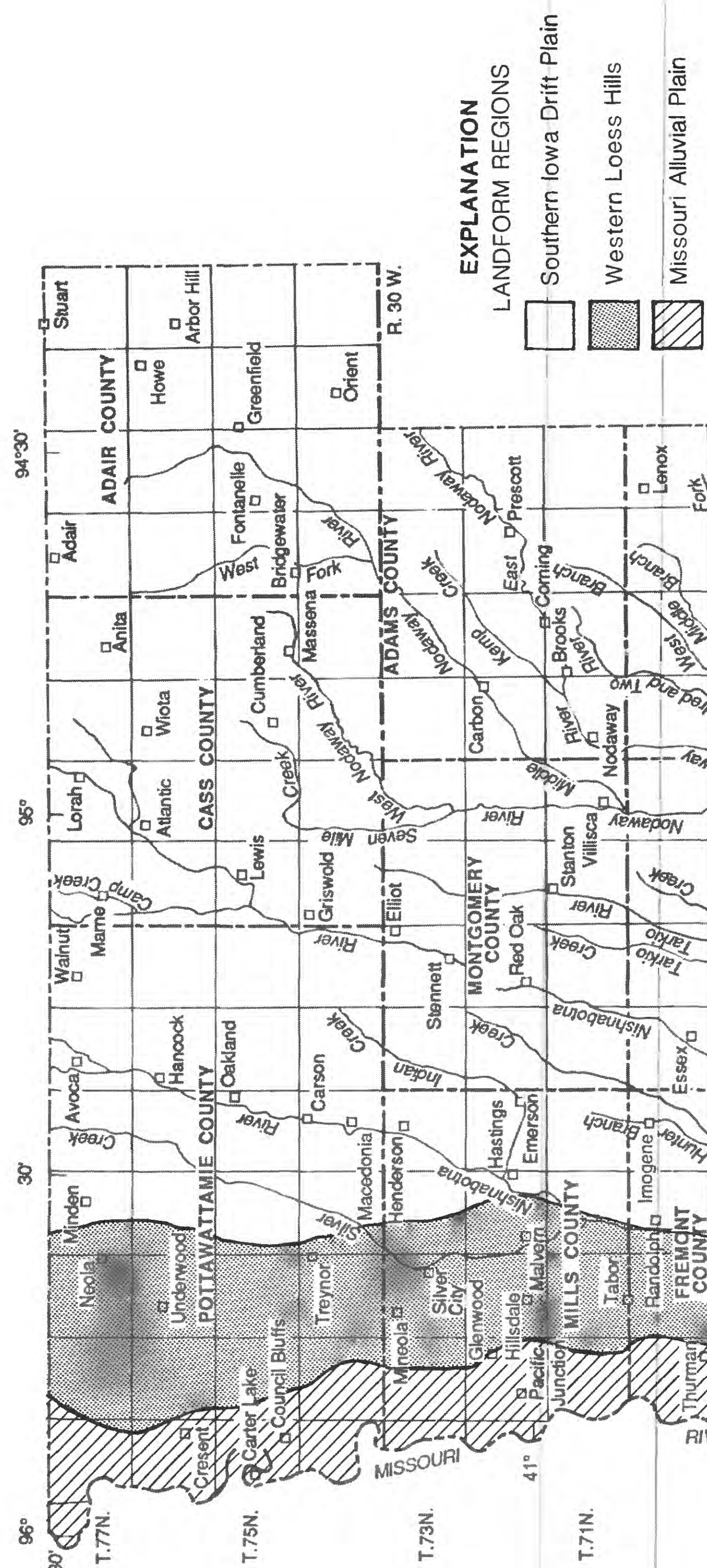


Figure 2. Landform regions (modified from Prior, 1976).

part of the study area (fig. 3). The period of greatest precipitation is during April through September (fig. 4). Average rainfall during this period is 4.3 in/mo at Red Oak in Montgomery County (National Oceanic and Atmospheric Administration, 1987). The average annual temperature for this area is 50.4 °F (National Oceanic and Atmospheric Administration, 1987). There is a large annual range in temperature (fig. 4); the hottest days occur in June, July, and August and the coldest in December, January, and February when the average monthly temperatures are below freezing.

Well-Location Numbering System

The wells and test holes referred to in this report are numbered according to a system of land survey in use by the U.S. Bureau of Land Management and the U.S. Geological Survey and is illustrated in figure 5. The first numeral denotes the township north of a base line, the second numeral denotes the range west of the fifth principal meridian, and the third numeral denotes the section in which the well is located. The letters A, B, C, and D designate the northeast, northwest, southwest, and southeast quarter of any area within a section. The first letter designates the location of the 160-acre quarter section; the second letter, the 40-acre quarter-quarter section; the third letter, the 10-acre quarter-quarter-quarter section; and the fourth letter, the 2.5-acre quarter-quarter-quarter-quarter section. Consecutive terminal numerals are added if more than one well or test hole is recorded within a 2.5-acre tract. For example, well 68-35-15BCDD is located in the southeast quarter of the southeast quarter of the southwest quarter of the northwest quarter of section 15 in Township 68 North and Range 35 West.

General Hydrologic Concepts

The term hydrology encompasses the distribution, movement, and quality of water. Water is in continual circulation between open bodies of water, the atmosphere, and the land. This dynamic circulation system is called the hydrologic cycle (fig. 6). This cycle has no recognized beginning, but for descriptive purposes the atmosphere is an adequate starting point. Water vapor in the atmosphere condenses and falls to earth as precipitation. Once removed from the atmosphere, the water may follow several pathways within the hydrologic cycle. Much of the water may evaporate back into the atmosphere, some will pond or flow across the land surface, and some will infiltrate into the ground. Water on the land surface may evaporate to the atmosphere or infiltrate into the ground. Water in the ground may be evaporated or transpired by plants and returned to the atmosphere. Any excess water in the soil moves downward by gravity to where the soil or rock is saturated. The top of the saturated zone is called the water table. Water in the saturated zone moves through fractures and small openings between grains of soil and rock. The rate of movement of the water is controlled by the hydraulic conductivity of the material through which it moves and the hydraulic gradient. The water eventually moves to areas where it returns to the land surface and either enters the surface-runoff pathway or evaporates to the atmosphere, completing the cycle.

Hydraulic conductivity is a term used to express the ability of a material to transmit water. It is controlled, in part, by the size and connection between openings in earth materials. Gravel, well-sorted sand, poorly cemented sandstone, and fractured rocks generally have large hydraulic-conductivity values. These materials form aquifers. Fine-grained materials such as silt, clay, and shale usually have small hydraulic-conductivity values and retard ground-water movement. These materials form confining units. The potential range of hydraulic conductivities of some of the typical materials present in the study area is shown in table 2 at the back of this report. Transmissivity, a measure of the ability of an aquifer to transmit water through connected openings, is a product of the hydraulic conductivity and the aquifer thickness.

Water in aquifers overlain by confining units may rise by hydraulic pressure in wells to altitudes higher than the top of the aquifer. These aquifers are called artesian aquifers. The level to which water will rise in a well that penetrates an aquifer is called the potentiometric surface at that location. Generally, artesian aquifers occur at greater depths below the land surface than water-table aquifers. In a water-table aquifer, the upper water surface is in equilibrium with atmospheric pressure.

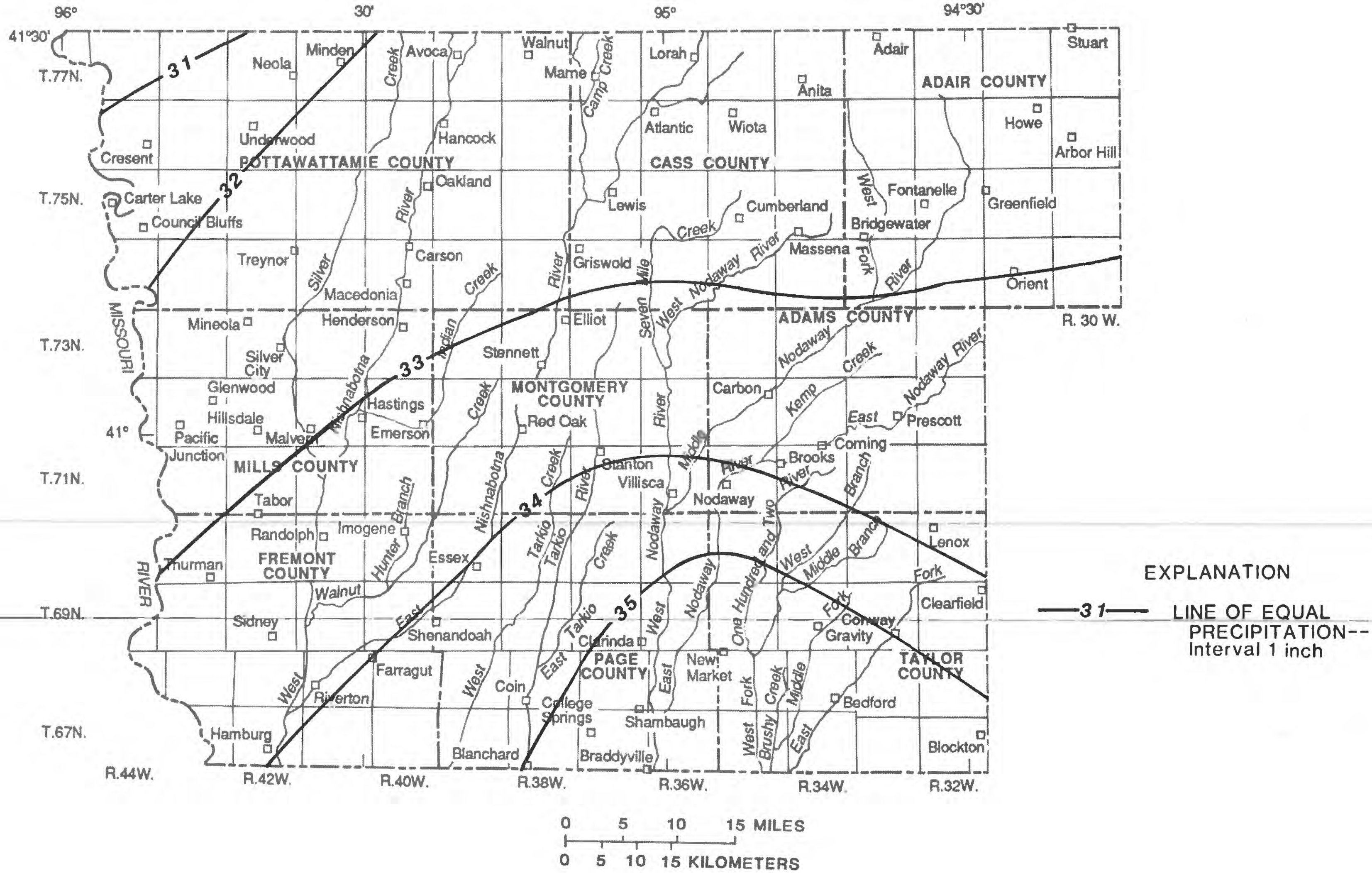


Figure 3. Average annual precipitation, 1951-80 (modified from Iowa Department of Agriculture and Land Stewardship, 1987).

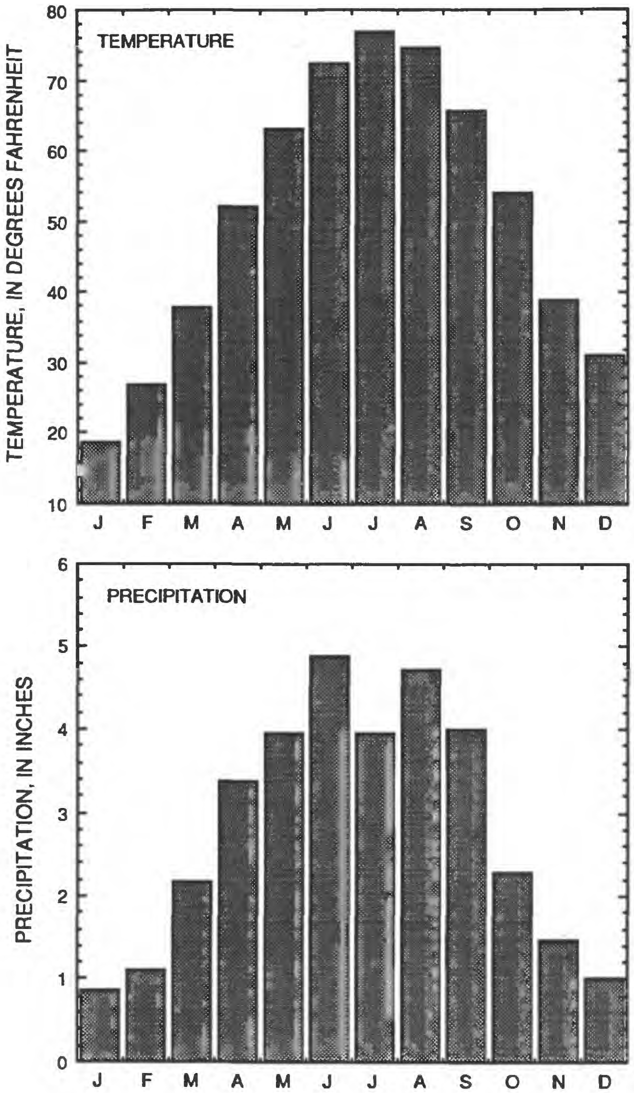


Figure 4. Average monthly temperature and precipitation at Red Oak, 1951-80 (data from National Oceanic and Atmospheric Administration, 1987).

Hydraulic gradient refers to the difference in water level between two points divided by the distance between the points. The movement of ground water is from areas of higher water level to areas of lower water level. The larger the gradient, the greater is the potential for flow to the point of lower water level. The most common method used to determine hydraulic gradients is to measure water levels in wells that penetrate the aquifer or aquifers of interest. Water-level altitudes then can be plotted and lines of equal water-level altitude drawn on a map. The direction of ground-water movement is downgradient and perpendicular to the lines of equal water-level altitude.

The water level in an aquifer fluctuates in response to recharge and discharge from the aquifer, usually indicating a change in the quantity of water stored in the aquifer. In Iowa, water-table aquifers near the land surface usually are recharged in the spring and fall by direct infiltration of precipitation or snowmelt. Recharge to these aquifers in the study area usually is sufficient to replace water losses caused by withdrawals from wells or natural ground-water movement. Aquifers that are confined by thick deposits of fine-grained materials are recharged at slow rates by leakage from above or below through the confining materials or by lateral movement of water through the aquifer from more distant recharge areas.

The suitability of ground water for various purposes is determined by the quantity of water available and by its chemical quality. As ground water moves through earth materials, it can dissolve minerals. In general, ground water becomes more mineralized with time and distance from the recharge area. Ground water in this report will be characterized by reference to the dominant anions and cations that it contains. Water is referred to as a cation-anion type, such as calcium-bicarbonate water. The dominant cations are calcium, magnesium, and sodium. The dominant anions are bicarbonate, sulfate, and chloride.

Drinking-Water Regulations

Public drinking-water regulations have been adopted by the U.S. Environmental Protection Agency as part of the Safe Drinking Water Act (PL 93-523). Primary regulations refer to Maximum Contaminant Levels (MCL), which are the maximum levels of contaminant permissible in a public-water supply. Secondary regulations apply to substances that affect aesthetic qualities of drinking water, such as taste and odor, and are not enforceable contaminant levels. In addition to aesthetic quality, health implications also may exist if considerably larger concentrations of the secondary-regulation substances occur. The National Drinking-Water Regulations are listed in table 3 at the back of this report.

Much of the current concern with regard to water quality in Iowa has focused on agricultural chemicals, particularly nitrate and pesticides.

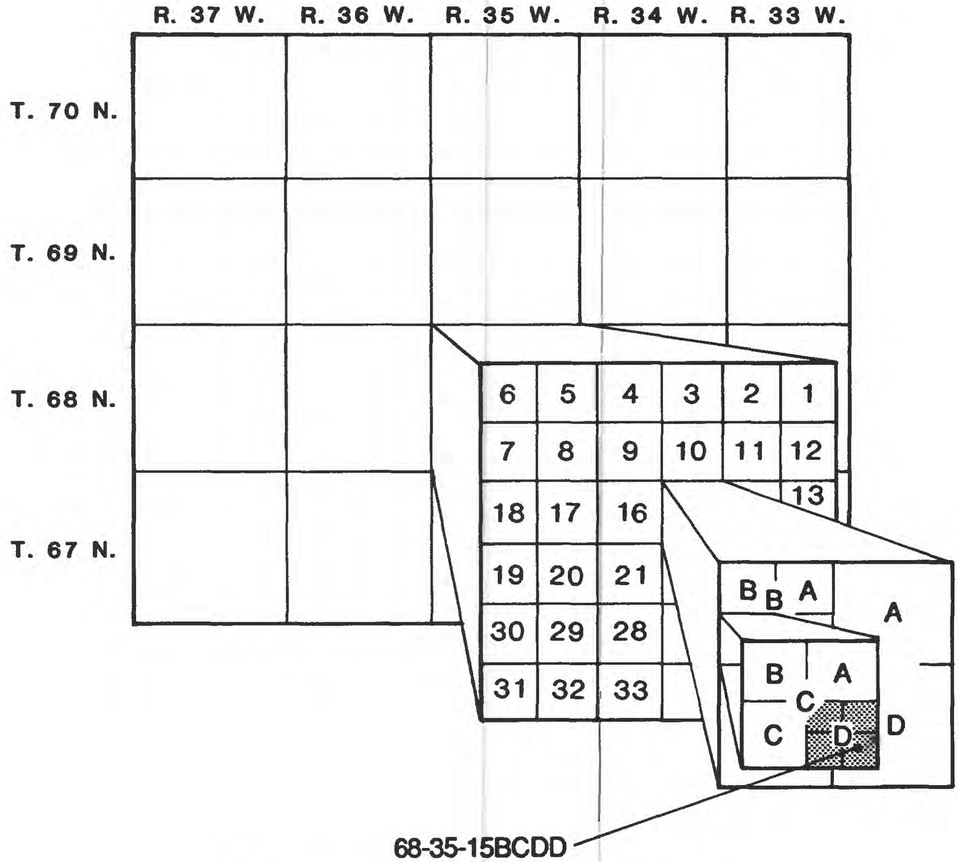


Figure 5. Well-location numbering system.

The occurrence of agricultural chemicals in Iowa's ground water is of concern not only because of acute health effects but also because of the potential hazard to health from long-term exposure to small concentrations. Large nitrate concentrations can cause methemoglobinemia (blue-baby syndrome) in infants, which may result in death. Long-term exposure to small concentrations of nitrate has been linked to birth defects, gastric cancer, and nervous-system impairment (Fraser and Chilvers, 1981; Dorsch and others, 1984; Forman and others, 1985). Much of the evidence for these additional adverse effects of nitrate is not established well yet.

The potential adverse health effects of pesticides are more difficult to assess as fewer studies have been done, particularly on the newer compounds. The U.S. Environmental Protection Agency is formulating approaches for dealing with pesticides in drinking water and has issued a proposed strategy (U.S. Environmental Protection Agency, written commun., 1989). This strategy has suggested the use of MCL regulations. However, at the present time (1989), few MCLs have been set for pesticides (table 3). For many of the compounds, interim regulations will be based on standard risk-assessment procedures. For non-carcinogenic chemicals, health advisories will be established on a No Observable Effect Level (NOEL) basis. For carcinogenic chemicals, risk-assessment concentrations will be established that correspond to a carcinogenic risk of one-in-a-million. Some of the proposed health advisories and risk-assessment concentrations for pesticides commonly detected in drinking water in Iowa are listed in table 4 at the back of this report.

Private wells in southwest Iowa have larger nitrate concentrations than private wells in other parts of the State, based on summary data supplied by the University of Iowa Hygienic Laboratory (University of Iowa Hygienic Laboratory, written commun., 1988). In this report, nitrate refers to nitrate concentrations as nitrogen. The data set consists of private water-well analyses that were evaluated between 1981 and 1986. Well location is limited to a

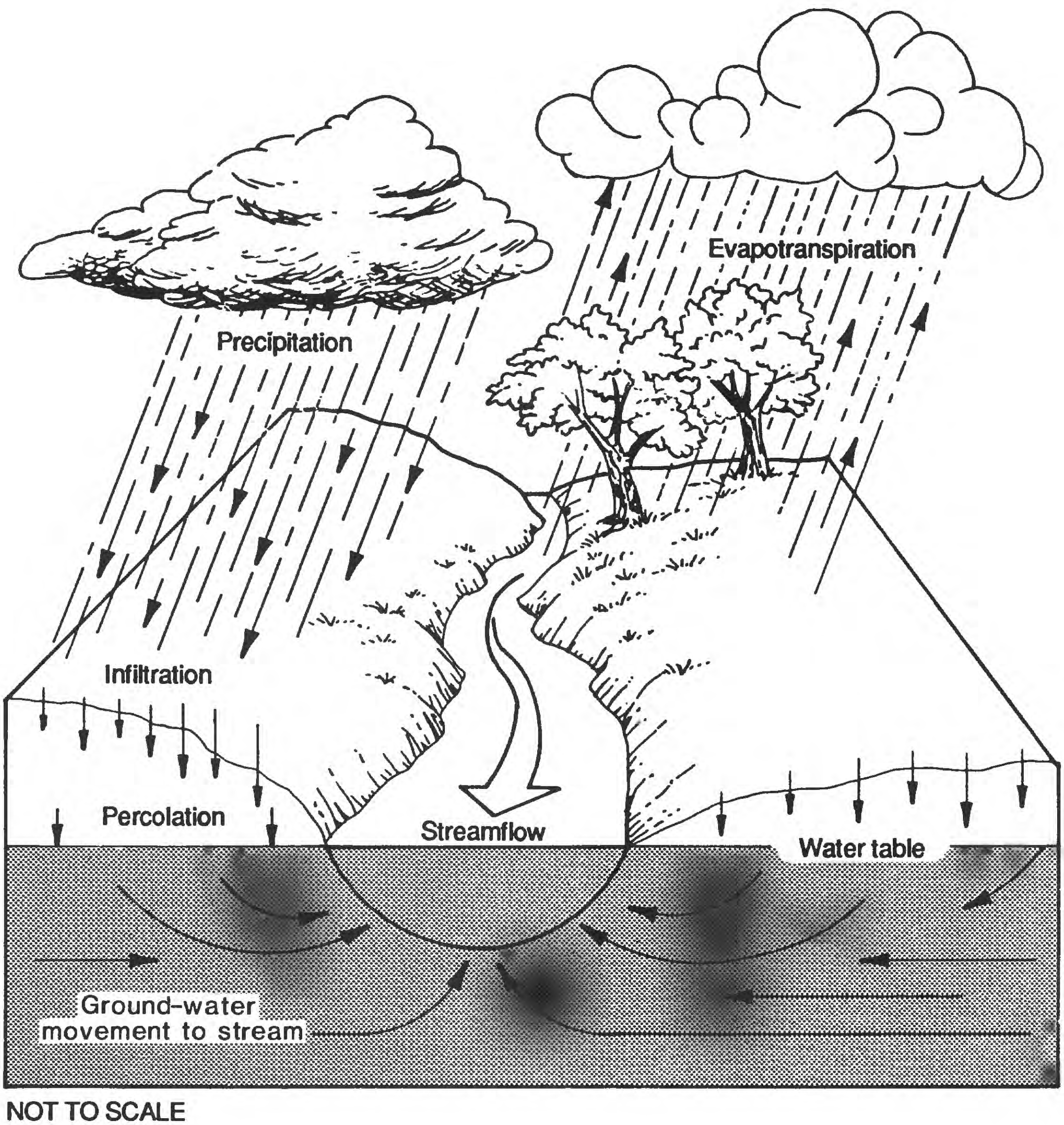


Figure 6. Hydrologic cycle.

mailing address and only occasionally is well depth reported by the individual submitting the sample. Thus, it is difficult to correlate these private analyses to aquifers. Private-well samples are voluntarily submitted and are usually submitted for a new well or when a known or suspected water-quality problem occurs. Private-well construction and maintenance are more variable than for municipal wells; thus, some of the analyses may reflect individual well problems. However, the large sample size of 3,437 wells generally compensates for any biases, and the data are believed to be a reasonable representation of overall nitrate concentration. The number and percentage of water samples containing nitrate concentrations of more than 10 mg/L (milligrams per liter) in each county from 1981 to 1986 are listed in table 5 at the back of this report.

The larger nitrate concentrations can be explained, in part, by reference to well depth in the area. It has been documented in Iowa that shallow wells, less than 100 ft deep, are especially susceptible to contamination from agricultural chemicals and other surface-derived contaminants (Hallberg and Hoyer, 1982; Hallberg and others, 1983; Libra and others, 1984; Bruner and Hallberg, 1987). In southwest Iowa, few deep aquifers are available, and the water quality in most of these deeper aquifers often is unacceptable because of large dissolved-solids concentrations. The use of shallow sources for private drinking-water supplies also is widespread. The reliance on shallow drinking-water supplies for private wells in southwest Iowa is the reason for the generally larger nitrate concentrations as compared to the remainder of the State and may account for the larger percentage of wells with constituents exceeding the MCL.

Acknowledgments

The authors acknowledge and thank those people who aided in the collection of data and provided technical support during the study. Drilling contractors provided information from their files and their personal observations. Information on municipal supplies and water use was provided by the many local water superintendents. Residents in the area cooperated in supplying information about their wells.

AVAILABILITY AND QUALITY OF GROUND WATER

The main sources of ground water in southwest Iowa are surficial deposits of Quaternary age and the Dakota Formation of Cretaceous age. The surficial deposits are composed of unconsolidated materials and can be divided into two general types--alluvium and glacial drift. The Dakota Formation is the uppermost bedrock in parts of the study area. Rocks of Pennsylvanian age, which underlie the entire area, form a regional confining unit. Although water may be available from some rocks of Pennsylvanian age, both quantity and quality generally are unacceptable for most uses. A diagrammatic east-west section illustrating the principal hydrogeologic units is shown in figure 7, and table 6 at the back of this report lists the generalized stratigraphy in southwest Iowa.

Alluvial Aquifers

Alluvium is water-deposited material commonly found in flood plains along streams and rivers and is comprised of permeable sand and gravel interbedded with less-permeable clay and silt. The entire sequence of permeable and less-permeable materials usually is considered as an aquifer because of the degree of hydraulic connection between permeable zones.

Alluvial flood plains are present along the major streams in southwest Iowa. These flood plains are the broad, flat areas adjacent to the river, characterized by low relief and poor drainage. Terraces are remnants of former alluvial plains that have been eroded and are present along the valley margins of many streams. Terraces within the study area typically are considered part of the alluvial aquifer with which they are associated. At some locations, the river channels may be in direct contact with the sand and gravel, but in most areas the bottom of the river is within the finer grained alluvium. Soils in the alluvial valley commonly are silt loams or silty-clay loams that are developed on silty alluvium.

Recharge to alluvial aquifers normally occurs by infiltration of precipitation through the soil. The thick layer of fine-grained alluvial sediment that overlies the sand and gravel may prevent rapid infiltration and cause the aquifer to be semiconfined. Recharge and discharge relations in an alluvial aquifer also may be complicated by the presence of other aquifers that underlie or are adjacent to the alluvium. There are several areas in southwest Iowa where the Dakota aquifer underlies the alluvium. These aquifers may recharge the alluvium, or they may be recharged by the alluvium. Recharge to the aquifer, although slow, also occurs from water movement through the loess, along the loess-glacial till interface, or through glacial till. A description of the hydraulic relations among these aquifers is beyond the scope of this report.

Alluvial aquifers typically discharge to streams. Base flow is the term used to describe the ground water that discharges to a stream. Occasionally, during rainfall, stream levels will rise rapidly, causing the level of the stream to be higher than the surrounding water table. Water then flows from the stream into the aquifer. The quantity of water transferred between the stream and the aquifer depends on the hydraulic conductivity of the streambed, the water-table gradient, the permeability or hydraulic conductivity of the aquifer materials, and the amount of time the surface water is higher than the ground-water level. As the stream level decreases, the gradient reverses, and ground

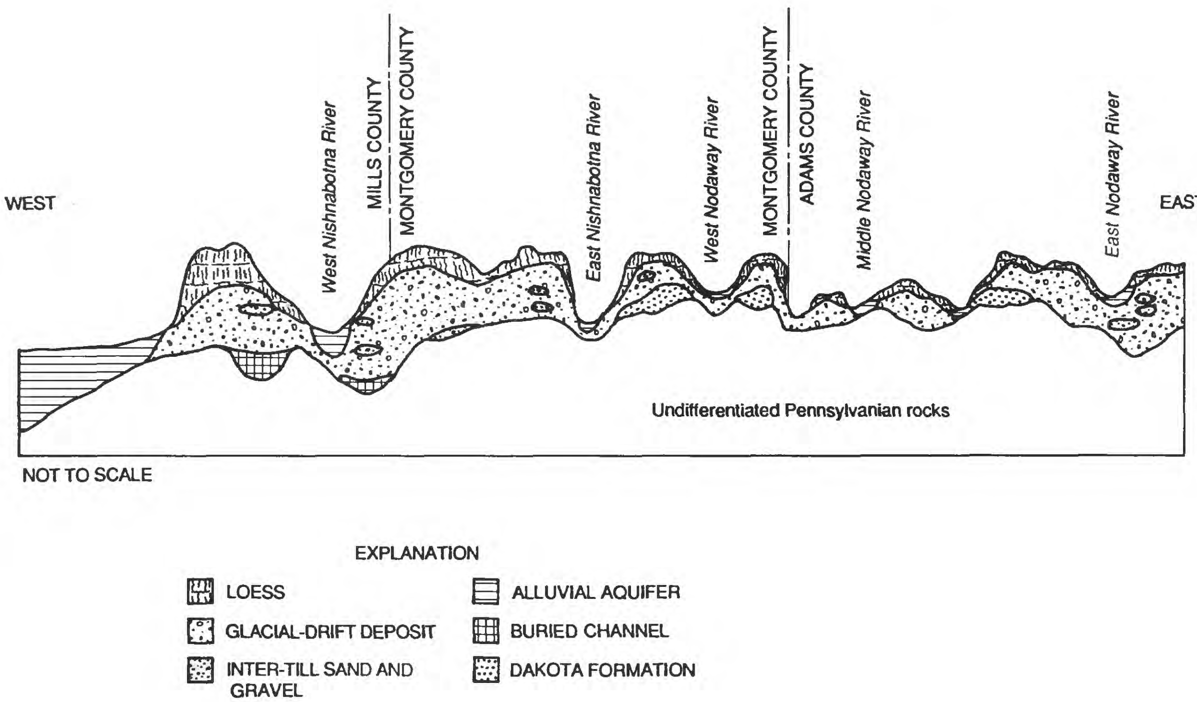


Figure 7. East-west hydrogeologic section across study area.

water discharges to the stream. This temporary storage of water in the aquifer is termed bank storage. If the aquifer consists of fine-grained material, bank-storage capacity may be less than if the aquifer consists of sand and gravel.

Water levels in an alluvial aquifer change throughout the year and usually are highest in late spring and fall. Water levels usually decline in summer because of increased evapotranspiration. Research on other alluvial aquifers in Iowa (Thompson, 1986, 1987) indicates that water levels tend to respond rapidly to precipitation; however, the thick cover of fine-grained sediment present in the alluvial aquifers of southwest Iowa may slow this response. Water levels measured in observation wells during this study are listed in table 7 at the back of this report.

Water levels also are affected by withdrawals from wells. When a well is pumped, water can be withdrawn from storage over a large area, and water levels decline (fig. 8). Prolonged pumping at high rates may eventually lower water levels below that of the stream, causing movement of water from the stream into the aquifer. The rate and area of water-level decline due to pumping depends on the aquifer boundaries, the hydraulic conductivity of the streambed, and the hydrogeologic properties of the aquifer.

The productivity of an aquifer is based, in part, on the thickness of the producing section. Areas of thicker sand and gravel generally will have larger yields. Additionally, areas where two aquifers are hydraulically connected, such as alluvium overlying the Dakota aquifer, may have larger yields. Specific-capacity data, a measure of aquifer yield, were gathered from historical records. From these data, and using an estimate for specific yield, transmissivities were calculated (Walton, 1960). The numbers presented in this report are a general guide to the availability of water because in alluvial systems the geology of the aquifer is highly variable and difficult to characterize. If large yields are needed, the aquifer needs to be evaluated by test drilling and pumping to determine the specific aquifer characteristics at a particular site.

Major alluvial aquifers occur along the East and West Nishnabotna Rivers and the Nodaway River. Minor aquifers occur along the Tarkio and One Hundred and Two Rivers. Two previous studies have been done on the alluvial aquifers in southwest Iowa, both of which focused on the Nishnabotna alluvial aquifer (Knochenmus, 1962; Stone, 1971).

Nishnabotna Alluvial Aquifer

The Nishnabotna alluvial valley is divided into two main branches along the West and East Nishnabotna Rivers (fig. 9). Both branches begin north of the study area in west-central Iowa. The West Nishnabotna River enters the study area near Avoca in Pottawattamie County, and the East Nishnabotna River enters near Lorah in Cass County. The branches join southwest of Riverton in Fremont County. At the junction, the West Nishnabotna has a drainage area of 1,650 mi^2, and the East Nishnabotna has a drainage area of 1,150 mi^2. The valley merges with that of the Missouri River valley south of Hamburg. The total drainage area is 2,820 mi^2 where the Nishnabotna River leaves the State.

Both the West and East Nishnabotna valleys are broad with low relief. Low terraces form part of the aquifer. The West Nishnabotna valley averages 2 mi in width; average width of the East Nishnabotna valley is 1.5 mi. The West Nishnabotna valley narrows to less than 1 mi from Carson to south of Macedonia. The same valley narrowing is present in the East Nishnabotna from just north of Stennett to Red Oak. In both cases, the widths of the valleys are constrained by the presence of Pennsylvanian bedrock at shallow depths. Topographic relief is considerable; the valley floor averages about 150 ft below the uplands.

Much of the Nishnabotna alluvial aquifer is comprised of thick fine-grained alluvial deposits. Data from 94 test holes indicate the fine-grained deposits range from 2 to 43 ft thick and average 21 ft thick. The range and average of the fine-grained deposits for the two aquifer branches are similar. The underlying sand and gravel ranges from 3 to 45 ft thick and averages 17 ft. The range of thickness of the sand and gravel for the two aquifer branches is similar, but the West Nishnabotna branch has a slightly greater average thickness, although the differences are not statistically significant. There is no systematic change in thickness along the valley in either the fine-grained increment or the sand and gravel. There is no apparent correlation between the thickness of the two units.

The Nishnabotna alluvial aquifer along the West Nishnabotna River is underlain by glacial drift, except for the area around Macedonia where the aquifer is underlain by Pennsylvanian rocks. The northern part of the Nishnabotna alluvial aquifer along the East Nishnabotna

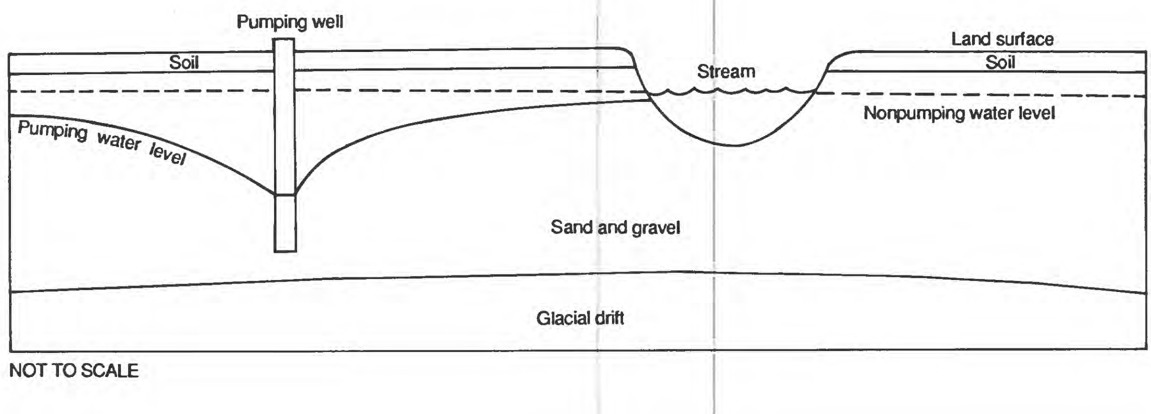


Figure 8. Relation between nonpumping and pumping water levels.

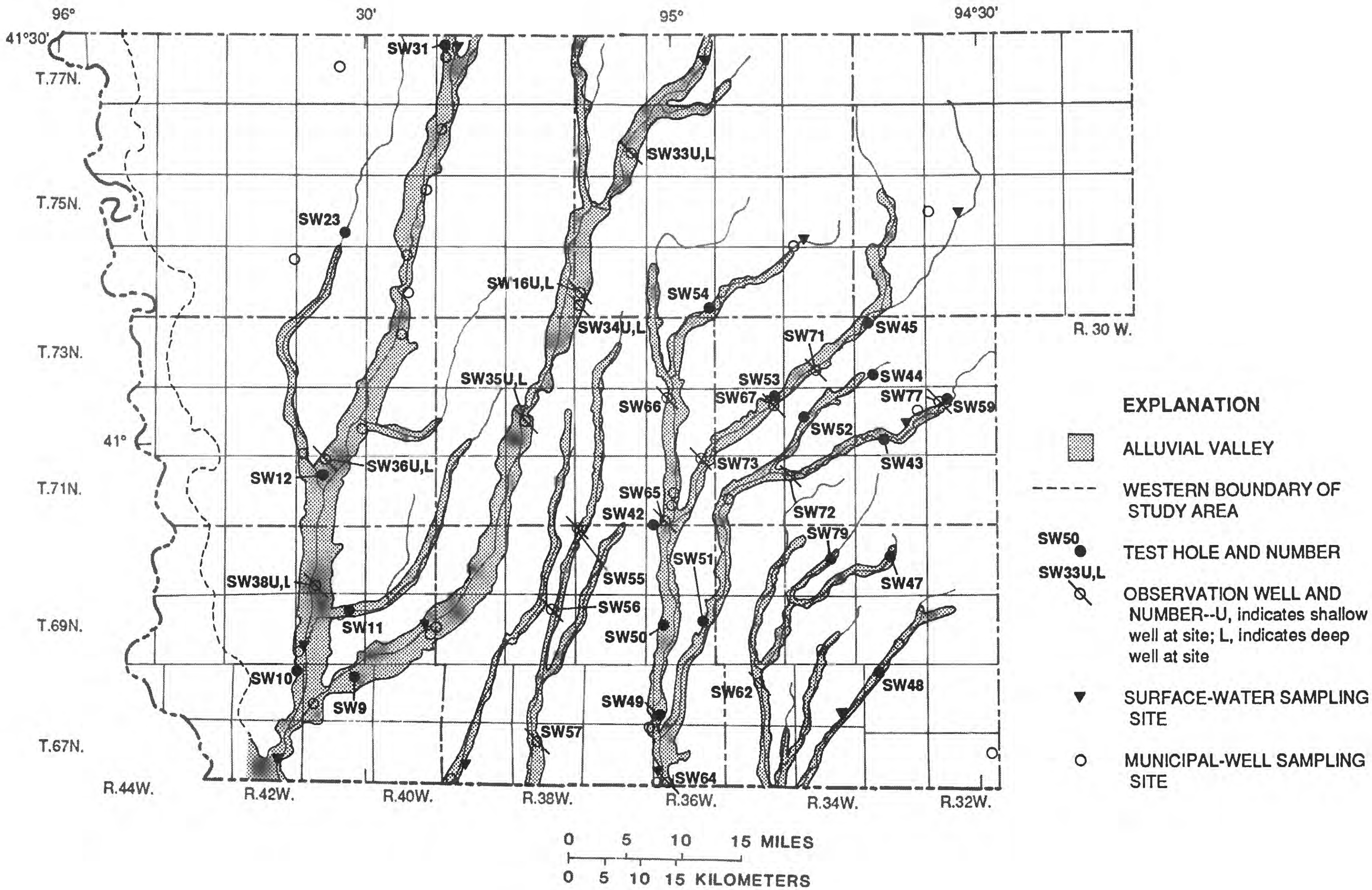


Figure 9. Location of alluvial valleys and text holes and observation wells.

River in Cass and Montgomery Counties is mostly underlain by Pennsylvanian and Cretaceous rocks. The southern part of the aquifer in Page and Fremont Counties is underlain by glacial drift.

Aquifer hydraulic properties were estimated from specific-capacity data that were available for a few municipal wells. Assuming a storage coefficient of 0.01, transmissivities in the Nishnabotna alluvial aquifer along the West Nishnabotna River range from approximately 1,000 to 4,300 ft^2/d. Along the East Nishnabotna River, specific-capacity data were available only for the southern part of the Nishnabotna alluvial aquifer at Shenandoah and Farragut. Again using an estimated storage coefficient of 0.01, transmissivities ranged from 1,700 to 8,000 ft^2/d. Well yields of as much as 2,000 gal/min have been reported, but most wells are pumped at maximum rates of 100 to 250 gal/min.

Water levels were measured in most observation wells from July 1986 to June 1988 (table 7). Frequent measurements were made in two alluvial wells, SW34L and SW16L (fig. 9). In general, water levels were deeper beneath terraces than beneath the flood plain. Water levels in terrace wells (SW16U, SW33U, SW38U) ranged from 10.15 to 20.30 ft below land surface. Water levels in three wells located on the flood plain (SW34U, SW35U, SW36U) ranged from 2.06 to 12.58 ft below land surface. The maximum observed water-level change in any well was 10.46 ft in well SW36U. Water levels in the wells rise in response to increased precipitation and discharge in the adjoining rivers as shown in figure 10.

When available, water levels from wells completed in the upper and lower parts of the alluvium were compared to evaluate vertical gradients. At three of five sites measured, vertical gradients were usually downward. Reversals of gradient direction did occur at some sites, but could not be related to any specific cause. The other two sites showed predominately upward gradients, with well SW36L (table 7) indicating a strong upward gradient on August 6, 1986. It is unknown whether this was caused by interconnection with other aquifers. The deep well at SW36 was completed in a different lithologic unit than the shallow well.

More water-quality data are available for the Nishnabotna alluvial aquifer than for other aquifers in southwest Iowa. Water samples were analyzed for major ions, trace elements, radionuclides, and pesticides from 10 municipal wells and 2 observation wells in the Nishnabotna alluvial aquifer along the West Nishnabotna River and 6 municipal wells and 5 observation wells in the Nishnabotna alluvial aquifer along the East Nishnabotna River (tables 8 through 10 at the back of this report). Historical water analyses (1950-86) also were examined to determine changes with time and to provide a larger data base. The number of analyses, the range of concentrations, and the mean concentration for water-quality properties and constituents in samples from the Nishnabotna alluvial aquifer are shown in table 11 at the back of this report. Mean concentrations were calculated with "less than" values set to zero. The mean concentrations of selected constituents are plotted in figure 11.

The water in both branches of the aquifer is classified as a calcium bicarbonate type. Water from the observation wells had sulfate concentrations that were less than those from the municipal wells. This difference in concentration may be caused by municipal pumping that induces recharge from other aquifers with larger sulfate concentrations. Iron concentrations were large and were often larger than the secondary regulation for iron (table 3).

Nitrate concentrations vary from well to well in the alluvium, making it difficult to characterize water quality. Three data sets from different sources were examined to evaluate nitrate concentrations. Historical data, 1950 to 1986 (table 11), indicated mean nitrate concentration of 2.0 mg/L for 216 analyses; the mean nitrate concentration for 216 samples collected during an Iowa Department of Natural Resources project in 1987 was 2.4 mg/L (Thompson and VanDorpe, 1988); and the mean nitrate concentration for 19 samples collected during this study, 1985 to 1987, was 7.83 mg/L (table 8).

Differences in the data sets reflect the variability in nitrate concentrations due to well location, climatic patterns, sampling frequency, and time of year. Concentrations of nitrate were less than concentrations in samples from in the

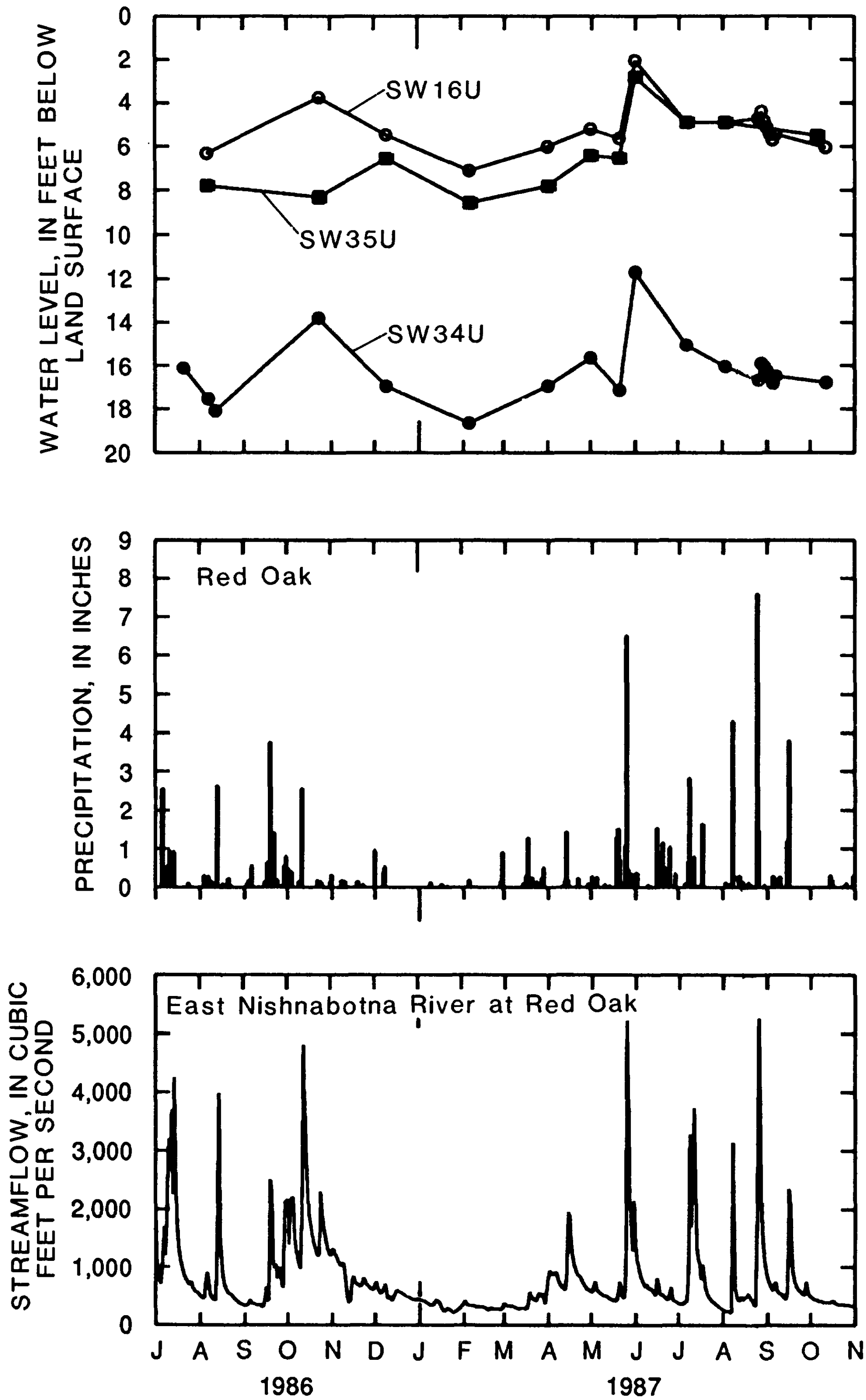
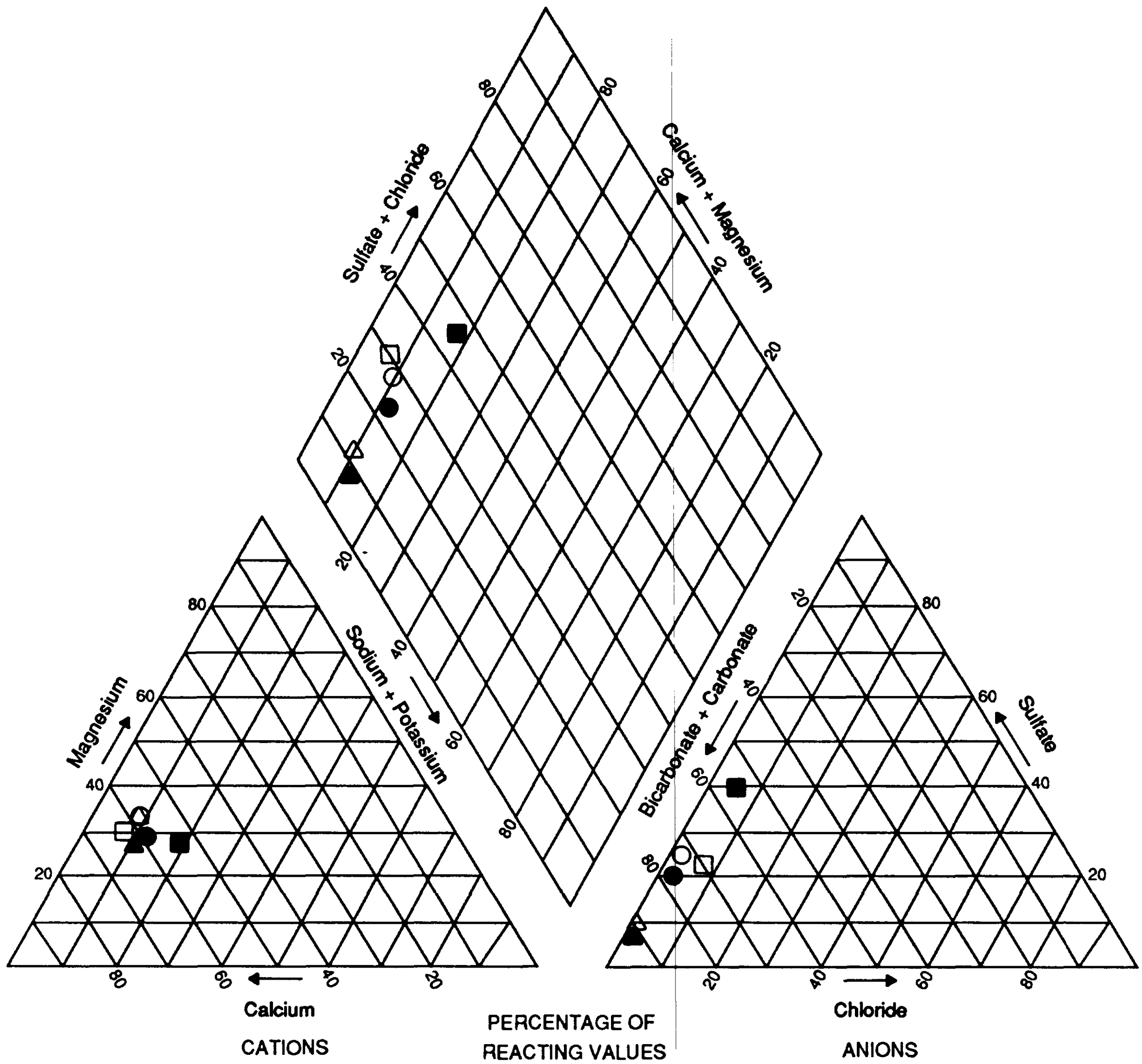


Figure 10. Water levels in selected alluvial-aquifer wells, precipitation at Red Oak, and streamflow in the East Nishnabotna River at Red Oak.



EXPLANATION

MUNICIPAL WELLS

East Nishnabotna branch

■ 1986-87, 4 samples

● 1950-86, 82 samples

West Nishnabotna branch

□ 1986-87, 8 samples

○ 1950-86, 102 samples

OBSERVATION WELLS

▲ East Nishnabotna branch, 3 samples

△ West Nishnabotna branch, 2 samples

Figure 11. Mean water quality in the Nishnabotna alluvial aquifer.

alluvial aquifers of the Ocheyedan-Little Sioux and Rock Rivers in northwest Iowa (Thompson 1986, 1987). The mean nitrate concentrations were similar to those in the West Fork Des Moines River alluvial aquifer in north-central Iowa where denitrification has been postulated as a process for decreasing nitrate concentrations (Wehmeyer, 1988; Iowa Department of Natural Resources, Geological Survey Bureau, written commun., 1989). Denitrification or other possibilities for decreasing nitrate concentrations may be occurring in the fine-grained alluvium in the Nishnabotna alluvial aquifer but were not investigated during this study.

Large mean nitrate concentrations, greater than 3.0 mg/L, appear to correlate with well position within the valley. Many of the wells with large mean nitrate concentrations are located near the valley edge. It has been hypothesized (Thompson and VanDorpe, 1988) that the alluvial aquifer is being recharged by shallow ground-water flow from the uplands containing larger nitrate concentrations.

A comparison of nitrate concentrations with precipitation and discharge records using previously collected data (Thompson and VanDorpe, 1988) produced varied results. Nitrate concentrations appear to correlate with rainfall at 5 of 14 monitored sites, 9 municipal wells, and 5 observation wells. At the other sites there was no apparent response in nitrate concentrations to rainfall.

Mean nitrate concentrations from surface-water samples collected during this study from both branches of the Nishnabotna River were larger than 41 mg/L (table 8). This may indicate that upland shallow ground-water flow is discharged to the river by tributary streams. Additionally, larger nitrate concentrations could occur at or near the water table in the fine-grained alluvium and be discharged laterally to the river instead of infiltrating to greater depths within the alluvium.

Atrazine is the most frequently detected pesticide in southwest Iowa and is the most common pesticide detected in Iowa. This is attributed to its long history of continual, widespread usage and its solubility. Metolachlor was the only pesticide other than atrazine detected at more than one location in southwest Iowa. The results of pesticide sampling of the Nishnabotna alluvial aquifer from all available data are summarized in table 12 at the back of this report. Table 12 includes 24 pesticide analyses from untreated municipal-well water samples and 17 analyses of treated municipal water samples collected by the U.S. Geological Survey between 1985 and 1987 (M.L. Clark, U.S. Geological Survey, oral commun., 1989); 6 samples collected from alluvial observation wells installed along the Nishnabotna River during this study (table 10); and analyses of 23 municipal-well samples and 33 observation-well samples available from a concurrent project (Thompson and VanDorpe, 1988). Concentrations of detected pesticides were less than proposed regulations (table 4) except for alachlor. All of the pesticide detections were from municipal wells. Local point-source contamination is possible; however, most of the well sites are upgradient from any known or suspected point sources of contamination. Municipal pumping may affect normal flow paths, drawing water from a larger contributing area. Surface water might also be a source of pesticides, but in general the wells are located away from the river and withdrawal rates are small enough to minimize any possible interaction.

Atrazine, cyanazine, alachlor, and metolachlor have been detected in surface-water samples from both the East and West Nishnabotna Rivers (table 10). Concentrations often are larger than those detected in ground water. Alachlor has exceeded the proposed regulations (table 4).

Tarkio Alluvial Aquifer

The Tarkio alluvial aquifer is present along three streams--the Tarkio River, West Tarkio Creek, and East Tarkio Creek (fig. 9). All three streams begin in Montgomery County. The Tarkio River at the Missouri border has a drainage area of 206 mi^2. Valley width varies from 0.25 to 1.25 mi and averages slightly more than 0.5 mi. West Tarkio Creek at the Missouri border has a drainage area of 92.5 mi^2. Valley width ranges from 0.25 to 0.75 mi and averages 0.5 mi. East Tarkio Creek joins the Tarkio River north of Coin where it has a drainage area of 58.2 mi^2. Average valley width is 0.4 mi.

The alluvial deposits along the main stem of the Tarkio River consist of a thin layer of sand and gravel, 4 to 9 ft thick, below a thick layer of fine-grained alluvium, 40 to 58 ft thick. No information is available on alluvial deposits along either East or West Tarkio Creeks. Because of the limited areal extent of all branches, only the main valley of the Tarkio River was investigated during this study. The only previous drilling information available is near the town of Coin (fig. 9), where the valley is underlain by glacial drift. Test holes at three other locations in Page County indicate that parts of the valley are underlain by Pennsylvanian shale.

Transmissivity was estimated from data collected at Blanchard (fig. 9). Assuming a storage coefficient of 0.01, transmissivities range from 210 to 250 ft^2/d. Yields from the Blanchard municipal wells are 20 to 30 gal/min.

Water levels were measured in observation wells SW55, SW56, and SW57 (fig. 9) in October and November 1987 and ranged from 9.53 to 27.65 ft below ground level (table 7). Water levels generally decreased during the months measured, corresponding to a decrease in the discharge of the Tarkio River. The maximum water-level change in any well was 1.05 ft.

The water from observation wells SW55 and SW56 (fig. 9), located north of the town of Blanchard, can be classified as a calcium bicarbonate type (fig. 12). There are noticeable differences in water from the two observation wells. Well SW56 has an extremely small concentration of sulfate, 9 mg/L, but a larger sodium concentration, 41 mg/L, than detected in other alluvial-aquifer samples (table 8). Well SW55 has more typical concentrations of the two ions--sulfate, 52 mg/L, and sodium, 14 mg/L. Both observation wells have less sulfate and chloride than the other samples from municipal wells (table 11), which may be related to the effects of ground-water withdrawal. Nitrate concentrations are small, less than 0.1 mg/L for the observation wells, and ranging from 0.2 to 1.4 mg/L in the other samples. One surface-water sample from the Tarkio River near Blanchard had a nitrate concentration of 4.2 mg/L during October 1987 (table 8). Water from observation wells SW55 and SW56 does indicate some chemical anomalies. Ammonia as nitrogen concentrations are large, 4.6 and 9.5 mg/L. There also is a larger than usual chemical oxygen demand, indicating a reducing environment may exist.

Observation wells SW55 and SW56 and the Tarkio River were sampled for pesticides in October 1987; none were detected (table 10). The well at Blanchard, the only municipal well in the Tarkio alluvial aquifer, did have a detection of atrazine, 0.25 μg/L (microgram per liter), in a sample of treated water during November 1986 (table 13 at the back of this report).

Nodaway Alluvial Aquifer

The Nodaway River is divided into three main streams--the West, Middle, and East Nodaway Rivers (fig. 9). The Middle Nodaway River begins in Adair County and joins the West Nodaway River just south of Villisca and has a drainage area of 341 mi^2. The East Nodaway River begins in Union County, south-central Iowa, and enters the study area in Adams County. A main tributary, Kemp Creek, flows into the East Nodaway River in Adams County northeast of Nodaway. The drainage area of the East Nodaway River at the junction with the West Nodaway River north of Braddyville is 334 mi^2. The Nodaway River leaves the State at Braddyville where it has a drainage area of 1,180 mi^2.

The alluvial valleys of the three main branches of the Nodaway River are moderately broad, ranging from 0.2 to 2 mi wide. The East Nodaway River valley has the smallest average width, 0.8 mi, and the Middle Nodaway River valley the largest, 1.2 mi. The valleys are constricted by bedrock outcrops at various points along their course. Low terraces are present along the valley margins and form part of the alluvial aquifer.

The sequence of alluvial sediments is similar to the other alluvial aquifers in southwest Iowa. On the basis of logs from 41 test holes, the fine-grained alluvium, ranging from 10 to 37 ft thick, overlies sand and gravel ranging from 0 to 30 ft thick. The fine-grained alluvium averages about 20 ft thick, and the sand and gravel averages about 10 ft thick. Ranges and averages are similar along all Nodaway River branches, except for the East Nodaway, which has a thicker layer of fine-grained alluvium. Most of the alluvium is underlain by shale or limestone of Pennsylvanian age. The upper reaches of the East Nodaway River and Kemp Creek in Adams County are underlain by glacial drift.

The yield of the Nodaway alluvial aquifer is small because of the thin sand and gravel. Using an estimated storage coefficient of 0.01, transmissivities range from 90 to 570 ft^2/d. Well yields range from 12 to 100 gal/min among the municipal wells that use the Nodaway alluvial aquifer. No irrigation permits have been issued for the Nodaway alluvial aquifer.

Water levels were measured in eight wells from September to November 1987 (table 7). Water levels varied from 1.00 to 21.53 ft below ground level. Water levels gradually decreased during the measurement period, as did discharge in the streams. The maximum water-level change observed in any well was 2.36 ft. All the sites are on the flood plain. However, the upper reaches of the river are more deeply incised, creating steeper water-table gradients and accounting for the large differences in water levels.

Water from the Nodaway alluvial aquifer is a calcium bicarbonate type as shown in figure 12. Historical data from 1950 to 1986 for the principal ions in samples from the Nodaway alluvial aquifer are summarized in table 11. A slight difference in anion concentration in samples exists between the observation wells and the municipal wells. Samples from the municipal wells usually have larger sulfate concentrations than samples from the observation wells. Pumping may induce flow from the underlying Pennsylvanian rocks, which generally have large concentrations of sulfate. Iron concentrations (table 8) ranged from less than 20 to 26,000 μg/L and commonly exceeded the secondary regulation of 300 μg/L (table 3). Nitrate concentrations in the Nodaway alluvial aquifer generally are less than 1.0 mg/L (table 8). Surface water in the basin also has large concentrations of nitrate, ranging from 2.0 to 4.9 mg/L for samples collected during October 1987 (table 8).

Pesticides were detected at only one municipal well completed in the Nodaway alluvial aquifer (table 13). An atrazine concentration of 0.28 μg/L and a cyanazine concentration of 0.1 μg/L were detected in a sample from one well at Fontanelle during August 1986. During August 1987, only atrazine was detected at a concentration of 0.11 μg/L. There were 21 pesticide analyses from untreated ground-water samples available from 11 municipal wells in 8 towns and 7 observation wells. An additional seven municipal treated-water samples were available. All pesticides detected were less than proposed regulations (table 4).

Five surface-water samples were collected from the Nodaway River system during October 1987 (table 10). Atrazine was detected at two sampling sites at concentrations of 0.10 and 0.18 μg/L. No pesticides were detected in March 1982 in a sample from Clarinda (fig. 9), which uses water from the Nodaway River. Atrazine, 0.20 μg/L, was detected in a treated-water sample from Clarinda during November 1986. The Page Rural Water District, which also uses water from the Nodaway River, had detections of atrazine, 0.65 μg/L, and cyanazine, 0.31 μg/L, in a sample collected during July 1987.

One Hundred and Two Alluvial Aquifer

The One Hundred and Two River is divided into three main streams--the East Fork, Middle Fork, and West Fork (fig. 9). Most of the river is within Taylor County. The West Fork One Hundred and Two River, including the West and Middle Fork tributaries, has a drainage area of 212 mi^2 at the Missouri border. Drainage areas of the Middle and East Fork One Hundred and Two Rivers at the border are 62.1 and 111 mi^2, respectively. The valleys generally are narrow, ranging from 0.2 to 1 mi in width and averaging about 0.5 mi.

Information on the One Hundred and Two River alluvial deposits is limited. Data from seven boreholes were available and indicate 1 to 15 ft of sand and gravel underlying 6 to 38 ft of fine-grained alluvium. At three of the four test holes or observation wells drilled for this study, the aquifer is underlain by glacial drift. One site, well SW62 (fig. 9), in western Taylor County near New Market, is underlain by shale of Pennsylvanian age.

Observation well SW62 (fig. 9) was installed in the One Hundred and Two alluvial aquifer during this study. Water levels in that well decreased from 21.70 to 23.09 ft below ground level during measurements made from September to November 1987 (table 7). The gradual decrease in water level corresponded to decreased precipitation and decreased discharge in the One Hundred and Two River during the same period. No data are available on specific capacity. Two towns, Conway and Gravity, currently use water from the One Hundred and Two alluvial aquifer, with well yields of 12 to 40 gal/min. The town of New Market previously used water from a well completed in the One Hundred and Two alluvial aquifer that had a yield of 50 gal/min.

One sample of water for chemical analysis was collected from observation well SW62 (table 8). There were an additional 16 analyses available from municipal wells (table 11). The water can be classified as a calcium bicarbonate type (fig. 12). Nitrate concentrations are small, ranging from less than 0.10 to 0.40 mg/L. A nitrate concentration of 1.0 mg/L was detected in a surface-water sample from the One Hundred and Two River near Bedford in October 1987. Iron concentrations (table 11) are large and are usually much larger than the secondary drinking-water regulation (table 3). No pesticides were detected in a sample from an observation well in October 1987 (table 10). Pesticide analyses were available for Conway and Gravity from samples of both treated and untreated water (table 13). Two pesticides, alachlor and atrazine, were detected at Conway; three pesticides, alachlor, metolachlor, and 2,4-D, were detected at Gravity. Concentrations of alachlor exceeded the proposed regulation (table 4). No pesticides were detected in a surface-water sample collected from the West Fork One Hundred and Two River during October 1987 (table 10).

Glacial-Drift Aquifers

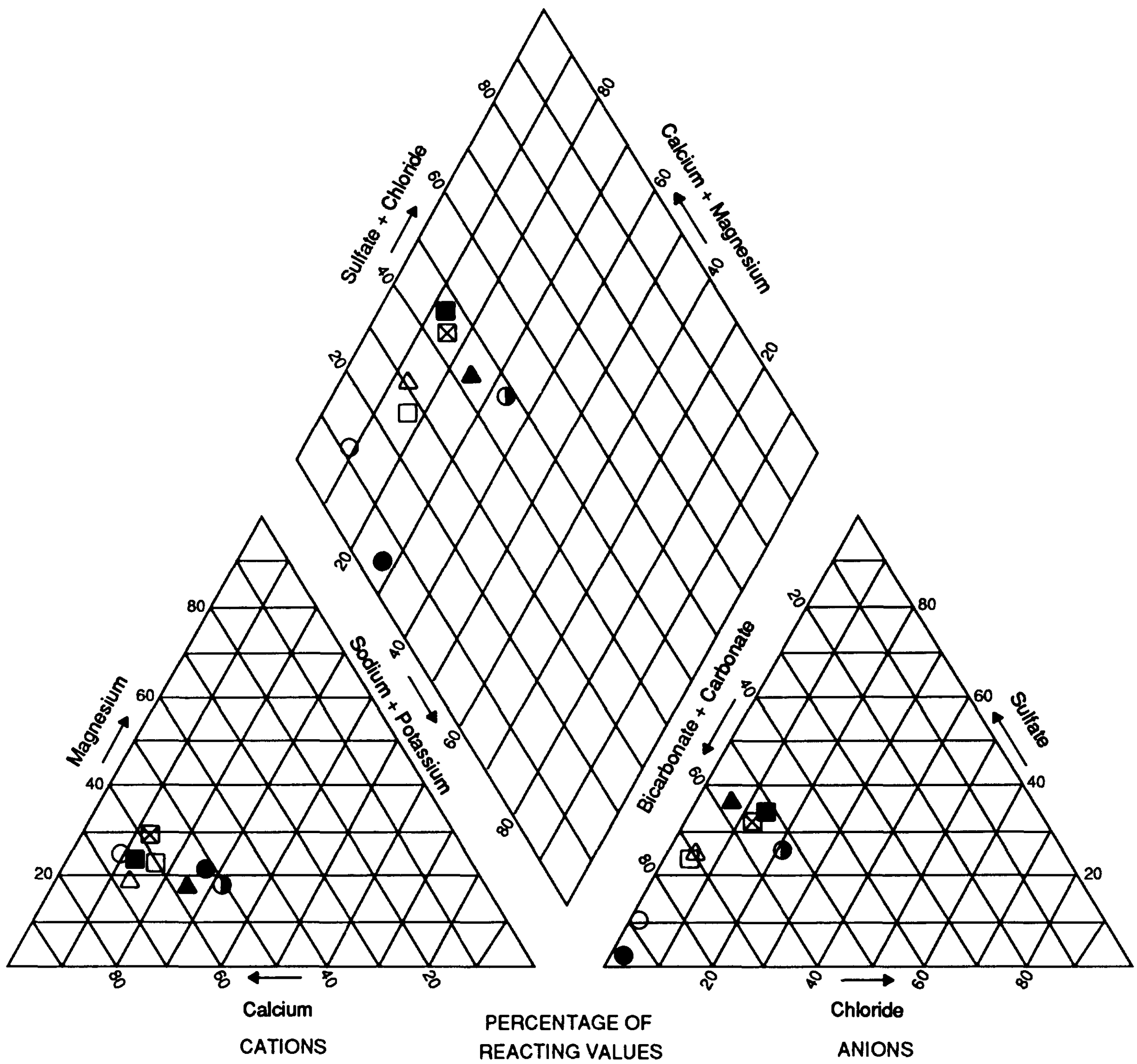
Glacial drift, for the purposes of this report, includes all deposits that predominantly are glacial in origin or are the result of multiple periods of glaciation that occurred in the area. Loess and buried-channel deposits, although not strictly interpreted to be of glacial origin, have been included within the glacial-drift definition because of their stratigraphic association with deposits of glacial origin. The thickness of the glacial drift in southwest Iowa is about 200 ft over upland areas of the bedrock surface and about 450 ft over some parts of valleys eroded into the bedrock surface. The typical known range of thickness of the glacial drift in southwest Iowa counties is shown in table 14 at the back of this report.

Loess, a wind-deposited material, mantles the other glacial-drift deposits in most areas of Iowa. Loess predominantly consists of silt-sized particles but also can be partially comprised of clay and minor quantities of fine sand. Loess deposits in southwest Iowa generally are less than 30 ft thick, except in the Western Loess Hills region (fig. 2) where the deposits generally are more than 50 ft thick and have a recorded maximum thickness of 152 ft. The loess deposits thin and decrease in particle size with distance from the Missouri River valley.

The glacial drift beneath the loess is a mixture of sediment transported and deposited by glaciers or resulting from meltwater between or during glacial periods. These deposits generally are classified into one of two types--glacial till and stratified drift. Glacial-till deposits are most prevalent in the study area and consist of an unsorted mixture of sand, silt, clay, gravel, and boulders. The stratified drift usually shows the effect of water transport during and between glacial periods by the degree of particle-size sorting in sand and gravel deposits. The stratified-drift sand and gravel deposits are discontinuous, generally thin and lenticular, and may be beneath or within the glacial till.

The fine-grained matrix characteristic of the glacial-till deposits and the discontinuity of the stratified-drift deposits make the glacial drift an effective confining material. However, aquifers underlying glacial drift can be recharged by slow vertical leakage. Stratified glacial drift within and at the base of the glacial till includes pockets or lenses of sand or sand and gravel that are sources of water.

Glacial-drift aquifers are most likely to occur in four settings (fig. 7). These are: (1) loess, (2) sand and gravel within the glacial till, (3) sand and gravel deposits at the base of the glacial-drift materials, and (4) sand and gravel deposits in former stream channels eroded into the bedrock surface and subsequently buried by glacial drift. Many rural domestic and livestock water supplies and several municipal supplies are



EXPLANATION

MUNICIPAL WELLS

○ Tarkio, 1950-86, 7 samples

■ Nodaway, 1987, 7 samples

⊠ Nodaway, 1950-86, 54 samples

▲ One Hundred and Two, 1950-86, 15 samples

OBSERVATION WELLS

○ Tarkio, SW55

● Tarkio, SW56

□ Nodaway, 7 samples

△ One Hundred and Two, well SW62, 1 sample

Figure 12. Mean water quality in the Tarkio, Nodaway, and One Hundred and Two alluvial aquifers.

obtained from glacial-drift aquifers although, except for buried channels, these aquifers generally are not considered to be sources of large volumes of water.

Loess Aquifer

Loess usually is not considered to be an aquifer in most areas of Iowa because of low permeability. However, loess materials generally are more permeable than underlying glacial-till deposits and allow seepage of water to large-diameter wells at rates that may sustain small withdrawals. The loess is an important source of water for some southwest Iowa rural-domestic and livestock supplies because of its near-surface occurrence and the lack of other acceptable water sources. Most of the southeastern part of the study area has had to depend on these aquifers as a principal source of ground water because other sources of potable water are not economically available. Yields from wells completed in the loess usually produce less than 5 gal/min although 5- to 10-gal/min yields are not uncommon. Only a few well yields of more than 20 gal/min have been reported. No municipal wells are known that use these aquifers.

Water levels in wells in the loess usually represent the water-table surface. The water levels usually are not deep, often less than 20 ft. These shallow water levels are responsive to local precipitation, which is the source of recharge to these aquifers. When excess moisture is available, the aquifer will be recharged, and the water level will rise. During periods of drought, little moisture is available for recharge, and the water level will decline.

The most common type of well that is completed in the loess is a bored well less than 50 ft deep and usually from 12 to 48 in. in diameter. The large diameter provides additional area for seepage of water into the well and also increases the volume of water that is stored within the well bore. The use of multiple wells is a method of obtaining a larger quantity of water for a user. Several shallow wells can be located in an area without causing interference during pumping.

Inter-till Sand and Gravel Aquifers

The inter-till sand and gravel aquifers within the glacial drift are comprised of thin, lenticular, and discontinuous sand or sand and gravel pockets. The location, altitude of the top, and the thickness of the sand and gravel deposits that have been recorded on available geological logs are shown in figure 13. Control points on the map without altitude and thickness data indicate a well location at which no sand or gravel deposits were logged. In general, the thicknesses of sand and gravel deposits, where present, is less than 10 ft. Only a few logs indicate recorded thicknesses greater than 15 ft.

Many rural residents use these inter-till sand and gravel aquifers. Often the yields are small, requiring the use of large-diameter seepage wells. At some locations, larger yields can be obtained, and several municipalities use this type of aquifer, including College Springs, Cumberland, Minden, and Underwood. Their wells are completed at depths from 22 to 156 ft, and well yields vary from 10 to 120 gal/min.

Basal Sand and Gravel Aquifers

The sand and gravel aquifers at the base of the glacial-drift materials are comprised of sand and gravel, intermixed with some silt, which were deposited on the bedrock surface. These deposits are discontinuous, generally on upland areas of the bedrock surface, and range from 1 to 39 ft thick. These aquifers typically are thinner in southwest Iowa than in areas to the north and east of the study area where the sand and gravel deposits in some locations are more than100 ft thick. Most of the aquifer material is fine-to-coarse sand or sand and gravel. The altitude of the top and thickness of basal sand and gravel deposits are shown in figure 14. Control points on the map without altitude and thickness data indicate a well location at which no basal sand or gravel deposits were recorded.

It has been recognized by some geologists and drilling contractors (Darwin Evans, Brian Witzke, Greg Ludvigson, Iowa Department of Natural Resources, Geological Survey Bureau, and D. Weilage, drilling contractor, oral commun., 1987) that there are two distinct types of "sand" present: (1) glacial-derived sand, which contains carbonate grains, and (2) "salt and pepper" sand, which contains volcanic-rock fragments and plagioclase feldspar (Witzke and Ludvigson, 1988). The "salt and pepper" sand may be equivalent to Miocene or Miocene and

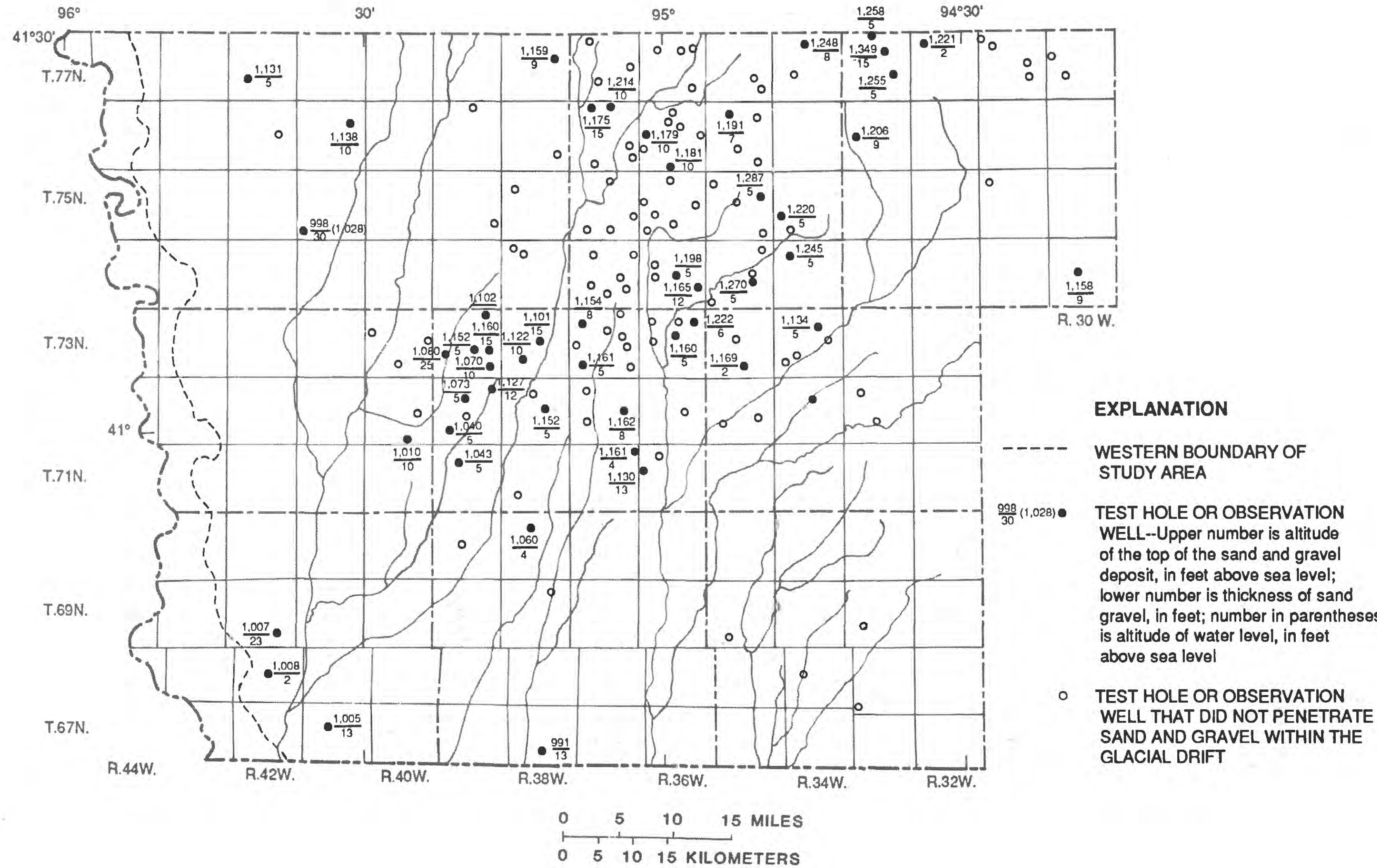


Figure 13. Attitude and thickness of inter-till sand and gravel deposits.

Pliocene strata in Nebraska. For purposes of this report, distinctions between these two units will not be considered because the distribution, physical geometry, and stratigraphic position of the "salt and pepper" sand are only now (1991) being evaluated and older well-log information has not been reevaluated.

The basal sand and gravel aquifers are important sources of water for rural-domestic and livestock supplies and for some municipal supplies. Emerson and Underwood (fig. 14) obtain their water supply from basal sand and gravel deposits. Several other towns have wells completed in these aquifers, but the wells are for standby or occasional use only and are not the main source of supply. Most rural wells in this type of aquifer are reported to yield 10 gal/min or less, but yields as large as 35 gal/min have been reported. About 98,000 gal/d are pumped from these deposits for municipal use. No attempt was made to calculate the potential yield of these aquifers because of the discontinuous nature of the materials and the small quantity of available information. Historical water levels range in altitude from more than 1,200 ft in the northeast to less than 1,000 ft in the west and southwest parts of the study area. Recharge to the aquifers is from leakage through the overlying glacial drift, and locally, some recharge may occur from the underlying Dakota aquifer where present.

Buried-Channel Aquifers

The bedrock surface in southwest Iowa (fig. 15) has been eroded to form uplands and valleys. In places the valleys of present-day streams are superimposed on the bedrock valleys, and exposures of the bedrock surface are present along the valley walls. In other areas, deposits of glacial drift have buried the bedrock valleys. Buried bedrock valleys that contain sand and gravel deposited by streams that flowed before, during, or between glacial advances are productive aquifers in many areas of Iowa and are called buried-channel aquifers.

Two bedrock valleys in southwest Iowa are known to contain sand and gravel deposits that form buried-channel aquifers. Data available for other parts of the study area where bedrock valleys are present indicate that some of these bedrock valleys are filled with fine-grained glacial drift and do not contain buried-channel aquifers. Several bedrock valleys are the upper part of bedrock valleys that contain sand and gravel deposits farther south in Missouri.

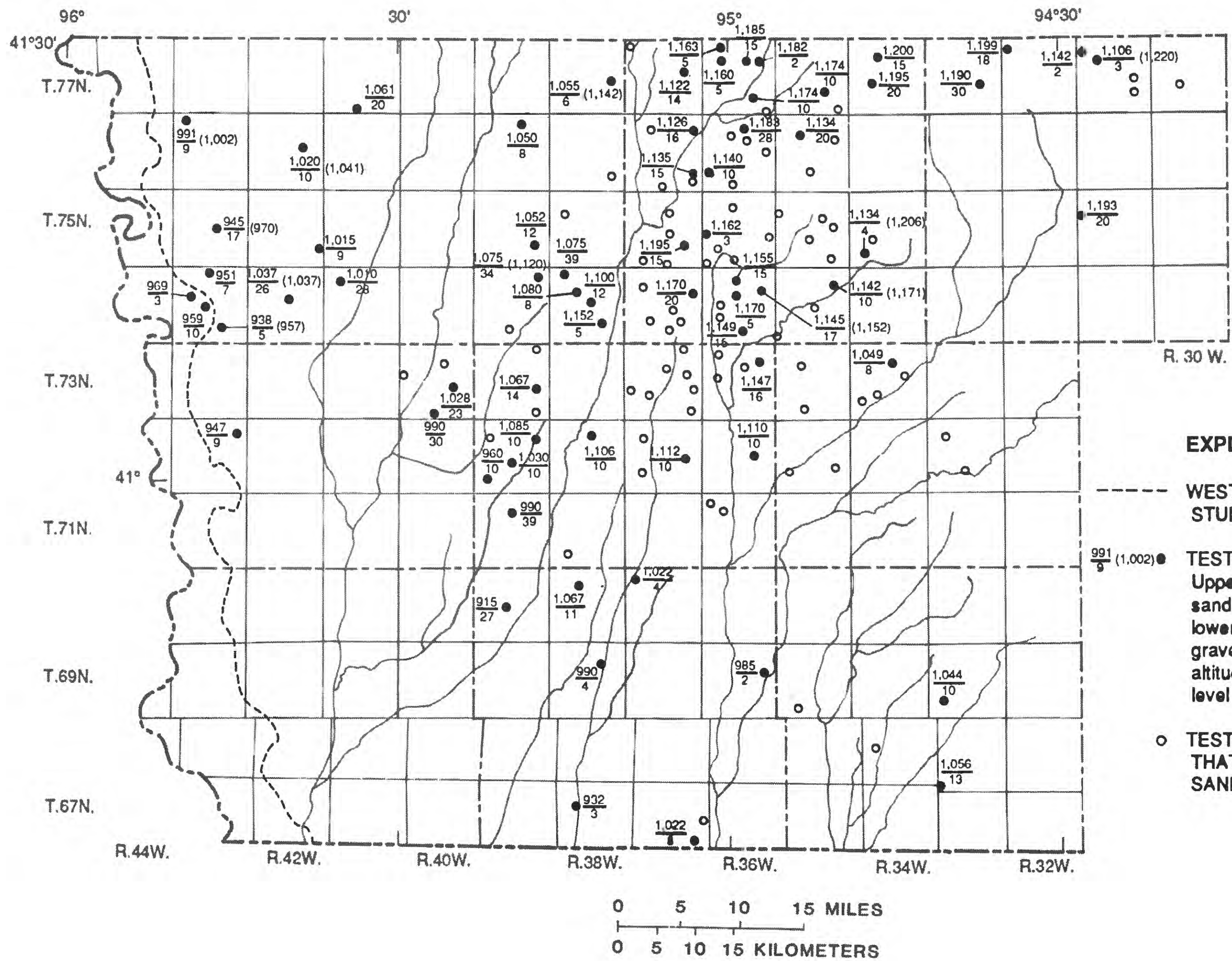
The quantity of aquifer material penetrated by test holes and observation wells in buried-channel areas is variable (fig. 16). The extent and thickness of the aquifer material cannot be predicted based on the limited information available in these areas. Additional exploration is needed to fully define the occurrence and hydraulic properties of these aquifers in southwest Iowa.

The Fremont channel (fig. 16) is the largest and best-known buried channel in southwest Iowa and crosses Pottawattamie, Mills, and Fremont Counties from north to south. It is part of a buried channel beginning in Minnesota north of northwest Iowa and continuing to the southeast through Fremont County into Missouri. The bedrock-contour map (fig. 15) also shows several large tributaries to the Fremont channel and several smaller channels paralleling the main channel.

The main Fremont channel is eroded into the bedrock nearly 200 ft below the altitude of the adjacent bedrock uplands (fig. 15). Logs of wells drilled into the channel indicate that sand and gravel deposits in the channel range from 10 to about 300 ft thick (fig. 16). The deposits generally are thickest in the deepest part of the channel. It is not known if all of the tributary bedrock channels contain sand and gravel deposits.

The potentiometric surface of the Fremont buried-channel aquifer ranges in altitude from 965 ft northwest of Randolph in Fremont County to 1,164 ft south of Hancock in Pottawattamie County. Average altitudes of water levels measured during this study in observation wells SW32, SW37, SW39U, and SW39L indicate that ground water is moving in the aquifer from north to south (table 7).

The sources of recharge to the Fremont buried-channel aquifer are inflow from the north and downward leakage through overlying glacial drift in areas where overlying materials have higher water levels. Some recharge-discharge relations may occur between the basal sand and gravel aquifers and the Fremont buried-channel aquifer. More observation wells would be needed



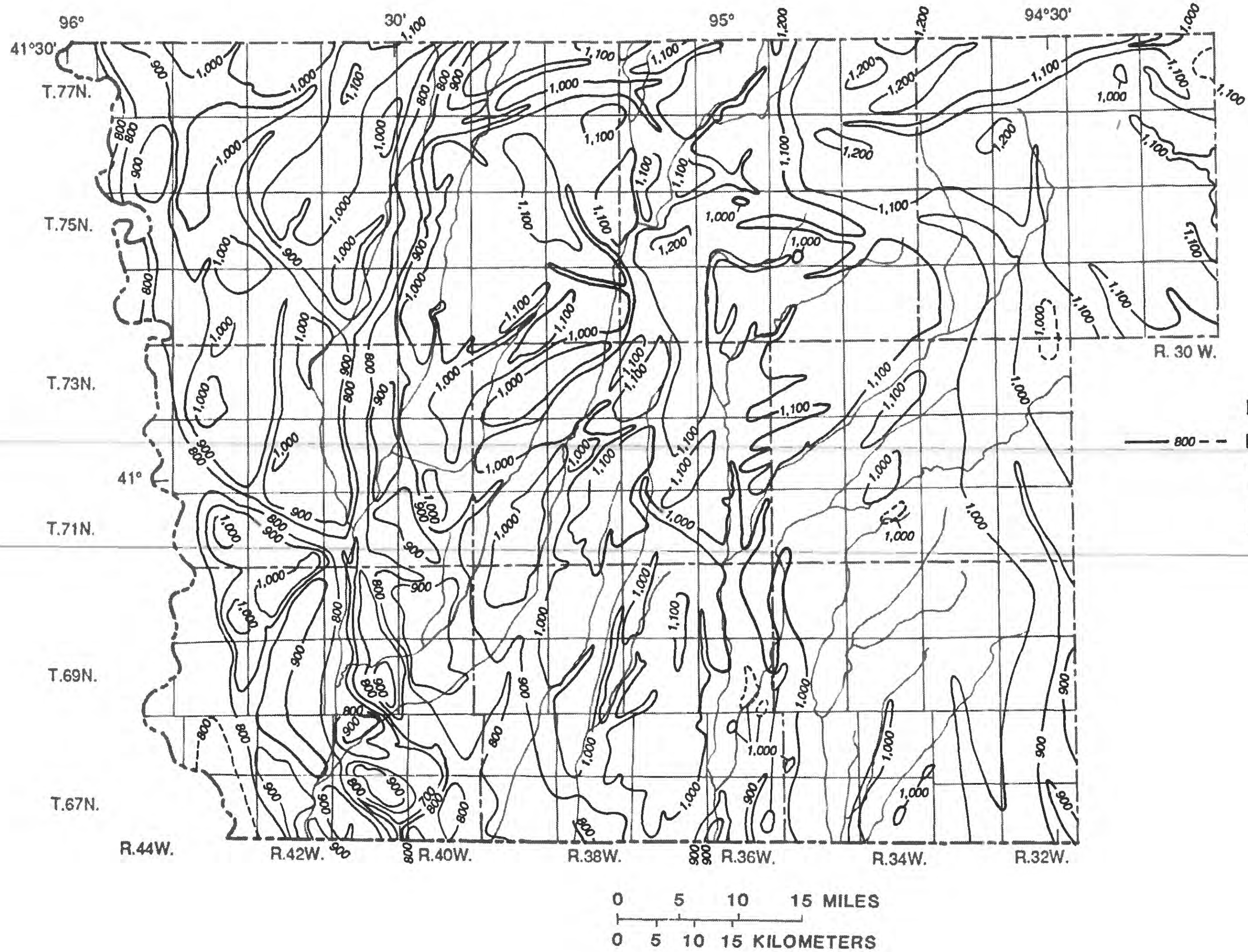
EXPLANATION

- - - - WESTERN BOUNDARY OF STUDY AREA

$\frac{991}{9}$ (1,002) ● TEST HOLE OR OBSERVATION WELL--Upper number is altitude of the top of the sand and gravel, in feet above sea level; lower number is thickness of sand and gravel, in feet; number in parentheses is altitude of water level, in feet above sea level

○ TEST HOLE OR OBSERVATION WELL THAT DID NOT PENETRATE BASAL SAND AND GRAVEL

Figure 14. Altitude and thickness of basal sand and gravel deposits.



EXPLANATION

—— 800 – – BEDROCK CONTOUR--Shows altitude of top of bedrock surface. Dashed where inferred. Contour interval is 100 feet. Datum is sea level

Figure 15. Bedrock topography (modified from Hansen, in press).

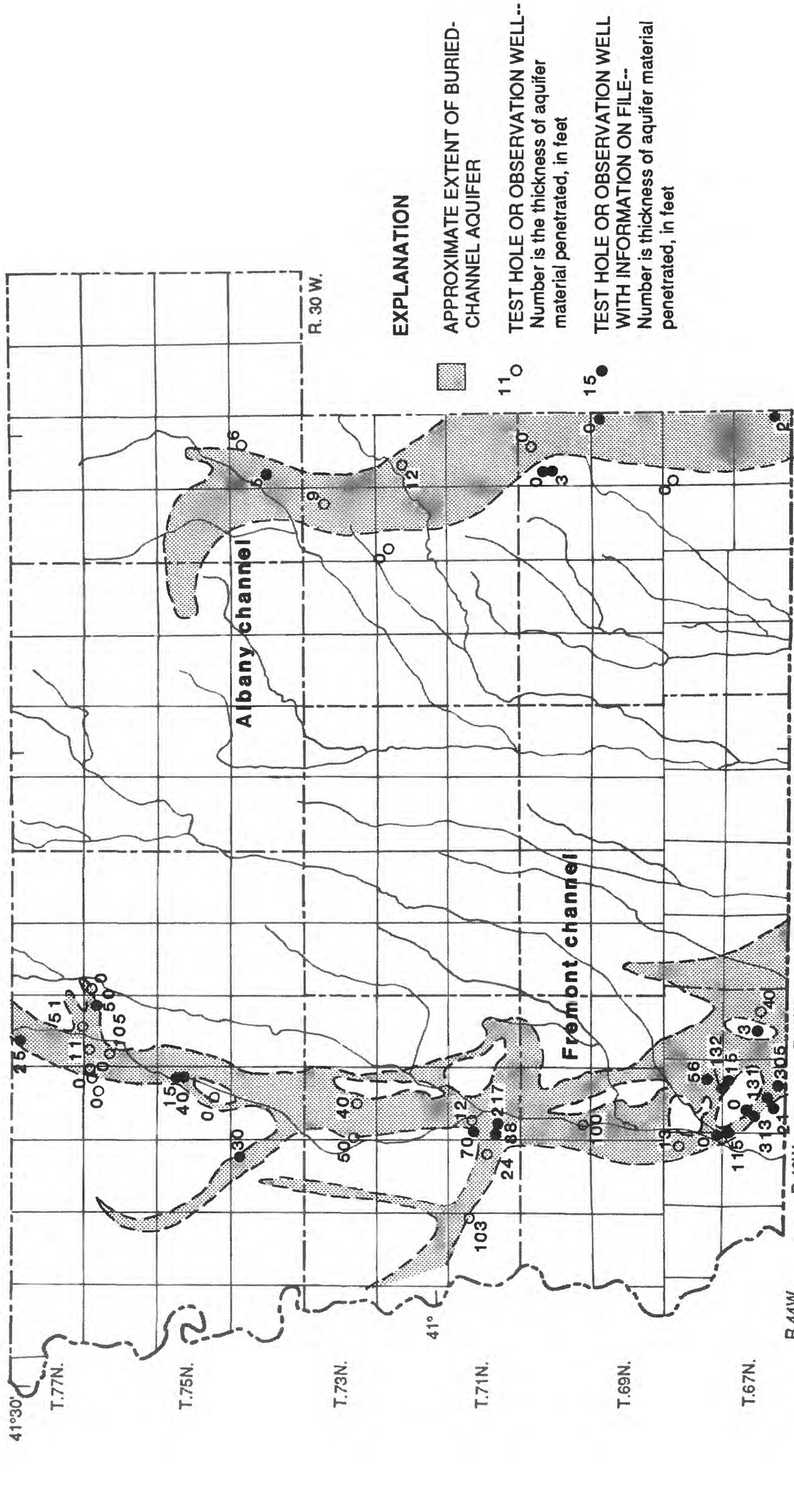


Figure 16. Extent and thickness of the Fremont and Albany buried-channel aquifers.

to determine the movement of water between these aquifers. Because of the discontinuous occurrence of the basal sand and gravel deposits, any exchange of water probably would have only local significance.

Most wells in the Fremont buried-channel aquifer are for rural use; however, the town of Treynor has wells that may be completed in the channel. Wells at Treynor, which range from 220 to 250 ft deep, are pumped at rates between 80 and 150 gal/min. On the basis of information from west-central Iowa (Runkle, 1987), the aquifer has an estimated transmissivity of 520 ft^2/d and possible yields of 800 gal/min. Although large yields are possible, testing usually is required to determine an appropriate yield for a particular area.

The Albany channel (fig. 16) is the upper part of a bedrock valley that contains sand and gravel deposits and extends farther south in Missouri. This valley trends northward from the southeast corner of Taylor County through Adams and into Adair and Cass Counties. Limited data are available for the Albany channel. According to local well drillers, the buried-channel aquifer underlies an area from southern Adair County southward through Taylor County. The existence of extensive sand and gravel deposits in the Albany channel is not indicated by available geologic logs and test-hole data. Previous work in south-central Iowa (Cagle and Heinitz, 1978) supports this conclusion. Sand and gravel deposits from 1 to 15 ft thick have been recorded.

Water levels in the Albany buried-channel aquifer were measured in observation well SW78 (fig. 1; table 7). The altitude of the potentiometric surface in an inter-till aquifer at the same location, well SW83, was 5.35 ft higher than the water level in the Albany buried-channel aquifer on August 8, 1988. This indicates a downward gradient at this location. As in the Fremont buried-channel aquifer, there probably is movement of ground water to the south and out of the area.

The town of Blockton in Taylor County obtains water from a well completed in the Albany buried-channel aquifer. Present pumpage for municipal use is about 15,000 gal/d. The town of Fontanelle in Adair County has a stand-by well completed in the Albany buried-channel aquifer with a reported potential withdrawal rate of 40 gal/min.

Water Quality

Analyses of water samples from the various glacial-drift aquifers (table 11) indicate that water from these aquifers generally is hard. Water from the inter-till and basal sand and gravel aquifers is usually of acceptable quality for most uses. Dissolved-solids concentrations ranged from 176 to 600 mg/L, and sulfate concentrations ranged from 6.0 to 97 mg/L. The water is generally a calcium bicarbonate type. However, water from observation well SW83 (table 8) is an exception. Water from this well is a sodium sulfate type, with a dissolved-solids concentration of 1,900 mg/L and sulfate concentration of 910 mg/L. Iron concentrations have exceeded the secondary drinking-water regulations (table 4) and ranged from less than 10 to 8,000 μg/L. Nitrate concentrations ranged from less than 0.10 to 120 mg/L.

Water in the Fremont buried-channel aquifer ranged from a calcium bicarbonate type to a sodium sulfate type. Dissolved-solids concentrations in samples from the observation wells and the town of Treynor ranged from 312 to 1,410 mg/L, and sulfate concentrations ranged from 20 to 620 mg/L (table 8). Iron concentrations were large and exceeded the secondary drinking-water regulation. Nitrate concentrations generally were small, usually less than 1.0 mg/L. Water in the Albany buried-channel aquifer is very hard with dissolved-solids concentrations ranging from 1,040 to 3,200 mg/L and sulfate concentrations from 240 to 1,900 mg/L (table 11). Iron concentrations generally exceeded the secondary drinking-water regulation. Nitrate concentrations were small, generally less than 0.50 mg/L.

None of the common pesticides were detected in samples from any inter-till, basal sand and gravel, or buried-channel aquifer wells during this study (table 10). There are seven other analyses available for untreated municipal water and six from treated municipal water from these aquifers (M.L. Clark, U.S. Geological Survey, oral commun., 1989). A well at Emerson, completed in the basal sand and gravel aquifer, had a detection of chlordane at 0.10 μg/L during June 1986 from an untreated water sample.

Dakota Aquifer

The Dakota aquifer consists of sandstone units within the Dakota Formation (table 6). In northwestern and west-central Iowa, the Dakota Formation consists of two members--the upper Woodbury Member, comprised of shale and sandstone, and the lower Nishnabotna Member, comprised of sandstone, gravel, and conglomerate. The Nishnabotna Member is the principal unit of the Dakota aquifer in these areas (Munter and others, 1983; Runkle, 1987). In southwest Iowa, the Dakota Formation generally consists of poorly cemented sandstone and gravel (Hershey and others, 1960) of the Nishnabotna Member (Witzke and Ludvigson, 1982).

Occurrence

The Dakota aquifer occurs primarily in Cass and Montgomery Counties (fig. 17). Outliers occur in Adair, Adams, Mills, and Pottawattamie Counties. Generally, identifiable Dakota Formation strata occur on bedrock uplands. In Cass and Montgomery Counties, it appears that the bedrock channels represent areas where the Dakota Formation was eroded. Thus, the Dakota Formation occurs as a group of isolated strata separated by bedrock channels.

The extent of the Dakota aquifer, as shown in figure 17, is different than previously published maps of the Cretaceous rocks in southwest Iowa (Hershey and others, 1960; Hershey, 1969; Witzke and Ludvigson, 1982). Presently (1991) available information indicates that the Dakota aquifer is more dissected and restricted than previously mapped. Interpretation of its extent is difficult because there are many drillers' logs that do not distinguish sand from sandstone. Also, some test holes may have stopped short of penetrating the Dakota aquifer beneath Dakota Formation shale.

The Dakota aquifer varies in thickness from a few feet to 140 ft, although the average thickness in most areas varies between 20 and 60 ft (fig. 17). The maximum probable thickness of the Dakota Formation in southwest Iowa is less than 150 ft because the formation is at the eastern edge of its geographic limit. Also, in several counties north of the study area, the maximum measured thickness is reported to be 150 ft (Runkle, 1987).

The top of the Dakota aquifer is generally at higher altitudes, 1,150 ft to more than 1,200 ft in the north and northeast and at slightly lower altitudes, 1,100 ft to less than 1,050 ft, toward the south and west. The Dakota Formation crops out along some streams in Cass and Montgomery Counties.

The potentiometric surface generally declines from the northeast to the southwest and also toward all major rivers (fig. 18). In northern Montgomery County, anomalously high water levels occur in an area between the East Nishnabotna and Tarkio Rivers. The water level in one well exceeded 1,250 ft, about 150 ft to 200 ft higher than other water levels in this area and adjacent areas of the Dakota aquifer. Yields to wells completed in the Dakota aquifer have been reported as large as 150 gal/min, but more typical values are about 20 gal/min. The hydraulic characteristics of parts of the Dakota aquifer in southwest Iowa are listed in table 15 at the back of this report.

Water Quality

Water from the Dakota aquifer is a calcium bicarbonate type (fig. 19), with magnesium a significant secondary cation and sulfate a significant secondary anion. In samples from municipal wells at Anita, sodium and magnesium are more common secondary cations than in the other samples. Water-quality data from nine municipalities in southwest Iowa using the Dakota aquifer are summarized in table 16 at the back of this report.

Water from the Dakota aquifer is hard to very hard, with total hardness ranging from 112 to 640 mg/L as calcium carbonate (table 16). Sulfate concentrations, although generally less than 50 mg/L, were as large as 430 mg/L in some areas. Only one sample exceeded the secondary drinking-water regulation of 250 mg/L for sulfate (table 3). Dissolved-solids concentrations rarely exceeded the secondary drinking-water regulation of 500 mg/L (table 3), and averaged about 325 mg/L throughout the area. Water from the Dakota aquifer in the Anita area contained larger dissolved-solids concentrations than any other area in southwest Iowa; specific conductance averaged 877 μS/cm (microsiemens

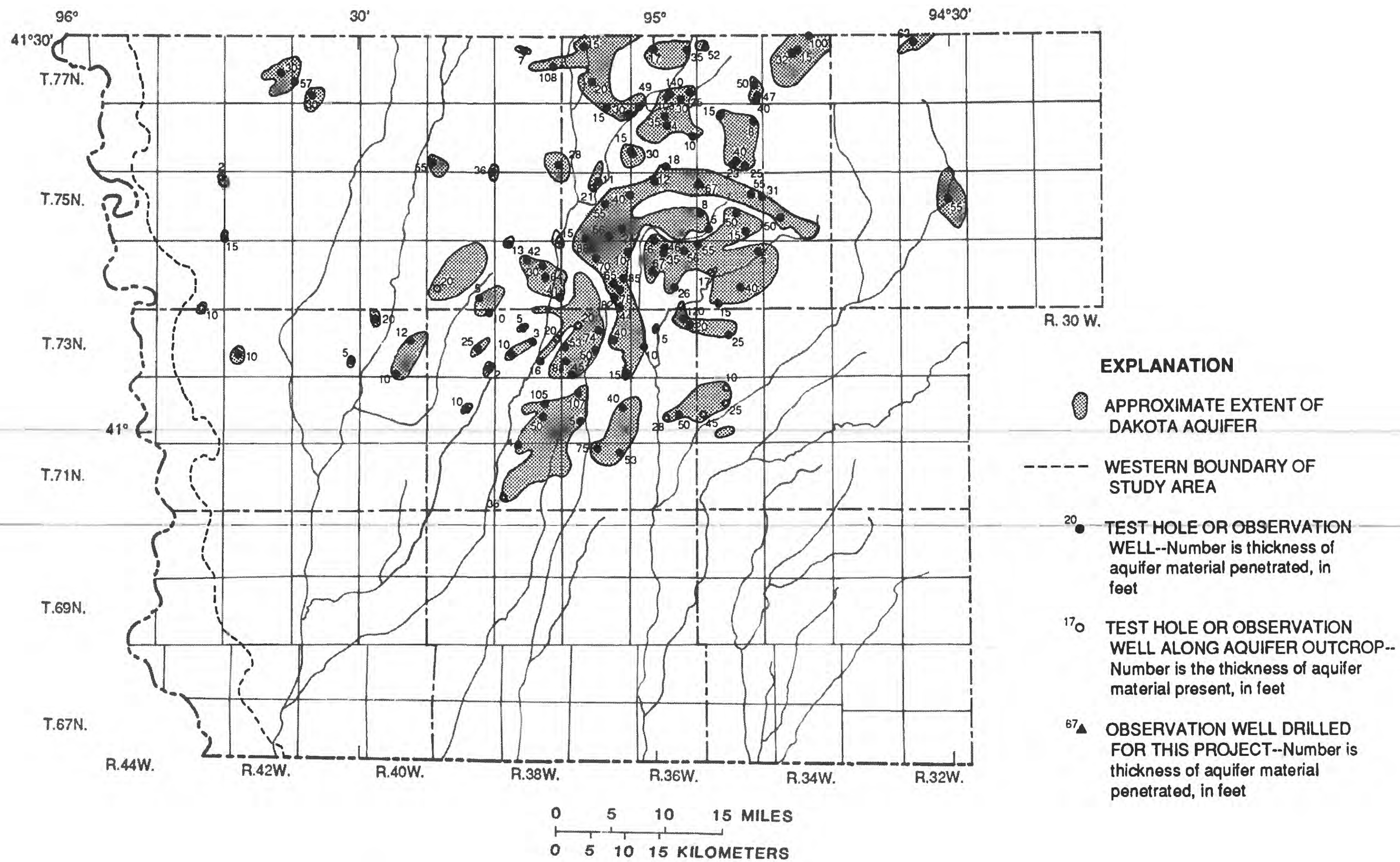


Figure 17. Extent and thickness of the Dakota aquifer.

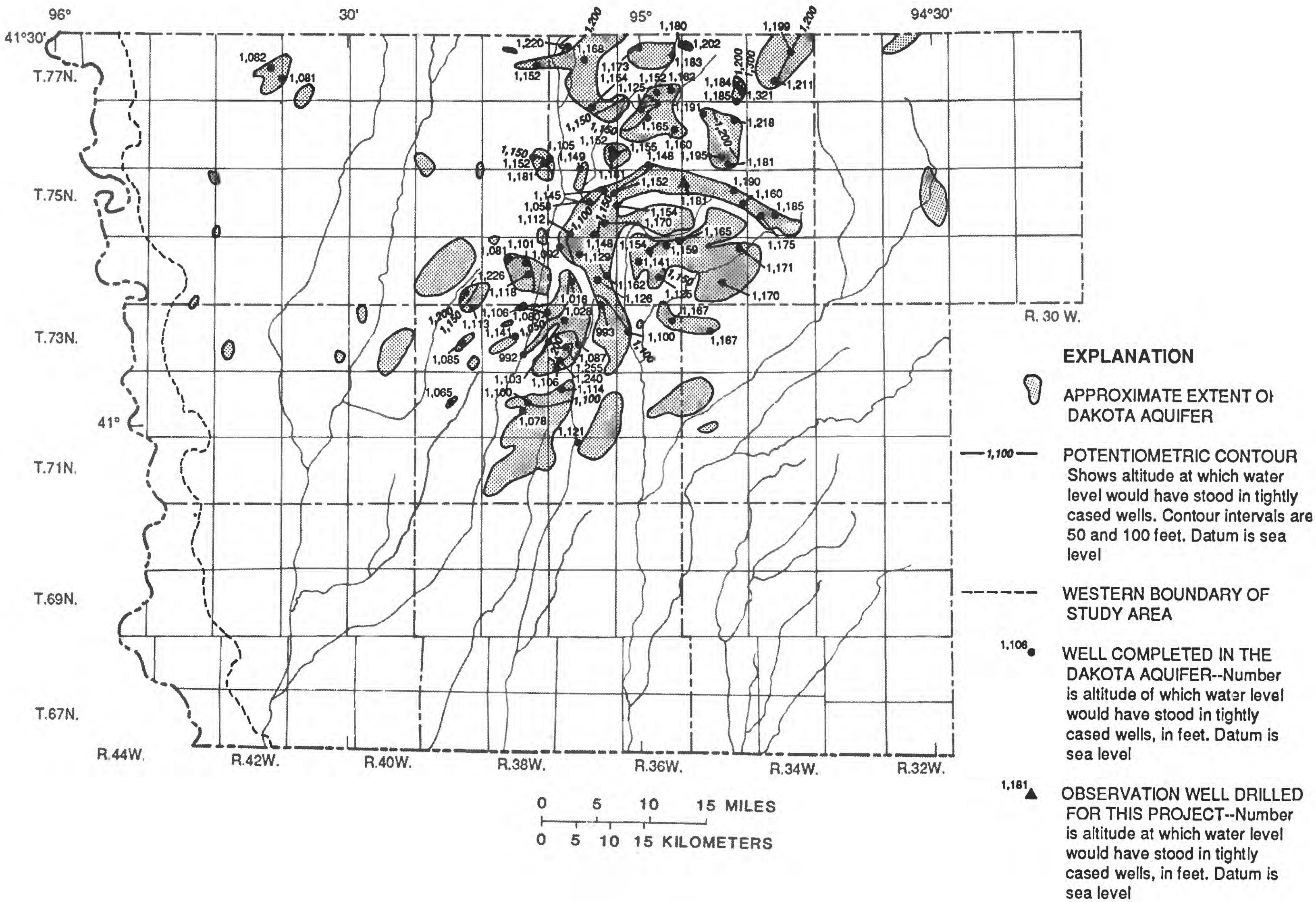
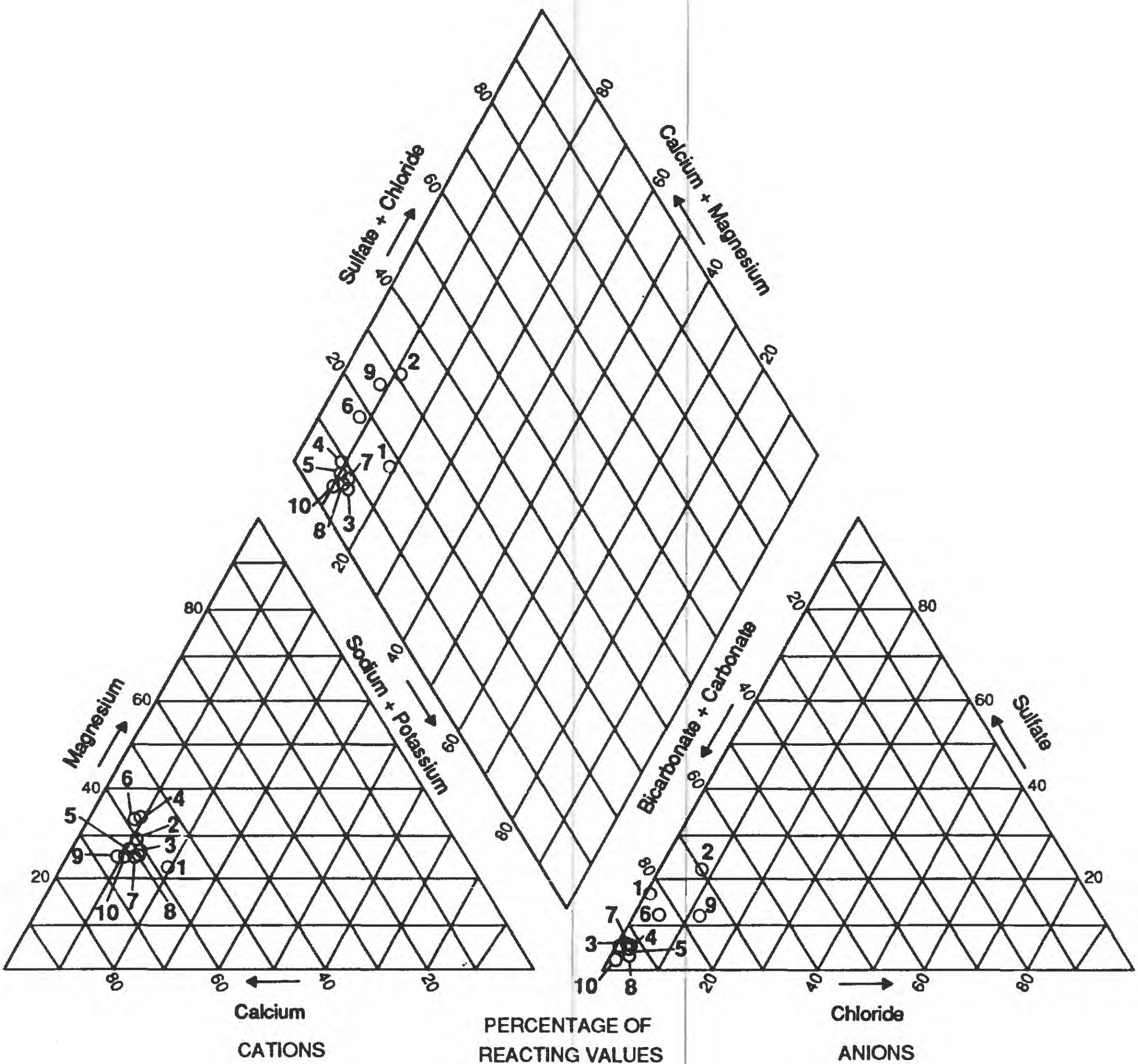


Figure 18. Potentiometric surface of the Dakota aquifer, 1986-88.



EXPLANATION

NUMBER	DAKOTA AQUIFER WELL
1	Anita, 6 samples
2	Atlantic, 52 samples
3	Cumberland, 9 samples
4	Griswold, 11 samples
5	Elliott, 5 samples
6	Neola, 8 samples
7	Red Oak, 20 samples
8	Stanton, 12 samples
9	Wiota, 7 samples
10	Observation well SW17, 1 sample

Figure 19. Historical water quality of the Dakota aquifer, 1950-86.

per centimeter at 25 degrees Celsius), sulfate averaged 162 mg/L, and dissolved-solids concentrations averaged 619 mg/L. Iron exceeded the secondary drinking-water regulations (table 3) in water from wells in four municipalities and ranged from less than 10 to 16,000 μg/L. Nitrate concentrations were about 3 mg/L throughout the area; 7 of 127 reported analyses exceeded the primary drinking-water regulation of 10 mg/L. The largest nitrate concentration reported was 13 mg/L. Atrazine, the only pesticide detected in Dakota aquifer water samples, was detected in a water sample from Atlantic at a concentration of 0.39 μg/L in January 1987. There were no other pesticide detections in10 raw-water samples.

Barium, copper, and zinc were the most common trace elements detected in water from the Dakota aquifer; concentrations ranged from less than 10 to 800 μg/L, less than 10 to 170 μg/L, and less than 10 to 940 μg/L, respectively (table 16 at the back of this report). Concentrations of other trace elements detected included: selenium, 2 samples at the MCL of 10 μg/L; arsenic, 3 samples at 10 μg/L; cadmium, 1 sample at 4 μg/L; and lead, 1 sample at 20 μg/L. The detection level for some of the metals analyzed also is the MCL for drinking water. Radium-226 has been detected, with concentrations ranging from 0.6 to 4.0 pCi/L (picocuries per liter), and radium-228 has been detected, with concentrations ranging from 1.3 to 1.8 pCi/L (table 16).

WATER USE

The major categories of water use in southwest Iowa are municipal, rural domestic, livestock, irrigation, and industrial/commercial (referred to as industrial in this report). Municipal water-use information, which includes rural-water systems, was collected by U.S. Geological Survey personnel from individual water-plant operators where possible or compiled from the files of the Iowa Department of Natural Resources. Estimates of the other water-use quantities were based on the permitted-use quantity or on use rates applied to population estimates. Estimates of the quantity of use for each category are listed in table 17 at the back of this report. Although the date of the annual water-use estimate varies slightly from one category to another, changes in use do not vary substantially from one year to the next, and the data are considered adequate for comparison between the categories for the purposes of this report.

Municipal Use, 1984

Municipal water use is the third largest use of water in southwest Iowa (table 17). The largest municipal use in 1984, about 9.3 Mgal/d, occurred in Pottawattamie County. The smallest use of less than 0.3 Mgal/d in 1984 was in Adams County. Ground-water resources supplied more than 60 percent of the water used for municipal purposes. The location, source, and relative quantity of withdrawal are shown in figure 20. Several municipalities and rural-water systems derive their water from or are located outside the study area. Additional information on the sources of water, population served, average use, and maximum use for each municipality and rural-water system is provided in table 18 at the back of this report.

Total maximum daily water use by municipal and rural-water systems, about 35 Mgal/d, is slightly more than double the average daily water use (table 17). For several communities, maximum water use is reported as four to seven times higher than average use (table 18). Water authorized for municipal use is generally restricted to a maximum of 2,000 gal/d per capita [State of Iowa Administrative Code (567), Ch. 52.2(3)].

Rural Domestic Use, 1984

Rural domestic water use is the quantity of water used by households not served by municipal or rural-water systems. Rural domestic water use (table 17) is estimated at 100 gal/d per capita. Rural domestic water supplies generally are dependent on shallow ground-water sources. In 1984, the largest rural domestic water use, about 1.8 Mgal/d, occurred in Pottawattamie County. This use is larger than the 1984 average municipal water use for seven of the nine counties in the study area.

Livestock Use, 1986

Livestock data are from Iowa Department of Agriculture and Land Stewardship (1987), and livestock water requirements are from Herrick

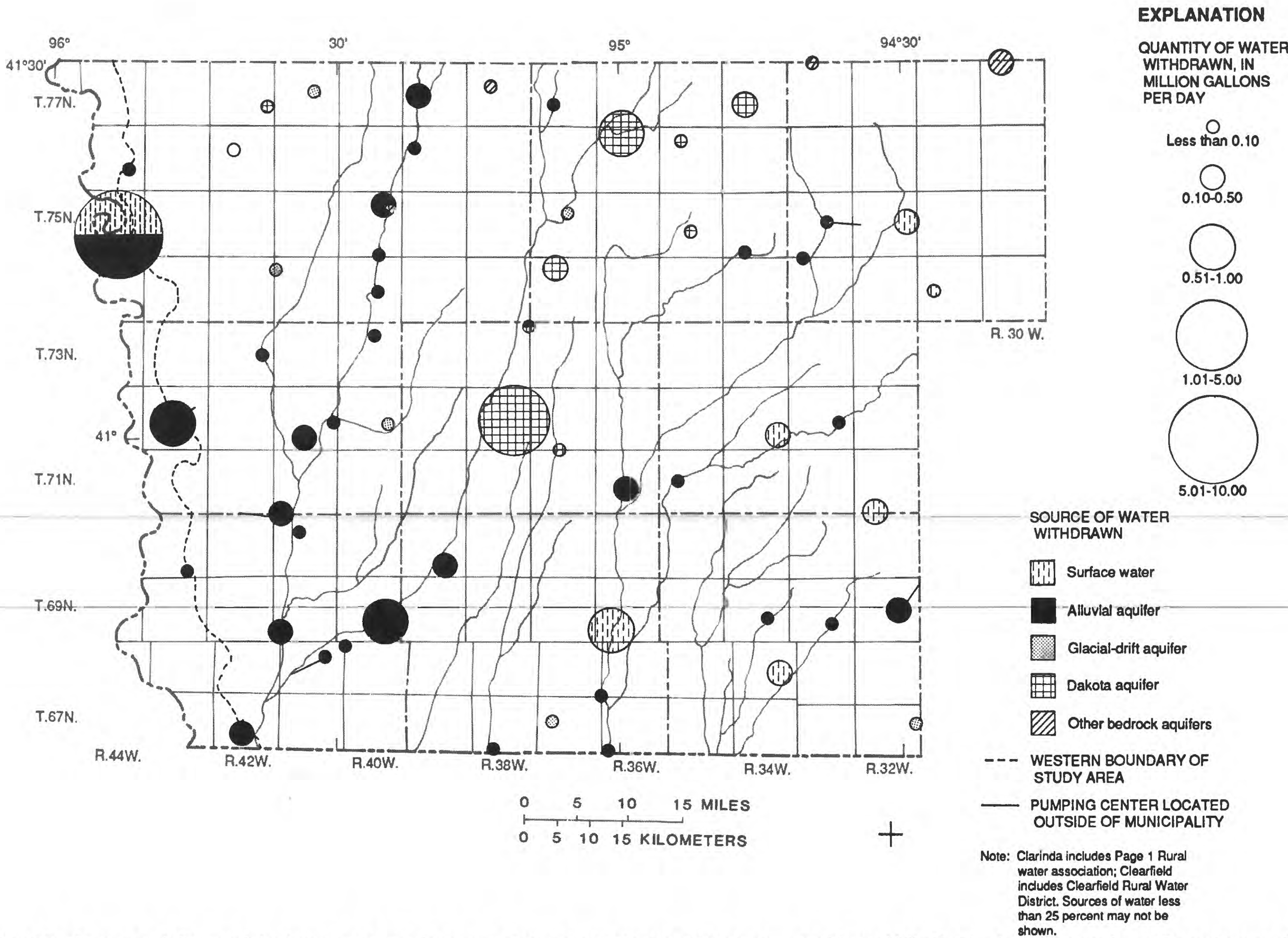


Figure 20. Average daily municipal water use and source of water withdrawn, 1984 (computed from U.S. Geological Survey, Iowa Department of Natural Resources, and various municipal water-supply files).

(1978). Livestock water use (table 17) will vary depending on current farm inventories. During the past few years there has been a decline in farm inventories in Iowa (Iowa Department of Agriculture and Land Stewardship, 1987). Although farm ponds are sources of surface water for some of the livestock population, no attempt was made to categorize these sources. Generally, water for livestock use in southwest Iowa is from shallow ground-water sources.

Permitted Water Use, 1987

Existing water-withdrawal permits for irrigation, industrial (including electric-generation cooling water), commercial feedlots, and miscellaneous uses are listed in table 17. Permits for municipal water supplies are not included. Permitted water use is the maximum quantity of water allowed to be withdrawn. Because actual water-use withdrawals vary yearly for certain categories, permitted water-use data are discussed in the following sections.

Irrigation

Irrigation permits are issued for seasonal withdrawals for general farm crops, such as row crops, small grain, and hay from April 1 to September 30, and specialty crops, such as vegetables, fruits, and sod from April 1 to October 31 [State of Iowa Administrative Code (567), Ch. 52.2(1)a]. General farm crops may be authorized 1 acre-ft, and specialty crops may be authorized 2 acre-ft [State of Iowa Administrative Code (567), Ch. 52.2(1)b].

In southwest Iowa, 75 percent or 20.3 Mgal/d of water permitted for irrigation use comes from ground water. Approximately 97 percent of the ground water used for irrigation, 19.6 Mgal/d, is derived from alluvial aquifers along the principal rivers, primarily the Missouri River. This quantity is nearly double the quantity of water used by municipal systems and industrial permits from alluvial aquifers (table 17).

Industrial

The permitted industrial use of water is predominantly from surface-water resources (83 percent of the total industrial use). Use of surface water for industrial purposes occurs mainly in Adair, Adams, Cass, Page, and Pottawattamie Counties. Ground water for industrial purposes is used mainly in Pottawattamie County.

Commercial Feedlots

Feedlots are permitted commercial water users. Water used by feedlots was subtracted from the total permitted water use in calculating total water use to prevent counting water used by livestock twice. Commercial feedlots account for about 8 percent of total livestock water use in the study area (table 17).

Miscellaneous

The principal miscellaneous permitted water user in the nine-county area is the Iowa Department of Natural Resources, which has a permitted use for recreational purposes of 9.13 Mgal/d or 87 percent of this category. The quantity of water authorized for recreational and also other purposes is determined on the basis of the proposed use [State of Iowa Administrative code (567), Ch. 52.2(4)].

Total Water Use

Total water use in southwest Iowa is about 91.8 Mgal/d (table 17). The largest use is for irrigation, 26.9 Mgal/d. Pottawattamie County uses 35 percent of the total water in southwest Iowa and more than twice as much water as the next largest water user, Fremont County. The proportion of total water use in southwest Iowa for each category of use is shown in figure 21. The proportion of total water use in each county for each category of use is shown in figure 22.

Domestic use, including municipal- and rural-water systems and rural domestic use, accounts for about 22.0 Mgal/d or 24 percent of total water use in southwest Iowa. Livestock use accounts for 10.3 Mgal/d or 11.2 percent of total water use; 26.9 Mgal/d or 29.4 percent of the total water use is for irrigation; 22.1 Mgal/d or 24 percent of the total use is for industrial use; and about 10.5 Mgal/d or 11.4 percent of the total use is for miscellaneous permitted water uses, primarily recreation. More than 55 percent or 51.2 Mgal/d of the total water use in southwest Iowa is from ground-water sources if livestock are assumed to be totally dependent on ground-water sources.

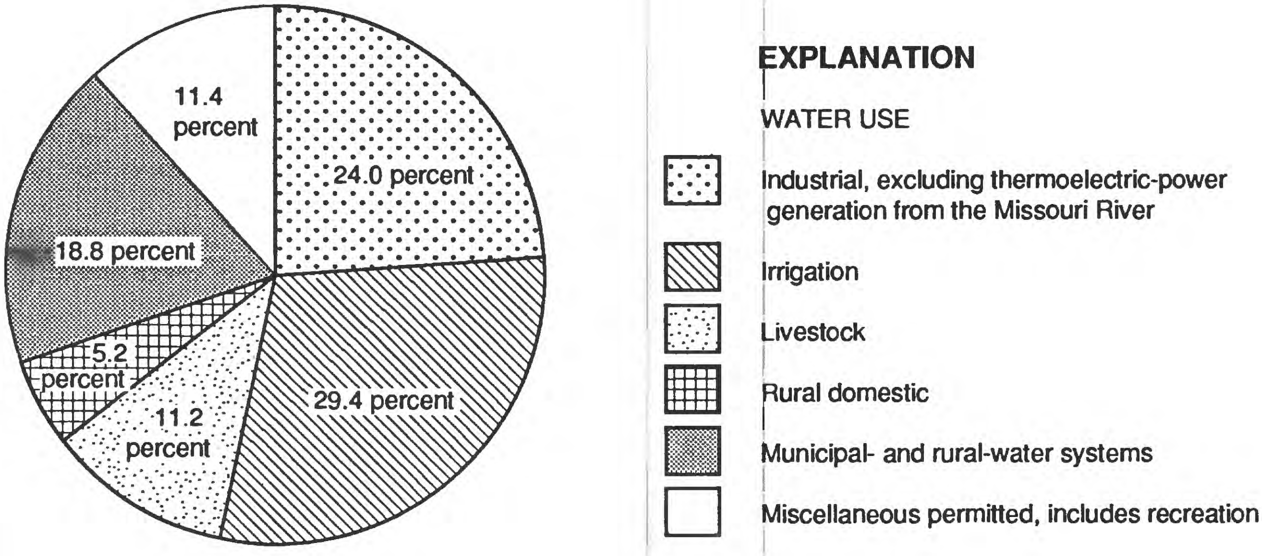


Figure 21. Total water use (compiled from U.S. Geological Survey, Iowa Department of Natural Resources, and various municipal water-supply files).

Surface Water

Surface-water use within the study area accounts for 34.4 Mgal/d or 44.3 percent of total water use. These uses are irrigation, 6.6 Mgal/d or 7.2 percent of the total use; industrial, 18.3 Mgal/d or 19.9 percent of the total use; miscellaneous, 9.3 Mgal/d or 10.1 percent; and commercial feedlots, 0.2 Mgal/d or less than 1 percent of the total use. Additionally, municipal- and rural-water systems using surface water account for 6.3 Mgal/d or 6.9 percent of all water used in the study area. Rural domestic and livestock are not substantially dependent on surface-water sources, although livestock use of farm ponds does occur.

Ground Water

Municipal- and rural-water systems using ground water account for 10.9 Mgal/d or 11.9 percent of total water use in the study area, and permitted irrigation, industrial, and miscellaneous ground-water use accounts for 25.2 Mgal/d or 27.5 percent of total water use. It is assumed that rural domestic, which accounts for 4.8 Mgal/d, and livestock, which accounts for 10.3 Mgal/d (5.2 and 11.2 percent of the total water use), are substantially dependent on ground-water sources.

Alluvial aquifers are the most important source of ground water in the study area. Alluvial sources supply approximately 97 percent or 19.6 Mgal/d of permitted ground water used for irrigation; 100 percent or 3.8 Mgal/d of the permitted ground water for industrial use; about 34 percent or 0.23 Mgal/d of permitted ground water for commercial feedlots; and about 98.6 percent or 1.15 Mgal/d of permitted ground water for miscellaneous uses. About 44 percent, 7.6 Mgal/d, of the municipal- and rural-water system use of ground water is derived from alluvial aquifers.

The Dakota aquifer is mainly used for domestic and municipal water supplies. Although nine municipalities rely on the Dakota aquifer, in part, for their water supplies (table 18), Red Oak and Atlantic are the principal users

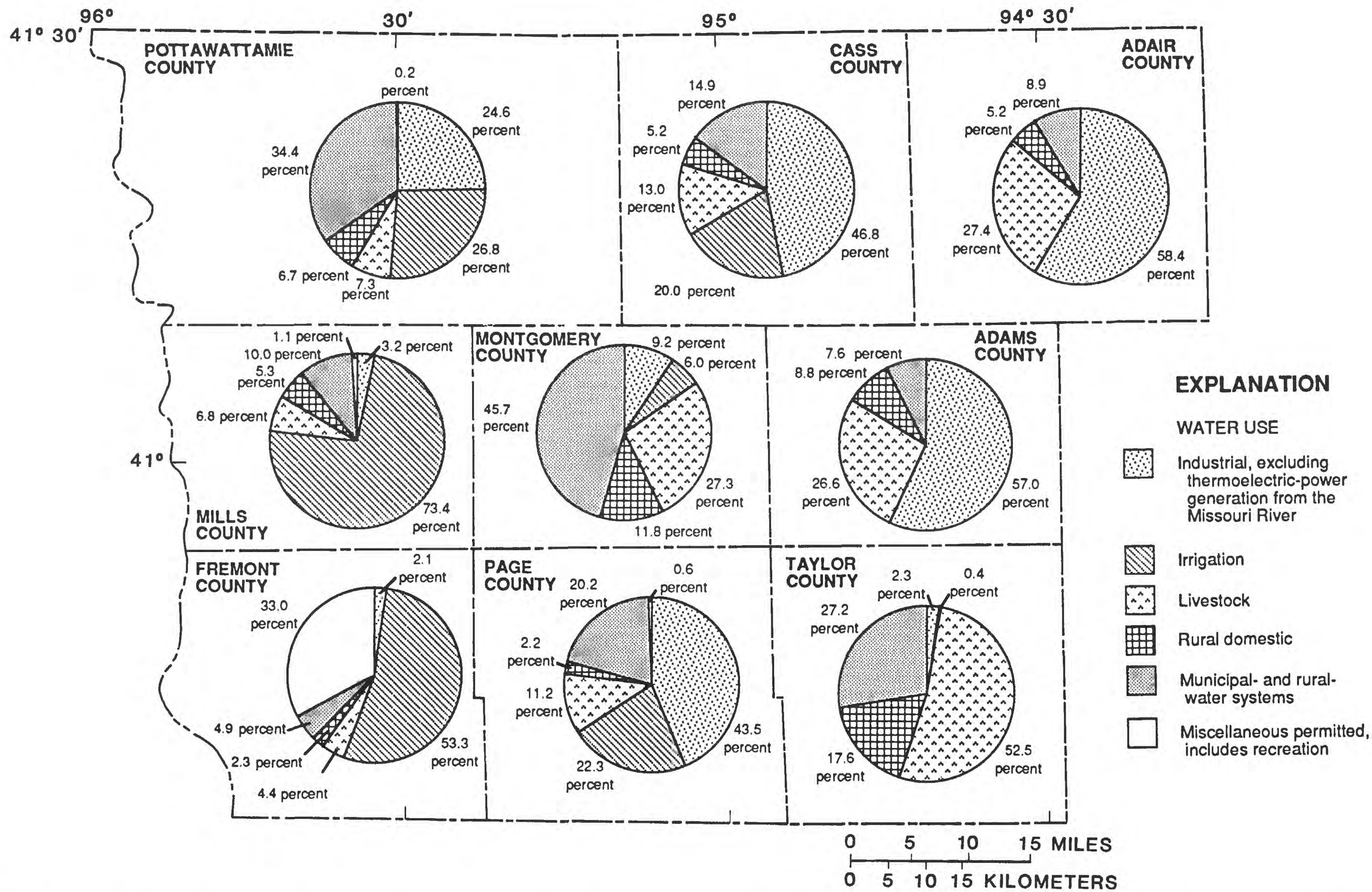


Figure 22. Total water use by county (compiled from U.S. Geological Survey, Iowa Department of Natural Resources, and various municipal water-supply files).

of the Dakota aquifer with withdrawals of about 1 Mgal/d each. Total municipal water use from the Dakota aquifer is 2.63 Mgal/d, which is about 3 percent of total water use.

Future Water Demands

Future demands for water in the study area probably will be met by increased use of surface-water sources and alluvial aquifers, particularly the Missouri River alluvial aquifer. The users that are already dependent on the Dakota aquifer will continue to rely on it. There may be some slight shift for the rural domestic and livestock users to use buried-channel deposits if these sources become better known, can provide adequate yields, and have acceptable water quality.

SUMMARY

Residents in southwest Iowa rely on shallow ground-water sources because of unacceptable water quality in deeper aquifers. These shallow aquifers are of limited extent, the water levels and thus the quantity of water in storage, are affected by climatic variations, and the aquifers are susceptible to contamination. Analyses of samples from private water wells from 1981 to 1986 indicate that wells in southwest Iowa have larger nitrate concentrations than wells in other parts of the State. An appraisal of the ground-water resources of a nine-county area in southwest Iowa was done to provide information needed to plan the development of the shallow water resources. Five types of unconsolidated aquifers and one bedrock aquifer were investigated.

Alluvial aquifers, comprised of sand and gravel, are present in the major river valleys. Four alluvial aquifers were investigated--the Nishnabotna, Nodaway, Tarkio, and One Hundred and Two. Alluvial deposits in southwest Iowa usually consist of a series of fine-grained deposits overlying sand and gravel.

The Nishnabotna alluvial aquifer is the most used source for municipal and domestic water. The alluvial deposits are variable; the average thickness of the fine-grained materials is 21 ft, overlying an average thickness of 17 ft of sand and gravel. Transmissivities range from 1,000 to 8,000 ft^2/d, and most wells are capable of yielding as much as 100 gal/min of water.

Water in the Nishnabotna alluvial aquifer is a calcium bicarbonate type. Nitrate concentrations are variable and have exceeded the MCL in samples from several municipal wells. Iron concentrations greater than the secondary drinking-water regulation of 300 μg/L are common. Pesticides were detected in water from nine municipal wells; none were detected in water from observation wells. Five pesticides were detected; concentrations for all pesticides except alachlor were less than proposed regulations.

The Nodaway alluvial aquifer also is an important source of water, although less used than the Nishnabotna alluvial aquifer. The average thickness of the fine-grained alluvial sediments is about 20 ft, overlying an average thickness of about 10 ft of sand and gravel. Transmissivities range from 90 to 570 ft^2/d, and yields range from 12 to 100 gal/min.

Water in the Nodaway alluvial aquifer is a calcium bicarbonate type. Nitrate concentrations generally are less than in the Nishnabotna alluvial aquifer. Iron concentrations commonly exceeded the secondary drinking-water regulation. One municipal well had detectable concentrations of two pesticides.

The other two alluvial aquifers, the Tarkio and the One Hundred and Two, are used less. Their limited areal extent and thin sand and gravel deposits limit their productivity to yields generally less than 50 gal/min. Both aquifers contain calcium bicarbonate type water. Nitrate concentrations are small, generally less than 1.0 mg/L. Pesticides have been detected in samples from municipal wells completed in each aquifer.

There are four types of glacial-drift aquifers in southwest Iowa--loess, inter-till sand and gravel, basal sand and gravel, and buried-channel sand and gravel. Except for buried channels, these aquifers are discontinuous and distributed locally. Wells completed in loess and inter-till sand and gravel are used by rural residents, who commonly use large-diameter seepage wells to obtain water from these low-yield sources. The inter-till and basal sand and gravel aquifers are used by a few municipalities. Yields to wells screened in these aquifers are variable. Loess wells typically yield less than 10 gal/min, and inter-till and basal sand and gravel aquifers yield from 10 to 120 gal/min.

There are two buried-channel aquifers in the study area--the Fremont and Albany. The Fremont buried-channel aquifer is the most extensive and contains sand and gravel deposits about 300 ft thick. The Albany buried-channel aquifer is less extensive, with thinner sand and gravel deposits. Only one municipality relies on water from a buried-channel aquifer; the town of Blockton in Taylor County has a well in the Albany buried-channel aquifer. Well yields from these buried-channel aquifers range from 40 to 150 gal/min.

Water from the loess and inter-till and basal sand and gravel aquifers is normally a calcium bicarbonate type. Nitrate concentrations in some samples exceeded the MCL. Iron concentrations have exceeded the secondary drinking-water regulation. No agricultural pesticides were detected; however, chlordane was detected in water from one municipal well completed in the basal sand and gravel aquifer.

Water in the buried-channel aquifers ranged from a calcium bicarbonate type to a sodium sulfate type. Sulfate, dissolved-solids, and iron concentrations in some samples exceeded the secondary drinking-water regulations. Nitrate concentrations were small, usually less than 1.0 mg/L, and no pesticides were detected in samples collected during this study.

The Dakota aquifer was the only bedrock aquifer investigated. In southwest Iowa, the Dakota aquifer exists as isolated outliers, primarily in Montgomery and Cass Counties. The thickness of the aquifer is variable, averaging between 20 and 60 ft. Yields to Dakota aquifer wells are quite variable. Water from the aquifer is a calcium bicarbonate type. Sulfate and dissolved-solids concentrations rarely exceeded the secondary drinking-water regulations, whereas iron concentrations often exceeded the secondary drinking-water regulation. Nitrate concentrations were small, usually about 3.0 mg/L, and pesticides were detected at only one municipal well.

Water-use statistics were tabulated for each county in southwest Iowa. Municipal- and rural-water systems rely primarily on surface water (37 percent), alluvial aquifers (44 percent), and the Dakota aquifer (15 percent). Rural residents rely on the alluvial and glacial-drift aquifers, although actual use data are not available.

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Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*

[Stratigraphic names and descriptions are those of the Iowa Department of Natural Resources; DDMMSS, degrees minutes seconds; U, shallow well at site; L, deep well at site; all well casing is 2-inch-diameter polyvinyl-chloride pipe]

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW1	**W-27553**	**67-41-17ADCC**	**403709-0953406**	**1,085**	**Fremont**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	3	No sample
	3	to	7	Silt, orange-brown, very argillaceous
	7	to	15	Silt, pale yellow, slightly argillaceous
	15	to	20	Silt, orange, very argillaceous
	20	to	30	Silt, maroon-orange
Pleistocene deposits	30	to	33	Till, orange, oxidized, leached
	33	to	33	Till, orange, oxidized, leached
	33	to	43	Till, orange-yellow, oxidized, leached
	43	to	45	Sand, colorless and varicolored, coarse to fine
	45	to	65	Till, yellow, oxidized, unleached
	65	to	73	Till, orange-brown, oxidized, unleached
	73	to	80	Till, light olive-gray, unoxidized, unleached
	80	to	94	Sand, colorless and varicolored, coarse to fine, subrounded, quartz; gravel, quartz, and metamorphic rock

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW2	**W-27554**	**67-41-20CDDD**	**403600-0953427**	**1,135**	**Fremont**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	10	Silt, yellow, argillaceous
	10	to	15	Silt, very light yellow, argillaceous
	15	to	20	Silt, yellow-orange, argillaceous
	20	to	26	Silt, gray-yellow, argillaceous
	26	to	30	Silt, pale maroon, argillaceous
	30	to	50	Silt, orange, argillaceous
	50	to	70	Silt, light orange-gray, very argillaceous
Pleistocene deposits	70	to	74	Till, orange, oxidized, leached
	74	to	108	Sand, colorless, varicolored, medium to fine and coarse, subrounded to subangular
	108	to	110	Till, dark green-gray, unoxidized, unleached
	110	to	122	Till, light olive-gray, unoxidized, unleached
	122	to	125	Till, light yellow, oxidized, leached
	125	to	131	Silt, very light yellow-orange, calcareous

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW2--Continued				
Pleistocene deposits--Continued	131	to	132	Silt, very light yellow-orange, calcareous; limestone, very light gray
	132	to	140	Silt, very light yellow-orange, calcareous, argillaceous
	140	to	155	Silt, very light yellow-orange, calcareous, argillaceous, trace sand
	155	to	164	Till, light gray, unoxidized, unleached
	164	to	169	Sand, colorless, varicolored, trace dark grains
Pennsylvanian rocks, undifferentiated	169	to	174	Dolostone, very light yellow-gray to gray, silty, sandy, calcareous, micaceous
	174	to	176	Shale, green-gray, lumpy, soft, micaceous, calcareous
	176	to	180	Siltstone, green-gray, argillaceous
	180	to	190	Shale, gray, silty, calcareous, with micaceous partings
	190	to	191	Limestone, gray, silt-grade, argillaceous
	191	to	192	Shale, gray, with limestone nodules
	192	to	193	Shale, very dark gray, blocky, carbonaceous
	193	to	197	Shale, green, blocky, silty
	197	to	199	Shale, gray, very light gray, lumpy
	199	to	201	Shale, very light gray, very dark gray, lumpy, silty, calcareous

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW3	**W-27555**	**67-41-30ABBB**	**403558-0953533**	**1,040**	**Fremont**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	No sample
	5	to	15	Silt, argillaceous, calcareous
	15	to	20	Silt, light yellow, argillaceous
	20	to	60	Silt, orange, argillaceous
	60	to	67	Silt, pale maroon, argillaceous
Cretaceous rocks Dakota Formation	67	to	75	Sand, colorless, orange, medium to fine and coarse, subrounded to angular
	75	to	78	Silt, orange-gray, argillaceous
Pennsylvanian rocks, undifferentiated	78	to	80	Shale, gray, slightly silty
	80	to	90	Shale, gray, lumpy
	90	to	99	Shale, gray, lumpy, slightly calcareous
	99	to	101	Shale, gray, lumpy, slightly calcareous, with limestone nodules

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)	Description
SW3--Continued		
Pennsylvanian rocks, undifferentiated--Continued	101 to 104	Siltstone, very light green, argillaceous, calcareous
	104 to 112	Siltstone, very light green, very argillaceous, calcareous
	112 to 120	Shale, green-gray, very silty, calcareous
	120 to 121.5	Limestone, green-gray, silty, very argillaceous
	121.5 to 122.5	Shale, dark, blocky
	122.5 to 128	Shale, very light green, lumpy, silty
	128 to 133	Shale, very light green, lumpy, silty, slightly calcareous
	133 to 140	Shale, very light green, lumpy, silty, calcareous

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW4	**W-27556**	**67-41-20CDDD**	**403600-0953427**	**1,138**	**Fremont**

Note: This is a rock core reposited at the Iowa Department of Natural Resources, Geological Survey Bureau.

Stratigraphic unit	Depth interval (feet)	Description
Pleistocene deposits	0 to 55	Peorian loess
	55 to 75	Loveland loess
	75 to 80	Till, oxidized, leached
	80 to 109	Sand and gravel
	109 to 111	Till, oxidized, unleached
	111 to 128	Till, unoxidized, unleached
Tertiary deposits	128 to 135.5	Clay, medium brown-gray, light medium brown-gray, very silty, slightly sandy; sandstone, very fine; siltstone
	135.5 to 151.5	Clay, silty
	151.5 to 155	Siltstone, clay
	155 to 166	Silt
	166 to 170	Silt
	170 to 174	Sand
Pennsylvanian rocks	174 to 1,116	Description available from: Iowa Department of Natural Resources, Geological Survey Bureau 123 N. Capitol St. Iowa City, IA 52242

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW5	**W-27704**	**67-40-14ADDD**	**403712-0952305**	**1,080**	**Fremont**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Fill and topsoil (driller's log)
	5	to	8	Clay, medium dark gray, silty
	8	to	10	Clay, brown-gray, silty
	10	to	20	Clay, gray, silty
	20	to	25	Silt, light gray, very argillaceous
	25	to	30	Silt, light gray, very argillaceous, with trace sand
Pleistocene deposits	30	to	34	Till, brown, oxidized, leached
	34	to	40	Silt, medium light gray, argillaceous, calcareous; till, gray, unoxidized, unleached, sandy
	40	to	43	Silt, gray, sandy, calcareous
	43	to	60	Till, gray, unoxidized, unleached
	60	to	65	Till, blue-gray (driller's log)
	65	to	80	Till, gray, unoxidized, unleached
	80	to	90	Till, blue-gray, softer, sandy
	90	to	110	Till, gray, unoxidized, unleached, subrounded, coarse to fine; shale, gray and green-gray, silty, sandy; limestone, gray, silt-grade
	110	to	120	Till, light olive-gray, unoxidized, unleached
	120	to	130	Till, medium dark gray, unoxidized, unleached
	130	to	150	Till, gray, unoxidized, unleached
	150	to	180	Till, light olive-gray, unoxidized, unleached
	180	to	200	Till, light olive-gray, unoxidized, unleached, sandy, gravelly
	200	to	250	Till, gray, unoxidized, unleached
	250	to	254	Till, light olive-green, unoxidized, unleached
	254	to	277	Till, gray, unoxidized, unleached
	277	to	300	Sand, colorless, orange, pink, yellow, dark, coarse to fine, subrounded, slightly silty, quartz
	300	to	317	Sand, colorless, orange, pink, yellow, dark, coarse to fine, subrounded, slightly silty, partly argillaceous, quartz
Pennsylvanian rocks, undifferentiated	317	to	320	Shale, gray, silty, sandy, calcareous
	320	to	323	Sandstone, colorless, trace pink and dark, subrounded, coarse to fine; shale, light gray, silty, sandy; gravel, very calcareous
	323	to	330	Sandstone, colorless, trace pink and dark, subrounded, coarse to fine; shale, gray and green-gray, silty, sandy
	330	to	331	Sandstone, colorless, trace pink and dark
	331	to	332	Shale, gray, silty, blocky, calcareous; trace limestone

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW5--Continued				
Pennsylvanian rocks, undifferentiated--Continued	332	to	335	Shale, gray, silty, sandy, blocky, calcareous
	335	to	337	Shale, medium dark gray, silty, sandy, calcareous
	337	to	339	Shale, medium dark gray, silty, sandy, calcareous; limestone, gray, dolomitic
	339	to	340	Limestone, gray; shale, gray, lumpy
	340	to	342	Limestone, gray; shale, dark, micaceous

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW6	**W-27705**	**67-40-30CBBB**	**403524-0952914**	**1,040**	**Fremont**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Topsoil and clay, brown, silty (driller's log)
	5	to	13	Silt, dark orange, argillaceous
	13	to	15	Sand, dark orange, oxidized, leached, argillaceous, silty
	15	to	20	Sand, yellow, argillaceous, silty
Pleistocene deposits	20	to	22	Sand, medium to fine and coarse
	22	to	25	Till, orange, oxidized, unleached, with quartz and 5 percent heavy grains
	25	to	27.5	Sand, clear, orange, pink, and dark, medium to fine
	27.5	to	34	Till, yellow, oxidized, unleached
	34	to	60	Till, gray, unoxidized, unleached
	60	to	65	Till, gray, unoxidized, unleached, sandy
	65	to	75	Sand, colorless and varicolored, fine, silty, quartz; gravel; metamorphic rocks; limestone
	75	to	80	Till (driller's log)

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW7	**W-27706**	**67-41-25AAAA**	**403551-0952918**	**1,075**	**Fremont**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	7	Roadbed (driller's log)
Quaternary deposits	7	to	20	Silt, dark orange, argillaceous
	20	to	24	Silt, orange, argillaceous
	24	to	40	Silt, light orange, argillaceous
	40	to	49	Silt, light orange, argillaceous, with trace sand
Pleistocene deposits	49	to	52	Till, dark orange, oxidized, unleached
	52	to	60	Till, gray, unoxidized, unleached, with trace till, orange, oxidized
	60	to	131	Till, light olive-gray, unoxidized, unleached
	131	to	133	Gravel, colorless; sand, coarse, subrounded
	133	to	150	Till, gray, unoxidized, unleached
	160	to	170	Till, light olive-gray, unoxidized, unleached
	170	to	190	Till, medium light gray, unoxidized, unleached
	190	to	200	Till, medium light gray, unoxidized, unleached, with trace till, orange, oxidized, unleached
	200	to	211	Sand, colorless, trace orange, medium to fine and coarse
	211	to	220	Till, medium light gray, unoxidized, unleached, with trace mollusk shells
	220	to	240	Till, gray, unoxidized, unleached, blocky
Pennsylvanian rocks, undifferentiated--Continued	240	to	242	Limestone, dark gray, argillaceous
	242	to	246	Shale, gray, very calcareous; limestone, dark gray, argillaceous
	246	to	255	Shale, gray, very calcareous; limestone, very light gray, silt-grade
	255	to	258	Siltstone, gray, calcareous, argillaceous
	258	to	261	Siltstone, gray, calcareous, very argillaceous

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW8	**W-27707**	**67-40-21CCAC**	**403602-0952659**	**1,065**	**Fremont**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	7	Roadbed (driller's log)
Quaternary deposits	7	to	9	Clay, medium dark gray, slightly silty, hard
	9	to	14	Clay, brown, with trace sand
	14	to	17	Clay, medium light gray, slightly silty
	17	to	20	Clay, gray, silty
	20	to	35	Clay, gray, slightly silty
	35	to	37	Clay, brown-gray
	37	to	40	Clay, yellow-gray clay
	40	to	50	Clay, medium light gray, slightly silty
	50	to	57	Clay, yellow-gray
	57	to	60	Clay, brown, silty
	60	to	63	Sand, colorless and varicolored; gravel, varicolored
Pleistocene deposits	63	to	65	Till, gray, unoxidized, unleached
	65	to	71	Till, light olive-gray, unoxidized, unleached
	71	to	75	Till, gray, unoxidized, unleached
	75	to	130	Till, light olive-gray, unoxidized, unleached, sandy
	130	to	140	Gravel, varicolored; sand, very dirty, subrounded
	140	to	160	Till, light olive-gray, unoxidized, unleached, sandy; with till, yellow, oxidized, leached
	160	to	180	Till, brown-gray, unoxidized, unleached
	180	to	240	Till, light olive-gray, unoxidized, unleached
	240	to	246	Till, light olive-gray, unoxidized, unleached; gravel
	246	to	255	Gravel, varicolored; sand, medium; with till matrix, light olive-gray, unoxidized, unleached
	255	to	260	Till, brown-gray, unoxidized, unleached
	260	to	288	Till, light gray, unoxidized, unleached
	288	to	300	Till, light olive-gray, unoxidized, unleached
	300	to	316	Till, light brown-gray, unoxidized, unleached
	316	to	318	Till, light brown-gray, unoxidized, unleached, very sandy
	318	to	344	Till, light olive-gray, unoxidized, unleached
	344	to	350	Till, light olive-gray, unoxidized, unleached; limestone, very light gray, silt-grade
Pennsylvanian rocks, undifferentiated	350			

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW9	**W-27708**	**68-41-11CDCC**	**404256-0953104**	**945**	**Fremont**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	3	Roadbed (driller's log)
Quaternary deposits	3	to	5	Clay, yellow-brown, silty (driller's log)
	5	to	20	Silt, medium dark orange-brown, argillaceous
	20	to	23	Sand, orange, medium to fine, subrounded, silty
	23	to	25	Silt, dark orange, argillaceous
	25	to	28	Clay, gray and orange, silty, sandy
	28	to	35	Sand, colorless and orange, coarse to fine, subrounded, very argillaceous
	35	to	40	Gravel, colorless and orange; sand, colorless, coarse, subrounded, very argillaceous sand
	40	to	51	Gravel, varicolored; sand, colorless and yellow, fine
	51	to	60	Gravel, varicolored; sand, colorless and yellow, argillaceous, fine
Pleistocene deposits	60	to	80	Till, light olive-gray, unoxidized, unleached
	80	to	115	Till, olive-gray, unoxidized, unleached; sand; gravel, varicolored and colorless
	115	to	138	Till, light olive-gray, unoxidized, unleached; gravel, varicolored, subrounded to angular
	138	to	160	Sand, colorless, varicolored, coarse to fine, subangular to subrounded
	160	to	170	Till, light olive-gray, unoxidized, unleached
	170	to	180	Till, gray, unoxidized, unleached
	180	to	202	Till, medium light gray, unoxidized, unleached, very gravelly
Pennsylvanian rocks, undifferentiated	202	to	208	Dolostone, gray, silt-grade; shale, gray
	208	to	211	Dolostone, gray, silt-grade, argillaceous
	211	to	211.5	Dolostone, gray, silt-grade, argillaceous; shale, gray
	211.5	to	214	Shale, very dark gray, blocky, silty, calcareous
	214	to	215	Dolostone, gray, silt-grade, argillaceous, very calcareous; sandstone, colorless, coarse to medium, subrounded

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW10	**W-27709**	**68-42-12ADAC**	**404324-0953554**	**935**	**Fremont**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Roadbed and topsoil (driller's log)
	5	to	12	Silt, yellow-orange, very argillaceous
	12	to	20	Clay, orange, silty
	20	to	27	Clay, very light yellow-orange, silty, calcareous
	27	to	35	Clay, gray, silty, calcareous
	35	to	36	Clay, medium dark brown, sandy
	36	to	37	Clay, gray, silty, calcareous
	37	to	42	Sand, colorless to varicolored, coarse to fine; gravel, subrounded
Pleistocene deposits	42	to	43	Till, gray, unoxidized, unleached, weakly calcareous
	43	to	47	Till, gray, unoxidized, unleached
	47	to	60	Till, gray, unoxidized, unleached, silty
	60	to	88	Till, light olive-gray, unoxidized, unleached
	88	to	90	Sand, colorless and varicolored, coarse to fine; gravel, subrounded, calcareous, argillaceous, silty
	90	to	151	Till, gray, unoxidized, unleached
	151	to	164	Sand, colorless, orange, pink, coarse to fine, subrounded, quartz; gravel, very clean; quartz; igneous, metamorphic, and carbonate rocks
Pennsylvanian rocks, undifferentiated	164	to	171	Shale, green, lumpy, calcareous, with calcareous nodules
	171	to	171.5	Dolostone, very light gray, silt-grade, crystalline; shale, green, lumpy, calcareous, sandy
	171.5	to	174	Shale, gray, silty, calcareous; dolostone, very light gray, silt-grade, crystalline dolostone
	174	to	176	Shale, gray; dolostone, gray, silt-grade, calcareous, very argillaceous
	176	to	180	Shale, green-gray, calcareous, with limestone nodules
	180	to	182	Shale, green-gray, silty, calcareous
	182	to	184	Shale, gray, silty, calcareous
	184	to	186	Shale, green-gray, silty, calcareous
	186	to	189	Shale, green-gray, silty, calcareous; limestone, dark green, silt-grade, argillaceous
	189	to	191	Shale, gray, silty, calcareous

Note: Well flows at the land surface from 300 to 500 gallons per minute from 150 to 164 feet below land surface after hole was completed.

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW11	**W-27710**	**70-41-32ABBB**	**404906-0953504**	**948**	**Fremont**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	8	Roadbed and topsoil (driller's log)
	8	to	10	Clay, dark gray, silty
	10	to	15	Silt, yellow and gray, very argillaceous
	15	to	17	Silt, orange, very argillaceous
	17	to	20	Silt, yellow-orange; sand, varicolored, subangular to subrounded
	20	to	50	Sand, quartz; gravel, colorless and varicolored, subrounded, coarse, igneous and metamorphic rocks
Pleistocene deposits	50	to	110	Till, light olive-gray, unoxidized, unleached
	110	to	140	Sand, colorless and varicolored, coarse to fine, quartz, with 5 percent dark, heavy grains; gravel, metamorphic and granite rocks
	140	to	160	Sand, very clear, colorless, yellow, pink, and dark grains, medium to coarse and fine
	160	to	180	Sand, very clear, colorless, yellow, pink, and dark grains, medium to coarse and fine; gravel, varicolored, very clean
	180	to	200	Sand, very clear, colorless, yellow, pink, and dark grains, medium to coarse and fine, slightly silty; gravel, varicolored, very clean
	200	to	210	Gravel, varicolored, subrounded to angular igneous and metamorphic rocks
Pennsylvanian rocks, undifferentiated	210	to	215	Dolostone, gray, calcareous, argillaceous; grading to dolostone, very light gray, non-argillaceous, silt-grade

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW12	**W-27711**	**71-41-09DDDD**	**405736-0953323**	**976**	**Fremont**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	8	Roadbed and fill (driller's log)
Quaternary deposits	8	to	15	Clay, brown, silty
	15	to	18	Clay, brown-gray, silty
	18	to	25	Clay, gray, sandy; sand, varicolored, coarse to fine; gravel
	25	to	34	Sand, colorless and varicolored, coarse to fine; gravel, varicolored, subrounded, silty
Pleistocene deposits	34	to	180	Till, light olive-gray, unoxidized, unleached
	180	to	211	Till, gray, unoxidized, unleached
	211	to	223	Gravel, varicolored, subrounded to angular; igneous, metamorphic rocks, and dolostone; sand, coarse, quartz, with gray, till-like matrix
Pennsylvanian rocks, undifferentiated	223	to	227	Limestone, very light gray, silty, silt-grade, argillaceous
	227	to	231	Limestone, very light gray, silty, silt-grade, argillaceous; shale, gray; sand
	231	to	244	Limestone, very light gray, silty, silt-grade, argillaceous; shale, gray
	244	to	249	Shale, very dark gray, blocky; limestone, very light gray, silty, silt-grade, argillaceous
	249	to	251	Shale, green-gray, calcareous
	251	to	256	Shale, dark gray, green-gray, calcareous

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW13	**W-27712**	**73-41-19ACAA**	**410645-0953556**	**1,115**	**Mills**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Roadbed and topsoil (driller's log)
	5	to	10	Silt, yellow-brown, argillaceous
	10	to	20	Silt, gray-orange, argillaceous
	20	to	30	Silt, yellow, argillaceous
Pleistocene deposits	30	to	34	Till, oxidized, leached, with sparse sand

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW13--Continued				
Pleistocene deposits--Continued	34	to	40	Till, yellow-orange, oxidized, unleached, weakly calcareous
	40	to	57	Till, yellow-orange, oxidized, unleached
	57	to	60	Till, dark orange and gray, partly unoxidized, unleached
	60	to	120	Till, light olive-gray, unoxidized, unleached
	120	to	160	Till, light olive-gray, unoxidized, unleached, gravelly
	160	to	170	Till, brown-gray, unoxidized, unleached
	176	to	180	Till, medium light gray, unoxidized, unleached
	180	to	181	Till, medium light gray, unoxidized, unleached, very sandy
Pennsylvanian rocks, undifferentiated	181	to	187	Limestone, very light gray; shale, gray; sand, colorless, coarse to fine
	187	to	189	Limestone, gray to very light gray, silt-grade, partly argillaceous
	189	to	197	Shale, green, lumpy, silty, sandy
	197	to	199	Limestone, very light gray to gray, silt-grade, partly argillaceous; limestone, very light gray, fine to medium
	199	to	202	Limestone, very light gray, fine to medium, partly argillaceous
	202	to	205	Limestone, very light gray, slightly argillaceous
	205	to	205.5	Limestone, very light gray, slightly argillaceous; shale, dark gray, carbonaceous
	205.5	to	206	Shale, gray, micaceous
	206	to	208.5	Shale, very dark gray, carbonaceous
	208.5	to	210	Limestone, light gray, silt-grade, argillaceous
	210	to	213	Limestone, gray, silt-grade, argillaceous, fragmented
	213	to	215	Limestone, silt-grade to fine; shale, gray
	215	to	216	Shale, gray; limestone, silt-grade to coarse, fragmented
	216	to	218	Shale, gray; limestone, silt-grade to coarse
	218	to	219	Limestone, silt-grade to medium, dolomitic

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW14	**W-27713**	**73-42-15BAAB**	**410751-0953947**	**1,142**	**Mills**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	3	Roadbed (driller's log)
Quaternary deposits	3	to	5	Clay, dark gray-brown, silty (driller's log)

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW14--Continued				
Quaternary deposits--Continued	5	to	11	Silt, dark orange, argillaceous, calcareous
	11	to	19	Silt, very pale yellow, argillaceous, calcareous
Pleistocene deposits	19	to	30	Till, yellow, oxidized, unleached
	30	to	42	Till, very pale yellow, oxidized, unleached
	42	to	43	Till, very pale yellow, oxidized, unleached, sandy
	43	to	50	Till, yellow-orange, oxidized, unleached
	50	to	65	Till, orange-yellow, oxidized, unleached
	65	to	70	Till, orange-brown, oxidized, unleached
	70	to	75	Till, light olive-gray, unoxidized, unleached
	75	to	80	Till, light olive-gray, unoxidized, unleached; till, orange, oxidized, unleached
	80	to	113	Till, gray, unoxidized, unleached
	113	to	116	Till, medium light gray, unoxidized, unleached
	116	to	118	Till, gray-brown, unoxidized, unleached
	118	to	119	Silt, brown, argillaceous, calcareous
	119	to	124	Till, gray to very light gray, partly oxidized, unleached
	124	to	133	Till, very light yellow gray, oxidized, partly unleached, partly leached
Tertiary deposits	136	to	140	Sand, colorless and varicolored, fine to coarse, subrounded, partly polished; gravel, quartz, granite, limestone
	140	to	150	Sand, colorless and varicolored, medium to coarse and fine, slightly silty, quartz, with trace dark heavy minerals
	150	to	160	Sand, colorless and varicolored, coarse to fine; gravel, quartz and dark minerals
	160	to	164	Gravel, igneous and metamorphic rocks; sand, varicolored, coarse, subrounded, dirty, quartz
Pennsylvanian rocks, undifferentiated	64	to	165	Siderite, brown, massive; chert, gray; gravel, igneous and metamorphic rocks
	165	to	168	Siderite, brown, massive, crystalline, and nodular
	168	to	168.5	Siderite, brown, massive, crystalline, and nodular; sand, varicolored, argillaceous
	168.5	to	169	Siderite, massive
	169	to	170	Shale, brown, very dark gray, gray; siderite
	170	to	171	Shale, very dark gray, lumpy
	171	to	171.5	Shale, gray, sandy, calcareous, till-like
	171.5	to	172	Shale, very dark gray, micaceous, blocky
	172	to	173	Limestone, medium light gray, silt-grade to fine
	173	to	174	Shale, gray and very dark gray, lumpy, calcareous
	174	to	175	Shale, gray
	175	to	177	Shale, very dark gray, silty, blocky
	177	to	178	Limestone, mottled gray to brown

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW15	**W-27714**	**73-43-26CBAB**	**410541-0954546**	**1,285**	**Mills**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Roadbed and topsoil (driller's log)
	5	to	15	Silt, yellow-orange
	15	to	20	Silt, orange
	20	to	30	Silt, yellow-orange
	30	to	50	Silt, pale orange, slightly argillaceous
	50	to	60	Silt, orange, argillaceous
	60	to	67	Silt, orange and gray
	67	to	80	Silt, orange, argillaceous
	80	to	90	Silt, orange-yellow
	90	to	100	Silt, yellow-orange
	100	to	110	Silt, very pale red-orange, argillaceous
	110	to	120	Silt, brown-orange, argillaceous
	120	to	130	Silt, pale orange
	130	to	150	Silt, very pale orange
	150	to	160	Silt, very light gray
	160	to	169	Silt, gray, very argillaceous
Pleistocene deposits	169	to	176	Till, light orange, oxidized, unleached
	176	to	190	Till, light gray to orange, partly oxidized, unleached
	190	to	205	Till, pale orange, oxidized, unleached
	205	to	216	Till, olive-gray, unoxidized, unleached, with trace till, orange, oxidized, unleached
	216	to	236	Gravel, varicolored, with argillaceous, silty, calcareous matrix
	236	to	270	Till, olive-gray, unoxidized, unleached
	270	to	280	Till, olive-gray, unoxidized, unleached; trace till, yellow, oxidized, unleached
	280	to	300	Till, olive-gray, unoxidized, unleached; gravel
	300	to	317	Till, olive-gray, unoxidized, unleached
Pennsylvanian rocks, undifferentiated	317	to	340	No samples
	317	to	323	Limestone; shale, gray-green, silty (driller's log)
	323	to	328	Siltstone, gray-green (driller's log)
	328	to	332	Limestone, gray-green and tan, shaly (driller's log)
	332	to	333	Shale, gray (driller's log)
	333	to	335	Limestone; shale, gray, gray-green (driller's log)
	335	to	338	Shale, gray-green and gray (driller's log)
	338	to	339	Limestone, blue-gray, shaley (driller's log)
	339	to	340	Shale, gray-green; limestone (driller's log)

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW16	**W-27715**	**74-37-30BBBB**	**411117-0950919**	**1,090**	**Cass**

SW16U casing	0	to	37	
	37	to	42	Slotted
SW16L casing	0	to	59	
	59	to	70	Slotted

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Topsoil and clay, dark brown, silty (driller's log)
	5	to	9	Clay, orange-brown, mottled, silty
	9	to	17	Silt, yellow, argillaceous
	17	to	23	Silt, yellow, mottled orange, argillaceous
	23	to	29	Clay, yellow, silty
	29	to	43	Sand, colorless, varicolored, medium to coarse to fine, subrounded; gravel
Pleistocene deposits	43	to	53	Sand, colorless, orange, pink, fine to medium, subangular, quartz
	53	to	54	Sand, colorless, varicolored, coarse to fine; gravel
	54	to	56	Silt, yellow argillaceous; gravel
	56	to	59	Clay, yellow and gray, silty, sandy
	59	to	67	Gravel, varicolored; sand, colorless, yellow, orange, fine to medium, subrounded
	67	to	70	Gravel, varicolored; sand, silty, argillaceous
	70	to	72	Clay, orange, silty, sandy
Pennsylvanian rocks, undifferentiated	72	to	75	Shale, gray, silty, sandy, unoxidized, leached
	75	to	96	Shale, gray, silty
	96	to	98	Shale, gray, silty, with siderite
	98	to	104	Shale, gray, silty; sandstone, colorless, orange, fine to coarse
	104	to	105	Siderite, brown, crystalline, medium to fine
	105	to	113	Shale, gray, very sandy
	113	to	130	Shale, gray, sandy, silty
	130	to	145	Shale, gray, lumpy, silty
	145	to	146	Chert, very light gray; shale, gray, lumpy, silty
	146	to	147	Chert, very light gray; siderite, crystalline
	147	to	148	Siderite, argillaceous
	148	to	150	Shale, gray, silty, calcareous
	150	to	152	Shale, gray, silty, calcareous; limestone, dark gray silt-grade
	152	to	154	Limestone, medium light gray, silt-grade partly argillaceous
	154	to	156	Shale, green, calcareous

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW17	**W-27747**	**75-35-07BBBA**	**411900-0945530**	**1,295**	**Cass**

SW17 casing	0	to	189	
	189	to	209	Slotted

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	10	Silt, yellow, argillaceous
	10	to	14	Silt, orange-yellow, argillaceous
Pleistocene deposits	14	to	17	Till, orange, oxidized, leached
	17	to	20	Till, orange, oxidized, unleached
	20	to	26	Till, orange, oxidized, unleached, weakly calcareous
	26	to	28	Silt, very light gray, argillaceous
	28	to	55	Clay, light gray, silty
	55	to	60	Till, yellow, oxidized, unleached
	60	to	75	Till, pale orange, oxidized, unleached
	75	to	77	Till, orange, oxidized, unleached
	77	to	83	Till, light gray, oxidized, unleached
	83	to	105	Till, yellow, oxidized, unleached
	105	to	131	Till, very light yellow, oxidized, unleached
	131	to	138	Till, very light gray, oxidized, unleached
Cretaceous rocks, undifferentiated	138	to	140	Clay, gray, silty
	140	to	145	Clay, gray, silty, very sandy
	145	to	152	Sandstone, colorless, medium to coarse and fine, angular, very silty, quartz
	152	to	160	Sandstone, colorless, orange, yellow, coarse to fine, angular, clean, quartz
	160	to	170	Sandstone, orange, coarse to fine, angular, clean, quartz
	170	to	205	Sandstone, orange, medium to coarse and fine, angular, clean, quartz
	205	to	210	Gravel, varicolored; sand, coarse, quartz; chert
Pennsylvanian rocks, undifferentiated	210	to	212	Gravel, varicolored; sand, coarse, quartz; chert; shale, gray, lumpy, silty
	212	to	218	Shale, green and yellow, sandy

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW18	**W-27745**	**77-37-13BBBB**	**412832-0950334**	**1,298**	**Cass**

SW18 casing	0	to	196	
	196	to	201	Slotted

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	1	Topsoil (driller's log)
	1	to	5	Loess, light yellow, argillaceous
	5	to	8	Loess, pale yellow, argillaceous
	8	to	23	Clay, light gray
	23	to	30	Clay, light gray; till, silty, sandy, highly oxidized, leached
	30	to	32	Till, very light gray and orange, oxidized, leached
	32	to	40	Till, very light gray and orange, oxidized, unleached
	40	to	59	Till, yellow, oxidized, unleached
	59	to	63	Till, gray, oxidized, unleached
	63	to	70	Till, yellow, oxidized, unleached
	70	to	80	Till, orange, oxidized, unleached
	80	to	103	Till, pale yellow, oxidized, unleached
	103	to	107	Till, pale yellow, unoxidized, unleached
	107	to	120	Till, gray, unoxidized, unleached
	120	to	145	Till, gray, unoxidized, unleached; till, yellow oxidized, unleached
	145	to	151	Till, gray, oxidized, unleached
	151	to	157	Till, yellow and orange, oxidized, partly leached
	157	to	176	Till, medium light gray and yellow, partly oxidized, unleached
	176	to	180	Till, medium dark gray and yellow, partly oxidized, unleached
	180	to	196	Sand, colorless and orange, medium to coarse and fine, quartz; clay, brown, sandy, calcareous
Pennsylvanian rocks, undifferentiated	196	to	201	Limestone, very light gray and dark gray, silt-grade to coarse

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW19	**W-27748**	**72-39-12CBBB**	**410308-0950337**	**1,285**	**Montgomery**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	2	Topsoil and clay, brown (driller's log)
	2	to	14	Silt, orange, argillaceous
	14	to	18	Silt, pale yellow, argillaceous
	18	to	20	Clay, gray and orange, silty
	20	to	30	Silt, very light yellow, very argillaceous
	30	to	40	Silt, very light gray
	40	to	50	Silt, very light gray, very argillaceous
	50	to	57	Shale, gray, silty
	57	to	60	Shale, gray, silty, calcareous
	60	to	75	Silt, yellow, calcareous
Pleistocene deposits	75	to	112	Till, yellow, oxidized, unleached
	112	to	115	Till, gray, medium light gray, oxidized, unleached
	115	to	118	Till, light gray and pale orange, oxidized, unleached
	118	to	120	Till, gray, unoxidized, leached; till, gray and pale orange, oxidized, unleached
	120	to	128	Till, orange, oxidized, unleached
	128	to	140	Clay, yellow, silty, slightly calcareous
	140	to	150	Silt, yellow, argillaceous, calcareous
	150	to	158	Silt, light gray, argillaceous, calcareous
	158	to	160	Till, yellow, oxidized, unleached
	160	to	170	Sand, colorless and varicolored, very silty, very argillaceous, medium to fine, poorly sorted, quartz, with till-like matrix
	170	to	190	Silt, pale, calcareous, sandy, argillaceous
	190	to	195	Till, very light gray, oxidized, unleached
	195	to	200	Till, light orange, oxidized, unleached
	200	to	210	Sand, colorless, varicolored, medium to fine, quartz; gravel, silty, argillaceous, calcareous; igneous and metamorphic rocks
Pennsylvanian rocks, undifferentiated	210	to	220	Shale, gray, lumpy, silty, soft
	220	to	252	Shale, olive-gray, silty, slightly calcareous, till-like
	252	to	260	Sandstone, colorless, varicolored, coarse to fine; shale, olive-gray, silty, slightly calcareous, till-like
	260	to	261	Shale, yellow, silty, slightly calcareous, till-like
	261	to	262	Dolostone, very light gray, silt-grade, very calcareous
	262	to	263	Shale, gray-green, lumpy
	263	to	267	Shale, green, maroon, tan
	267	to	270	Shale, green; trace limestone

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW20	**W-27749**	**72-36-04DCDC**	**410333-0945927**	**1,082**	**Montgomery**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Fill (driller's log)
	5	to	10	Clay, brown, silty
	10	to	20	Silt, brown, very argillaceous
	20	to	23	Silt, brown, very sandy
	23	to	26	Gravel; sand, varicolored, fine, very argillaceous, silty
	26	to	35	Gravel; sand, varicolored, fine, clean
	35	to	36	Gravel; sand, varicolored, fine, clean; clay, yellow-gray, silty
Pennsylvanian rocks, undifferentiated	36	to	38	Shale, gray, silty, sandy
	38	to	38.5	Siderite, brown, silt-grade; shale, gray
	38.5	to	40	Shale, green
	40	to	45	Shale, maroon-gray, lumpy, silty, sandy
	45	to	65	Shale, gray
	65	to	65.5	Siderite, brown, silt-grade; shale, gray
	65.5	to	80	Shale, gray
	80	to	95	Shale, gray, very silty
	95	to	115	Shale, gray, lumpy, silty
	115	to	120	Shale, gray-green, lumpy, silty
	120	to	130	Shale, gray
	130	to	131	Dolostone, gray, argillaceous; shale
	131	to	132	Dolostone, gray, argillaceous; shale, dark gray
	132	to	134	Shale, dark gray, carbonaceous
	134	to	136	Limestone, gray, silt-grade, argillaceous; shale
	136	to	138	Limestone, gray, argillaceous
	138	to	140	Limestone, gray, argillaceous; shale
	140	to	142	Shale, very dark gray, blocky
	142	to	144	Limestone, very light gray, argillaceous; shale, dark gray, silty
	144	to	145	Limestone; shale, gray
	145	to	147	Shale, green, silty; limestone
	147	to	149	Limestone, very light gray to gray, partly fragmented; shale, green
	149	to	150	Limestone, very light gray to gray, partly fragmented
	150	to	151	Limestone, very light gray to gray, partly fragmented; shale, green, lumpy
	151	to	152	Shale, gray-green; some limestone (driller's log)

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW21	**W-27746**	**74-39-01CCCC**	**411351-0951719**	**1,245**	**Pottawattamie**

SW21 casing	0 to 189	
	189 to 206	Slotted

Stratigraphic unit	Depth interval (feet)	Description
Quaternary deposits	0 to 2	Clay, yellow-brown, silty (driller's log)
	2 to 8	Clay, orange-brown, silty
Pleistocene deposits	8 to 40	Till, yellow, oxidized, unleached
	40 to 44	Till, pale yellow, oxidized, unleached
	44 to 50	Till, medium light gray, unoxidized, unleached
	50 to 65	Till, medium light gray, unoxidized, unleached; trace till, oxidized, unleached
	65 to 70	Till, dark gray, unoxidized, unleached; till, yellow, oxidized, unleached
	70 to 72	Till, yellow-orange, oxidized, unleached
	72 to 77	Gravel, varicolored; sand, coarse, silty
	77 to 79	Till, yellow, oxidized, unleached
	79 to 80	Gravel, varicolored, subrounded; sand, coarse, silty
	80 to 87	Till, yellow and trace orange, oxidized, unleached
	87 to 89	Till, very light yellow, gray to orange, oxidized, unleached
	89 to 93	Gravel, varicolored; sand, coarse, subrounded
	93 to 95	Till, orange to dark orange, oxidized, unleached
	95 to 105	Till, orange-brown, oxidized, unleached
	105 to 140	Till, gray, unoxidized, unleached
	140 to 143	Till, brown-orange, orange, partly oxidized, unleached, very sandy
	143 to 155	Sand, colorless, yellow, pink, dark, medium to fine and coarse, clean, quartz, with dark grains
	155 to 170	Till, medium dark gray and orange, partly oxidized, unleached
	170 to 172	Till, medium dark gray and orange, partly oxidized, unleached; quartz
	172 to 191	Sand, colorless, varicolored, dark, medium to fine and coarse, subrounded, frosted, quartz; gravel, quartz, and metamorphic rocks
	191 to 195	Sand, colorless, varicolored, dark, coarse to fine, subrounded, frosted, quartz
	195 to 200	Sand, colorless, varicolored, dark, fine, subrounded, frosted, quartz
	200 to 207	Sand, colorless, varicolored, dark, fine to medium, subrounded to subangular, quartz

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW21--Continued				
Pennsylvanian rocks, undifferentiated	207	to	209	Shale, yellow and gray, partly oxidized, unleached, till-like
	209	to	216	Shale, maroon and gray, calcareous, sandy; gravel

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW22	**W-27750**	**75-38-07AAAA**	**411904-0951507**	**1,298**	**Pottawattamie**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	2	Topsoil (driller's log)
	2	to	5	Silt, yellow, slightly argillaceous
	5	to	12	Silt, yellow, argillaceous
	12	to	22	Clay, yellow-tan
	22	to	35	Clay, very light gray
	35	to	37	Clay, very light gray, sandy
Pleistocene deposits	37	to	40	Till, orange, oxidized, unleached
	40	to	50	Till, yellow, oxidized, unleached
	50	to	60	Till, dark yellow-orange, oxidized, unleached
	60	to	70	Till, yellow, oxidized, unleached
	70	to	80	Till, dark yellow-orange, oxidized, unleached
	80	to	87	Till, orange, oxidized, unleached
	87	to	90	Till, medium dark gray, unoxidized, unleached
	90	to	96	Till, gray, unoxidized, leached
	96	to	110	Till, medium dark orange, oxidized, unleached
	110	to	120	Till, medium dark orange, oxidized, unleached, sandy
	120	to	128	Till, orange and gray, partly unoxidized, unleached
	128	to	158	Till, light olive-gray, unoxidized, unleached
	158	to	159	Till, gray, orange, maroon, partly oxidized, unleached
	159	to	160	Till, gray and orange, partly oxidized, unleached
Pennsylvanian rocks, undifferentiated	160	to	164	Clay, very light gray to orange, silty, sandy, calcareous
	164	to	168	Clay, maroon and gray, silty, sandy, calcareous
	168	to	171	Sand, colorless and pink, quartz; clay, maroon and gray, silty, sandy, calcareous
	171	to	175	Clay, orange and trace maroon, very sandy, calcareous
	175	to	177	Clay, yellow, maroon, green, sandy

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW22--Continued				
Pennsylvanian rocks undifferentiated--Continued	177	to	180	Clay, maroon, sandy, silty
	180	to	187	Clay, yellow, sandy, silty, slightly calcareous
	187	to	189	Clay, yellow, very sandy, silty, slightly calcareous
	189	to	191	Clay, green, very sandy, silty, slightly calcareous
	191	to	195	Clay, yellow, very sandy, silty, slightly calcareous
	195	to	200	Clay, yellow-gray, maroon
	200	to	205	Clay, yellow, gray, brown, sandy, calcareous
	205	to	208	Clay, yellow, gray, maroon, sandy, calcareous
	208	to	215	Shale, gray and yellow-gray, maroon, sandy, partly silty, calcareous, with trace gypsum
	215	to	218	Shale, yellow-green to yellow, sandy, slightly calcareous
	218	to	221	Shale, gray, orange, maroon, sandy, slightly calcareous

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW23	**W-27751**	**75-41-26ACBB**	**411615-0953137**	**1,102**	**Pottawattamie**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Roadbed and topsoil (driller's log)
	5	to	10	Silt, brown, very argillaceous
	10	to	18	Silt, slightly lighter brown, very argillaceous
	18	to	20	Clay, brown, silty
	20	to	24	Silt, brown-gray, argillaceous
	24	to	30	Clay, very pale yellow and medium dark gray, silty
	30	to	38	Clay, yellow, silty
	38	to	41	Sand, colorless, varicolored, coarse to fine; gravel, varicolored, dirty
	41	to	44	Silt, brown, argillaceous
	44	to	45	Silt, brown, argillaceous; gravel
Pleistocene deposits	45	to	80	Till, gray, unoxidized, unleached
	80	to	100	Till, gray, unoxidized, unleached, gravelly
	100	to	150	Till, gray, unoxidized, unleached, sandy
	150	to	157	Till, very light gray, unoxidized, unleached
Pennsylvanian rocks, undifferentiated	157	to	158	Limestone, brown, silt-grade to fine
	158	to	166	Shale, yellow-green, sandy, calcareous
	166	to	168	Limestone, very yellow, silt-grade
	168	to	173	Limestone, very light pink, silt-grade
	173	to	179	Shale, gray, silty, calcareous
	179	to	181	Limestone, very light gray, silt-grade; shale, gray, silty, calcareous

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW24	**W-27752**	**76-41-29DDDD**	**412051-0953431**	**1,215**	**Pottawattamie**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Roadbed and topsoil (driller log)
	5	to	10	Clay, medium dark brown-gray, silty
	10	to	12	Clay, brown, silty
	12	to	20	Silt, brown, very argillaceous
	20	to	24	Silt, brown, very argillaceous, calcareous
	24	to	31	Silt, medium light brown-gray, very argillaceous
	31	to	34	Clay, light gray, silty
	34	to	39	Silt, very light yellow
	39	to	42	Silt, pale orange and gray, very argillaceous, calcareous
	42	to	51	Clay, brown-gray, silty, slightly calcareous
Pleistocene deposits	51	to	78	Till, orange, oxidized, unleached
	78	to	80	Till, orange-brown, partly oxidized, unleached
	80	to	100	Till, brown-gray, unoxidized, unleached; trace till, orange, oxidized, unleached
	100	to	110	Till, light olive-gray, unoxidized, unleached
	110	to	140	Till, light olive-gray, unoxidized, unleached
	140	to	145	Till, brown-gray, unoxidized, unleached
	145	to	150	Till, light olive-gray, unoxidized, unleached
	150	to	164	Till or clay, gray to light gray, calcareous, very silty, slightly sandy
	164	to	169	Silt, very light gray, argillaceous, very slightly calcareous, with trace sand
	169	to	169.5	Chert, gray to brown-gray, smooth; sand, colorless, varicolored
Pennsylvanian rocks, undifferentiated	169.5	to	174	Shale, orange, silty, lumpy; shale, gray, lumpy; chert, gray to brown-gray, smooth
	174	to	176	Shale, green and orange, lumpy
	176	to	178	Shale, green and orange, lumpy;
	178	to	180	Limestone, very light gray, silt-grade to fine, dolomitic
	180	to	182	Limestone, pale yellow, silt-grade to fine, dolomitic
	182	to	184	Shale, gray, lumpy, silty
	184	to	186	Limestone, very light gray, silt-grade to fine, dolomitic

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW25	**W-27775**	**77-41-33CDCC**	**412510-0953408**	**1,156**	**Pottawattamie**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	6	Roadbed and topsoil (driller's log)
	6	to	13	Clay, gray, silty
	13	to	20	Clay, slightly lighter gray, silty
	20	to	26	Clay, gray, silty
	26	to	30	Silt, very light gray to yellow-gray, slightly silty, slightly calcareous, with trace sand
	30	to	35	Clay, orange, silty, sandy, gravelly
	35	to	40	Silt, pale orange, very argillaceous, calcareous
	40	to	46	Silt, pale yellow, argillaceous
	46	to	54	Clay, dark orange, silty, calcareous, with wood
	54	to	56	Gravel to sand, varicolored, coarse, subrounded to subangular, dirty
	56	to	69	Clay, gray, silty, calcareous, with much wood
Pleistocene deposits	69	to	86	Till, light olive-gray, unoxidized, unleached
	86	to	89	Till, gray-orange, partly oxidized, unleached
	89	to	90	Till, orange, oxidized, leached
	90	to	95	Till, medium light gray, unoxidized, unleached, very sandy
	95	to	100	Sand, colorless, varicolored, fine to medium, quartz, with trace dark grains
	100	to	110	Sand, colorless, varicolored, coarse, quartz, with trace dark grains
	110	to	114	Sand, colorless, varicolored, coarse, quartz, with trace dark grains; gravel
	114	to	118	Clay, orange, slightly silty; gravel
Pennsylvanian rocks, undifferentiated	118	to	120	Clay, brown and orange, slightly calcareous
	120	to	122	Clay, maroon, green, orange, slightly silty, calcareous
	122	to	123	Limestone, very light green-gray, silt-grade, argillaceous; shale, green
	123	to	125	Limestone, very light green-gray, silt-grade, argillaceous
	125	to	127	Limestone, very light green-gray, silt-grade, argillaceous; shale, green
	127	to	128	Limestone, pale maroon, very argillaceous
	128	to	129	Shale, green, maroon, calcareous
	129	to	133	Limestone, very light gray, silt-grade
	133	to	137	Limestone, very light gray, silt-grade; shale, gray, lumpy
	137	to	138	Limestone, very light gray, silt-grade; shale, green
	138	to	140	Limestone, very light gray, silt-grade
	140	to	141	Limestone, very light gray, silt-grade; shale, gray
	141	to	145	Shale, gray, very calcareous

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW25--Continued				
Pennsylvanian rocks, undifferentiated--Continued	145	to	146	Shale, green and orange
	146	to	148	Limestone, medium light gray, silt-grade
	148	to	150	Chert, dark gray; limestone, medium light gray, silt-grade
	150	to	151	Limestone, gray and very light gray, mottled, silt-grade

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW26	**W-27776**	**76-41-12BBCC**	**412407-0953058**	**1,248**	**Pottawattamie**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	7	Roadbed and fill (driller's log)
Quaternary deposits	7	to	14	Clay, medium dark gray to brown, silty
	14	to	16	Clay, gray, yellow-orange, silty
	16	to	30	Clay, gray, silty
	30	to	33	Silt, orange-yellow, gray, argillaceous
	33	to	36	Silt, orange, very light gray
	36	to	45	Silt, gray, calcareous
Pleistocene deposits	45	to	50	Till, medium light gray, unoxidized, unleached
	50	to	63	Till, orange, unoxidized, unleached
	63	to	80	Till, yellow, oxidized, unleached
	80	to	83	Till, yellow, oxidized, unleached, very sandy
	83	to	88	Gravel; sand, varicolored, coarse, subrounded, dirty
	88	to	94	Till, gray, unoxidized, unleached, sandy, gravelly
	94	to	99	Sand, colorless, varicolored, coarse to fine, subrounded; gravel, varicolored, dirty
	99	to	110	Till, gray, unoxidized, unleached, sandy, very gravelly
	110	to	120	Gravel, varicolored, subrounded to angular; sand, colorless, coarse, subrounded, very dirty
	120	to	163	Till, gray, unoxidized, unleached, gravelly
	163	to	210	Till, light olive-gray, unoxidized, unleached
	210	to	225	Till, medium light gray, unoxidized, unleached
	225	to	227	Till, medium light gray, unoxidized, unleached; gravel, varicolored; sand, coarse

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW26--Continued				
Pennsylvanian rocks, undifferentiated	227	to	229	Limestone, orange and very light gray
	229	to	233	Limestone, green, argillaceous
	233	to	235	Limestone, very light gray, yellow, silt-grade
	235	to	237	Limestone, very light gray, yellow, coarse
	237	to	239	Dolostone, gray, silt-grade

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW27	**W-27777**	**76-40-06CABB**	**412431-0952950**	**1,220**	**Pottawattamie**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Roadbed and topsoil (driller's log)
	5	to	10	Silt, brown, sandy, very argillaceous
	10	to	30	Silt, orange, very argillaceous
	30	to	55	Silt, gray, argillaceous, slightly calcareous
	55	to	59	Gravel, varicolored; sand, coarse; till, gray, unoxidized, unleached
Pleistocene deposits	59	to	67	Till, yellow, oxidized, unleached
	67	to	82	Till, gray, unoxidized, unleached
	82	to	87	Gravel, varicolored; sand; till, orange, oxidized, unleached
	87	to	100	Till, gray, unoxidized, unleached
	100	to	130	Till, light olive-gray, unoxidized, unleached
	130	to	220	Till, light olive-gray, unoxidized, unleached, very sandy
	220	to	240	Till, light olive-gray, unoxidized, unleached, sandy
	240	to	257	Till, gray, unoxidized, unleached
	257	to	260	Till, gray, unoxidized, unleached, with little sand
	260	to	300	Till, gray, unoxidized, unleached, gravelly, with little sand
Pennsylvanian rocks, undifferentiated	300	to	307	Chert, blue-gray, smooth; limestone, very light gray, silt-grade to fine, fragmented, dolomitic
	307	to	313	Chert, blue-gray, smooth; limestone, gray, silt-grade to fine, fragmented, dolomitic; shale, very dark gray
	313	to	315	Limestone, gray, silt-grade to fine, fragmented, dolomitic

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW28	**W-27778**	**76-40-05BCCB**	**412447-0952846**	**1,222**	**Pottawattamie**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Roadbed and topsoil
	5	to	15	Clay, medium dark gray, slightly silty
	15	to	20	Clay, medium light gray, very silty
	20	to	25	Silt, medium light gray, very argillaceous
	25	to	29	Silt, yellow, gray, argillaceous
	29	to	38	Silt, yellow, gray, orange, argillaceous
Pleistocene deposits	38	to	40	Clay, gray, argillaceous
	40	to	43	Till, orange, oxidized, unleached
	43	to	47	Till, gray, orange, partly oxidized, unleached
	47	to	50	Till, light olive-gray, unoxidized, unleached
	50	to	53	Till, medium dark gray, unoxidized, leached
	53	to	55	Till, gray, orange, partly oxidized, leached
	55	to	57	Gravel, varicolored, with orange, argillaceous matrix
	57	to	60	Till, pale yellow, oxidized, unleached
	60	to	70	Till, pale yellow, oxidized, unleached, very gravelly, sandy
	70	to	73	Till, orange, oxidized, unleached
	73	to	84	Till, gray, unoxidized, unleached
	84	to	88	Gravel, varicolored; sand, coarse, subrounded
	88	to	100	Gravel, colorless, varicolored; sand, coarse, subrounded; till, unoxidized, unleached
	100	to	120	Till, gray, unoxidized, unleached; sand, coarse, subrounded; gravel, colorless, varicolored
	120	to	160	Till, gray, unoxidized, unleached
	160	to	180	Till, gray, unoxidized, unleached, sandy, gravelly
	180	to	209	Till, light olive-gray, unoxidized, unleached
	209	to	216	Till, light olive-gray, unoxidized, unleached; gravel, varicolored, coarse
	216	to	218	Till, gray, unoxidized, unleached; limestone, very light gray, abundant
	218	to	228	Till, gray, unoxidized, unleached
	228	to	240	Till, gray, unoxidized, unleached, with abundant sand and gravel
	240	to	250	Till, gray, unoxidized, unleached
	250	to	260	Till, gray, unoxidized, unleached; till, yellow, oxidized, unleached
	260	to	268	Till, gray, light gray, unoxidized, unleached; till, yellow, oxidized, unleached

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW28--Continued				
Pennsylvanian rocks, undifferentiated	268	to	272	Limestone, very light gray, silt-grade to fine
	272	to	273	Shale, green, gray, lumpy
	273	to	275	Shale, very dark gray, blocky
	275	to	278	Shale, gray, lumpy, calcareous
	278	to	281	Shale, green-gray, lumpy, calcareous
	281	to	287	Chert, very light gray
	287	to	289	Limestone, very light gray, silt-grade to medium, fragmented

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW29	**W-27779**	**76-40-09BAAB**	**412415-0952710**	**1,165**	**Pottawattamie**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Roadbed and topsoil (driller's log)
	5	to	9	Clay, dark gray, silty
	9	to	18	Clay, medium light gray, silty
	18	to	30	Silt, light gray, argillaceous
	30	to	34	Silt, light gray, argillaceous, calcareous
	34	to	38	Silt, medium light gray, argillaceous, calcareous
Pleistocene deposits	38	to	40	Silt, medium light gray, argillaceous, calcareous, sandy, gravelly, unoxidized, unleached
	40	to	80	Till, gray, unoxidized, unleached
	80	to	120	Till, medium light gray, unoxidized, unleached
	120	to	140	Till, gray
	140	to	160	Till, medium light gray
	160	to	180	Till, blue-gray (driller's log)
	180	to	230	Till, light olive-gray, unoxidized, unleached
	230	to	240	Till, blue-gray, very sandy (driller's log)
	240	to	245	Gravel, varicolored; sand, coarse; till, light olive-gray, unoxidized, unleached
	245	to	260	Till, light olive-gray, unoxidized, unleached
	260	to	280	Sand, colorless, dark, varicolored, medium to coarse and fine, very argillaceous, quartz
	280	to	300	Sand, colorless, dark, varicolored, medium to coarse and fine, clean, quartz
	300	to	320	Sand, gray-tan, fine to coarse, with clay at the base (driller's log)
	320	to	330	Sand, colorless, dark, varicolored, medium to coarse and fine, quartz

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW29--Continued				
Pleistocene deposits--Continued	330	to	340	Sand, colorless, dark, varicolored, medium to coarse and fine, quartz; gravel, dirty, igneous, metamorphic, limestone rocks
	340	to	350	Sand, colorless, dark, varicolored, coarse to fine, silty, argillaceous, quartz; gravel, dirty; igneous, metamorphic, limestone rocks
	350	to	360	Sand, fine to medium fine; cemented gravel (driller's log)
	360	to	365	Gravel, varicolored, quartz; metamorphic, limestone rocks, with argillaceous, calcareous cement
Pennsylvanian rocks, undifferentiated	365	to	370	Limestone, very light gray, partly sandy; shale, dark gray, blocky
	370	to	372	Limestone, very light gray, silt-grade; shale
	372	to	374	Shale, gray
	374	to	375	Shale, very dark gray, blocky
	375	to	377	Sandstone, gray, calcareous, fine; shale, gray

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW30	**W-27780**	**77-40-35CDDD**	**412508-0952446**	**1,235**	**Pottawattamie**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	8	Roadbed and fill (driller's log)
Quaternary deposits	8	to	12	Silt, brown-gray, argillaceous
	12	to	24	Silt, gray, argillaceous, slightly calcareous
	24	to	32	Silt, pale yellow, argillaceous
	32	to	37	Silt, lighter pale yellow, argillaceous
	37	to	43	Silt, brown-gray, argillaceous
	43	to	47	Gravel, varicolored, colorless, subrounded; sand, colorless, medium
Pleistocene deposits	47	to	66	Till, yellow, oxidized, unleached
	66	to	70	Till, light gray, oxidized, unleached
	70	to	155	Till, light olive-gray, unoxidized, unleached
	155	to	200	Till, light olive-gray, unoxidized, unleached, sandy
	200	to	300	Till, light olive-gray, unoxidized, unleached
	300	to	340	Till, light olive-gray, unoxidized, unleached, sandy
	340	to	348	Till, gray, unoxidized, unleached
	348	to	380	Sand, quartz; gravel, colorless, varicolored, coarse to fine, quartz and metamorphic rocks

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW30--Continued				
Pleistocene deposits--Continued	380	to	396	Sand, quartz; gravel, colorless, varicolored, coarse to fine, clean, quartz and metamorphic rocks
	396	to	399	Gravel, colorless, varicolored, coarse to fine, clean, quartz and metamorphic rocks; limestone, very light gray, silt-grade, dolomitic
Pennsylvanian rocks, undifferentiated	399	to	400	Shale, very light gray
	400	to	405	Shale, gray, lumpy, silty, calcareous
	405	to	408	Dolostone, very light gray, silt-grade
	408	to	411	Limestone, very light gray, silt-grade

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW31	**W-27781**	**76-39-05BCCC**	**412443-0952155**	**1,125**	**Pottawattamie**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	5	Roadbed and fill (driller's log)
Quaternary deposits	5	to	20	Silt, yellow-orange, argillaceous
	20	to	31	Silt, light gray, trace orange, argillaceous
	31	to	39	Gravel, orange, varicolored; sand, medium
Pleistocene deposits	39	to	60	Till, gray, unoxidized, unleached
	60	to	109	Till, light olive-gray, unoxidized, unleached, sandy
Pennsylvanian rocks, undifferentiated	109	to	111	Limestone, very light gray, silt-grade, argillaceous; shale, light gray, lumpy
	111	to	113	Dolostone, very light gray, silt-grade; limestone, orange
	113	to	118	Limestone, very light gray, silt-grade; shale, very calcareous
	118	to	120	Limestone, very light gray, silt-grade
	120	to	121	Limestone, very light gray, silt-grade; shale, green-gray
	121	to	123	Shale, green-gray
	123	to	125	Shale, very dark gray, silty, blocky
	125	to	126	Shale, gray, lumpy
	126	to	129	Shale, gray, sandy, calcareous, lumpy
	129	to	130	Limestone, gray, oolitic

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW32	**W-27838**	**76-40-04AAAA**	**412505-0952629**	**1,177**	**Pottawattamie**

SW32 casing	0	to	335	
	335	to	340	Well screen

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	6	Fill and topsoil (driller's log)
	6	to	9	Clay, brown, silty
	9	to	16	Silt, gray, very argillaceous
	16	to	40	Silt, medium light yellow-gray, argillaceous
	40	to	44	Clay, yellow-gray, silty, very sandy; gravel, till-like
	44	to	50	Gravel, varicolored; sand, colorless, medium
Pleistocene deposits	50	to	80	Till, olive-gray, unoxidized, unleached
	80	to	180	Till, light olive-gray, unoxidized, unleached
	180	to	220	Till, light olive-gray, unoxidized, unleached; gravel, varicolored, dirty
	220	to	240	Till, light olive-gray, unoxidized, unleached, sandy, gravelly
	240	to	260	Till, light olive-gray, unoxidized, unleached, sandy, gravelly; gravel
	260	to	300	Till, light olive-gray, unoxidized, unleached, gravelly
	300	to	340	Till, gray, unoxidized, unleached, gravelly
	340	to	360	Till, gray, unoxidized, unleached, very sandy
	360	to	372	Till, gray, unoxidized, unleached, very sandy; sand, colorless, coarse to fine; gravel, varicolored; quartz, metamorphic, and limestone rocks
	372	to	375	Gravel, varicolored, subrounded; igneous or metamorphic and limestone rocks

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW33	**W-27753**	**76-37-23DABB**	**412204-0950351**	**1,142**	**Cass**

SW33U casing	0 to 40	
	40 to 45	Well screen
SW33L casing	0 to 60	
	60 to 65	Well screen

Stratigraphic unit	Depth interval (feet)	Description
Quaternary deposits	0 to 2	Topsoil (driller's log)
	2 to 12	Silt, yellow, argillaceous
	12 to 15	Silt, very light gray and orange, very argillaceous
	15 to 20	Sand, colorless, orange, dark coarse to fine, partly with argillaceous cement
	20 to 22	Silt, gray and yellow, very argillaceous
	22 to 35	Silt, gray, with trace hard sand
	35 to 42	Gravel, colorless, varicolored; sand, fine
	42 to 52	Silt, gray, argillaceous, calcareous
	52 to 54	Silt, medium dark gray, argillaceous
Pleistocene deposits	54 to 59	Till, gray, unoxidized, unleached
	59 to 66	Sand, colorless, yellow, coarse to medium; gravel, quartz, trace igneous, granite; gravel, light gray, silt-grade, limestone rocks
Pennsylvanian rocks, undifferentiated	66 to 68	Limestone, light gray, silt-grade, Kansas City Group

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW34	**W-27834**	**74-38-36BAAA**	**411025-0950956**	**1,073**	**Pottawattamie**

SW34U casing	0 to 20	
	20 to 25	Well screen
SW34L casing	0 to 34	
	34 to 39	Well screen

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW34--Continued				
Quaternary deposits	0	to	3	Fill and topsoil (driller's log)
	3	to	5	Clay, dark gray (driller's log)
	5	to	9	Clay, gray, yellow-gray, silty
	9	to	11	Silt, orange, argillaceous
	11	to	15	Silt, gray, yellow-gray, argillaceous
	15	to	18	Sand, colorless, yellow, orange, dark, medium to fine and coarse, quartz
	18	to	24	Sand, colorless, yellow, orange, dark, medium to fine and coarse, quartz; gravel, partly argillaceous
	24	to	31	Gravel; sand, colorless, yellow, orange, dark, medium to fine and coarse, quartz
	31	to	40	Sand, colorless, yellow, orange, dark, medium to fine and coarse, quartz; gravel
	40	to	55	Sandstone; gravel; dolostone; very light gray, silt-grade
	55	to	60	Gravel, igneous and dolostone rocks; sand
Cretaceous rocks	60	to	100	Sandstone, colorless, orange, medium to coarse and fine, quartz
Dakota Formation	100	to	101	Sandstone, yellow-brown and tan, fine to medium (driller's log)

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW35	**W-27835**	**72-38-20ACAA**	**410130-0951417**	**1,038**	**Montgomery**

SW35U casing	0	to	14	
	14	to	17	Slotted
SW35L casing	0	to	22	
	22	to	27	Slotted

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Topsoil and clay, gray (driller's log)
	5	to	12	Silt, orange-gray, very argillaceous
	12	to	15	Silt, orange-gray, very argillaceous; sand, coarse; gravel, varicolored
	15	to	17	Sand, colorless and orange, coarse to fine, clean
	17	to	20	Sand, colorless, yellow, orange, dark, coarse to medium
	20	to	30	Sand, colorless, yellow, orange, dark, coarse to medium; gravel

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW35--Continued				
Pennsylvanian rocks, undifferentiated Virgil Series	30	to	33	Limestone, brown to yellow, with iron oxide

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW36	**W-27836**	**71-41-04AAAA**	**405911-0953324**	**977**	**Mills**

SW36U casing	0	to	40	
	40	to	44	Slotted
SW36L casing	0	to	57	
	57	to	62	Well screen

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	3	Topsoil (driller's log)
	3	to	5	Clay, yellow-gray, silty (driller's log)
	5	to	8	Silt, pale yellow, very argillaceous
	8	to	16	Silt, orange, very argillaceous
	16	to	20	Silt, orange, very argillaceous, calcareous
	20	to	27	Silt, very pale yellow, very argillaceous, calcareous
	27	to	29	Silt, brown-gray, argillaceous
	29	to	30	Sand, colorless and dark coarse to fine; gravel
	30	to	32	Silt, gray, very argillaceous, slightly sandy
	32	to	40	Clay, gray, silty
	40	to	50	Sand, colorless and very light gray, coarse to fine, subrounded to angular
	50	to	68	Gravel, varicolored; sand, colorless and very light gray, coarse to fine, subrounded to angular
	68	to	69	Clay, dark orange and brown, gravelly, sandy

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW37	**W-27837**	**73-41-23BCCC**	**410636-0953215**	**1,068**	**Mills**

SW37 casing	0	to	255	
	255	to	260	Well screen

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW37--Continued				
Quaternary deposits	0	to	2	Topsoil (driller's log)
	2	to	8	Clay, gray, silty
	8	to	12	Silt, orange, argillaceous
Pleistocene deposits	12	to	20	Till, yellow, oxidized, unleached
	20	to	24	Till, light gray, unoxidized, unleached
	24	to	32	Till, pale yellow, oxidized, unleached
	32	to	36	Till, medium light gray, unoxidized, unleached
	36	to	40	Till, medium light gray, unoxidized, unleached, with sparse sand
	40	to	50	Till, light olive-gray, unoxidized, unleached
	50	to	60	Sand, varicolored, colorless, coarse to fine; gravel, subrounded, partly very argillaceous
	60	to	80	Till, light olive-gray, unoxidized, unleached, very sandy
	80	to	100	Till, light olive-gray, unoxidized, unleached
	100	to	134	Till, light olive-gray, unoxidized, unleached, very gravelly
	134	to	170	Gravel, varicolored, subrounded; quartz; metamorphic and limestone rocks; till, light olive-gray, unoxidized, unleached, very gravelly
	170	to	175	Gravel, varicolored, subrounded, quartz; metamorphic and limestone rocks
	175	to	239	Till, light olive-gray, unoxidized, unleached; gravel, varicolored, subrounded; quartz, metamorphic, and limestone rocks
	239	to	279	Sand, colorless, varicolored, coarse to fine, quartz, with 10 percent dark grains; gravel, subrounded to subangular
Pennsylvanian rocks, undifferentiated	279	to	285	Shale, gray-green (driller's log)

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW38	**W-27839**	**70-41-32AABB**	**404906-0953446**	**960**	**Fremont**

SW38U casing	0	to	35	
	35	to	38	Slotted
SW38L casing	0	to	50	
	50	to	55	Well screen

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW38--Continued				
Quaternary deposits	0	to	2	Topsoil (driller's log)
	2	to	5	Clay, yellow-brown, silty (driller's log)
	5	to	17	Silt, yellow, argillaceous
	17	to	20	Silt, yellow, argillaceous, calcareous
	20	to	26	Silt, orange, very light gray, argillaceous, calcareous
	26	to	30	Clay, very light gray, calcareous, silty
	30	to	32	Clay, very light gray, calcareous, silty; silt, argillaceous
	32	to	34	Clay, very light gray, calcareous, silty; silt, orange, argillaceous; sand, colorless, coarse to fine
	34	to	40	Sand, colorless, varicolored, coarse to fine; gravel
	40	to	56	Sand, colorless, varicolored, coarse to fine; gravel, subrounded to subangular
Pleistocene deposits	56	to	58	Gravel, gray; till, gray unoxidized, leached

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW39	**W-27840**	**70-41-32AABB**	**404906-0953446**	**960**	**Fremont**

SW39U casing	0	to	130	
	130	to	135	2-inch diameter polyvinyl-chloride well screen
SW39L casing	0	to	216	
	216	to	221	2-inch diameter polyvinyl-chloride well screen

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	56	No samples (see log for SW38)
Pleistocene deposits	56	to	60	Till, olive-gray, unoxidized, unleached, weakly calcareous
	60	to	100	Till, olive-gray, unoxidized, unleached
	100	to	119	Till, gray, unoxidized, unleached
	119	to	121	Till, gray, unoxidized, unleached, gravelly
	121	to	125	Till, light olive-gray, unoxidized, unleached
Tertiary deposits				
Pliocene deposits	125	to	140	Sand, colorless, yellow, orange, dark medium to fine and coarse, subrounded, quartz, with 5 percent heavy, igneous or metamorphic grains
	140	to	160	Sand, colorless, yellow, orange, dark coarse to fine, quartz, with trace heavy minerals

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW39--Continued				
Pliocene deposits--Continued	160	to	180	Sand, colorless, yellow, orange, dark coarse to fine, quartz, with trace heavy minerals; gravel, quartz and igneous granite
	180	to	200	Sand, colorless, yellow, orange, dark coarse to fine, quartz, with trace heavy minerals
	200	to	223	Sand, colorless, yellow, orange, dark medium to coarse and fine, quartz, with trace heavy minerals
Pennsylvanian rocks, undifferentiated	223	to	225	Limestone (driller's log)

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW40	**W-27841**	**71-42-07BBCD**	**415812-0954328**	**1,122**	**Mills**

SW40 casing	0	to	332	
	332	to	342	Slotted

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Clay, gray-brown, silty (driller's log)
	5	to	15	Silt, brown-gray, argillaceous
	15	to	30	Silt, medium dark gray, argillaceous
	30	to	40	Silt, very light gray, calcareous
	40	to	44	Silt, medium light gray, gray, calcareous
	44	to	50	Silt, light gray, calcareous
	50	to	55	Silt, gray and orange, mottled, very calcareous
	55	to	63	Silt, gray and orange, mottled, very calcareous, with trace sand
Pleistocene deposits	63	to	65	Till, oxidized, leached
	65	to	69	Till, oxidized, leached, with sparse sand and gravel
	69	to	70	Till, orange, mottled, oxidized, leached
	70	to	73	Till, orange, mottled, oxidized, unleached
	73	to	80	Till, olive-gray, unoxidized, unleached
	80	to	82	Gravel, varicolored; sand, coarse
	82	to	86	Gravel, varicolored; sand, medium, dirty
	86	to	130	Till, light olive-gray, unoxidized, unleached
	130	to	137	Sand, colorless, orange, pink, yellow, dark, medium to fine and coarse
	137	to	240	Till, light olive-gray, unoxidized, unleached
	240	to	245	Till, light gray, unoxidized, unleached
	250	to	270	Sand, colorless, yellow, pink, dark, heavy, medium

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW40--Continued				
Pleistocene deposits--Continued				to fine and coarse, subrounded to subangular, quartz, with trace heavy mineral grains
	270	to	310	Sand, colorless, yellow, pink, dark, heavy, coarse to fine, subrounded to subangular, quartz, with trace heavy mineral grains; gravel
	310	to	348	Sand, colorless, yellow, pink, dark, heavy, coarse to fine, subrounded to subangular, silty, quartz, with trace heavy mineral grains; gravel
Pennsylvanian rocks, undifferentiated	348	to	351	Limestone, very light gray, silt-grade

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW41	**W-27842**	**71-42-24AAAA**	**405640-0953651**	**1,102**	**Mills**

Stratigraphic unit	Depth interval (feet)			Description
SW41 casing	0	to	240	
	240	to	250	Slotted
Quaternary deposits	0	to	2	Topsoil (driller's log)
	2	to	5	Clay, yellow-brown and brown, silty (driller's log)
	5	to	10	Silt, yellow, argillaceous
	10	to	20	Silt, yellow, very argillaceous
Pleistocene deposits	20	to	30	Till, light yellow, oxidized, leached
	30	to	60	Till, light yellow, oxidized, unleached
	60	to	80	Till, gray and orange, mottled, partly oxidized, unleached
	80	to	100	Till, light olive-gray, unoxidized, unleached
	100	to	105	Gravel, varicolored; sand, coarse, subrounded, very dirty
	105	to	120	Till, light olive to gray, unoxidized, unleached
	120	to	140	Till, light olive-gray, unoxidized, unleached, gravelly
	140	to	156	Till, light olive-gray, unoxidized, unleached
	156	to	180	Till, medium light gray, unoxidized, unleached
	180	to	226	Till, medium light gray, unoxidized, unleached, very gravelly
	226	to	240	Sand, colorless, yellow, pink, dark medium to fine and coarse, quartz, with trace heavy grains; partly with calcareous cement
	240	to	250	Sand, colorless, yellow, pink, dark coarse to fine, quartz, with trace heavy grains
Pennsylvanian rocks, undifferentiated	250	to	255	Limestone, very light gray, silt-grade

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW42	**W-28041**	**71-36-32DDDD**	**405403-0950017**	**1,031**	**Montgomery**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	2	Topsoil (driller's log)
	2	to	4	Clay, dark gray (driller's log)
	4	to	6	Clay, medium dark gray, silty
	6	to	9	Clay, medium light gray, silty
	9	to	14	Clay, light yellow, silty
	14	to	16	Silt, light yellow, orange
	16	to	21	Sand, colorless, trace varicolored, trace dark, clean, fine, with partly argillaceous cement
	21	to	27	Clay, gray, silty, trace sandy
	27	to	34	Silt, light brown, argillaceous, sandy
	34	to	37	Sand, colorless, varicolored, medium to fine and coarse, subrounded
	37	to	40	Gravel, varicolored; sand, with silty cement
	40	to	47	Sand, colorless, yellow, pink, coarse to fine
Pennsylvanian rocks, undifferentiated	47	to	53	Shale, light green, slightly silty
	53	to	55	Dolostone, light gray, silt-grade
	55	to	56.5	Shale, gray, calcareous to dolomitic; shale, very dark gray
	56.5	to	58	Shale, medium dark gray, blocky
	58	to	59	Shale, medium light gray to medium dark gray
	59	to	60.5	Shale, very dark gray; coal
	60.5	to	61	Shale, medium light gray, calcareous, lumpy

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW43	**W-28042**	**72-33-28ADAA**	**410040-0943832**	**1,140**	**Adams**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	2	Topsoil (driller's log)
	2	to	8	Clay, gray, silty
	8	to	12	Silt, very light gray and orange, very argillaceous
	12	to	14	Clay, very light orange, very silty
	14	to	18	Clay, light gray and light orange, very silty
	18	to	30	Sand, orange, colorless, dark, coarse to fine; gravel
	30	to	34	Gravel; sand, coarse

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW43--Continued				
Pleistocene deposits	34	to	60	Till, light olive-gray, unoxidized, unleached
	60	to	72	Till, medium light gray, unoxidized, unleached, very sandy, gravelly
	72	to	77	Till, light yellow, with gray, partly oxidized, unleached
	77	to	100	Till, light yellow, oxidized, unleached
	100	to	120	Till, light yellow, oxidized, unleached; with till, orange, oxidized, unleached
	120	to	135	Till, light yellow, pale orange, oxidized, unleached
	135	to	140	Till, medium dark gray, unoxidized, unleached; till, orange, mottled, oxidized, unleached
	140	to	148	Till, dark gray, unoxidized, unleached
Pennsylvanian rocks, undifferentiated	148	to	149	Limestone, light gray, maroon; much sand
	149	to	150	Shale, light green
	150	to	151	Shale, maroon, calcareous
	151	to	155	Shale, green, lumpy
	155	to	161	Shale, medium light green-gray, slightly calcareous

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW44	**W-28043**	**73-33-28BCCC**	**410537-0943938**	**1,190**	**Adams**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	13	Clay, gray, slightly silty
	13	to	16	Clay, medium light gray-brown, silty
	16	to	20	Clay, light gray-yellow, silty
	20	to	28	Clay, light gray, silty
	28	to	30	Silt, yellow, sandy; gravel
	30	to	38	Gravel, varicolored, subrounded; sand, coarse, argillaceous
	38	to	44	Gravel, varicolored, subrounded; sand, coarse, argillaceous, with calcareous matrix

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW44--Continued				
Pleistocene deposits	44	to	50	Till, olive-gray, unoxidized, unleached
	50	to	80	Till, light olive-gray, unoxidized, unleached
	80	to	90	Till, light olive-gray, unoxidized, unleached, with trace till, orange, oxidized, unleached
	90	to	130	Till, light olive-gray, unoxidized, unleached
	130	to	140	Till, medium light gray, unoxidized, unleached
	140	to	151	Till, light olive-gray, unoxidized, unleached
	151	to	155	Till, medium light gray, unoxidized, unleached, gravelly
	155	to	178	Till, light gray, unoxidized, unleached
	178	to	180	Till, medium light brown-gray, unoxidized, unleached
	180	to	187	Silt, brown-gray, sandy, slightly calcareous
	187	to	197	Reworked shale and limestone fragments (driller's log)
Pennsylvanian rocks, undifferentiated	197	to	199	Dolostone, light gray, silt-grade to coarse, fragmented
	199	to	205	Shale, gray, silty, micaceous, calcareous
	205	to	207	Shale, dark gray, blocky, silty
	207	to	208	Dolostone, medium light gray, silt-grade, calcareous, argillaceous
	208	to	212	Dolostone, medium light gray, silt-grade, calcareous; shale, medium light gray, lumpy, silty, calcareous

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW45	**W-28044**	**74-33-31DDDD**	**410930-0944034**	**1,134**	**Adair**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	5	Fill (driller's log)
Quaternary deposits	5	to	8	Clay, medium light gray, slightly silty
	8	to	10	Clay, medium light gray, orange, slightly silty
	10	to	15	Silt, very light orange-gray with orange mottling, argillaceous
	15	to	18	Silt, very light orange-gray with light gray mottling, argillaceous
	18	to	20	Sand, colorless, varicolored, coarse to fine, subrounded

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW45--Continued				
Quaternary deposits--Continued	20	to	25	Sand, colorless, varicolored, coarse to fine, subrounded; gravel, fine, subrounded, with argillaceous matrix
	25	to	29	Sand, colorless, varicolored, coarse to fine, subrounded; gravel, fine, subrounded, with slightly argillaceous matrix
Pleistocene deposits	29	to	40	Till, blue-gray (driller's log)
	40	to	48	Till, medium light gray, unoxidized, unleached
	48	to	50	Gravel, varicolored, subrounded; sand, coarse
Pennsylvanian rocks, undifferentiated	50	to	54	Shale, light green and yellow, lumpy, soft, calcareous
	54	to	55	Shale, gray, lumpy, hard, calcareous
	55	to	57	Dolostone, light gray, silt-grade, calcareous
	57	to	59	Shale, light green, lumpy, calcareous
	59	to	60	Siltstone, yellow, calcareous; shale, green, lumpy, calcareous
	60	to	61	Limestone, very light yellow, silt-grade; shale, light green
	61	to	63	Shale, green, calcareous, lumpy
	63	to	65	Limestone, very light gray, silt-grade to fine, dense
	65	to	68	Shale, very light green-gray, silty, calcareous
	68	to	69	Shale, very light green-gray, silty, calcareous; limestone
	69	to	70	Shale; limestone; shale, dark gray, subflaky
	70	to	72.5	Shale, dark gray, silty, calcareous
	72.5	to	75	Shale, light green, silty, calcareous
	75	to	76	Dolostone, very light gray, silt-grade, argillaceous; shale, light green, silty, calcareous
	76	to	78	Limestone, very light gray, argillaceous; shale, light green, silty, calcareous
	78	to	79	Limestone, very light gray, silt-grade; shale, dark gray
	79	to	80	Limestone, very light gray, fine to silt-grade, crystalline
	80	to	81	Limestone, very light gray, fine to silt-grade, crystalline, dolomitic
	81	to	83	Limestone, very light gray, silt-grade
	83	to	85	Dolostone, medium light gray, argillaceous
	85	to	87	Limestone, medium light gray, silt-grade, argillaceous
	87	to	95	Shale, medium dark gray, silty, calcareous

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land surface altitude (feet above sea level)	County
SW46	**W-28045**	**76-33-20CCCC**	**412136-0944049**	**1,227**	**Adair**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	5	Roadbed and fill (driller's log)
Quaternary deposits	5	to	13	Clay, medium light brown, silty
	13	to	14	Clay, orange-brown, silty
	14	to	19	Clay, gray with orange mottling, hard
	19	to	21	Clay, gray, orange to yellow, silty, sandy
	21	to	30	Gravel; sand, varicolored, subrounded, coarse, partly with argillaceous and silty cement
	30	to	33	Clay, dark yellow, very silty, sandy
	33	to	35	Gravel, varicolored; sand, coarse, subrounded
Pleistocene deposits	35	to	43	Till, medium light yellow, oxidized, unleached
	43	to	56	Till, orange-yellow, oxidized, unleached
	56	to	63	Till, yellow-orange, oxidized, leached
Pennsylvanian rocks, undifferentiated	63	to	64	Dolostone, very light gray, silt-grade, calcareous
	64	to	67	Dolostone, very light gray, silt-grade, calcareous; limestone
	67	to	68	Dolostone, yellow-orange, silt-grade, calcareous
	68	to	69	Dolostone, yellow-orange, silt-grade, calcareous; chert, brown
	69	to	70	Limestone, orange, silt-grade
	70	to	71	Limestone, very light orange-gray, silt-grade
	71	to	72	Limestone, very light orange-gray, silt-grade, fragmented
	72	to	73	Limestone, light brown, silt-grade
	73	to	74	Limestone, very light yellow, silt-grade
	74	to	76	Limestone, light brown, silt-grade
	76	to	77	Limestone, light brown, silt-grade, dense
	77	to	79	Limestone, very light gray, light orange, silt-grade
	79	to	81	Limestone, very light gray, orange, silt-grade to medium

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW47	**W-28046**	**70-33-21AABB**	**405122-0943851**	**1,168**	**Taylor**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	15	Roadbed and fill (driller's log)
Quaternary deposits	15	to	20	Clay, gray, silty
	20	to	25	Clay, gray, very silty
	25	to	27	Silt, orange, gray, very argillaceous
	27	to	29	Silt, orange, sandy, argillaceous
	29	to	31	Silt, very light gray and orange, argillaceous
	31	to	33	Silt, argillaceous, sandy
	33	to	36	Silt, gray-brown, argillaceous
	36	to	42	Silt, brown, argillaceous
	42	to	45	Sand, colorless, varicolored, coarse to fine; gravel, subrounded, with silty, argillaceous matrix
Pleistocene deposits	45	to	48	Till, yellow, oxidized, unleached
	48	to	52	Till, light yellow, oxidized, unleached
	52	to	60	Till, gray and orange, partly oxidized, unleached
	60	to	78	Till, light olive-gray, unoxidized, unleached
	78	to	80	Till, medium light brown, unoxidized, unleached
	80	to	90	Till, gray, unoxidized, unleached
	90	to	131	Till, light olive-gray, unoxidized, unleached
	131	to	133	Clay, light gray, silty, calcareous, with limestone clasts
	133	to	137	Clay, medium light gray, with gravel, calcareous
	137	to	140	Till, medium light gray, light yellow, partly oxidized, unleached
	140	to	143	Clay, medium light gray to orange
Pennsylvanian rocks, undifferentiated	143	to	152	Shale, green, lumpy, calcareous
	152	to	153	Dolostone, very light gray to orange, silt-grade to fine, with ostracodes and fusulinids
	153	to	154	Limestone, very light gray-brown, light orange
	154	to	155	Limestone, very light gray-brown, light orange, green-gray
	155	to	156	Limestone, very light gray-brown, light orange, green-gray, fragmented
	156	to	157	Shale, very dark gray, gray, micaceous, subflaky
	157	to	159	Shale, gray, blocky, calcareous
	159	to	160	Limestone, very light gray, orange, silt-grade
	160	to	161	Limestone, medium light gray
	161	to	165	Shale, medium dark gray, blocky, silty, slightly calcareous
	165	to	167	Shale, very dark gray, calcareous
	167	to	170	Shale, very dark gray, calcareous; shale, medium light gray, lumpy
	170	to	172	Shale, light gray, lumpy; limestone, very light gray
	172	to	174	Shale, gray, very calcareous, blocky
	174	to	176	Shale, green, medium light gray, lumpy calcareous
	176	to	177	Limestone, very light gray, brown, silt-grade

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW48	**W-28047**	**68-33-08AAAB**	**404245-0943945**	**1,122**	**Taylor**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	5	Roadbed (driller's log)
Quaternary deposits	5	to	16	Clay, light brown-gray, slightly silty
	16	to	20	Clay, light gray, mottled orange, silty
	20	to	29	Clay, light gray, mottled orange, very silty
	29	to	38	Silt, orange-brown, argillaceous
	38	to	41	Gravel, varicolored, subrounded; sand, coarse
Pleistocene deposits	41	to	60	Till, light olive-gray, unoxidized, unleached
	60	to	70	Till, medium light gray, unoxidized, unleached
	70	to	80	Till, medium light gray, unoxidized, unleached; sand, colorless, varicolored, coarse to medium; gravel, subrounded
	80	to	89	Till, medium light gray, unoxidized, unleached
	89	to	92	Till, medium light gray, unoxidized, unleached, gravelly
	92	to	97	Till, medium light gray, unoxidized, unleached
	97	to	98	Till, medium light gray, unoxidized, unleached; gravel, varicolored
Pennsylvanian rocks, undifferentiated	98	to	102	Limestone, very light gray, silt-grade; shale, very pale green, calcareous
	102	to	103	Limestone, very light gray, silt-grade
	103	to	104	Limestone, very light gray with dark gray mottling
	104	to	107	Shale, brown, blocky; shale, very dark gray
	107	to	109	Shale, dark gray
	109	to	110	Shale, gray, calcareous
	110	to	111	Limestone, gray, silt-grade, calcareous
	111	to	112	Shale, gray
	112	to	114	Dolostone, gray, argillaceous, silt-grade; shale
	114	to	115	Dolostone, very light gray, silt-grade
	115	to	117	Dolostone, light gray, silt-grade, calcareous
	117	to	120	Dolostone, very light gray, silt-grade
	120	to	121	Dolostone, very light gray, light gray, silt-grade

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW49	**W-28048**	**68-36-31BCCA**	**403938-0950138**	**960**	**Page**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Roadbed and topsoil (driller's log)
	5	to	12	Clay, brown, silty
	12	to	14	Clay, gray and dark brown, silty
	14	to	20	Clay, medium light gray, silty
	20	to	27	Gravel; sand, medium, subrounded to subangular; trace silty, argillaceous matrix
Pennsylvanian rocks, undifferentiated	27	to	28	Shale, gray, yellow, lumpy, calcareous
	28	to	30	Shale, gray, lumpy, calcareous
	30	to	31	Shale, light gray, flaky, silty, calcareous
	31	to	33	Limestone, light gray, argillaceous
	33	to	34	Limestone, light gray, argillaceous; shale
	34	to	36	Dolostone, very light gray, silt-grade to coarse, crystalline, very calcareous
	36	to	38	Dolostone, very light gray, silt-grade to coarse, crystalline, very calcareous; limestone, dark gray, mottled, argillaceous

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW50	**W-28049**	**69-36-16CBCB**	**404634-0950010**	**992**	**Taylor**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Roadbed and topsoil (driller's log)
	5	to	10	Clay, gray, slightly silty
	10	to	15	Clay, medium light gray, slightly silty
	15	to	21	Clay, light gray with orange mottling, slightly silty
	21	to	25	Clay, gray, medium light gray, slightly silty
	25	to	27	Clay, gray and orange mottled, silty, with plant fossils
Pleistocene deposits	27	to	30	Till, gray, unoxidized, unleached
Pennsylvanian rocks, undifferentiated	30	to	32	Shale, gray, lumpy, soft, calcareous, micaceous
	32	to	35	Shale, green-gray, lumpy, soft, calcareous, micaceous
	35	to	36	Shale, blue-gray, silty, calcareous, lumpy

Stratigraphic unit	Depth interval (feet)			Description
SW50--Continued				
Pennsylvanian rocks, undifferentiated--Continued	36	to	37	Shale, blue-gray, silty, very calcareous, lumpy; limestone
	37	to	38	Dolostone, medium light gray, very argillaceous; shale
	38	to	40	Shale, brown and medium dark gray, silty, calcareous, subflaky
	40	to	41	Shale, medium light gray, lumpy, silty, calcareous; shale, dark gray, subflaky, silty, calcareous

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW51	**W-28050**	**69-36-13ACCB**	**404648-0945614**	**1,015**	**Page**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	4	Roadbed (driller's log)
Quaternary deposits	4	to	13	Clay, gray, silty
	13	to	15	Clay, very light brown, silty
	15	to	17	Clay, very light gray, silty
	17	to	20	Clay, pale orange, pale brown, silty
	20	to	27	Clay, very light gray, silty
	27	to	30	Clay, medium light brown-gray, silty
	30	to	32	Gravel, varicolored; sand, coarse, with argillaceous matrix
Pennsylvanian rocks, undifferentiated	32	to	35	Shale
	35	to	36	Shale, gray-brown, very calcareous
	36	to	38.5	Shale, gray, flaky, silty
	38.5	to	39	Shale, very dark gray, blocky, carbonaceous
	39	to	40	Shale, very light gray, blocky, carbonaceous, calcareous; dolostone, light brown, silt-grade, argillaceous
	40	to	41	Shale, very light gray, blocky, carbonaceous, calcareous; limestone, gray, silt-grade

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW52	**W-28051**	**72-34-16DCAC**	**410153-0944622**	**1,135**	**Adams**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Roadbed and clay, blue, sandy (driller's log)
	5	to	11	Clay, gray, slightly silty
	11	to	15	Clay, medium light gray, light gray, orange, silty
	15	to	20	Clay, medium light gray, silty
	20	to	25	Clay, medium light gray, orange, very sandy, silty
	25	to	31	Clay, dark orange, silty
	31	to	38	Silt, orange-gray, argillaceous
	38	to	41	Silt, orange-gray, argillaceous; gravel, abundant; sand, varicolored
Pennsylvanian rocks, undifferentiated	41	to	43	Shale, green, very calcareous
	43	to	45	Shale, green, very calcareous; limestone, yellow
	45	to	47	Shale, yellow-green, very calcareous
	47	to	48	Shale, yellow-green, very calcareous; limestone; gypsum, crystalline
	48	to	49	Limestone, very light gray, yellow-green, argillaceous
	49	to	50	Dolostone, orange
	50	to	52	Dolostone, orange, very calcareous
	52	to	53	Dolostone, very light gray, yellow, calcareous
	53	to	55	Dolostone, very light gray, silt-grade, calcareous
	55	to	56	Dolostone, very light gray, argillaceous; shale, green-gray
	56	to	56.5	Dolostone, very light gray, silt-grade, calcareous
	56.5	to	57	Dolostone, light green, silt-grade; shale, green and gray, very calcareous
	57	to	58.5	Dolostone, light gray
	58.5	to	63	Shale, gray, lumpy, calcareous
	63	to	66	Shale, gray, lumpy, silty, calcareous
	66	to	67	Limestone, light gray, yellow, silt-grade; shale, gray, lumpy, silty, calcareous
	67	to	68	Limestone, very light gray, silt-grade to fine
	68	to	69	Limestone, very light gray, yellow, silt-grade to fine

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW53	**W-28052**	**72-35-12BDAA**	**410318-0944928**	**1,090**	**Adams**

Stratigraphic unit	Depth interval (feet)	Description
	0 to 5	Roadbed (driller's log)
Quaternary deposits	5 to 10	Clay, gray-brown, silty
	10 to 13	Clay, gray-brown
	13 to 15	Clay, gray-brown, silty
	15 to 19	Silt, orange and gray, argillaceous
	19 to 25	Silt, gray-brown, argillaceous
	25 to 35	Sand, colorless, varicolored, coarse; gravel, fine, subrounded, partly with argillaceous matrix
Pennsylvanian rocks, undifferentiated	35 to 40	Shale, medium light gray, slightly silty, slightly calcareous
	40 to 41	Dolostone, very light gray, calcareous
	41 to 44	Shale, medium light gray, blocky, silty, calcareous
	44 to 46	Shale, medium light green, calcareous, blocky
	46 to 47	Dolostone, very light gray, silt-grade, calcareous
	47 to 48	Dolostone, very light gray, silt-grade, calcareous, partly argillaceous
	48 to 50	Dolostone, very light gray, silt-grade
	50 to 52	Shale, medium light gray, silty, calcareous; dolostone
	52 to 53	Limestone, very light gray, silt-grade; shale
	53 to 54	Limestone, very light gray, silt-grade; shale, medium light gray
	54 to 55	Limestone, very light gray, gray mottled
	55 to 56	Dolostone, gray, calcareous, argillaceous
	56 to 58	Shale, gray, micaceous, blocky
	58 to 59	Shale, gray, subflaky, slightly calcareous
	59 to 61	Shale, gray, subflaky, slightly calcareous, lumpy

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW54	**W-28053**	**74-35-31CBBC**	**410951-0945537**	**1,130**	**Cass**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	5	Roadbed (driller's log)
Quaternary deposits	5	to	8	Clay, brown, silty
	8	to	13	Clay, medium dark gray, silty
	13	to	18	Clay, gray with orange mottling, silty
	18	to	20	Clay, darker gray with orange mottling, silty
	20	to	31	Silt, light yellow-gray
	31	to	36	Sand, colorless, varicolored, coarse to fine; gravel, subrounded
	36	to	40	Sand, colorless, varicolored, coarse to fine, trace medium to fine; gravel, subrounded
	40	to	43.5	Sand, colorless, varicolored, coarse to fine; gravel, subrounded; partly with argillaceous matrix
Pennsylvanian rocks, undifferentiated	43.5	to	44	Shale, gray, blocky, hard
	44	to	45	Shale, gray, lumpy, calcareous; trace dolostone
	45	to	46	Shale, gray, lumpy, calcareous, with calcareous fossils
	46	to	47	Shale, gray, lumpy, calcareous, with fusulinids
	47	to	48	Shale, light green-gray and gray, calcareous
	48	to	50	Dolostone, very light gray, silt-grade, calcareous
	50	to	51	Shale, very dark gray, flaky
	51	to	53	Shale, medium dark gray, calcareous, silty, lumpy
	53	to	54	Dolostone, orange, calcareous; shale, green, calcareous
	54	to	55	Dolostone, very light gray, calcareous
	55	to	58	Limestone, very light gray, yellow, silt-grade
	58	to	60	Limestone, very light gray, light yellow, silt-grade

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW55	**W-28054**	**70-37-06AADD**	**405351-0950814**	**1,080**	**Page**

SW55 casing	0	to	58	
	58	to	62	Slotted

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	3	Topsoil (driller's log)
	3	to	5	Clay, blue-gray (driller's log)
	5	to	14	Clay, gray, silty, blocky
	14	to	18	Clay, light gray, silty, blocky
	18	to	26	Clay, light gray, slightly silty, blocky
	26	to	30	Silt, very light gray, very argillaceous
	30	to	36	Clay, very light gray, very silty
	36	to	50	Clay, light gray, silty
	50	to	58	Silt, medium light gray, argillaceous
	58	to	60	Sand, colorless, varicolored, coarse; gravel, medium, dirty
	60	to	62	Sand, colorless, varicolored, coarse; gravel, medium, dirty; with argillaceous and silty matrix
Pennsylvanian rocks, undifferentiated	62	to	65	Dolostone, medium light gray, very argillaceous

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW56	**W-28117**	**69-38-11ABAB**	**404801-0951053**	**1,040**	**Page**

SW56 casing	0	to	50	
	50	to	54	Slotted

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Topsoil and fill (driller's log)
	5	to	12	Clay, gray, silty
	12	to	19	Clay, medium light gray, silty
	19	to	28	Silt, light yellow, argillaceous
	28	to	31	Clay, brown-gray, silty
	31	to	40	Silt, light yellow, argillaceous

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW56--Continued				
Quaternary deposits--Continued	40	to	50	Silt, light brown, argillaceous
	50	to	54	Gravel, varicolored, subrounded; sand, coarse, clean
Pennsylvanian rocks, undifferentiated	54	to	57	Shale, gray, blocky, lumpy
	57	to	58	Dolostone, very light gray, silt-grade, calcareous

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW57	**W-28118**	**67-38-08DADD**	**403743-0951317**	**980**	**Page**

SW57 casing	0	to	45	
	45	to	51	Slotted

Stratigraphic unit	Depth interval (feet)			Description
	0	to	10	Roadbed and fill (driller's log)
Quaternary deposits	10	to	14	Clay, gray, silty
	14	to	25	Clay, medium light gray, silty
	25	to	30	Clay, pale yellow, gray
	30	to	35	Clay, gray and orange, silty
	35	to	40	Silt, gray and orange, argillaceous
	40	to	46	Gravel, varicolored; sand, medium, subrounded; with calcareous, argillaceous matrix
	46	to	48	Clay, yellow-gray, silty, sandy; gravel
	48	to	51	Gravel, varicolored; sand, coarse, subrounded
Pleistocene deposits	51	to	58	Till, gray, unoxidized, unleached

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW58	**W-28119**	**72-33-08DDDC**	**410237-0943943**	**1,175**	**Adams**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Roadbed and topsoil (driller's log)
	5	to	11	Clay, gray, silty
	11	to	15	Clay, gray with trace orange mottling, silty
	15	to	25	Clay, light gray, silty

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW58--Continued				
Quaternary deposits--Continued	25	to	33	Clay, medium light gray, silty
Pleistocene deposits	33	to	80	Till, light olive-gray, unoxidized, unleached
	80	to	96	Till, olive-gray, unoxidized, unleached
	96	to	123	Till, light yellow, oxidized, unleached
	123	to	128	Clay, light gray
	128	to	131	Clay, light gray, with trace sand, light orange
Pennsylvanian rocks, undifferentiated	131	to	133	Shale, light green, yellow, gray
	133	to	135	Dolostone, very light gray, light yellow, silt-grade, calcareous
	135	to	137	Shale, yellow, very calcareous
	137	to	138	Dolostone, yellow, silt-grade; shale, gray, blocky, hard, slightly dolomitic
	138	to	139	Dolostone, yellow, silt-grade; shale, gray, blocky, hard, dolomitic
	139	to	141	Shale, gray, lumpy, silty, calcareous

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW59	**W-28120**	**72-32-09BCCB**	**410308-0943247**	**1,168**	**Adams**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	6	Roadbed and fill (driller's log)
Quaternary deposits	6	to	11	Clay, medium light gray, silty
	11	to	20	Silt, very light gray, orange, argillaceous
	20	to	26	Clay, light gray, very silty
	26	to	32	Silt, very light gray, argillaceous
	32	to	35	Gravel, varicolored, subrounded; sand, coarse; with argillaceous matrix
	35	to	40	Sand, varicolored, coarse; gravel, medium, subrounded, clean
Pleistocene deposits	40	to	46	Till, light gray, oxidized, unleached, very weakly calcareous
	46	to	54	Till, light gray, unoxidized, unleached
	54	to	60	Till, very light gray, oxidized, unleached
	60	to	64	Till, light olive-gray, unoxidized, unleached, weakly calcareous
	64	to	65	Till, gray, unoxidized, unleached, weakly calcareous
	65	to	73	Till, very pale green, oxidized, unleached
	73	to	80	Till, gray, unoxidized, unleached, very weakly calcareous
	80	to	82	Till, gray (driller's log)

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW59--Continued				
	82			Sand and gravel (driller's log)

Note: Well flows at the land surface from 300 to 400 gallons per minute from 82 feet below land surface.

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW60	**W-28121**	**75-32-28CDDD**	**411532-0943212**	**1,205**	**Adair**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Clay, medium light gray, silty
	5	to	8	Silt, light yellow, light orange mottled
	8	to	13	Silt, light yellow, light orange mottled, very argillaceous
	13	to	28	Silt, very light yellow, argillaceous
	28	to	31	Silt, gray-brown, argillaceous, sandy
	31	to	36	Gravel, varicolored, subrounded; sand, colorless, subrounded
Pleistocene deposits	36	to	38	Till, light yellow, oxidized, unleached
	38	to	39	Till, green-yellow, oxidized, unleached
	39	to	40	Till, medium light gray, unoxidized, unleached; till, orange, oxidized, unleached
	40	to	60	Till, medium light green-gray, unoxidized, unleached
	60	to	70	Till, medium light gray, unoxidized, unleached
	70	to	110	Till, light olive-gray, unoxidized, unleached
	110	to	115	Till, medium light olive-gray, unoxidized, unleached
	115	to	120	Till, medium light gray, unoxidized, unleached
	120	to	129	Till, light yellow, oxidized, unleached
	129	to	134	Till, light yellow, oxidized, unleached; clay, gray, slightly silty
	134	to	140	Clay, gray, slightly silty, with till-like areas, yellow, mottled, calcareous
	140	to	145	Silt, medium light gray, very sandy, argillaceous
	145	to	146	Sand, colorless, varicolored, medium to coarse and fine, subangular to subrounded; gravel, varicolored, subrounded
Pennsylvanian rocks, undifferentiated	146	to	148	Limestone, very light gray and orange, silt-grade to medium
	148	to	150	Limestone, very light gray and orange, silt-grade to medium; shale, green
	150	to	152	Shale, maroon and green, lumpy
	152	to	154	Dolostone, orange and very light gray, silt-grade; maroon and green, lumpy
	154	to	156	Shale, yellow, lumpy

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW60--Continued				
Pennsylvanian rocks, undifferentiated--Continued	156	to	157	Limestone, medium light gray, silt-grade, fragmented, argillaceous
	157	to	159	Limestone, medium light gray, silt-grade, partly argillaceous
	159	to	161	Limestone, medium light gray, silt-grade; shale, brown
	161	to	163	Shale, gray, lumpy, calcareous
	163	to	165	Dolostone, very light gray, silt-grade, very cherty, very calcareous
	165	to	167	Limestone, very light gray, silt-grade, very calcareous
	167	to	169	Limestone, very light gray, silt-grade to coarse
	169	to	171	Limestone, very light gray, silt-grade to fine
	171	to	172	Limestone, very light gray, silt-grade to fine, fragmented
	172	to	173	Chert, very light gray, smooth; limestone, very light gray, silt-grade to coarse, fragmented

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW61	**W-28122**	**70-32-03BBBB**	**405357-0943138**	**1,200**	**Taylor**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	10	Fill (driller's log)
Quaternary deposits	10	to	15	Clay, gray, silty
	15	to	19	Clay, gray, orange mottled, silty
	19	to	20	Clay, light gray and yellow orange, silty, sandy
Pleistocene deposits	20	to	24	Till, yellow, oxidized, unleached
	24	to	35	Till, yellow to orange, oxidized, unleached
	35	to	40	Till, yellow, oxidized, unleached
	40	to	46	Till, very light yellow-gray, oxidized, unleached
	46	to	60	Till, yellow-orange, oxidized, unleached
	60	to	85	Till, yellow, oxidized, unleached
	85	to	100	Till, light olive-gray; till, trace yellow, oxidized, unleached
	100	to	130	Till, light olive-gray, unoxidized, unleached
	130	to	140	Till, olive-gray, unoxidized, unleached
	140	to	200	Till, light olive-gray, unoxidized, unleached
	200	to	220	Till, medium light olive-gray, unoxidized, unleached
	220	to	240	Till, light olive-gray, unoxidized, unleached
	240	to	246	Till, light olive-gray, unoxidized, unleached, very sandy, gravelly
	246	to	250	Till, gray, unoxidized, unleached, very sandy, gravelly; till, yellow, oxidized, unleached

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW61--Continued				
Pleistocene deposits--Continued	250	to	255	Till, yellow, medium light gray, oxidized, unleached, very sandy, gravelly
Pennsylvanian rocks, undifferentiated	255	to	257	Dolostone, light tan, silt-grade, calcareous
	257	to	258	Dolostone, light tan, very light gray, silt-grade
	258	to	260	Dolostone, very light gray, light tan, silt-grade, slightly calcareous
	260	to	265	Dolostone, very light gray, light tan, silt-grade, calcareous
	265	to	266	Dolostone, very light gray, light tan, silt-grade, calcareous; limestone
	266	to	268	Limestone; shale
	268	to	270	Shale, light green-gray, calcareous, lumpy

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW62	**W-28123**	**68-35-15BCDD**	**404200-0945109**	**1,070**	**Taylor**

SW62 casing	0	to	29	
	29	to	37	Slotted

Stratigraphic unit	Depth interval (feet)			Description
	0	to	12	Fill (driller's log)
Quaternary deposits	12	to	14	Silt, yellow-orange, sandy, argillaceous
	14	to	16	Silt, brown-gray, sandy, very argillaceous
	16	to	22	Clay, gray, silty
	22	to	24	Sand, colorless, coarse to medium; gravel, subrounded, dirty
	24	to	33	Gravel, varicolored; sand, medium, subrounded to subangular; partly with argillaceous cement
Pleistocene deposits	33	to	35	Till, light gray, oxidized, leached
	35	to	37	Till, light gray, oxidized, unleached, very gravelly
	37	to	38	Till, yellow, oxidized, unleached, gravelly
	38	to	39	Till, yellow, gray, gravelly, partly oxidized, unleached
Pennsylvanian rocks, undifferentiated	39	to	40	Shale, medium light gray, silty, calcareous, micaceous, blocky

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW63	**W-28124**	**67-36-02AAAA**	**403859-0945602**	**1,020**	**Page**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	7	Roadbed and fill (driller's log)
Quaternary deposits	7	to	10	Clay, medium dark gray, silty
	10	to	16	Clay, medium light gray
	16	to	20	Silt, yellow, argillaceous
	20	to	26	Silt, yellow, very argillaceous
	26	to	27	Silt, gray and orange, very argillaceous
	27	to	35	Silt, gray, argillaceous; sand, coarse; gravel
Pennsylvanian rocks, undifferentiated	35	to	38	Shale, medium light gray, flaky
	38	to	40	Shale, medium light gray, flaky; shale, very dark gray, carbonaceous
	40	to	42	Shale, medium light gray, flaky
	42	to	43	Shale, very dark gray, flaky, carbonaceous
	43	to	45	Shale, light green-gray, micaceous, subflaky, slightly calcareous
	45	to	50	Shale, light green-gray, micaceous, subflaky, calcareous
	50	to	53	Shale, gray, soft, lumpy, subflaky, silty
	53	to	56	Shale, gray, subflaky, micaceous, calcareous
	56	to	60	Shale, gray, subflaky, micaceous, calcareous; limestone, gray
	60	to	61	Shale, light green-gray, subflaky, micaceous, calcareous; limestone, gray
	61	to	63	Shale, light green-gray, subflaky, micaceous, calcareous; dolostone
	63	to	64	Dolostone, gray, argillaceous
	64	to	66	Shale, very dark gray, gray, blocky
	66	to	67	Dolostone, gray, argillaceous, silt-grade to coarse
	67	to	69	Dolostone, gray, calcareous, argillaceous
	69	to	70	Dolostone, light green, silt-grade, argillaceous
	70	to	71	Shale, gray, lumpy, dolomitic
	71	to	74	Shale, gray, lumpy, dolomitic; dolostone
	74	to	75	Limestone, light brown-gray, silt-grade to coarse
	75	to	77	Shale, pale green, lumpy, calcareous
	77	to	78	Dolostone, very light gray, silt-grade, argillaceous
	78	to	80	Dolostone, very light gray, silt-grade, calcareous, argillaceous
	80	to	81	Shale, medium light green-gray, very calcareous

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW64	**W-28125**	**67-36-30DCCD**	**403446-0950107**	**948**	**Page**

SW64 casing	0	to	16	
	16	to	20	Slotted

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	1	Topsoil (driller's log)
	1	to	9	Clay, gray and light orange, silty
	9	to	15	Silt, light yellow, argillaceous
	15	to	20	Gravel, varicolored; sand, medium, subrounded
Pennsylvanian rocks, undifferentiated	20	to	23	Limestone, very light gray, silt-grade, argillaceous; shale
	23	to	26	Shale, light gray, calcareous

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW65	**W-28216**	**71-36-32DDDD**	**405403-0950017**	**1,021**	**Montgomery**

SW65 casing	0	to	37	
	37	to	42	Slotted

Same location as SW42, see log for SW42 for description.

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW66	**W-28206**	**72-36-04CDDD**	**410333-0945942**	**1,076**	**Montgomery**

	Depth interval (feet)			
SW66 casing	0	to	29	
	29	to	34	Slotted

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	1	Topsoil (driller's log)
	1	to	5	Clay, gray (driller's log)
	5	to	11	Silt, light gray, very argillaceous
	11	to	13	Sand, colorless, varicolored, medium to fine, very silty
	13	to	15	Clay, gray, very silty
	15	to	25	Sand, colorless, varicolored, coarse to fine; gravel, subrounded to angular, silty, argillaceous
	25	to	35	Gravel, varicolored; sand, medium, clean, subrounded
	35	to	37	Gravel, varicolored; sand, coarse, clean, subrounded

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW67	**W-28207**	**72-35-12ACBC**	**410314-0944926**	**1,085**	**Adams**

	Depth interval (feet)			
SW67 casing	0	to	13	
	13	to	17	Slotted

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	1	Topsoil (driller's log)
	1	to	5	Clay, yellow-gray (driller's log)
	5	to	10	Sand, varicolored, medium to fine, subrounded, with silty and argillaceous matrix
	10	to	14	Clay, brown, light yellow, silty
	14	to	17	Sand, varicolored, coarse to fine; gravel; very argillaceous, calcareous matrix
Pennsylvanian rocks, undifferentiated	17	to	19	Shale, gray, hard, calcareous, silty

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW68	**W-28205**	**74-34-22ABAB**	**411215-0944419**	**1,328**	**Cass**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	15	Roadbed and fill (driller's log)
Pleistocene deposits	15	to	20	Till, bright yellow-orange, oxidized, leached
	20	to	40	Till, light yellow, oxidized, unleached
	40	to	46	Till, yellow, oxidized, unleached
	46	to	48	Till, gray, orange mottling, oxidized, unleached
	48	to	52	Till, yellow, very light gray mottling, oxidized, unleached
	52	to	60	Clay, light gray
	60	to	64	Till, very light gray, unoxidized, unleached
	64	to	66	Till, yellow, orange, oxidized, unleached
	66	to	80	Till, very pale yellow, oxidized, unleached
	80	to	105	Till, light yellow, oxidized, unleached
	105	to	110	Till, very light yellow, unoxidized, unleached
	110	to	114	Till, very light yellow, unoxidized, unleached; clay, light gray
	114	to	115	Clay, light gray, slightly calcareous
	115	to	117	Clay, light yellow, slightly calcareous
	117	to	120	Till, very light yellow-gray, oxidized, unleached
	120	to	147	Till, light yellow, oxidized, unleached
	147	to	155	Sand, colorless, dark, medium to fine, subrounded, with argillaceous, calcareous cement
	155	to	160	Till, olive-gray and orange, partly oxidized, unleached
	160	to	164	Till, orange and gray, partly oxidized, unleached
	164	to	170	Till, olive-gray and orange, partly oxidized, unleached
	170	to	180	Till, very light gray, unoxidized, unleached
	180	to	195	Till, light gray, sandy, gravelly, slightly calcareous
	195	to	199	Till, very light yellow, oxidized, unleached
	199	to	203	Till, light yellow, very light gray, very argillaceous, oxidized, unleached
Pennsylvanian rocks, undifferentiated	203	to	208	Limestone, very light yellow, silt-grade

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW69	**28203**	**77-32-28CCCD**	**412555-0943242**	**1,315**	**Adair**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	3	Roadbed (driller's log)
Quaternary deposits	3	to	6	Clay, black (driller's log)
	6	to	8	Clay, dark gray to gray (driller's log)
	8	to	11	Clay, medium light gray, silty
	11	to	16	Clay, gray, slightly silty
	16	to	20	Silt, yellow and orange, very argillaceous
	20	to	24	Silt, light yellow and orange, very argillaceous
	24	to	28	Gravel; sand, varicolored, medium, subrounded, with silty, argillaceous, calcareous matrix
Pleistocene deposits	28	to	40	Till, gray, yellow, partly oxidized, unleached
	40	to	57	Gravel, varicolored; sand, medium, subrounded, partly dolomitic, with till-like matrix
	57	to	70	Till, gray, unoxidized, unleached; gravel, varicolored; sand, medium subrounded, partly dolomitic, with till-like matrix
	70	to	80	Till, gray, unoxidized, unleached, very gravelly
	80	to	100	Till, light yellow-orange, gray, partly oxidized, unleached
	100	to	110	Till, light yellow-orange, gray, partly oxidized, unleached, gravelly
	110	to	120	Till, yellow, light gray, oxidized, unleached
	120	to	135	Till, light yellow, oxidized, unleached
	135	to	150	Till, light yellow, oxidized, unleached; till, medium light gray, unoxidized, unleached till
	150	to	160	Till, medium light gray, unoxidized, unleached
	160	to	174	Till, yellow, mottled, oxidized, unleached
	174	to	180	Till, yellow, oxidized, unleached
	180	to	189	Till, yellow, oxidized, unleached, sandy
	189	to	203	Till, medium light gray, unoxidized, unleached; till, light yellow, oxidized, unleached
	203	to	220	Sand, colorless, yellow, orange, dark, heavy, fine to medium, subrounded to subangular, clean, quartz, with trace heavy minerals
	220	to	239	Sand, colorless, yellow, orange, dark, heavy, fine to medium, subrounded to subangular, clean, quartz, with trace heavy minerals; gravel, trace metamorphic rocks
	239	to	243	Sandstone; gravel, quartz, metamorphic rocks
	243	to	250	Gravel, subrounded to angular; sand, medium; much till, orange
	250	to	252	Gravel, subrounded to angular; sand, medium; with Inoceramus fragments

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW70	**W-28209**	**75-31-20CCDC**	**411622-0942657**	**1,345**	**Adair**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	4	Roadbed (driller's log)
Quaternary deposits	4	to	9	Loess, with yellow, argillaceous matrix
	9	to	11	Clay, brown, orange, yellow, silty, trace sandy
	11	to	16	Clay, very light yellow, orange, silty
Pleistocene deposits	16	to	20	Till, light orange, oxidized, leached
	20	to	54	Till, light orange, oxidized, unleached
	54	to	60	Till, gray and yellow, partly oxidized, leached, with sparse sand
	60	to	65	Till, medium light gray, partly oxidized, leached, with sparse sand
	65	to	68	Till, light gray, partly oxidized, leached
	68	to	73	Till, light orange, oxidized, unleached
	73	to	80	Till, light orange, oxidized, unleached, more calcareous
	80	to	90	Till, orange-yellow, oxidized, unleached
	90	to	93	Till, light gray, oxidized, unleached
	93	to	100	Till, gray, unoxidized, unleached
	100	to	110	Till, light olive-gray, unoxidized, unleached
	110	to	127	Till, olive-gray, unoxidized, unleached
	127	to	128	Clay, dark brown, sandy
	128	to	134	Till, medium light gray, unoxidized, unleached
	134	to	140	Till, light gray, unoxidized, unleached
	140	to	170	Till, light yellow, oxidized, unleached
	170	to	190	Till, light yellow, oxidized, unleached; till, light gray, mottled, unoxidized, unleached
	190	to	199	Till, light gray, unoxidized, unleached; till, yellow-orange, oxidized, unleached, mottled
	199	to	220	Till, yellow-orange, oxidized, unleached
	220	to	230	Till, very light yellow, oxidized, unleached, with abundant limestone gravel
	230	to	233	Till, very light gray, very light yellow gray, oxidized, unleached
Pennsylvanian rocks, undifferentiated	233	to	241	Dolostone, light orange, silt-grade, partly very calcareous; shale, light green, lumpy
	241	to	242	Dolostone, light orange, silt-grade, partly very calcareous; shale, very pale green, lumpy
	242	to	245	Shale, yellow and gray, lumpy shale

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW71	**W-28204**	**73-34-27BCBB**	**410547-0944524**	**1,108**	**Adams**

SW71 casing	0	to	25	
	25	to	30	Well screen

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Topsoil and clay, dark brown (driller's log)
	5	to	13	Silt, medium light gray-brown, very argillaceous
	13	to	15	Silt, gray, very argillaceous
	15	to	18	Clay, gray-brown, partly very sandy, silt
	18	to	20	Silt, gray, argillaceous
	20	to	26	Sand, colorless, varicolored, coarse to fine; gravel
	26	to	30	Sand, colorless, varicolored, medium; gravel, fine
	30	to	33	Sand, medium to fine and coarse
Pennsylvanian rocks, undifferentiated	33	to	34	Shale, gray-green (driller's log)

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW72	**W-28208**	**71-34-07DCCD**	**415732-0944811**	**1,094**	**Adams**

SW72 casing	0	to	35	
	35	to	40	Well screen

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Roadbed and clay, brown (driller's log)
	5	to	9	Silt, brown, argillaceous
	9	to	14	Clay, brown, silty
	14	to	15	Clay, orange-brown, silty
	15	to	19	Sand, medium; gravel, varicolored, subrounded, fine; with argillaceous and silty cement
	19	to	20	Clay, blue-gray, silty and sandy (driller's log)
	20	to	37	Silt, medium light brown-gray, argillaceous, sandy
	37	to	40	Silt, medium light brown-gray, argillaceous, sandy, calcareous
Pennsylvanian rocks, undifferentiated	40	to	41	Dolostone, orange, silt-grade to fine, calcareous

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW73	**W-28210**	**71-36-01BDCD**	**405848-0945625**	**1,052**	**Montgomery**

SW73 casing	0	to	27	
	27	to	32	Well screen

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Topsoil and clay, very dark gray (driller's log)
	5	to	10	Clay, brown, silty
	10	to	14	Clay, light gray and orange, very silty, sandy
	14	to	16	Sand, colorless, subrounded, medium to fine, with argillaceous, silty matrix
	16	to	20	Sand, colorless, varicolored, dark, subrounded to angular, medium to coarse and fine
	20	to	25	Sand, colorless, varicolored, coarse to fine; gravel, subrounded to angular, clean
	25	to	30	Sand, colorless, varicolored, coarse to fine; gravel, subrounded to angular, clean; partly with argillaceous cement
	30	to	34	Clay, gray, orange, lumpy, calcareous

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW74	**W-28211**	**75-30-22BBBB**	**411713-0941753**	**1,165**	**Adair**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	5	Roadbed and clay, dark gray (driller's log)
	5	to	10	Clay, gray-brown, silty
	10	to	15	Clay, medium dark gray, orange, sandy, silty
	15	to	17	Sand, colorless, varicolored, medium to fine, silty
	17	to	19	Sand, colorless, varicolored, coarse to fine; gravel
	19	to	27	Silt, light yellow, argillaceous
	27	to	38	Gravel, varicolored; sand, colorless, coarse to medium, subrounded, partly argillaceous
	38	to	39	Gravel, varicolored

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW74--Continued				
Pleistocene deposits	39	to	5	Till, gray, unoxidized, unleached
	52	to	60	Till, medium light gray, oxidized, leached
	60	to	70	Till, light yellow, oxidized, unleached
Pennsylvanian rocks, undifferentiated	70	to	75	Limestone, very light gray, silt-grade to coarse, partly fragmented; shale, light green
	75	to	75.5	Limestone, very light gray; shale, very light green-gray, with fusulinids
	75.5	to	77	Limestone, very light gray; shale, green, with calcareous fossil debris
	77	to	78	Limestone, very light gray, silt-grade; shale, yellow
	78	to	80	Dolostone, very light gray, silt-grade; shale
	80	to	82	Dolostone, light gray, light yellow gray, silt-grade
	82	to	84	Limestone, very light gray, silt-grade, argillaceous; shale, very light green
	84	to	85	Shale, dark gray, gray, calcareous, micaceous
	85	to	86.5	Limestone, very light gray, silt-grade
	86.5	to	90	Limestone, very light gray, silt-grade; shale, gray
	90	to	93	Shale, medium light green, lumpy
	93	to	97	Limestone, maroon, silt-grade, argillaceous
	97	to	100	Shale, maroon, calcareous

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW75	**W-28215**	**74-30-21CBAA**	**411134-0941846**	**1,310**	**Adair**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	2	Roadbed (driller's log)
Quaternary deposits	2	to	10	Silt, yellow, argillaceous, trace sandy
	10	to	15	Silt, very light gray, orange mottled, argillaceous, trace sandy
Pleistocene deposits	15	to	20	Till, very light yellow, oxidized, leached
	20	to	30	Till, orange, oxidized, leached
	30	to	40	Till, very pale yellow, oxidized, unleached
	40	to	41	Gravel, varicolored, subrounded; sand, coarse, dirty
	41	to	50	Till, light yellow, gray, partly oxidized, unleached

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW75--Continued				
Pleistocene deposits--Continued	50	to	60	Till, gray, unoxidized, unleached
	60	to	70	Till, medium light gray, unoxidized, unleached; till, light yellow, oxidized, unleached
	70	to	80	Till, medium light gray, unoxidized, unleached; till, trace light yellow, oxidized, unleached
	80	to	93	Till, medium light gray, unoxidized, unleached
	93	to	100	Till, medium light brown, unoxidized, unleached
	100	to	106	Till, gray and yellow, oxidized, unleached
	106	to	110	Till, medium light to very light gray, partly oxidized, partly leached, very sandy
	110	to	142	Till, light yellow, oxidized, unleached
	142	to	153	Till, light yellow, very sandy, oxidized, unleached
	153	to	160	Till, light yellow, very sandy, oxidized, unleached; till, gray, unoxidized, unleached
	160	to	170	Till, light olive-gray, unoxidized, unleached; till, trace light yellow, oxidized, unleached
	170	to	190	Till, gray, unoxidized, unleached
	190	to	218	Till, gray, unoxidized, unleached; till, yellow, oxidized, unleached
Pennsylvanian rocks, undifferentiated	218	to	220	Dolostone, gray, medium light yellow, calcareous
	220	to	221	Dolostone, gray, medium light yellow, calcareous; sand, varicolored, coarse to fine, subrounded
	221	to	223	Shale, medium dark gray, partly sandy
	223	to	225	Shale, green, sandy
	225	to	229	Shale, light green, lumpy, calcareous
	229	to	232	Dolostone, very light gray, silt-grade; shale, light green, lumpy, calcareous
	232	to	235	Dolostone, very light gray, silt-grade, calcareous
	235	to	237	Shale, very pale green, soft, calcareous
	237	to	238	Dolostone, very light gray, silt-grade to fine, very calcareous
	238	to	239	Dolostone, very light gray, silt-grade to fine, very calcareous much cave
	239	to	240	Shale, medium light gray, lumpy, calcareous; dolostone, very light gray, silt-grade to fine, very calcareous

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW76	**W-28214**	**73-33-11BDDA**	**410816-0943650**	**1,274**	**Adams**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	5	Roadbed (driller's log)
Quaternary deposits	5	to	9	Clay, brown, silty
	9	to	13	Clay, yellow-orange, silty
	13	to	17	Clay, light gray with orange mottling
	17	to	19	Clay, light gray with orange mottling, trace sandy
	19	to	39	Till, light yellow-orange, oxidized, unleached
	39	to	50	Till, medium light yellow-orange, oxidized, unleached
	50	to	60	Till, pale light yellow-gray, oxidized, unleached
	60	to	90	Till, medium light gray, oxidized, unleached
	90	to	99	Till, medium light gray, unoxidized, unleached
	99	to	102	Till, light olive-gray, unoxidized, unleached
	102	to	111	Till, medium light brown, unoxidized, unleached
	111	to	114	Till, very light brown, unoxidized, unleached
	114	to	117	Till, pale yellow, oxidized, unleached
	117	to	120	Till, medium light gray, oxidized, unleached
	120	to	138	Till, pale yellow-orange, oxidized, unleached
	138	to	145	Till, pale yellow-orange, oxidized, unleached, sandy
	145	to	160	Till, medium light gray, unoxidized, unleached
	160	to	170	Till, medium light gray, unoxidized, unleached; till, trace yellow, oxidized, unleached
	170	to	260	Till, light olive-gray, unoxidized, unleached
	260	to	280	Gravel, varicolored, subrounded, quartz, metamorphic, and limestone rocks, with till-like matrix; till, light olive-gray, unoxidized, unleached
	280	to	300	Gravel, varicolored, subrounded, quartz, metamorphic, and limestone rocks, with till-like matrix; till, light olive-gray, unoxidized, unleached; sand, medium
	300	to	320	Gravel, varicolored, subrounded, quartz, metamorphic, and limestone rocks, with till-like matrix; till, light olive-gray, unoxidized, unleached; sand, partly subangular
	320	to	329	Gravel, varicolored, subrounded, quartz, metamorphic, and limestone rocks, with till-like matrix
Pennsylvanian rocks, undifferentiated	329	to	340	Shale, gray; possible limestone layer at top (driller's log)

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW77	**W-28213**	**72-32-09BBCC**	**410316-0943247**	**1,168**	**Adams**

SW77 casing	0	to	35	
	35	to	40	Well screen

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	6	Clay, dark gray (driller's log)
	6	to	9	Clay, medium light gray, slightly silty
	9	to	15	Silt, light orange, very sandy, argillaceous
	15	to	17	Silt, orange and very light gray
	17	to	19	Silt, orange and very light gray, sandy
	19	to	21	Sand, colorless, varicolored; partly with argillaceous, silty cement
	21	to	28	Silt, light yellow, argillaceous, sandy
	28	to	31	Sand, varicolored, coarse; gravel, fine, subrounded
	31	to	37	Silt, light gray, sandy, gravelly, argillaceous
	37	to	41	Sand, colorless, varicolored, coarse; gravel, fine, subrounded to subangular, partly argillaceous
	41	to	42	Till, gray (driller's log)

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW78	**W-28212**	**72-32-09CCBB**	**410248-0943248**	**1,220**	**Adams**

SW78 casing	0	to	266	
	266	to	276	Slotted

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	11	Silt, light yellow, argillaceous
Pleistocene deposits	11	to	20	Till, light yellow, oxidized, unleached
	20	to	70	Till, medium light yellow-gray, oxidized, unleached
	70	to	75	Till, yellow-gray, oxidized, unleached
	75	to	80	Till, pale yellow, oxidized, unleached
	80	to	90	Till, pale yellow-gray, oxidized, unleached
	90	to	102	Till, pale yellow-gray, oxidized, unleached, weakly calcareous
	102	to	102.5	Clay, gray-brown, brown-gray
	102.5	to	113	Till, light yellow-gray, oxidized, unleached
	113	to	120	Clay, medium light gray, silty, slightly calcareous
	120	to	123	Till, medium light gray, unoxidized, unleached

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW78--Continued				
Pleistocene deposits--Continued	123	to	132	Gravel, colorless, varicolored, quartz and metamorphic rock; sand, coarse, subrounded, dirty, quartz
	132	to	240	Till, light olive-gray, unoxidized, unleached
	240	to	244	Till, medium light gray, unoxidized, unleached
	244	to	251	Till, medium light gray, unoxidized, unleached, gravelly
	251	to	256	Till, gray, maroon, partly oxidized, unleached, very gravelly
	256	to	263	Clay, gray, maroon, calcareous, very sandy
	263	to	275	Gravel, varicolored, dirty, quartz, limestone, trace chert rocks
Pennsylvanian rocks, undifferentiated	275	to	279	Limestone, very light gray, silt-grade, sublithographic

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW79	**W-28652**	**70-34-22AAAA**	**405123-0944419**	**1,158**	**Taylor**

Stratigraphic unit	Depth interval (feet)			Description
Pleistocene deposits	0	to	5	Clay, yellow-gray sandy (driller's log)
	5	to	6	Silt; clay, very light gray
	6	to	7	Sand, varicolored, coarse; gravel; silt and clay matrix
	7	to	16	Till, pale orange, oxidized, unleached
	16	to	18	Till, light yellow-gray, oxidized, unleached
	18	to	27	Till, light yellow-gray, oxidized, unleached; till, gray, unoxidized, unleached
	27	to	32	Till, yellow, oxidized, unleached; till, brown, unoxidized, unleached
	32	to	37	Till, yellow, oxidized, unleached; till, gray, unoxidized, unleached
	37	to	40	Till, gray, yellow and orange mottling, unoxidized, unleached
	40	to	61	Till, gray, trace orange, unoxidized, unleached
	61	to	70	Silt, very light gray, orange, argillaceous, calcareous
Pennsylvanian rocks, undifferentiated	70	to	78	Shale, yellow, silty, blocky, slightly calcareous
	78	to	81	Shale, yellow, silty, blocky, slightly calcareous; limestone, gray

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Stratigraphic unit	Depth interval (feet)			Description
SW79--Continued				
Pennsylvanian rocks, undifferentiated--Continued	81	to	84	Shale, gray, calcareous
	84	to	87	Shale, gray, calcareous; limestone
	87	to	89	Shale, gray, calcareous; limestone, gray
	89	to	90	Shale, very dark gray, blocky, silty, calcareous
	90	to	90.5	Shale, medium dark gray, lumpy
	90.5	to	92	Limestone, medium light gray, silt-grade, partly argillaceous
	92	to	93	Limestone, brown, silt-grade
	93	to	94	Shale, light green, lumpy, calcareous
	94	to	95	Shale, light green, lumpy, calcareous; dolostone, silt-grade
	95	to	97	Shale, light green, silty, calcareous
	97	to	97.5	Shale, medium dark green, calcareous
	97.5	to	98	Limestone, very light gray, silt-grade, fragmented; shale, very light gray
	98	to	100	Shale, very light gray, lumpy, very calcareous, silty
	100	to	102	Shale, light green, calcareous, silty, lumpy
	102	to	105	Shale, medium light green-gray, calcareous, silty, lumpy
	105	to	106	Shale, green-gray, calcareous, silty, lumpy
	106	to	106.5	Dolostone, very light gray, calcareous; shale, medium light gray
	106.5	to	108	Shale, maroon, blocky; shale, medium light maroon, calcareous
	108	to	109	Shale, gray, very calcareous, with brachiopod debris
	109	to	110	Shale, maroon-gray, calcareous
	110	to	112	Shale, maroon-gray, calcareous; limestone, brown
	112	to	112.5	Shale, dark gray
	112.5	to	113.5	Limestone, very light gray, fragmented
	113.5	to	114	Limestone, very light gray, silt-grade to medium
	114	to	115	Shale, medium light green-gray, lumpy, calcareous

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW80	**W-28315**	**68-32-06BCCC**	**404312-0943506**	**1,170**	**Taylor**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	3	Roadbed (driller's log)
Quaternary deposits	3	to	20	Clay, medium dark gray, silty
	20	to	22	Silt, gray, very light gray, very argillaceous, sandy
	22	to	26	Silt, gray, very light gray, very argillaceous, very sandy, gravelly
	26	to	30	Silt, gray, very light gray, very argillaceous, very sandy, gravelly sand, colorless, coarse; gravel, varicolored
Pleistocene deposits	30	to	44	Till, light orange, very light gray, oxidized, unleached
	44	to	47	Till, light orange, very light gray, oxidized, unleached; till, gray unoxidized, unleached
	47	to	49	Till, light orange, very light gray, partly oxidized, unleached
	49	to	55	Till, orange, oxidized, unleached
	55	to	60	Till, medium light gray, unoxidized, unleached
	60	to	63	Till, medium light gray, unoxidized, unleached; trace orange, oxidized, unleached
	63	to	65	Till, olive-gray, unoxidized, unleached
	65	to	80	Till, olive-gray, trace medium light orange, unoxidized, unleached
	80	to	90	Till, olive-gray, unoxidized, unleached, with abundant gravel, subrounded
	90	to	120	Till, olive-gray, unoxidized, unleached, with abundant gravel
	120	to	130	Till, olive-gray, unoxidized, unleached; till, trace orange, partly oxidized, unleached
	130	to	188	Till, olive-gray, unoxidized, unleached
	188	to	196	Till, gray, unoxidized, unleached, sandy; gravel
	196	to	203	Till, medium light gray, brown, unoxidized, unleached
Pennsylvanian rocks, undifferentiated	203	to	205	Dolostone, orange, very calcareous; gravel, varicolored; sand, colorless
	205	to	208	Limestone, very light gray, fragmented; shale, green, sandy
	208	to	210	Shale, maroon, gray, calcareous, lumpy
	210	to	221	Shale, maroon, calcareous, lumpy

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW81	**W-28316**	**67-32-11AADD**	**403718-0942926**	**1,077**	**Taylor**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	4	Fill (driller's log)
Quaternary deposits	4	to	6	Clay, gray, silty
	6	to	8	Clay, medium light brown-gray, silty
	8	to	15	Clay, light yellow with orange mottling, silty
	15	to	16	Clay, brown, silty
	16	to	17	Clay, orange, very silty
	17	to	18	Silt, medium light gray, with trace orange, very argillaceous
	18	to	20	Silt, medium light gray, argillaceous
	20	to	24	Sand, colorless, orange, subrounded to subangular, very argillaceous, silty, medium to fine
	24	to	30	Gravel, colorless, varicolored; sand, fine
Pleistocene deposits	30	to	60	Till, light olive-gray, unoxidized, unleached
	60	to	72	Till, gray, unoxidized, unleached
	72	to	74	Till, medium dark gray, unoxidized, unleached
	74	to	80	Till, gray, unoxidized, unleached
	80	to	110	Till, light olive-gray, unoxidized, unleached
	110	to	120	Till, medium light gray, unoxidized, unleached
	120	to	129	Till, light olive-gray, unoxidized, unleached
	129	to	140	Gravel, varicolored; sand, colorless, medium; till, light olive-gray, unoxidized, unleached
	140	to	180	Till, olive-gray, unoxidized, unleached
	180	to	200	Till, light olive-gray, unoxidized, unleached
	200	to	220	Till, medium light olive-gray, unoxidized, unleached
	220	to	225	Till, light olive-gray, unoxidized, unleached
	225	to	240	Sand, colorless, dark trace varicolored, medium to fine and coarse, subrounded
	240	to	252	Till, medium light gray, unoxidized, unleached
Pennsylvanian rocks, undifferentiated	252	to	260	Shale, medium light green, gray, slightly micaceous
	260	to	267	Shale, medium light green, gray, slightly micaceous, unoxidized, unleached

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW82	**W-28317**	**71-34-26CBBC**	**405514-0944416**	**1,280**	**Adams**

Stratigraphic unit	Depth interval (feet)			Description
Quaternary deposits	0	to	2	Fill and topsoil (driller's log)
Pleistocene deposits	2	to	8	Clay, yellow-brown (driller's log)
	8	to	10	Clay, gray to yellow-gray (driller's log)
	10	to	19	Clay, yellow-gray (driller's log)
	19	to	38	Till, yellow-orange and yellow-gray (driller's log)
	38	to	55	Clay, gray (driller's log)
	55	to	62	Grading to till, yellow-brown and yellow-gray (driller's log)
	62	to	78	Till, yellow-brown (driller's log)
	78	to	81	Till, grading to till, blue-gray (driller's log)
	81	to	86	Till, blue-gray (driller's log)
	86	to	101	Till, blue-gray and yellow-brown (driller's log)
	101	to	104	Till (driller's log)
	104	to	150	Till, yellow-brown (driller's log)
	150	to	165	Till, blue-gray (driller's log)

Note: This is a core reposited at the Iowa Department of Natural Resources, Geological Survey Bureau.

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW83	**W-28318**	**72-32-09CCBB**	**410248-0943248**	**1,220**	**Adams**

SW83 casing	0	to	130	
	130	to	136	Slotted

Same location as SW78, see log for SW78 for description.

Table 1. *Geologic logs of test holes and observation wells drilled in southwest Iowa, 1985-87*--Continued

Southwest Iowa study identification number (fig. 1)	Geological Survey Bureau identification number	Township-range-section identification number	Latitude-longitude identification number (DDMMSS-DDDMMSS)	Land-surface altitude (feet above sea level)	County
SW84	**W-28319**	**71-31-31ABDC**	**405437-0942732**	**1,158**	**Union**

Stratigraphic unit	Depth interval (feet)			Description
	0	to	4	Roadbed (driller's log)
Quaternary deposits	4	to	10	Clay, very light gray, orange, silty
	10	to	17	Clay, light gray, orange, silty
	17	to	20	Silt, gray, argillaceous
	20	to	27	Silt, medium light gray, argillaceous
	27	to	30	Sand, colorless, dark, trace varicolored, coarse to fine, subrounded
	30	to	35	Gravel, varicolored, subrounded
Pleistocene deposits	35	to	42	Till, light brown-gray, unoxidized, unleached
	42	to	60	Till, light gray, unoxidized, unleached
	60	to	70	Till, medium light gray, unoxidized, unleached
	70	to	80	Till, light olive-gray, unoxidized, unleached
	80	to	90	Till, medium light gray, unoxidized, unleached
	90	to	100	Till, light olive-gray, unoxidized, unleached
	100	to	105	Till, medium light gray, unoxidized, unleached
	105	to	115	Silt, medium light gray, argillaceous
	115	to	118	Till, very light gray, oxidized, unleached
	118	to	121	Till, gray, oxidized, unleached
	121	to	130	Till, light olive-gray, unoxidized, unleached
	130	to	160	Till, olive-gray, unoxidized, unleached
	160	to	175	Till, medium light gray, unoxidized, unleached
	175	to	180	Till, medium light brown, unoxidized, unleached
	180	to	203	Till, gray, unoxidized, unleached, very sandy
	203	to	206	Gravel, varicolored, argillaceous, subrounded
	206	to	220	Till, brown-gray, unoxidized, unleached
	220	to	230	Till, medium light gray, unoxidized, unleached
	230	to	250	Till, light olive-gray, unoxidized, unleached
	250	to	255	Till, light gray, unoxidized, unleached
Pennsylvanian rocks, undifferentiated	255	to	259	Shale, green, calcareous, very sandy
	259	to	261	Limestone, very light gray, silt-grade to medium
	261	to	262	Shale, green
	262	to	272	Shale, gray, lumpy, calcareous

Table 2. *Ranges of hydraulic conductivity of selected earth materials (modified from Freeze and Cherry, 1979)*

[ft/d, feet per day; >, greater than; <, less than]

Material	Hydraulic conductivity (ft/d)		
	Unconsolidated material		
Glacial till	0.00000011	to	1.1
Silt, loess	.0011	to	13
Silty sand	.1	to	650
Clean sand	1.5	to	6,700
Gravel	650	to	> 150,000
	Bedrock		
Shale	< .000000067	to	.00067
Limestone and dolostone	.00067	to	1.5
Sandstone	.000067	to	1.5

Table 3. *U.S. Environmental Protection Agency drinking-water regulations*

[MCL, maximum contaminant level; SMCL, secondary maximum contaminant level; --, no established regulation; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; source, U.S. Environmental Protection Agency, 1988a, 1988b, 1988c, 1988d, 1989]

Property or constituent	Primary regulation (MCL)	Secondary regulation (SMCL)
pH	--	6.5 - 8.5 pH units
Sulfate	--	250 mg/L
Chloride	--	250 mg/L
Fluoride	4.0 mg/L	2.0 mg/L
Dissolved solids	--	500 mg/L
Nitrate as nitrogen	10 mg/L	--
Arsenic	50 µg/L	--
Barium	1,000 µg/L	--
Cadmium	10 µg/L	--
Chromium	50 µg/L	--
Copper	--	1,000 µg/L
Iron	--	300 µg/L
Lead	50 µg/L	--
Manganese	--	50 µg/L
Mercury	2 µg/L	--
Selenium	10 µg/L	--
Silver	50 µg/L	--
Zinc	--	5,000 µg/L
Radium (radium-226 and radium-228 combined)	5 pCi/L	--
Gross-alpha activity (including radium-226 but not radon or uranium)	15 pCi/L	--
Gross-beta activity as Cesium 137	200 pCi/L	--
Endrin	.2 µg/L	--
Lindane	4 µg/L	--
Methoxychlor	100 µg/L	--
Toxaphene	5 µg/L	--
2,4-D	100 µg/L	--
2,4,5-TP (Silvex)	10 µg/L	--
Benzene	5 µg/L	--
Carbon tetrachloride	5 µg/L	--
1,2-dichloroethane	5 µg/L	--
1,1-dichloroethylene	7 µg/L	--
Paradichlorobenzene	75 µg/L	--
1,1,1-trichloroethane	200 µg/L	--
Trichloroethylene	5 µg/L	--
Vinyl chloride	2 µg/L	--

Table 4. *Health advisory and risk-assessment concentrations for selected pesticides in drinking water*

[µg/L, micrograms per liter; --, no data; source, U.S. Environmental Protection Agency, 1987, 1989]

	Health advisory (µg/L)	Risk-assessment concentration (µg/L)
Alachlor	0	0.15 - 1.5
Atrazine	3.0	--
Cyanazine	9.0	--
Metolachlor	10	--
Simazine	35	--

Table 5. *Summary of nitrate analyses of samples from private wells, 1981-86*

[Data from University of Iowa Hygienic Laboratory, written commun., 1988]

Year	Number of samples that exceeded primary drinking-water regulations	Percentage of samples exceeding primary drinking-water regulations of 10 milligrams per liter of nitrogen
	Adair County	
1981	29	42
1982	33	57
1983	15	39
1984	20	44
1985	19	40
1986	23	41
	Adams County	
1981	10	43
1982	8	29
1983	12	33
1984	16	33
1985	18	33
1986	14	37
	Cass County	
1981	24	29
1982	29	31
1983	19	22
1984	20	26
1985	26	29
1986	26	30
	Fremont County	
1981	13	30
1982	15	32
1983	13	45
1984	19	44
1985	20	34
1986	13	25
	Mills County	
1981	14	25
1982	13	28
1983	16	39
1984	24	26
1985	22	26
1986	17	19

Table 5. *Summary of nitrate analyses of samples from private wells, 1981-86*--Continued

Year	Number of samples that exceeded primary drinking-water regulation	Percentage of samples exceeding primary drinking-water regulation of 10 milligrams per liter of nitrogen
	Montgomery County	
1981	9	20
1982	16	33
1983	20	39
1984	36	53
1985	23	42
1986	16	26
	Page County	
1981	11	48
1982	21	57
1983	18	44
1984	15	42
1985	14	35
1986	25	39
	Pottawattamie County	
1981	25	21
1982	22	19
1983	36	28
1984	55	33
1985	39	23
1986	39	20
	Taylor County	
1981	12	35
1982	7	26
1983	20	45
1984	19	39
1985	16	39
1986	11	26
	Statewide	
1981	1,382	18
1982	1,449	21
1983	1,763	23
1984	1,568	21
1985	1,393	19
1986	1,632	18

Table 6. *Stratigraphic units in the study area*

[The stratigraphic nomenclature used herein is that of the Iowa Department of Natural Resources, Geological Survey Bureau]

Era	Period	Epoch	Formation	Member	Lithology
Cenozoic	Quaternary	Holocene			Alluvium, loess, and glacial drift
		Pleistocene			
	Tertiary	Pliocene			
Mesozoic	Cretaceous		Dakota	Woodbury	Shale, sandstone
				Nishnabotna	Sandstone, shale
Paleozoic	Pennsylvanian	(Late)	Undifferentiated (for this report)		Limestone, shale
	Mississippian		Undifferentiated (for this report)		Limestone, dolomite, shale
	Devonian		Undifferentiated (for this report)		Limestone, dolomite, shale
	Silurian		Undifferentiated (for this report)		Dolomite
	Ordovician		Undifferentiated (for this report)		Dolomite, shale, limestone, sandstone
	Cambrian		Undifferentiated (for this report)		Sandstone, shale, dolomite

Table 7. *Water levels in selected observation wells, 1986-88*

[Water levels in feet below land surface; MP, measuring point is the top of 2-inch-diameter pipe, in feet above land surface; +, indicates water level in feet above land surface; a, indicates water level before well was developed; U, shallow well at site; L, deep well at site. Location of observation wells shown in figure 1]

Date	Water level	Date	Water level	Date	Water level
SW-16U, Nishnabotna alluvial aquifer, location 74-37-30BBBB1, altitude 1,090 feet, depth 42 feet, MP 2.35 feet					
7-21-86	16.13	5-01-87	15.65	8-30-87	16.05
8-07-86	17.54	5-21-87	17.15	9-01-87	16.25
8-12-86	18.09	6-01-87	11.69	9-03-87	16.53
10-23-86	13.80	7-07-87	15.05	9-05-87	16.84
12-09-86	16.97	8-03-87	16.05	9-07-87	16.50
2-05-87	18.65	8-26-87	16.68	10-12-87	16.80
4-01-87	16.96	8-28-87	15.90	11-05-87	17.92

Date	Water level	Date	Water level	Date	Water level
SW-16L, Nishnabotna alluvial aquifer, location 74-37-30BBBB2, altitude 1,090 feet, depth 70 feet, MP 2.10 feet					
7-21-86	16.02	2-10-87	18.59	5-21-87	17.05
8-07-86	17.48	2-25-87	18.85	5-25-87	16.57
8-12-86	17.96	3-10-87	18.59	6-01-87	11.62
10-23-86	13.75	3-25-87	17.86	6-10-87	13.60
12-09-86	16.88	4-01-87	17.16	6-25-87	15.84
12-24-86	17.15	4-10-87	15.98	7-07-87	14.90
1-10-87	17.88	4-25-87	15.15	7-10-87	14.64
1-25-87	18.17	5-01-87	15.55	7-25-87	15.60
2-05-87	18.60	5-10-87	16.44	8-03-87	14.90

Table 7. *Water levels in selected observation wells, 1986-88*--Continued

Date	Water level	Date	Water level	Date	Water level
SW-16L--Continued					
8-10-87	16.16	10-10-87	16.57	2-25-88	19.06
8-25-87	16.67	10-12-87	16.70	3-10-88	19.18
8-26-87	16.58	10-25-87	17.36	3-25-88	19.29
8-28-87	15.82	11-05-87	17.80	4-10-88	19.27
8-30-87	15.97	11-10-87	17.97	4-25-88	19.46
9-01-87	16.16	11-29-87	18.20	5-10-88	19.58
9-03-87	16.42	12-10-87	17.97	5-25-88	19.79
9-05-87	16.74	12-25-87	18.18	6-10-88	20.10
9-07-87	16.40	1-11-88	18.40	6-25-88	20.30
9-10-87	16.60	1-26-88	18.67		
9-24-87	15.05	2-10-88	18.89		

Date	Water level	Date	Water level	Date	Water level
SW-17, Dakota aquifer, location 75-35-07BBBA, altitude 1,295 feet, depth 209 feet, MP 2.35 feet					
7-21-86	114.51	12-08-86	113.57	5-20-87	114.16
8-19-86	114.70	2-05-87	114.55	10-12-87	114.40
10-23-86	113.80				

Date	Water level	Date	Water level	Date	Water level
SW-18, Pennsylvanian aquifer, location 77-37-13BBBB, altitude 1,298 feet, depth 201 feet, MP 2.20 feet					
7-21-86	117.09	12-08-86	115.90	10-12-87	117.70
8-15-86	117.71	2-05-87	116.00		
10-23-86	116.40	5-21-87	117.12		

Table 7. *Water levels in selected observation wells, 1986-88*--Continued

Date	Water level	Date	Water level	Date	Water level
SW-21, Glacial-drift aquifer, location 74-39-01CCCC, altitude 1,245 feet, depth 206 feet, MP 2.32 feet					
7-22-86	a 110.71	2-24-87	126.74	8-25-87	125.86
8-15-86	a 109.20	3-11-87	126.84	9-29-87	125.78
8-20-86	129.38	3-18-87	126.05	10-12-87	125.73
10-23-86	127.08	4-15-87	126.23	11-12-87	125.36
12-09-86	127.04	4-21-87	126.67	11-17-87	125.15
12-10-86	127.09	5-21-87	126.19	12-16-87	125.71
12-15-86	127.02	5-27-87	126.19	1-03-88	125.45
1-02-87	126.71	6-01-87	126.09	2-24-88	125.66
1-12-87	126.75	6-18-87	126.16	4-04-88	124.87
1-22-87	126.56	7-15-87	125.97	5-16-88	125.38
2-02-87	126.53	8-03-87	126.08	6-28-88	125.52
2-04-87	127.02	8-18-87	125.97		
2-05-87	127.38				

Date	Water level	Date	Water level	Date	Water level
SW-32, Fremont buried-channel aquifer, location 76-40-04AAAA, altitude 1,177 feet, depth 340 feet, MP 1.85 feet					
8-07-86	a 33.53	12-09-86	13.32	5-21-87	13.15
10-23-86	13.00	2-05-87	13.25	10-06-87	13.52

Table 7. *Water levels in selected observation wells, 1986-88*--Continued

Date	Water level	Date	Water level	Date	Water level
SW-33U, Nishnabotna alluvial aquifer, location 76-37-23DABB1, altitude 1,142 feet, depth 45 feet, MP 2.65 feet					
8-06-86	11.14	4-01-87	12.68	10-12-87	13.28
10-23-86	10.15	5-01-87	12.05	11-05-87	13.79
12-08-86	11.70	5-21-87	12.61		
2-05-87	13.30	6-01-87	11.20		

Date	Water level	Date	Water level	Date	Water level
SW-33L, Glacial-drift aquifer, location 76-37-23DABB2, altitude 1,142 feet, depth 65 feet, MP 2.50 feet					
8-06-86	13.78	4-01-87	12.28	10-12-87	10.78
10-23-86	10.50	5-01-87	12.20	11-05-87	13.76
12-08-86	11.88	5-21-87	12.79		
2-05-87	13.30	6-01-87	11.15		

Date	Water level	Date	Water level	Date	Water level
SW-34U, Nishnabotna alluvial aquifer, location 74-38-36BAAA1, altitude 1,073 feet, depth 25 feet, MP 2.50 feet					
8-06-86	6.30	6-01-87	2.06	9-03-87	5.44
10-23-86	3.75	7-07-87	4.90	9-05-87	5.69
12-09-86	5.47	8-03-87	4.90	9-07-87	5.44
2-05-87	7.10	8-26-87	4.72	10-12-87	6.04
4-01-87	6.01	8-28-87	4.39	11-05-87	6.98
5-01-87	5.21	8-30-87	4.84		
5-21-87	5.62	9-01-87	5.14		

Table 7. *Water levels in selected observation wells, 1986-88*--Continued

Date	Water level	Date	Water level	Date	Water level
SW-34L, Nishnabotna alluvial aquifer, location 74-38-36BAAA2, altitude 1,073 feet, depth 39 feet, MP 2.20 feet					
8-06-86	6.39	5-21-87	5.69	9-05-87	5.75
10-23-86	3.80	5-25-87	5.00	9-07-87	5.51
12-09-86	5.54	6-01-87	2.11	9-10-87	5.81
12-24-86	5.94	6-10-87	3.97	9-24-87	5.08
1-10-87	6.68	6-25-87	5.47	10-10-87	6.16
1-25-87	6.87	7-07-87	5.80	10-12-87	6.13
2-05-87	7.20	7-10-87	3.57	10-25-87	6.57
2-10-87	7.29	7-25-87	5.30	11-05-87	6.98
2-25-87	7.55	8-03-87	4.80	11-10-87	6.98
3-10-87	7.29	8-10-87	5.03	11-29-87	7.14
3-25-87	6.64	8-25-87	5.49	12-10-87	6.89
4-01-87	6.31	8-26-87	4.78	12-25-87	7.22
4-10-87	5.64	8-28-87	4.46	1-11-88	7.34
4-25-87	5.17	8-30-87	4.89	1-26-88	7.49
5-01-87	5.36	9-01-87	5.20	2-10-88	7.58
5-10-87	5.86	9-03-87	5.50	2-25-88	7.74

Date	Water level	Date	Water level	Date	Water level
SW-35U, Nishnabotna alluvial aquifer, location 72-38-20ACAA1, altitude 1,038 feet, depth 17 feet, MP 2.90 feet					
8-06-86	7.78	4-01-87	7.80	7-07-87	4.90
10-23-86	8.30	5-01-87	6.41	8-03-87	4.90
12-09-86	6.55	5-21-87	6.52	10-06-87	5.50
2-05-87	8.55	6-01-87	2.81	11-05-87	6.72

Table 7. *Water levels in selected observation wells, 1986-88*--Continued

Date	Water level	Date	Water level	Date	Water level
SW-35L, Nishnabotna alluvial aquifer, location 72-38-20ACAA2, altitude 1,038 feet, depth 27 feet, MP 2.58 feet					
8-06-86	8.01	4-01-87	7.76	7-07-87	4.82
10-23-86	5.02	5-01-87	6.39	8-03-87	4.82
12-09-86	6.46	5-21-87	6.45	10-06-87	5.32
2-05-87	8.42	6-01-87	2.74	11-05-87	6.59

Date	Water level	Date	Water level	Date	Water level
SW-36U, Nishnabotna alluvial aquifer, location 71-41-04AAAA1, altitude 997 feet, depth 44 feet, MP 2.73 feet					
8-06-86	12.58	4-01-87	10.40	8-03-87	5.67
10-23-86	8.47	5-21-87	5.95	10-06-87	6.97
12-09-86	9.53	6-01-87	2.12	11-04-87	6.09
2-05-87	10.52	7-07-87	5.67		

Date	Water level	Date	Water level	Date	Water level
SW-36L, Nishnabotna alluvial aquifer, location 71-41-04AAAA2, altitude 997 feet, depth 62 feet, MP 2.50 feet					
8-06-86	10.64	4-01-87	10.11	8-03-87	6.70
10-23-86	8.20	5-21-87	8.48	10-06-87	8.50
12-09-86	9.17	6-01-87	3.03	11-04-87	9.53
2-05-87	10.20	7-07-87	6.70		

Table 7. *Water levels in selected observation wells, 1986-88*--Continued

Date	Water level	Date	Water level	Date	Water level
SW-37, Fremont buried-channel aquifer, location 73-41-23BCCC, altitude 1,068 feet, depth 260 feet, MP 2.70 feet					
6-11-87	5.45+	9-16-87	5.00+		

Date	Water level	Date	Water level	Date	Water level
SW-38U, Nishnabotna alluvial aquifer, location 70-41-32AABB1, altitude 960 feet, depth 38 feet, MP 2.25 feet					
8-13-86	18.48	5-01-87	15.92	7-07-87	16.95
10-23-86	18.35	5-21-87	16.93	8-03-87	16.95
12-09-86	18.06	6-01-87	12.46	10-06-87	17.05
2-05-87	19.10	6-10-87	14.00	11-04-87	18.20
4-01-87	17.10				

Date	Water level	Date	Water level	Date	Water level
SW-38L, Nishnabotna alluvial aquifer, location 70-41-32AABB2, altitude 960 feet, depth 55 feet, MP 2.05 feet					
8-13-86	18.39	5-01-87	15.83	7-07-87	16.95
10-23-86	18.30	5-21-87	16.89	8-03-87	16.95
12-09-86	18.02	6-01-87	12.52	10-06-87	16.95
2-05-87	19.05	6-10-87	13.95	11-04-87	18.18
4-01-87	17.07				

Table 7. *Water levels in selected observation wells, 1986-88*--Continued

Date	Water level	Date	Water level	Date	Water level
SW-39U, Fremont buried-channel aquifer, location 70-41-32AABB3, altitude 960 feet, depth 135 feet, MP 2.48 feet					
6-10-87	5.61+	8-26-87	4.68+		
7-07-87	5.38+	9-16-87	4.58+		

Date	Water level	Date	Water level	Date	Water level
SW-39L, Fremont buried-channel aquifer, location 70-41-32AABB4, altitude 960 feet, depth 221 feet, MP 2.48 feet					
6-10-87	5.51+	8-26-87	4.50+		
7-07-87	5.20+	9-16-87	4.40+		

Date	Water level	Date	Water level	Date	Water level
SW-40, Buried-channel aquifer, location 71-42-07BBCD, altitude 1,122 feet, depth 342 feet, MP 1.80 feet					
10-23-86	168.35	5-21-87	167.85	8-03-87	167.90
12-09-86	167.96	6-10-87	166.78	10-12-87	168.95
2-05-87	168.50	7-07-87	167.90		

Date	Water level	Date	Water level	Date	Water level
SW-41, Buried-channel aquifer, location 71-42-24AAAA, altitude 1,102 feet, depth 250 feet, MP 2.10 feet					
10-23-86	138.55	6-10-87	136.86	8-03-87	137.10
12-09-86	137.64	7-07-87	137.10	10-12-87	138.05
5-21-87	137.24				

Table 7. *Water levels in selected observation wells, 1986-88*--Continued

Date	Water level	Date	Water level	Date	Water level
SW-55, Tarkio alluvial aquifer, location 70-37-06AADD, altitude 1,080 feet, depth 62 feet, MP 2.30 feet					
10-06-87	9.80	10-20-87	10.47	11-06-87	9.53

Date	Water level	Date	Water level	Date	Water level
SW-56, Tarkio alluvial aquifer, location 69-38-11ABAB, altitude 1,040 feet, depth 54 feet, MP 2.00 feet					
10-06-87	10.80	10-21-87	11.00	11-06-87	11.17

Date	Water level	Date	Water level	Date	Water level
SW-57, Tarkio alluvial aquifer, location 67-38-08DADD, altitude 980 feet, depth 51 feet, MP 2.60 feet					
10-06-87	26.60	10-21-87	27.33	11-06-87	27.65

Date	Water level	Date	Water level	Date	Water level
SW-62, One Hundred and Two River alluvial aquifer, location 68-35-15BCDD, altitude 1,070 feet, depth 37 feet, MP 2.60 feet					
9-10-87	21.70	10-21-87	23.07		
10-06-87	22.90	11-06-87	23.09		

Table 7. *Water levels in selected observation wells, 1986-88*--Continued

Date	Water level	Date	Water level	Date	Water level
SW-64, Nodaway alluvial aquifer, location 67-36-30DCCD, altitude 948 feet, depth 20 feet, MP 2.00 feet					
9-10-87	1.00	10-21-87	2.77		
10-06-87	2.80	11-06-87	1.69		

Date	Water level	Date	Water level	Date	Water level
SW-65, Nodaway alluvial aquifer, location 71-36-32DDDD, altitude 1,021 feet, depth 42 feet, MP 2.40 feet					
9-10-87	11.90	10-21-87	13.50		
10-06-87	13.00	11-06-87	14.26		

Date	Water level	Date	Water level	Date	Water level
SW-66, Nodaway alluvial aquifer, location 72-36-04CDDD, altitude 1,076 feet, depth 34 feet, MP 2.30 feet					
10-06-87	12.30	10-19-87	12.96	11-05-87	13.65

Date	Water level	Date	Water level	Date	Water level
SW-67, Nodaway alluvial aquifer, location 72-35-12ACBC, altitude 1,085 feet, depth 17 feet, MP 2.10 feet					
10-06-87	8.20	10-20-87	9.44	11-05-87	9.91

Table 7. *Water levels in selected observation wells, 1986-88*--Continued

Date	Water level	Date	Water level	Date	Water level
SW-71, Nodaway alluvial aquifer, location 73-34-27BCBB, altitude 1,108 feet, depth 30 feet, MP 1.90 feet					
10-06-87	17.50	10-20-87	17.57	11-05-87	17.60

Date	Water level	Date	Water level	Date	Water level
SW-72, Nodaway alluvial aquifer, location 71-34-07DCCD, altitude 1,094 feet, depth 40 feet, MP 2.10 feet					
10-06-87	20.90	10-20-87	20.45	11-05-87	21.53

Date	Water level	Date	Water level	Date	Water level
SW-73, Nodaway alluvial aquifer, location 71-36-01BDCD, altitude 1,052 feet, depth 32 feet, MP 2.50 feet					
10-06-87	13.80	10-20-87	13.57	11-05-87	14.64

Date	Water level	Date	Water level	Date	Water level
SW-77, Nodaway alluvial aquifer, location 72-32-09BBCC, altitude 1,168 feet, depth 40 feet, MP 2.20 feet					
10-12-87	2.30	11-04-87	1.65	11-06-87	1.75

Table 7. *Water levels in selected observation wells, 1986-88*--Continued

Date	Water level	Date	Water level	Date	Water level
SW-78, Albany buried-channel aquifer, location 72-32-09CCBB1, altitude 1,220 feet, depth 276 feet, MP 1.40 feet					
10-12-87	4.30	11-06-87	2.80	8-08-88	6.94
11-04-87	1.59				

Date	Water level	Date	Water level	Date	Water level
SW-83, Glacial-drift aquifer, location 72-32-09CCBB2, altitude 1,220 feet, depth 136 feet, MP 2.75 feet					
8-08-88	1.59				

Table 8. *Water-quality properties and constituents, 1985-87*

[All constituents are dissolved, except as indicated; ft, feet; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; $CaCO_3$, calcium carbonate; mg/L, milligrams per liter; NO_2, nitrite; NO_3, nitrate; PO_4, phosphate; µg/L, micrograms per liter; pCi/L, picocuries per liter; --, no data; <, less than]

Well or surface-water name (fig. 9)	Station ID	Well depth (ft)	Open interval (ft)	Date of sample	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)	Total hardness (mg/L as $CaCO_3$)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)
				Surface water							
West Nishnabotna River at Avoca	--	--	--	8-20-86	610	8.2	21.0	286	75	24	9.0
East Nishnabotna River at Lorah	--	--	--	8-20-86	560	8.1	20.0	283	77	22	9.1
Tarkio River at Blanchard	--	--	--	10-21-87	470	8.0	5.0	--	58	15	11
West Nodaway River at Massena	--	--	--	10-27-87	420	7.7	10.0	--	50	16	8.4
Middle Nodaway River at Fontanelle	--	--	--	10-22-87	460	7.9	8.0	--	58	15	8.0
East Nodaway River at Prescott	--	--	--	10-20-87	410	7.8	8.0	--	48	14	11
Nodaway River at Braddyville	--	--	--	10-21-87	460	8.1	7.0	--	57	15	9.7
East Fork One Hundred and Two River at Bedford	--	--	--	10-21-87	440	8.0	10.0	--	53	14	14
				West Nishnabotna River alluvium							
SW36L	405911095302302	62.0	57 to 62	8-06-86	580	7.6	12.0	304	79	26	9.7
SW38L	404946095344802	55.0	50 to 55	8-13-86	520	7.9	12.0	246	67	19	6.5
Avoca 2	412812095211201	37.5	22.5 to 37.5	8-20-86	940	7.3	13.0	473	140	30	19
Hancock 6	412327095215401	48.0	--	8-20-86	800	7.4	13.0	396	110	30	25
Oakland 11	411838095252801	42.0	--	8-20-86	550	7.5	12.0	270	72	22	11
Carson 2	411445095251601	26.8	21.8 to 26.8	8-20-86	660	7.3	12.5	332	90	26	10
Macedonia 1	411201095252801	39.0	34 to 39	8-20-86	660	7.4	12.5	333	89	27	10
Henderson 2	410830095253801	66.0	--	8-20-86	850	7.3	13.0	456	120	35	14

Table 8. *Water-quality properties and constituents, 1985-87*--Continued

Well or surface-water name (fig. 9)	Station ID	Well depth (ft)	Open interval (ft)	Date of sample	Specific conductance (μS/cm)	pH (standard units)	Water temperature (°C)	Total hardness (mg/L as $CaCO_3$)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)
				West Nishnabotna River alluvium--Continued							
Hastings 1	410114095300001	53.0	48 to 53	8-20-86	660	7.2	13.0	311	82	26	19
Sidney 6 (8)	404432095361701	32.0	22 to 32	10-16-86	630	7.1	--	314	88	23	14
				East Nishnabotna River alluvium							
SW16U	411117095091901	42.0	37 to 42	8-12-86	440	8.0	12.0	201	54	16	8.0
SW16L	411117095091902	70.0	59 to 70	8-11-86	380	8.1	12.0	173	48	13	6.8
SW33L	412204095035202	65.0	60 to 65	8-06-86	650	7.4	12.0	320	92	22	12
SW34L	411024095095502	39.0	34 to 39	8-06-86	310	7.4	11.0	159	44	12	10
SW35L	410134095141602	27.0	22 to 27	8-06-86	900	7.2	12.0	479	130	35	12
Essex 5	404957095183501	44.5	--	8-14-86	470	7.2	12.0	201	54	16	7.8
Shenandoah 17	404635095224901	73.3	--	8-14-86	980	7.8	13.5	460	120	36	21
Shenandoah 25	404521095235801	33.5	23.5 to 33.5	8-14-86	440	7.0	13.0	187	50	15	7.6
Riverton 2	404224095310601	57.0	47 to 57	8-14-86	710	7.6	--	314	83	26	14
				Tarkio River alluvium							
SW55	405350095081701	62.0	59 to 62	10-20-87	1,000	6.9	12.0	--	110	26	14
SW56	404801095105301	54.0	50 to 54	10-21-87	720	7.2	13.5	--	75	20	41
				West Nodaway River alluvium							
SW65	405403095004401	42.0	37 to 42	10-19-87	420	6.9	12.0	--	52	13	10
SW66	410103095594501	34.0	29 to 34	10-19-87	450	6.7	12.0	--	55	12	13
Massena 3 (79-1)	411503094465401	35.0	--	10-19-87	460	6.9	13.0	--	62	14	9.9
Shambaugh 3	403906095015001	--	--	10-19-87	490	6.6	--	--	60	11	19
Villisca 7	405559094591501	41.5	26.5 to 41.5	10-20-87	710	6.6	12.0	--	79	21	18
Villisca 8	405604094593701	41.5	25.5 to 40.5	10-20-87	480	6.6	12.0	--	62	13	16
				Middle Nodaway River alluvium							
SW71	410548094452101	30.0	25 to 30	10-20-87	270	6.6	12.0	--	35	8.5	6.9
SW73	405850094561001	32.0	27 to 32	10-19-87	470	6.8	11.0	--	66	13	9.4

Table 8. *Water-quality properties and constituents, 1985-87*--Continued

Well or surface-water name (fig. 9)	Station ID	Well depth (ft)	Open interval (ft)	Date of sample	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)	Total hardness (mg/L as $CaCO_3$)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)
				East Nodaway River alluvium							
SW72	405731094480801	40.0	35 to 40	10-20-87	580	7.2	12.0	--	78	16	16
SW77	410317094324801	40.0	35 to 40	11-04-87	580	6.6	10.5	--	53	16	30
Prescott 2	410115094362201	40.0	--	10-20-87	750	6.7	13.0	--	80	21	28
Nodaway 3	405631094560802	36.0	26 to 36	10-20-87	580	6.8	12.0	--	76	23	11
				Nodaway River alluvium							
SW64	403446095010701	20.0	16 to 20	10-21-87	630	6.9	14.0	--	79	18	18
Braddyville 2	403445095011501	31.8	27 to 31.8	10-21-87	400	6.7	13.0	--	50	11	9.5
				West Fork One Hundred and Two River alluvium							
SW62	404200094510901	40.0	29 to 37	10-21-87	510	7.5	13.0	--	68	12	13
				Glacial-drift aquifer							
SW21	411359095171901	206.0	189 to 206	8-20-86	730	7.9	13.0	293	76	25	54
SW83	410247094324802	136.0	130 to 136	12-21-87	2,400	7.4	--	786	210	61	270
Minden 2	412812095322701	48.0	--	6-06-86	835	7.4	11.0	439	120	33	12
				Albany buried-channel aquifer							
SW78	410247094324801	276.0	266 to 276	11-04-87	1,400	7.7	13.0	--	40	13	270
Blockton 1	403659094285301	271.0	--	8-25-85	1,700	7.8	10.0	130	36	10	330
				Fremont buried-channel aquifer							
SW32	412505095262901	340.0	335 to 340	8-06-86	2,000	8.1	12.0	250	67	20	340
SW37	410636095321501	260.0	255 to 260	8-13-86	2,000	8.1	24.0	284	76	23	330
SW39U	404946095344601	135.0	130 to 135	8-13-86	640	8.0	12.0	239	66	18	38
SW39L	404946095344602	221.0	116 to 221	8-20-86	640	8.1	--	224	60	18	50
Treynor 3	411356095360801	250.0	232 to 250	8-06-85	940	7.8	12.5	370	100	29	73

Table 8. *Water-quality properties and constituents, 1985-87*--Continued

Well or surface-water name (fig. 9)	Station ID	Well depth (ft)	Open interval (ft)	Date of sample	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)	Total hardness (mg/L as $CaCO_3$)	Calcium (mg/L as Ca)	Magnesium (mg/L as Mg)	Sodium (mg/L as Na)
					Dakota aquifer						
SW17	411900094530101	218.0	189 to 209	8-20-86	360	7.9	12.0	186	53	13	7.5
					Pennsylvanian aquifer						
SW18	412832095033501	201.0	196 to 201	8-20-86	3,100	7.9	--	1,590	420	130	220

Table 8. *Water-quality properties and constituents, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Potassium (mg/L)	Alkalinity, total (mg/L as $CaCO_3$)	Bicarbonate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Dissolved solids (mg/L)
				Surface water					
West Nishnabotna River at Avoca	8-20-86	4.7	230	280	42	12	0.4	18	324
East Nishnabotna River at Lorah	8-20-86	4.5	190	230	34	15	.2	18	310
Tarkio River at Blanchard	10-21-87	3.5	190	--	19	9.0	.4	--	240
West Nodaway River at Massena	10-27-87	3.6	160	--	17	18	.4	--	216
Middle Nodaway River at Fontanelle	10-22-87	2.2	190	--	21	9.0	.4	--	260
East Nodaway River at Prescott	10-27-87	3.1	140	--	25	11	.4	--	202
Nodaway River at Braddyville	10-21-87	4.2	170	--	30	10	.4	--	218
East Fork One Hundred and Two River at Bedford	10-21-87	4.5	170	--	27	9.0	.4	--	228
				West Nishnabotna River alluvium					
SW36L	8-06-86	4.0	90	350	18	2.0	.4	23	322
SW38L	8-13-86	4.9	240	290	28	1.0	.4	24	270
Avoca 2	8-20-86	4.9	290	350	170	37	.2	14	624
Hancock 6	8-20-86	3.8	280	350	85	33	.2	20	518
Oakland 11	8-20-86	3.6	58	320	26	6.0	.2	19	308
Carson 2	8-20-86	1.0	83	340	48	7.0	.4	17	390
Macedonia 1	8-20-86	<.1	250	300	77	7.0	.4	19	408
Henderson 2	8-20-86	4.6	330	410	64	25	.4	22	512
Hastings 1	8-20-86	4.4	220	270	65	21	.2	20	388
Sidney 6 (8)	10-16-86	2.6	290	350	40	6.0	.3	19	250

Table 8. *Water-quality properties and constituents, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Potassium (mg/L)	Alkalinity, total (mg/L as $CaCO_3$)	Bicarbonate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Dissolved solids (mg/L)
			East Nishnabotna River alluvium						
SW16U	8-12-86	3.0	200	240	20	12	0.4	20	202
SW16L	8-11-86	3.0	210	220	5.5	1.0	.2	19	180
SW33L	8-06-86	2.7	320	400	10	6.0	.2	22	330
SW34L	8-06-86	1.4	170	210	7.9	2.0	.2	20	178
SW35L	8-06-86	2.2	420	520	42	9.0	.2	28	538
Essex 5	8-14-86	3.7	150	180	57	12	.2	17	258
Shenandoah 17	8-14-86	4.7	290	350	210	34	.3	18	606
Shenandoah 25	8-14-86	4.4	150	180	58	6.0	.2	21	214
Riverton 2	8-14-86	4.8	36	410	32	4.0	.4	22	360
			Tarkio River alluvium						
SW55	10-20-87	5.6	520	--	52	2.0	.2	--	606
SW56	10-21-87	5.3	370	--	9	7.0	.4	--	404
			West Nodaway River alluvium						
SW65	10-19-87	1.0	160	--	49	4.0	.4	--	226
SW66	10-19-87	1.8	140	--	70	10	.3	--	286
Massena 3 (79-1)	10-19-87	1.8	220	--	20	5.0	.4	--	296
Shambaugh 3	10-22-87	1.9	150	--	44	47	.2	--	302
Villisca 7	10-20-87	3.4	140	--	120	61	.2	--	402
Villisca 8	10-20-87	3.0	120	--	95	6.0	.2	--	300
			Middle Nodaway River alluvium						
SW71	10-20-87	<.1	110	--	23	2.0	.3	--	150
SW73	10-19-87	1.0	180	--	35	14	.3	--	280

Table 8. *Water-quality properties and constituents, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Potassium (mg/L)	Alkalinity, total (mg/L as $CaCO_3$)	Bicarbonate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Dissolved solids (mg/L)
			East Nodaway River alluvium						
SW72	10-20-87	3.8	250	--	40	16	0.3	--	340
SW77	11-04-87	2.8	250	--	59	4.0	.4	--	330
Prescott 2	10-20-87	3.7	150	--	150	49	.3	--	482
Nodaway 3	10-20-87	2.0	160	--	110	18	.2	--	354
			Nodaway River alluvium						
SW64	10-21-87	2.7	190	--	95	19	.2	--	344
Braddyville 2	10-21-87	3.6	160	--	30	9.0	.2	--	218
			West Fork One Hundred and Two River alluvium						
SW62	10-21-87	2.3	180	--	52	10	.2	--	314
			Glacial-drift aquifer						
SW21	8-20-86	4.9	350	420	49	3.0	.5	24	440
SW83	12-21-87	6.9	400	480	910	25	.2	19	1,900
Minden 2	6-06-86	1.4	310	380	36	48	.3	19	468
			Albany buried-channel aquifer						
SW78	11-04-87	4.8	310	--	240	95	.7	--	970
Blockton 1	8-25-85	2.8	420	510	240	109	.8	12	1,080
			Fremont buried-channel aquifer						
SW32	8-06-86	5.1	270	330	620	25	.4	18	1,410
SW37	8-13-86	5.0	330	400	600	65	.2	17	1,320
SW39U	8-13-86	4.6	320	390	21	2.0	.2	25	350
SW39L	8-20-86	4.6	320	390	20	3.0	.2	28	312
Treynor 3	8-06-85	3.8	380	470	140	3.5	.3	29	566

Table 8. *Water-quality properties and constituents, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Potassium (mg/L)	Alkalinity, total (mg/L as $CaCO_3$)	Bicarbonate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Dissolved solids (mg/L)
				Dakota aquifer					
SW17	8-20-86	3.2	180	220	7.8	2.0	0.2	20	180
				Pennsylvanian aquifer					
SW18	8-20-86	5.1	200	250	1,700	22	.2	18	2,830

Table 8. *Water-quality properties and constituents, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Nitrogen $NO_2 + NO_3$ (mg/L as N)	Ammonia (mg/L as N)	Nitrogen, organic (mg/L as N)	Nitrogen, khjedahl (mg/L as N)	Phosphorus (mg/L as PO_4)	Chemical oxygen demand, total (mg/L)	Carbon, organic (mg/L)	Iron (µg/L)	Manganese (µg/L as N)
Surface water										
West Nishnabotna River at Avoca	8-20-86	37	--	--	--	--	--	--	3,300	280
East Nishnabotna River at Lorah	8-20-86	46	--	--	--	--	--	--	2,600	20
Tarkio River at Blanchard	10-21-87	4.2	0.20	<0.10	0.20	0.40	16	2.3	<20	70
West Nodaway River at Massena	10-27-87	4.3	<.10	.40	.40	<.10	8	3.6	<20	270
Middle Nodaway River at Fontanelle	10-22-87	4.9	<.10	.40	.40	.30	12	4.0	300	240
East Nodaway River at Prescott	10-20-87	4.9	<.10	.30	.30	<.10	16	3.7	300	120
Nodaway River at Braddyville	10-21-87	2.2	<.10	.30	.30	.10	16	2.8	<20	60
East Fork One Hundred and Two River at Bedford	10-21-87	1.0	<.10	.30	.30	<.10	16	4.6	<20	140
West Nishnabotna River alluvium										
SW36L	8-06-86	.40	--	--	--	--	--	--	420	170
SW38L	8-13-86	.40	--	--	--	--	--	--	550	220
Avoca 2	8-20-86	.60	--	--	--	--	--	--	2,600	1,600
Hancock 6	8-20-86	7.2	--	--	--	--	--	--	30	300
Oakland 11	8-20-86	2.5	--	--	--	--	--	--	620	140
Carson 2	8-20-86	13	--	--	--	--	--	--	640	320
Macedonia 1	8-20-86	13	--	--	--	--	--	--	30	<20
Henderson 2	8-20-86	31	--	--	--	--	--	--	<20	<20
Hastings 1	8-20-86	33	--	--	--	--	--	--	<20	<20
Sidney 6 (8)	10-16-86	.30	.09	--	--	.23	--	--	1,300	250

Table 8. *Water-quality properties and constituents, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Nitrogen $NO_2 + NO_3$ (mg/L as N)	Ammonia (mg/L as N)	Nitrogen, organic (mg/L as N)	Nitrogen, khjedahl (mg/L as N)	Phosphorus (mg/L as PO_4)	Chemical oxygen demand, total (mg/L)	Carbon, organic (mg/L)	Iron (µg/L)	Manganese (µg/L as N)
				East Nishnabotna River alluvium						
SW16U	8-12-86	0.40	--	--	--	--	--	--	750	50
SW16L	8-11-86	7.4	--	--	--	--	--	--	290	20
SW33L	8-06-86	8.3	--	--	--	--	--	--	2,000	400
SW34L	8-06-86	1.2	--	--	--	--	--	--	170	<20
SW35L	8-06-86	20	--	--	--	--	--	--	480	50
Essex 5	8-14-86	3.4	--	--	--	--	--	--	220	40
Shenandoah 17	8-14-86	<.10	--	--	--	--	--	--	2,300	440
Shenandoah 25	8-14-86	5.9	--	--	--	--	--	--	60	<20
Riverton 2	8-14-86	.70	--	--	--	--	--	--	90	200
				Tarkio River alluvium						
SW55	10-20-87	<.10	9.5	.10	9.6	1.7	40	14	20,000	670
SW56	10-21-87	<.10	4.6	.10	4.7	.90	20	6.9	8,300	770
				West Nodaway River alluvium						
SW65	10-19-87	< .10	.10	.30	.40	.10	21	4.3	4,900	1,400
SW66	10-19-87	<.10	.20	.20	.40	.60	8	1.3	11,000	1,300
Massena 3	10-19-87	<.10	.40	.20	.60	.80	8	2.6	13,000	1,200
Shambaugh 3	10-22-87	<.10	<.10	.70	.70	.50	12	1.3	4,100	340
Villisca 7	10-20-87	<.10	.20	.10	.30	.40	13	1.4	14,000	2,000
Villisca 8	10-20-87	<.10	<.10	.20	.20	.40	8	1.1	13,000	1,400
				Middle Nodaway River alluvium						
SW71	10-20-87	1.0	< .10	< .10	<.10	<.10	8	.5	<20	<20
SW73	10-20-87	<.10	<.10	.20	.20	.30	4	.9	5,300	760

Table 8. *Water-quality properties and constituents, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Nitrogen $NO_2 + NO_3$ (mg/L as N)	Ammonia (mg/L as N)	Nitrogen, organic (mg/L as N)	Nitrogen, khjedahl (mg/L as N)	Phosphorus (mg/L as PO_4)	Chemical oxygen demand, total (mg/L)	Carbon, organic (mg/L)	Iron (µg/L)	Manganese (µg/L as N)
				East Nodaway River alluvium						
SW72	10-20-87	< 0.10	0.90	1.1	2.0	0.40	21	2.2	2,700	530
SW77	11-04-87	<.10	1.0	.40	1.4	1.0	12	4.1	19,000	2,200
Prescott 2	10-20-87	<.10	.80	.40	1.2	.70	16	1.9	26,000	2,900
Nodaway 3	10-20-87	.80	<.10	.10	.10	.40	4	2.0	1,400	80
				Nodaway River alluvium						
SW64	10-21-87	<.10	<.10	.20	.20	< .10	8	1.1	1,600	500
Braddyville 2	10-21-87	<.10	.70	.10	.80	.40	12	28	7,300	2,400
				West Fork One Hundred and Two River alluvium						
SW62	10-21-87	< .10	.40	.10	.5	1.6	12	2.0	15,000	1,500
				Glacial-drift aquifer						
SW21	8-20-86	.40	--	--	--	--	--	--	820	410
SW83	12-21-87	<.10	--	--	--	--	--	--	2,500	60
Minden 2	6-06-86	10	--	--	--	--	--	--	<20	<20
				Albany buried-channel aquifer						
SW78	11-04-87	< .10	2.1	1.8	3.9	.20	36	.8	320	20
Blockton 1	8-25-85	<.02	--	--	--	--	--	--	650	40
				Fremont buried-channel aquifer						
SW32	8-06-86	<.10	--	--	--	--	--	--	1,300	20
SW37	8-13-86	.20	--	--	--	--	--	--	830	50

Table 8. *Water-quality properties and constituents, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Nitrogen $NO_2 + NO_3$ (mg/L as N)	Ammonia (mg/L as N)	Nitrogen, organic (mg/L as N)	Nitrogen, khjedahl (mg/L as N)	Phosphorus (mg/L as PO_4)	Chemical oxygen demand, total (mg/L)	Carbon, organic (mg/L)	Iron (μg/L)	Manganese (μg/L as N)
				Fremont buried-channel aquifer --Continued						
SW39U	8-13-86	0.30	--	--	--	--	--	--	540	70
SW39L	8-20-86	1.0	--	--	--	--	--	--	810	80
Treynor 3	8-06-85	.20	1.8	--	--	0.09	--	--	360	200
				Dakota aquifer						
SW17	8-20-86	.60	--	--	--	--	--	--	1,300	60
				Pennsylvanian aquifer						
SW18	8-20-86	.40	--	--	--	--	--	--	2,900	1,500

Table 8. *Water-quality properties and constituents, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radium 226 (pCi/L)	Radium 228 (pCi/L)
		Surface water			
West Nishnabotna River at Avoca	8-20-86	--	--	--	--
East Nishnabotna River at Lorah	8-20-86	--	--	--	--
Tarkio River at Blanchard	10-21-87	--	--	--	--
West Nodaway River at Massena	10-27-87	--	--	--	--
Middle Nodaway River at Fontanelle	10-22-87	--	--	--	--
East Nodaway River at Prescott	10-20-87	--	--	--	--
Nodaway River at Braddyville	10-21-87	--	--	--	--
East Fork One Hundred and Two River at Bedford	10-21-87	--	--	--	--
		West Nishnabotna River alluvium			
SW36L	8-06-86	1.9	2.0	--	--
SW38L	8-13-86	1.0	<1.1	--	--
Avoca 2	8-20-86	2.1	<1.2	--	--
Hancock 6	8-20-86	5.5	2.0	0.3	1.0
Oakland 11	8-20-86	4.8	<1.0	.5	<1.0
Carson 2	8-20-86	4.5	7.0	.3	<1.0
Macedonia 1	8-20-86	1.8	1.0	--	--
Henderson 2	8-20-86	7.6	6.0	.5	<1.0
Hastings 1	8-20-86	3.3	4.0	.4	<1.0
Sidney 6 (8)	10-16-86	4.5	2.0	.5	1.2

Table 8. *Water-quality properties and constituents, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radium 226 (pCi/L)	Radium 228 (pCi/L)
		East Nishnabotna River alluvium			
SW16U	8-12-86	2.4	5.0	--	--
SW16L	8-11-86	2.3	4.0	--	--
SW33L	8-06-86	9.2	<2.6	1.6	1.7
SW34L	8-06-86	1.5	3.0	--	--
SW35L	8-06-86	5.0	6.0	.2	2.1
Essex 5	8-14-86	6.8	<1.0	.7	<.9
Shenandoah 17	8-14-86	17	<1.4	1.4	<.9
Shenandoah 25	8-14-86	2.1	10	--	--
Riverton 2	8-14-86	59	17	1.2	<.9
		Tarkio River alluvium			
SW55	10-20-87	--	--	--	--
SW56	10-21-87	--	--	--	--
SW65	10-19-87	--	--	--	--
SW66	10-19-87	--	--	--	--
Massena 3 (79-1)	10-19-87	--	--	--	--
Shambaugh 3	10-22-87	--	--	--	--
Villisca 7	10-20-87	--	--	--	--
Villisca 8	10-20-87	--	--	--	--
		Middle Nodaway River alluvium			
SW71	10-20-87	--	--	--	--
SW73	10-19-87	--	--	--	--
		East Nodaway River alluvium			
SW72	10-20-87	--	--	--	--
SW77	11-04-87	--	--	--	--
Prescott 2	10-20-87	--	--	--	--
Nodaway 3	10-20-87	--	--	--	--

Table 8. *Water-quality properties and constituents, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Gross alpha (pCi/L)	Gross beta (pCi/L)	Radium 226 (pCi/L)	Radium 228 (pCi/L)
		Nodaway River alluvium			
SW64	10-21-87	--	--	--	--
Braddyville 2	10-21-87	--	--	--	--
		West Fork One Hundred and Two River alluvium			
SW62	10-21-87	--	--	--	--
		Glacial-drift aquifer			
SW21	8-20-86	2.1	4.0	--	--
SW83	12-21-87	--	--	--	--
Minden 2	6-06-86	1.4	2.0	--	--
		Albany buried-channel aquifer			
SW78	11-04-87	--	--	--	--
Blockton 1	8-25-85	<.2	2.0	--	--
		Fremont buried-channel aquifer			
SW32	8-06-86	4.9	<1.5	0.6	1.5
SW37	8-13-86	4.6	2.0	.9	<.9
SW39U	8-13-86	2.0	3.0	--	--
SW39L	8-20-86	.9	<1.0	--	--
Treynor 3	8-06-85	2.8	<.5	--	--
		Dakota aquifer			
SW17	8-20-86	2.2	<1.0	--	--
		Pennsylvanian aquifer			
SW18	8-20-86	2.9	11	--	--

Table 9. *Concentrations of dissolved trace elements in selected wells, 1985-87*

[ft, feet; <, less than; --, no data]

Well name (fig. 9)	Station ID	Well depth (ft)	Open interval (ft)	Date of sample	Dissolved trace element, micrograms per liter									
					Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Selenium	Silver	Zinc
					West Nishnabotna River alluvium									
SW36L	405911095302302	62	57 to 62	8-06-86	<10	260	<1	<10	<10	<10	<1	<10	<10	<10
SW38L	404946095344802	55	50 to 55	8-13-86	<10	240	<1	<10	<10	<10	<1	<10	<10	<10
Avoca 2	412812095211201	37.5	22.5 to 37.5	8-20-86	<10	180	<1	<10	<10	<10	<1	<10	<10	<10
Carson 2	411445095251601	26.8	21.8 to 26.8	8-20-86	<10	260	<1	<10	<10	<10	<1	<10	<10	<10
Hancock 6	412327095215401	48	--	8-20-86	<10	180	<1	<10	<10	<10	<1	<10	<10	<10
Hastings 1	410114095300001	53	48 to 53	8-20-86	<10	140	<1	<10	<10	<10	<1	<10	<10	30
Henderson 2	410830095253801	66	--	8-20-86	<10	190	<1	<10	<10	<10	<1	<10	<10	<10
Macedonia 1	411201095252801	39	34 to 39	8-20-86	<10	90	<1	<10	<10	<10	<1	<10	<10	<10
Oakland 11	411838095252801	42	--	8-20-86	<10	220	<1	<10	<10	<10	<1	<10	<10	<10
Sidney 6 (8)	404432095361701	32	22 to 32	10-16-86	<10	210	<1	<10	<10	<10	<1	<10	<10	<20
					East Nishnabotna River alluvium									
~~SW16U~~	~~411117095091901~~	42	~~37 to 42~~	~~8-12-86~~	<10	160	~~<1~~	~~<10~~	<10	<10	~~<1~~	<10	<10	<10
SW16L	411117095091902	70	59 to 70	8-11-86	<10	110	<1	<10	<10	<10	<1	<10	<10	<10
SW33L	412204095035202	65	60 to 65	8-06-86	<10	660	<1	<10	<10	<10	<1	<10	<10	<10
SW34L	411024095095502	39	34 to 39	8-06-86	<10	90	<1	<10	<10	<10	<1	<10	<10	<10
SW35L	410134095141602	27	22 to 27	8-06-86	<10	260	<1	<10	<10	<10	<1	<10	<10	<10
Essex 5	404957095183501	44.5	--	8-14-86	<10	180	<1	<10	<10	<10	<1	<10	<10	<10
Riverton 2	404224095310601	57	47 to 57	8-14-86	<10	350	<1	<10	<10	<10	<1	<10	<10	20
Shenandoah 17	404635095224901	73.3	--	8-14-86	<10	200	<1	<10	<10	<10	<1	<10	<10	<10
Shenandoah 25	404521095235801	33.5	23.5 to 33.5	8-14-86	<10	90	<1	<10	<10	<10	<1	<10	<10	<1
					Glacial drift									
SW21	411359095171901	206	189 to 206	8-20-86	<10	350	<1	<10	<10	<10	<1	<10	<10	<10
SW83	410247094324802	136	130 to 136	12-21-87	<10	<50	<1	<10	10	<10	<1	<10	<10	<10
Minden 2	412812095322701	48	--	6-06-86	<10	340	<1	10	<10	<10	--	<10	<10	<10

Table 9. *Concentrations of dissolved trace elements in selected wells, 1985-87*--Continued

Well name (fig. 9)	Station ID	Well depth (ft)	Open interval (ft)	Date of sample	Dissolved trace element, micrograms per liter									
					Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Selenium	Silver	Zinc
					Fremont channel									
SW32	412505095262901	340	335 to 340	8-06-86	<10	<50	<1	<10	<10	<10	<1	<10	<10	<10
SW37	410636095321501	260	255 to 260	8-13-86	<10	<50	<1	<10	<10	<10	<1	<10	<10	<10
SW39U	404946095344601	135	130 to 135	8-13-86	<10	140	<1	<10	<10	<10	<1	<10	<10	<10
SW39L	404946095344602	221	116 to 221	8-20-86	<10	100	<1	<10	<10	<10	<1	<10	<10	<10
Treynor 3	411356095360801	250	232 to 250	8-06-85	<10	<100	<1	<10	<10	<10	--	<10	<10	<10
					Albany channel									
Blockton 1	403659094285301	271	--	8-20-85	<10	200	<1	<10	<10	<10	<1	<10	<10	10
					Dakota aquifer									
SW17	411900094530101	218	189 to 209	8-20-86	<10	90	<1	<10	<10	<10	<1	<10	<10	<10
					Pennsylvanian aquifer									
SW18	412832095033501	201	196 to 201	8-20-86	<10	20	<1	<10	<10	<10	<1	<10	<10	<10

Table 10. *Concentrations of selected pesticides, 1985-87*

[ft, feet; --, no data; <, less than]

Well or surface-water name (fig. 9)	Station ID	Well depth (ft)	Open interval (ft)	Date of sample	Pesticide concentration, in micrograms per liter						
					Aldrin	Atrazine	Alachlor	Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC
Surface Water											
West Nishnabotna River at Avoca	--	--	--	8-20-86	--	0.20	0.32	--	--	--	--
Nishnabotna River at Hamburg	--	--	--	10-27-87	--	<.10	<.10	--	--	--	--
East Nishnabotna River at Lorah	--	--	--	8-20-86	--	.26	<.10	--	--	--	--
Tarkio River at Blanchard	--	--	--	10-21-87	--	<.10	<.10	--	--	--	--
West Nodaway River at Massena	--	--	--	10-27-87	--	<.10	<.10	--	--	--	--
Middle Nodaway River at Fontanelle	--	--	--	10-22-87	--	.18	<.10	--	--	--	--
East Nodaway River at Prescott	--	--	--	10-20-87	--	.10	<.10	--	--	--	--
Nodaway River at Braddyville	--	--	--	10-21-87	--	<.10	<.10	--	--	--	--
East Fork One Hundred and Two River at Bedford	--	--	--	10-21-87	--	<.10	<.10	--	--	--	--
West Nishnabotna River alluvium											
SW36L	405911095302302	62.0	57 to62	8-06-86	--	<.10	<.10	--	--	--	--
SW38L	404946095344802	55.0	50 to 55	8-13-86	<0.04	<.10	<.10	<0.04	<0.04	<0.04	<0.04
Avoca 2	412812095211201	37.5	22.5 to 37.5	8-20-86	--	.53	<.10	--	--	--	--
Hancock 6	412327095215401	48.0	--	8-20-86	--	.18	<.10	--	--	--	--
Oakland 8	411830095244701	30.0	20 to 30	6-01-87	--	<.10	<.10	--	--	--	--
Oakland 11	411838095252801	42.0	--	8-20-86	--	<.10	<.10	--	--	--	--
Oakland 11	411838095252801	42.0	--	6-01-87	--	<.10	<.10	--	--	--	--
Carson 2	411445095251601	26.8	21.8 to 26.8	8-20-86	--	<.10	<.10	--	--	--	--
Macedonia 1	411201095252801	39.0	34 to 39	8-20-86	--	.23	<.10	--	--	--	--
Henderson 2	410830095253801	66.0	--	8-20-86	--	<.10	<.10	--	--	--	--

Table 10. *Concentrations of selected pesticides, 1985-87*--Continued

Well or surface-water name (fig. 9)	Station ID	Well depth (ft)	Open interval (ft)	Date of sample	Pesticide concentration, in micrograms per liter						
					Aldrin	Atrazine	Alachlor	Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC
					West Nishnabotna River alluvium--Continued						
Hastings 1	410114095300001	53.0	48 to 53	8-20-86	--	0.16	<0.10	--	--	--	--
Malvern 11	410007095330501	56.0	41 to 56	6-01-87	--	<.10	<.10	--	--	--	--
Sidney 6	404432095361701	32.0	22 to 32	10-16-86	<0.04	.15	<.10	<0.04	<0.04	<0.04	<0.04
					East Nishnabotna River alluvium						
SW16U	411117095091901	42.0	37 to 42	8-12-86	<.04	<.10	<.10	<.04	<.04	<.04	<.04
SW33L	412204095035202	65.0	60 to 65	8-06-86	--	<.10	<.10	--	--	--	--
SW34L	411024095095502	39.0	34 to 39	8-06-86	--	<.10	<.10	--	--	--	--
SW35L	410134095141602	27.0	22 to 27	8-06-86	--	<.10	<.10	--	--	--	--
Essex 5	404957095183501	44.5	--	8-14-86	<.04	<.10	<.10	<.04	<.04	<.04	<.04
Shenandoah 17	404635095224901	73.3	--	8-14-86	<.08	<.10	<.10	<.08	<.08	<.08	<.08
Shenandoah 18	404618095233901	36.0	--	6-01-87	--	<.10	<.10	--	--	--	--
Shenandoah 25	404521095235801	33.5	23.5 to 33.5	8-14-86	<.08	<.10	<.10	<.08	<.08	<.08	<.08
Shenandoah 26	404501095245101	36.0	26 to 36	3-16-87	--	.10	<.10	--	--	--	--
Riverton 2	404224095310601	57.0	47 to 57	8-14-86	<.04	<.10	<.10	<.04	<.04	<.04	<.04
					Tarkio River alluvium						
SW55	405350095081701	62.0	59 to 62	10-20-87	--	<.10	<.10	--	--	--	--
SW56	404801095105301	54.0	50 to 54	10-21-87	--	<.10	<.10	--	--	--	--
					West Nodaway River alluvium						
SW65	405403095004401	42.0	37 to 42	10-19-87	--	<.10	<.10	--	--	--	--
SW66	410103095594501	34.0	29 to 34	10-19-87	--	<.10	<.10	--	--	--	--
Massena 3	411503094465401	35.0	--	10-19-87	--	<.10	<.10	--	--	--	--
Shambaugh 3	403906095015001	--	--	10-22-87	--	<.10	<.10	--	--	--	--
Villisca 7	405559094591501	41.5	26.5 to 41.5	10-20-87	--	<.10	<.10	--	--	--	--
Villisca 8	405604094593701	41.5	25.5 to 40.5		--	<.10	--	--	--	--	--

Table 10. *Concentrations of selected pesticides, 1985-87*--Continued

Well or surface-water name (fig. 9)	Station ID	Well depth (ft)	Open interval (ft)	Date of sample	Pesticide concentration, in micrograms per liter						
					Aldrin	Atrazine	Alachlor	Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC
				Middle Nodaway River alluvium							
SW71	410548094452101	30.0	25 to 30	10-20-87	--	<0.10	<0.10	--	--	--	--
SW73	405850094561001	32.0	27 to 32	10-19-87	--	<.10	<.10	--	--	--	--
				East Nodaway River alluvium							
SW72	405731094480801	40.0	35 to 40	10-20-87	--	<.10	<.10	--	--	--	--
SW77	410317094324801	40.0	35 to 40	11-04-87	--	<.10	<.10	--	--	--	--
Prescott 2	410115094362201	40.0	--	10-20-87	--	<.10	<.10	--	--	--	--
Nodaway 3	405631094560802	36.0	26 to 36	10-20-87	--	<.10	<.10	--	--	--	--
				Nodaway River alluvium							
SW64	403446095010701	20.0	16 to 20	10-21-87	--	<.10	<.10	--	--	--	--
Braddyville 2	403445095011501	31.8	27 to 31.8	10-21-87	--	<.10	<.10	--	--	--	--
				West Fork One Hundred and Two River alluvium							
SW62	404200094510901	40.0	29 to 37	10-21-87	--	<.10	<.10	--	--	--	--
				Glacial-drift aquifer							
SW21	411359095171901	206.0	189 to 206	8-20-86	--	<.10	<.10	--	--	--	--
Minden 2	412812095322701	48.0	--	6-06-86	<0.04	<.10	<.10	<0.04	<0.04	<0.04	<0.04
				Albany buried-channel aquifer							
SW78	410247094324801	276.0	266 to 276	11-04-87	--	<.10	<.10	--	--	--	--
Blockton 1	403659094285301	271.0	--	8-20-85	<.02	<.10	<.10	<.01	<.02	<.02	<.01
				Fremont buried-channel aquifer							
SW39U	404946095344601	135.0	130 to 135	8-13-86	<.08	<.10	<.10	<.08	<.08	<.08	<.08
Treynor 3	411356095360801	250.0	232 to 250	8-06-85	<.02	<.10	<.10	<.01	<.02	<.02	<.01

Table 10. *Concentrations of selected pesticides, 1985-87*--Continued

Well or surface-water name (fig. 9)	Station ID	Well depth (ft)	Open interval (ft)	Date of sample	Pesticide concentration, in micrograms per liter						
					Aldrin	Atrazine	Alachlor	Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC
					Dakota aquifer						
SW17	4119000945530101	218.0	189 to 209	8-20-86	--	<0.10	<0.10	--	--	--	--
					Pennsylvanian aquifer						
SW18	412832095033501	201.0	196 to 201	8-20-86	--	<.10	<.10	--	--	--	--

Table 10. *Concentrations of selected pesticides, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Pesticide concentration, im micrograms per liter									
		Butylate	Carbofuran	Chloramben	Chlordane	Cyanazine	DDD	DDE	DDT	Dicamba	Dieldrin
				Surface Water							
West Nishnabotna River at Avoca	8-20-86	<0.10	--	--	--	0.10	--	--	--	--	--
Nishnabotna River at Hamburg	10-27-87	<.10	--	--	--	<.10	--	--	--	--	--
East Nishnabotna River at Lorah	8-20-86	<.10	--	--	--	<.10	--	--	--	--	--
Tarkio River at Blanchard	10-21-87	<.10	--	--	--	<.10	--	--	--	--	--
West Nodaway River at Massena	10-27-87	<.10	--	--	--	<.10	--	--	--	--	--
Middle Nodaway River at Fontanelle	10-22-87	<.10	--	--	--	<.10	--	--	--	--	--
East Nodaway River at Prescott	10-20-87	<.10	--	--	--	<.10	--	--	--	--	--
Nodaway River at Braddyville	10-21-87	<.10	--	--	--	<.10	--	--	--	--	--
East Fork One Hundred and Two River at Bedford	10-21-87	<.10	--	--	--	<.10	--	--	--	--	--
				West Nishnabotna River alluvium							
SW36L	8-06-86	<0.10	--	--	--	<.10	--	--	--	--	--
SW38L	8-13-86	<.10	--	<0.10	<0.20	<.10	<0.04	<0.04	<0.04	<0.1	<0.04
Avoca 2	8-20-86	<.10	--	--	--	<.10	--	--	--	--	--
Hancock 6	8-20-86	<.10	--	--	--	<.10	--	--	--	--	--
Oakland 8	6-01-87	<.10	<0.10	--	--	<.10	--	--	--	--	--
Oakland 11	8-20-86	<.10	--	--	--	<.10	--	--	--	--	--
Oakland 11	6-01-87	<.10	<.10	--	--	<.10	--	--	--	--	--
Carson 2	8-20-86	<.10	--	--	--	<.10	--	--	--	--	--
Macedonia 1	8-20-86	<.10	--	--	--	<.10	--	--	--	--	--
Henderson 2	8-20-86	<.10	--	--	--	<.10	--	--	--	--	--
Hastings 1	8-20-86	<.10	--	--	--	<.10	--	--	--	--	--
Malvern 11	6-01-87	<.10	<.10	--	--	<.10	--	--	--	--	--
Sidney 6	10-16-86	<.10	<.10	<.10	<.20	<.10	<.04	<.04	<.04	<.1	<.04

Table 10. *Concentrations of selected pesticides, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Pesticide concentration, im micrograms per liter									
		Butylate	Carbofuran	Chloramben	Chlordane	Cyanazine	DDD	DDE	DDT	Dicamba	Dieldrin
				East Nishnabotna River alluvium							
SW16U	8-12-86	<0.10	--	<0.10	<0.20	<0.10	<0.04	<0.04	<0.04	<0.10	<0.04
SW33L	8-06-86	<.10	--	--	--	<.10	--	--	--	--	--
SW34L	8-06-86	<.10	--	--	--	<.10	--	--	--	--	--
SW35L	8-06-86	<.10	--	--	--	<.10	--	--	--	--	--
Essex 5	8-14-86	<.10	<0.10	<.10	<.20	<.10	<.04	<.04	<.04	<.10	<.04
Shenandoah 17	8-14-86	<.10	<.10	<.10	<.40	<.10	<.08	<.08	<.08	<.10	<.08
Shenandoah 18	6-01-87	<.10	<.10	--	--	<.10	--	--	--	--	--
Shenandoah 25	8-14-86	<.10	<.10	<.10	<.40	<.10	<.08	<.08	<.08	<.10	<.08
Shenandoah 26	3-16-87	<.10	--	--	--	<.10	--	--	--	--	--
Riverton 2	8-14-86	<.10	<.10	<.10	<.20	<.10	<.04	<.04	<.04	<.10	<.04
				Tarkio River alluvium							
SW55	10-20-87	<.10	--	--	--	<.10	--	--	--	--	--
SW56	10-21-87	<.10	--	--	--	<.10	--	--	--	--	--
				West Nodaway River alluvium							
SW65	10-19-87	<.10	--	--	--	<.10	--	--	--	--	--
SW66	10-19-87	<.10	--	--	--	<.10	--	--	--	--	--
Massena 3	10-19-87	<.10	--	--	--	<.10	--	--	--	--	--
Shambaugh 3	10-22-87	<.10	--	--	--	<.10	--	--	--	--	--
Villisca 7	10-20-87	<.10	--	--	--	<.10	--	--	--	--	--
Villisca 8		<.10	--	--	--	<.10	--	--	--	--	--
				Middle Nodaway River alluvium							
SW71	10-20-87	<.10	--	--	--	<.10	--	--	--	--	--
SW73	10-19-87	<.10	--	--	--	<.10	--	--	--	--	--
				East Nodaway River alluvium							
SW72	10-20-87	<.10	--	--	--	<.10	--	--	--	--	--
SW77	11-04-87	<.10	--	--	--	<.10	--	--	--	--	--
Prescott 2	10-20-87	<.10	--	--	--	<.10	--	--	--	--	--
Nodaway 3	10-20-87	<.10	--	--	--	<.10	--	--	--	--	--

Table 10. *Concentrations of selected pesticides, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Pesticide concentration, im micrograms per liter									
		Butylate	Carbofuran	Chloramben	Chlordane	Cyanazine	DDD	DDE	DDT	Dicamba	Dieldrin
				Nodaway River alluvium							
SW64	10-21-87	<0.10	--	--	--	<0.10	--	--	--	--	--
Braddyville 2	10-21-87	<.10	--	--	--	<.10	--	--	--	--	--
				West Fork One Hundred and Two River alluvium							
SW62	10-21-87	<.10	--	--	--	<.10	--	--	--	--	--
				Glacial-drift aquifer							
SW21	8-20-86	<.10	--	--	--	<.10	--	--	--	--	--
Minden 2	6-06-86	--	<0.10	<0.10	<0.20	<.10	<0.04	<0.04	<0.04	<0.10	<0.04
				Albany buried-channel aquifer							
SW78	11-04-87	<.10	--	--	--	<.10	--	--	--	--	--
Blockton 1	8-20-85	--	--	--	<.10	<.10	<.04	<.02	<.04	<.07	<.02
				Fremont buried-channel aquifer							
SW39U	8-13-86	<.10	--	<.10	<.40	<.10	<.08	<.08	<.08	<.10	<.08
Treynor 3	8-06-85	--	--	--	<.10	<.10	<.04	<.02	<.04	<.07	<.02
				Dakota aquifer							
SW17	8-20-86	<.10	--	--	--	<.10	--	--	--	--	--
				Pennsylvanian aquifer							
SW18	8-20-86	<.10	--	--	--	<.10	--	--	--	--	--

Table 10. *Concentrations of selected pesticides, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Pesticide concentration, in micrograms per liter								
		Endosulfan I	Endosulfan II	Endosulfan sulfate	Endrin aldehyde	Endrin	Ethoprop	Fonofos	Heptachlor epoxide	Metolachlor
					Surface water					
West Nishnabotna River at Avoca	8-20-86	--	--	--	--	--	--	--	--	0.30
Nishnabotna River at Hamburg	10-27-87	--	--	--	--	--	--	--	--	<.10
East Nishnabotna River at Lorah	8-20-86	--	--	--	--	--	--	--	--	<.10
Tarkio River at Blanchard	10-21-87	--	--	--	--	--	--	--	--	<.10
West Nodaway River at Massena	10-27-87	--	--	--	--	--	--	--	--	<.10
Middle Nodaway River at Fontanelle	10-22-87	--	--	--	--	--	--	--	--	<.10
East Nodaway River at Prescott	10-20-87	--	--	--	--	--	--	--	--	<.10
Nodaway River at Braddyville	10-21-87	--	--	--	--	--	--	--	--	<.10
East Fork One Hundred and Two River at Bedford	10-21-87	--	--	--	--	--	--	--	--	<.10
				West Nishnabotna River alluvium						
SW36L	8-06-86	--	--	--	--	--	--	--	--	<.10
SW38L	8-13-86	<0.04	<0.04	<0.04	<0.04	<0.04	<0.10	<0.10	<0.04	<.10
Avoca 2	8-20-86	--	--	--	--	--	--	--	--	<.10
Hancock 6	8-20-86	--	--	--	--	--	--	--	--	<.10
Oakland 8	6-01-87	--	--	--	--	--	--	<.10	<.10	<.10
Oakland 11	8-20-86	--	--	--	--	--	--	--	--	<.10
Oakland 11	6-01-87	--	--	--	--	--	--	<.10	<.10	<.10
Carson 2	8-20-86	--	--	--	--	--	--	--	--	.14
Macedonia 1	8-20-86	--	--	--	--	--	--	--	--	<.10
Henderson 2	8-20-86	--	--	--	--	--	--	--	--	<.10
Hastings 1	8-20-86	--	--	--	--	--	--	--	--	<.10
Malvern 11	6-01-87	--	--	--	--	--	--	<.10	<.10	<.10
Sidney 6	10-16-86	<.04	<.04	<.04	<.04	<.04	<.10	<.10	<.04	<.10

Table 10. *Concentrations of selected pesticides, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Pesticide concentration, in micrograms per liter								
		Endosulfan I	Endosulfan II	Endosulfan sulfate	Endrin aldehyde	Endrin	Ethoprop	Fonofos	Heptachlor epoxide	Metolachlor
					East Nishnabotna River alluvium					
SW16U	8-12-86	<0.04	<0.04	<0.04	<0.04	<0.04	<0.10	<0.10	<0.04	<0.10
SW33L	8-06-86	--	--	--	--	--	--	--	--	<.10
SW34L	8-06-86	--	--	--	--	--	--	--	--	<.10
SW35L	8-06-86	--	--	--	--	--	--	--	--	<.10
Essex 5	8-14-86	<.04	<.04	<.04	<.04	<.04	<.10	<.10	<.04	<.10
Shenandoah 17	8-14-86	<.08	<.08	<.08	<.08	<.08	<.10	<.10	<.08	<.10
Shenandoah 18	6-01-87	--	--	--	--	--	<.10	<.10	--	<.10
Shenandoah 25	8-14-86	<.08	<.08	<.08	<.08	<.08	<.10	<.10	<.08	<.10
Shenandoah 26	3-16-87	--	--	--	--	--	--	--	--	<.10
Riverton 2	8-14-86	<.04	<.04	<.04	<.04	<.04	<.10	<.10	<.04	<.10
					Tarkio River alluvium					
SW55	10-20-87	--	<.10	--	--	--	--	--	--	<.10
SW56	10-21-87	--	--	--	--	--	--	--	--	<.10
					West Nodaway River alluvium					
SW65	10-19-87	--	--	--	--	--	--	--	--	<.10
SW66	10-19-87	--	--	--	--	--	--	--	--	<.10
Massena 3	10-19-87	--	--	--	--	--	--	--	--	<.10
Shambaugh 3	10-22-87	--	--	--	--	--	--	--	--	<.10
Villisca 7	10-20-87	--	--	--	--	--	--	--	--	<.10
Villisca 8		--	--	--	--	--	--	--	--	<.10
					Middle Nodaway River alluvium					
SW71	10-20-87	--	--	--	--	--	--	--	--	<.10
SW73	10-19-87	--	--	--	--	--	--	--	--	<.10

Table 10. *Concentrations of selected pesticides, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Pesticide concentration, in micrograms per liter								
		Endosulfan I	Endosulfan II	Endosulfan sulfate	Endrin aldehyde	Endrin	Ethoprop	Fonofos	Heptachlor epoxide	Metolachlor
				East Nodaway River alluvium						
SW72	10-20-87	--	--	--	--	--	--	--	--	<0.10
SW77	11-04-87	--	--	--	--	--	--	--	--	<.10
Prescott 2	10-20-87	--	--	--	--	--	--	--	--	<.10
Nodaway 3	10-20-87	--	--	--	--	--	--	--	--	<.10
				Nodaway River alluvium						
SW64	10-21-87	--	--	--	--	--	--	--	--	<.10
Braddyville 2	10-21-87	--	--	--	--	--	--	--	--	--
				West Fork One Hundred and Two River alluvium						
SW62	10-21-87	--	--	--	--	--	--	--	--	<.10
				Glacial-drift aquifer						
SW21	8-20-86	--	--	--	--	--	--	--	--	<.10
Minden 2	6-06-86	<0.04	<0.04	<0.04	<0.04	--	<0.10	<0.10	<0.04	<.10
				Albany buried-channel aquifer						
SW78	11-04-87	--	--	--	--	--	--	--	--	<.10
Blockton 1	8-20-85	<.02	<.04	<.04	<.05	--	--	<.10	<.02	<.10
				Fremont buried-channel aquifer						
SW39U	8-13-86	<.08	<.08	<.08	<.08	<.08	<.10	<.10	<.08	<.10
Treynor 3	8-06-85	<.02	<.04	<.04	<.05			<.10	<.02	<.10
				Dakota aquifer						
SW17	8-20-86	--	--	--	--	--	--	--	--	0.10
				Pennsylvanian aquifer						
SW18	8-20-86	--	--	--	--	--	--	--	--	<.10

Table 10. *Concentrations of selected pesticides, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Pesticide concentration, in micrograms per liter									
		Metribuzin	Pendimethalin	Phorate	Propachlor	Terbufos	Toxaphene	Trifluralin	Silvex	Sulprofos	2,4-D
					<u>Surface water</u>						
West Nishnabotna River at Avoca	8-20-86	<0.10	<0.10	--	<0.10	--	--	<0.10	--	<0.10	--
Nishnabotna River at Hamburg	10-27-87	<.10	--	--	--	--	--	<.10	--	--	--
East Nishnabotna River at Lorah	8-20-86	<.10	<.10	--	<.10	--	--	<.10	--	<.10	--
Tarkio River at Blanchard	10-21-87	<.10	--	--	--	--	--	<.10	--	--	--
West Nodaway River at Massena	10-27-87	<.10	--	--	--	--	--	<.10	--	--	--
Middle Nodaway River at Fontanelle	10-22-87	<.10	--	--	--	--	--	<.10	--	--	--
East Nodaway River at Prescott	10-20-87	<.10	--	--	--	--	--	<.10	--	--	--
Nodaway River at Braddyville	10-21-87	<.10	--	--	--	--	--	<.10	--	--	--
East Fork One Hundred and Two River at Bedford	10-21-87	<.10	--	--	--	--	--	<.10	--	--	--
					<u>West Nishnabotna River alluvium</u>						
SW36L	8-06-86	<.10	<.10	--	<.10	--	--	<.10	--	<.10	--
SW38L	8-13-86	<.10	--	<0.10	--	<0.10	<0.5	<.10	<0.10	--	<0.10
Avoca 2	8-20-86	<.10	<.10	--	<.10	--	--	<.10	--	<.10	--
Hancock 6	8-20-86	<.10	<.10	--	<.10	--	--	--	--	<.10	--
Oakland 8	6-01-87	<.10	--	<.10	--	<.10	--	<.10	--	--	--
Oakland 11	8-20-86	<.10	<.10	--	<.10	--	--	<.10	--	<.10	--
Oakland 11	6-01-87	<.10	--	<.10	--	<.10	--	<.10	--	--	--
Carson 2	8-20-86	<.10	<.10	--	<.10	--	--	<.10	--	<.10	--
Macedonia 1	8-20-86	<.10	<.10	--	<.10	--	--	<.10	--	<.10	--
Henderson 2	8-20-86	--	<.10	--	<.10	--	--	<.10	--	<.10	--
Hastings 1	8-20-86	--	<.10	--	<.10	--	--	<.10	--	<.10	--
Malvern 11	6-01-87	<.10	--	<.10	--	<.10	--	<.10	--	--	--
Sidney 6	10-16-86	<.10	--	<.10	--	<.10	<.5	<.10	<.10	--	<.10

Table 10. *Concentrations of selected pesticides, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Pesticide concentration, in micrograms per liter									
		Metribuzin	Pendimethalin	Phorate	Propachlor	Terbufos	Toxaphene	Trifluralin	Silvex	Sulprofos	2,4-D
					East Nishnabotna River alluvium						
SW16U	8-12-86	<0.10	--	<0.10	--	<0.10	<0.5	<0.10	<0.10	--	<0.10
SW33L	8-06-86	<.10	<0.10	--	<0.10	--	--	<.10	--	<0.10	--
SW34L	8-06-86	<.10	<.10	--	<.10	--	--	<.10	--	<.10	--
SW35L	8-06-86	<.10	<.10	--	<.10	--	--	<.10	--	<.10	--
Essex 5	8-14-86	<.10	--	<.10	--	<.10	<.5	<.10	<.10	--	<.10
Shenandoah 17	8-14-86	<.10	--	<.10	--	<.10	<1.0	<.10	<.10	--	<.10
Shenandoah 18	6-01-87	<.10	--	<.10	--	<.10	--	<.10	--	--	--
Shenandoah 25	8-14-86	<.10	--	<.10	--	<.10	<1.0	<.10	<.10	--	<.10
Shenandoah 26	3-16-87	<.10	<.10	--	<.10	--	--	<.10	--	<.10	--
Riverton 2	8-14-86	<.10	--	<.10	--	<.10	<.5	<.10	<.10	--	<.10
					Tarkio River alluvium						
SW55	10-20-87	<.10	--	--	--	--	--	<.10	--	--	--
SW56	10-21-87	--	--	--	--	--	--	<.10	--	--	--
					West Nodaway River alluvium						
SW65	10-19-87	<.10	--	--	--	--	--	<.10	--	--	--
SW66	10-19-87	<.10	--	--	--	--	--	<.10	--	--	--
Massena 3	10-19-87	<.10	--	--	--	--	--	<.10	--	--	--
Shambaugh 3	10-22-87	<.10	--	--	--	--	--	<.10	--	--	--
Villisca 7	10-20-87	<.10	--	--	--	--	--	<.10	--	--	--
Villisca 8		<.10	--	--	--	--	--	<.10	--	--	--
					Middle Nodaway River alluvium						
SW71	10-20-87	<.10	--	--	--	--	--	<.10	--	--	--
SW73	10-19-87	<.10	--	--	--	--	--	<.10	--	--	--

Table 10. *Concentrations of selected pesticides, 1985-87*--Continued

Well or surface-water name (fig. 9)	Date of sample	Pesticide concentration, in micrograms per liter									
		Metribuzin	Pendimethalin	Phorate	Propachlor	Terbufos	Toxaphene	Trifluralin	Silvex	Sulprofos	2,4-D
					East Nodaway River alluvium						
SW72	10-20-87	<0.10	--	--	--	--	--	<0.10	--	--	--
SW77	11-04-87	<.10	--	--	--	--	--	<.10	--	--	--
Prescott 2	10-20-87	<.10	--	--	--	--	--	<.10	--	--	--
Nodaway 3	10-20-87	<.10	--	--	--	--	--	<.10	--	--	--
					Nodaway River alluvium						
SW64	10-21-87	<.10	--	--	--	--	--	--	--	--	--
Braddyville 2	10-21-87	--	--	--	--	--	--	<.10	--	--	--
					West Fork One Hundred and Two River alluvium						
SW62	10-21-87	<.10	--	--	--	--	--	<.10	--	--	--
					Glacial-drift aquifer						
SW21	8-20-86	<.10	<0.10	--	<0.10	--	--	<.10	--	<.10	--
Minden 2	6-06-86	<.10	--	<0.10	--	<0.10	<0.5	<.05	<0.10	--	<0.10
					Albany buried-channel aquifer						
SW78	11-04-87	<.10	--	--	--	--	--	<.10	--	--	--
Blockton 1	8-20-85	<.05	--	<.10	--	--	<.5	<.05	<.05	--	<.07
SW39U	8-13-86	<.10	--	<.10	--	<.10	<1.0	<.10	<.10	--	<.10
Treynor 3	8-06-85	<.05	--	<.10	--	--	<.5	<.05	<.05	--	<.02
					Dakota aquifer						
SW17	8-20-86	<.10	<.10	--	<.10	--	--	<.10	--	<.10	--
					Pennsylvanian aquifer						
SW18	8-20-86	<.10	<.10	--	<.10	--	--	<.10	--	<.10	--

Table 11. *Statistical summary of historical, 1950-86, water-quality properties and constituents for alluvial aquifers*

[Data from Iowa Department of Natural Resources, Geological Survey Bureau; all constituents are dissolved, except as indicated; µS/cm, microsiemens per centimeter at 25 degrees Celsius; $CaCO_3$, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; --, no data]

	Specific conductance, laboratory (µS/cm)	pH, laboratory (standard units)	Total hardness, (mg/L as $CaCO_3$)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Dissolved solids (mg/L)	Nitrogen, NO_3 (mg/L as N)	Iron (µg/L)	Manganese (µg/L)
							West Nishnabotna River alluvial aquifer								
Maximum	1,100	8.0	600	160	52	54	8.0	470	280	130	0.6	809	10	6,700	4,300
Minimum	450	6.5	200	54	17	7.4	0	200	10	1	0	272	<.10	<200	<10
Mean	708	--	370	100	29	13	2.7	340	82	16	.3	457	1.5	1,220	630
Number of samples	124	127	120	130	130	127	120	130	130	130	130	122	130	127	127
							East Nishnabotna River alluvial aquifer								
Maximum	1,400	8.3	750	180	72	29	11.4	460	280	100	0.6	963	22	8,800	20,000
Minimum	253	6.5	150	38	8.7	6.4	.9	140	5	<.5	.2	193	<.10	<200	<10
Mean	659	--	330	900	27	15	2.7	260	110	21	.3	457	2.6	1,630	580
Number of samples	89	88	88	89	89	88	83	88	89	89	89	82	89	89	89
							Tarkio River alluvial aquifer								
Maximum	788	7.6	320	96	22	27	5.0	200	150	70	0.4	524	1.4	18,000	2,000
Minimum	500	6.7	210	63	13	22	2.3	130	82	16	.2	348	.20	1,300	1,600
Mean	629	--	280	76	18	25	3.0	170	110	43	.3	426	.90	10,000	1,700
Number of samples	7	7	7	7	7	7	7	7	7	7	7	6	6	7	7
							Nodaway River alluvial aquifer								
Maximum	940	7.7	450	130	41	40	5.0	430	280	100	1.1	695	22	30,000	5,500
Minimum	300	6.2	120	31	9.2	8.5	.1	70	16	1.5	.2	199	<.10	<200	<10
Mean	596	--	280	74	20	17	2.0	200	99	26	.3	407	2.4	7,100	1,100
Number of samples	52	53	50	54	54	53	53	49	54	54	54	54	54	54	54

Table 11. *Statistical summary of historical, 1950-86, water-quality properties and constituents for alluvial aquifers*--Continued

	Specific conductance, laboratory (µS/cm)	pH, laboratory (standard units)	Total hardness, (mg/L as $CaCO_3$)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Dissolved solids (mg/L)	Nitrogen, NO_3 (mg/L as N)	Iron (µg/L)	Manganese (µg/L)
							One Hundred and Two River alluvial aquifer								
Maximum	720	7.6	330	83	21	38	2.1	360	180	42	0.6	476	0.40	26,000	3,900
Minimum	450	6.5	180	48	9.7	13	.2	160	9	1	.1	276	<.10	800	500
Mean	559	--	250	69	17	23	1.4	250	67	15	.3	368	.10	12,600	1,800
Number of samples	15	16	16	16	16	15	15	16	16	16	16	16	15	16	16
							Inter-till sand and gravel aquifers								
Maximum	860	7.4	490	130	38	22	4.5	860	97	48	.4	600	120	8,000	1,200
Minimum	330	6.6	150	42	11	8.2	.8	170	6	<.5	.2	176	<.10	< 10	< 10
Mean	608	--	350	96	25	14	2.4	280	39	24	.3	430	33	1,140	170
Number of samples	15	17	16	17	17	17	17	17	17	17	17	17	17	17	17
							Basal sand and gravel aquifers								
Maximum	750	7.5	360	91	26	15	2.3	310	58	5.5	.4	482	79	310	< 10
Minimum	500	7.0	260	70	19	7.9	<.1	220	10	<.5	.2	313	6.2	< 10	< 10
Mean	575	--	290	78	22	11	1.4	260	20	2.1	.3	351	25	60	< 10
Number of samples	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
							Albany buried-channel aquifer								
Maximum	3,400	7.9	1,500	350	140	350	11	510	1,900	110	.8	3,200	.20	7,800	370
Minimum	1,600	7.3	130	34	9.8	310	2.8	300	240	18	.2	1,040	<.10	500	20
Mean	2,360	--	670	160	62	330	6.4	390	870	71	.6	1,920	.12	3,500	150
Number of samples	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Table 11. *Statistical summary of historical, 1950-86, water-quality properties and constituents for alluvial aquifers*--Continued

	Specific conductance laboratory (µS/cm)	pH, laboratory (standard units)	Total hardness, (mg/L as $CaCO_3$)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Dissolved solids (mg/L)	Nitrogen, NO_3 (mg/L as N)	Iron (µg/L)	Manganese (µg/L)
							Fremont buried-channel aquifer								
Maximum	980	7.8	380	100	31	78	3.8	470	150	8.0	0.3	619	16	1,800	290
Minimum	610	7.1	310	83	25	26	2.7	320	23	1.5	.2	352	<.10	270	120
Mean	798	--	340	93	28	51	3.3	380	80	3.9	.3	488	3.6	680	230
Number of samples	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Table 12. *Selected pesticide analyses for water samples from the Nishnabotna River system, 1985-87*

[Data from the Iowa Department of Natural Resources, Geological Survey Bureau; <, less than; --, no data]

Site name (fig. 9)	Sample date	Pesticide concentration, in micrograms per liter					
		Atrazine	Alachlor	Cyanazine	Metolachlor	Metribuzin	Simazine
			<u>Surface water</u>				
West Nishnabotna River near Avoca	6-01-87	1.3	0.35	4.10	< 0.10	0.28	--
	7-01-87	.21	<.10	.11	<.10	<.10	--
West Nishnabotna River near Sidney	6-01-87	3.7	.73	7.10	.93	.33	--
	7-01-87	.33	<.10	.16	<.10	<.10	--
East Nishnabotna River near Lorah	6-01-87	.90	.39	1.40	.84	<.10	--
	7-01-87	.13	<.10	<.10	<.10	<.10	--
East Nishnabotna River near Shenandoah	6-01-87	4.15	.35	3.40	1.20	.28	--
	7-01-87	.35	<.10	.18	<.10	<.10	--
			<u>West Nishnabotna River alluvium</u>				
Avoca 2	6-19-86	0.29	< .10	< .10	< .10	< .10	--
	8-20-86	.53	<.10	<.10	<.10	<.10	--
Avoca 3	5-04-87	.39	<.10	<.10	<.10	<.10	--
	6-01-87	.17	<.10	<.10	<.10	<.10	0.98
Avoca (treated water)	1-07-87	.26	<.20	<.20	<.20	<.20	--
Hancock 6	8-20-86	.18	<.10	<.10	<.10	<.10	--
Oakland 11	7-01-87	.16	< .10	1.70	<.10	<.10	--
Carson 2	6-09-86	<.10	<.10	<.10	.10	<.10	--
Carson 2	8-20-86	<.10	<.10	<.10	.14	<.10	--
Macedonia 1	8-20-86	.23	<.10	<.10	<.10	<.10	--
Macedonia 2	8-06-85	.24	<.10	<.10	<.10	<.05	--
Macedonia (treated water)	6-17-87	.31	.87	<.20	.64	<.20	--
Hastings 1	8-19-86	.16	<.10	<.10	<.10	<.10	--
Sidney 6	10-16-86	.15	<.10	<.10	<.10	<.10	--
Randolph (treated water)	9-22-87	.88	<.20	<.20	<.20	<.20	--

Table 13. *Selected pesticide analyses for water samples from the Tarkio, Nodaway, and One Hundred and Two River systems, 1986-87*

[Data from Iowa Department of Natural Resources, Geological Survey Bureau; <, less than; --, no data]

Site name (fig. 9)	Sample date	Pesticide concentration, in micrograms per liter				
		Atrazine	Alachlor	Cyanazine	Metolachlor	2,4-D
			Surface water			
Middle Nodaway River at Fontanelle	10-22-87	0.10	<0.10	<0.10	<0.10	--
East Nodaway River at Prescott	10-20-87	.10	<.10	<.10	<.10	--
			Tarkio River alluvium			
Blanchard (treated water)	11-18-86	.25	< .20	< .20	< .20	<0.20
			Middle Nodaway River alluvium			
Fontanelle 5	8-15-86	.28	.10	< .10	< .10	< .10
	4-04-87	.11	<.10	<.10	<.10	--
			One Hundred and Two River alluvium			
Gravity 3	7-11-86	< .10	.32	< .10	.36	< .10
Gravity (treated water)	4-13-87	<.20	<.20	<.20	<.20	.25
Conway 1	7-18-86	.31	.73	<.10	<.10	<.10
	8-04-87	1.4	2.1	<.10	<.10	--
Conway	11-12-86	<.20	1.1	<.20	<.20	<.20

Table 14. *Thickness of glacial drift in southwest Iowa*

County	Thickness (feet)
Adair	50-293
Adams	11-329
Cass	18-260
Fremont	24-398
Mills	40-263
Montgomery	6-230
Page	25-220
Pottawattamie	6-452
Taylor	20-274

Table 15. *Water levels and potential yields of the Dakota aquifer*

[ft, feet; gal/min, gallons per minute; ft^2/d, feet squared per day; >, greater than; --, no data]

Location	Aquifer thickness (feet)	Altitude of water level (feet above sea level)	Average yield to well (gal/min)	Estimated average transmissivity (ft^2/d)
Anita area	15 to >32	1,200	--	--
Anita town wells	24 to 36	1,200	90 to 120	1,765
Atlantic area	10 to 103	1,150 to 1,200	7 to 50	--
Atlantic town wells	40 to >47	1,125	175 to 230	3,074
Cass County areas	5 to 52	1,150 to 1,200	10 to 60	--
Cumberland area	15 to >67	1,125 to 1,175	10 to 20	--
Cumberland town wells	27 to >52	1,175	25 to 100	--
Elliott area	10 to 95	1,075 to >1,250	0 to 20	--
Elliott town well	>63	1,075	150	2,763
Griswold area	5 to 88	1,100 to 1,175	15 to 30	--
Griswold town wells	19 to 88	--	125 to 450	--
Neola area	30 to >57	1,080	--	--
Neola town wells	>41	1,075	90	1,706
Red Oak area	4 to>122	1,075 to 1,100	--	--
Red Oak town wells	50 to>122	1,050 to 1,100	135 to 900	3,026
Stanton area	40 to>113	1,120	--	--
Stanton town wells	>113	1,115	120 to 250	1,945
Wiota area	15 to >50	1,200	16 to >25	--
Wiota town well	15	1,181	80	6,211

Table 16. *Statistical summary of historical, 1950-86, water-quality properties and constituents and trace-element and radionuclide concentrations for nine municipalities using the Dakota aquifer*

[Data from Iowa Department of Natural Resources, Geological Survey Bureau; all constituents are dissolved, except as indicated; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; $CaCO_3$, calcium carbonate; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than; --, no data]

	Specific conductance, laboratory (µS/cm)	pH, laboratory (standard units)	Temperature, water (°C)	Total hardness, (mg/L as $CaCO_3$)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity, laboratory (mg/L as $CaCO_3$)	Bicarbonate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Dissolved solids (mg/L)	Nitrogen, NO_3 (mg/L as N)	Iron (µg/L)	Manganese (µg/L)
									Anita									
Maximum	1,300	7.7	11.0	640	180	47	76	4.6	290	350	430	2.0	0.5	27	1,040	0.09	170	1,000
Minimum	650	7.1	10.0	280	78	17	26	3.0	260	310	81	.5	.4	20	384	<.02	<10	430
Mean	877	--	11.0	410	120	29	39	3.9	270	330	160	1.0	.5	23	619	--	--	590
Number of samples	6	6	4.0	6	6	6	5	5	6	6	5	5	5	6	6	5	5	5
									Atlantic									
Maximum	830	7.3	25.0	410	100	34	20	4.2	180	220	200	36	.4	30	614	11	12,000	1,400
Minimum	260	6.1	11.0	110	27	8.8	5.4	1.0	92	110	17	<.5	.1	20	167	<.10	<10	<50
Mean	425	--	12.5	200	53	16	9.8	2.0	130	160	65	--	.3	24	290	--	--	--
Number of samples	51	51	50	52	51	51	50	49	51	50	52	52	51	49	50	50	51	51

Table 16. *Statistical summary of historical, 1950-86, water-quality properties and constituents and trace-element and radionuclide concentrations for nine municipalities using the Dakota aquifer*--Continued

	Arsenic (µg/L)	Barium (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Lead (µg/L)	Mercury (µg/L)	Selenium (µg/L)	Silver (µg/L)	Zinc (µg/L)	Total alpha radiation (pCi/L)	Total beta radiation (pCi/L)	Radium 226 (pCi/L)	Radium 228 (pCi/L)	Radon 222 (pCi/L)
Anita															
Maximum	<10	<10	<10	<10	20	<10	<1	<10	<10	40	3	7	2.3	--	0
Minimum	<10	<10	<1	<10	<10	<10	<1	<10	<10	<10	.7	4	2.3	--	0
Mean	--	--	--	--	--	--	--	--	--	--	2	6	2.3	--	0
Number of samples	4	4	4	4	4	4	4	4	4	4	4	4	1	0	1
Atlantic															
Maximum	<10	200	<10	<10	170	<10	<1	10	<10	40	4	4	--	1.8	<10
Minimum	<10	<100	<1	<10	<10	<10	<1	<10	<10	<10	.3	1	--	1.8	<10
Mean	--	--	--	--	--	--	--	--	--	--	2	2	--	1.8	--
Number of samples	22	22	22	22	22	22	11	11	12	22	12	10	0	1	1

Table 16. *Statistical summary of historical, 1950-86, water-quality properties and constituents and trace-element and radionuclide concentrations for nine municipalities using the Dakota aquifer*--Continued

	Specific conductance, laboratory (µS/cm)	pH, laboratory (standard units)	Temperature, water (°C)	Total hardness, (mg/L as $CaCO_3$)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity, laboratory (mg/L as $CaCO_3$)	Bicarbonate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Dissolved solids (mg/L)	Nitrogen, NO_3 (mg/L as N)	Iron (µg/L)	Manganese (µg/L)
									<u>Cumberland</u>									
Maximum	390	7.3	13.5	200	56	16	19	2.9	200	250	36	5.0	0.4	25	247	0.44	12,000	290
Minimum	340	6.7	11.0	190	51	12	9	1.3	180	220	6.7	<.5	.2	21	218	<.02	130	<50
Mean	378	--	12.5	190	53	14	11	1.9	190	230	19	--	.3	23	232	--	2,000	--
Number of samples	9	9	6	9	9	9	9	8	9	9	9	9	9	7	8	9	7	9
									<u>Elliott</u>									
Maximum	360	7.2	14.5	180	51	14	9.2	2.0	150	190	18	3.0	.3	25	219	4.4	580	<50
Minimum	320	6.6	10.0	160	42	8.7	6.4	.7	130	160	9.7	1.0	.2	21	193	2.9	<10	<10
Mean	342	--	12.5	160	46	12	7.8	1.2	150	180	15	3.0	.2	23	211	3.6	--	--
Number of samples	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Table 16. *Statistical summary of historical, 1950-86, water-quality properties and constituents and trace-element and radionuclide concentrations for nine municipalities using the Dakota aquifer*--Continued

	Arsenic (µg/L)	Barium (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Lead (µg/L)	Mercury (µg/L)	Selenium (µg/L)	Silver (µg/L)	Zinc (µg/L)	Total alpha radia-tion (pCi/L)	Total beta radia-tion (pCi/L)	Radium 226 (pCi/L)	Radium 228 (pCi/L)	Radon 222 (pCi/L)
Cumberland															
Maximum	<10	200	<10	<10	<10	<10	<1	<10	<10	30	3	7	--	--	--
Minimum	<10	200	<10	<10	<10	<10	<1	<10	<10	20	3	1	--	--	--
Mean	--	200	--	--	--	--	--	--	--	25	3	4	--	--	--
Number of samples	2	2	2	2	2	2	2	2	2	2	2	2	0	0	0
Elliott															
Maximum	<10	500	<10	<10	90	<10	<1	<10	<10	22	--	--	--	--	--
Minimum	<10	500	<10	<10	10	<10	<1	<10	<10	<10	--	--	--	--	--
Mean	--	500	--	--	56	--	--	--	--	--	--	--	--	--	--
Number of samples	3	3	3	3	3	3	1	1	1	3	0	0	0	0	0

Table 16. *Statistical summary of historical, 1950-86, water-quality properties and constituents and trace-element and radionuclide concentrations for nine municipalities using the Dakota aquifer*--Continued

	Specific conductance, laboratory (µS/cm)	pH, laboratory (standard units)	Temperature, water (°C)	Total hardness, (mg/L as $CaCO_3$)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity, laboratory (mg/L as $CaCO_3$)	Bicarbonate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Dissolved solids (mg/L)	Nitrogen, NO_3 (mg/L as N)	Iron (µg/L)	Manganese (µg/L)
									Griswold									
Maximum	430	7.3	15.0	220	55	20	7.2	1.8	160	200	24	8.5	0.4	28	266	7.1	280	120
Minimum	316	6.4	10.0	150	35	12	5.0	.7	130	160	8.2	1	.2	19	165	3.1	<10	<10
Mean	354	--	12.0	180	45	16	6.5	1.0	150	180	16	3.6	.3	22	222	4.6	--	--
Number of samples	11	11	7	11	10	10	10	10	11	10	11	11	11	10	10	11	10	11
									Neola									
Maximum	979	7.9	15.0	470	130	78	23	3.5	360	430	140	36	.4	30	629	4.9	2,500	2,900
Minimum	670	7.0	11.0	350	95	28	7.9	1.2	320	390	42	1.0	.2	14	427	<.02	<10	450
Mean	788	--	12.5	410	110	38	14	2.6	340	400	79	13	.3	25	493	--	--	1,600
Number of samples	8	8	7	8	8	8	8	8	8	7	8	8	8	8	8	8	8	8

Table 16. *Statistical summary of historical, 1950-86, water-quality properties and constituents and trace-element and radionuclide concentrations for nine municipalities using the Dakota aquifer*--Continued

	Arsenic (µg/L)	Barium (µg/L)	Cadmium (µg/L)	Chromium (µg/L)	Copper (µg/L)	Lead (µg/L)	Mercury (µg/L)	Selenium (µg/L)	Silver (µg/L)	Zinc (µg/L)	Total alpha radiation (pCi/L)	Total beta radiation (pCi/L)	Radium 226 (pCi/L)	Radium 228 (pCi/L)	Radon 222 (pCi/L)
							Griswold								
Maximum	<10	200	<10	<10	30	<10	<1	<10	<10	20	1	4	--	--	--
Minimum	<10	<100	<1	<10	<10	<10	<1	<10	<10	<10	.3	1	--	--	--
Mean	--	--	--	--	--	--	--	--	--	--	.6	2	--	--	--
Number of samples	6	6	6	6	6	6	4	4	4	6	4	3	0	0	0
							Neola								
Maximum	10	400	<10	<10	40	<10	<1	<10	<10	70	6	10	1.9	1.7	<10
Minimum	<10	200	<1	<10	<10	<10	<1	<10	<10	<10	1	4	.6	1.3	<10
Mean	--	300	--	--	--	--	--	--	--	--	3	8	1.1	1.5	--
Number of samples	5	5	5	5	5	5	4	4	4	5	4	4	3	2	1

Table 16. *Statistical summary of historical, 1950-86, water-quality properties and constituents and trace-element and radionuclide concentrations for nine municipalities using the Dakota aquifer*--Continued

	Specific conductance, laboratory (µS/cm)	pH, laboratory (standard units)	Temperature, water (°C)	Total hardness, (mg/L as $CaCO_3$)	Calcium (mg/L)	Mangesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity, laboratory (mg/L as $CaCO_3$)	Bicarbonate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Dissolved solids (mg/L)	Nitrogen, NO_3 (mg/L as N)	Iron (µg/L)	Manganese (µg/L)
									Red Oak									
Maximum	450	7.9	14.5	220	66	16	26	1.7	230	280	38	7.0	1.9	26	278	4.0	520	10
Minimum	372	6.6	11.0	180	48	9.7	7.6	1.1	150	180	8.0	<.1	.2	18	221	.10	<10	<10
Mean	411	--	11.5	200	57	14	11	1.4	190	230	19	--	.5	21	244	2.4	--	--
Number of samples	20	20	10	20	20	20	20	17	20	20	20	20	20	14	19	20	14	20
									Stanton									
Maximum	540	8.0	15.0	270	77	19	18	4.0	280	340	22	13	1.1	26	332	.67	16,000	560
Minimum	440	6.5	11.0	230	61	15	8.8	.7	230	280	4.8	<.5	.3	12	270	<.02	1,500	<10
Mean	514	--	12.5	260	72	18	14	2.2	260	310	16	--	.4	23	306	--	3,800	--
Number of samples	12	12	8	12	12	12	12	12	12	12	12	12	12	11	12	12	11	12

Table 16. *Statistical summary of historical, 1950-86, water-quality properties and constituents and trace-element and radionuclide concentrations for nine municipalities using the Dakota aquifer*--Continued

	Arsenic, (μg/L)	Barium, (μg/L)	Cadmium, (μg/L)	Chromium, (μg/L)	Copper, (μg/L)	Lead, (μg/L)	Mercury, (μg/L)	Selenium, (μg/L)	Silver, (μg/L)	Zinc, (μg/L)	Total alpha radia-tion, (pCi/L)	Total beta radia-tion, (pCi/L)	Radium 226, (pCi/L)	Radium 228, (pCi/L)	Radon 222, (pCi/L)
							Red Oak								
Maximum	<10	300	<10	<10	30	<10	<1	<10	<10	30	2	5	--	--	--
Minimum	<10	<100	<1	<10	<10	<10	<1	<10	<10	<10	.8	2	--	--	--
Mean	--	--	--	--	--	--	--	--	--	--	2	3	--	--	--
Number of samples	9	9	9	9	9	9	5	5	5	9	5	5	0	0	0
							Stanton								
Maximum	10	800	4	<10	160	20	<1	<10	<10	940	14	7	4.0	--	<10
Minimum	<10	400	<1	<10	<10	<10	<1	<10	<10	10	.9	1	2.8	--	<10
Mean	--	587	--	--	--	--	--	--	--	172	6	3	3.4	--	--
Number of samples	7	7	7	7	7	7	5	5	5	7	5	4	3	0	1

Table 16. *Statistical summary of historical, 1950-86, water-quality properties and constituents and trace-element and radionuclide concentrations for nine municipalities using the Dakota aquifer*--Continued

	Specific conductance, laboratory (µS/cm)	pH, laboratory (standard units)	Temperature, water (°C)	Total hardness, (mg/L as $CaCO_3$)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity, laboratory (mg/L as $CaCO_3$)	Bicarbonate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Dissolved solids (mg/L)	Nitrogen, NO_3 (mg/L as N)	Iron (µg/L)	Manganese (µg/L)
									Wiota									
Maximum	510	7.4	14.5	250	73	18	11	1.4	150	180	50	24	0.3	23	330	13	580	140
Minimum	403	6.8	5.5	220	61	12	5.8	.8	140	170	25	10	.2	20	273	9.3	20	<10
Mean	465	--	11.5	230	67	16	8.4	1.1	140	180	37	17	.3	22	298	11	127	--
Number of samples	6	7	6	7	7	7	7	7	7	6	7	7	7	6	7	7	6	7

Table 16. *Statistical summary of historical, 1950-86, water-quality properties and constituents and trace-element and radionuclide concentrations for nine municipalities using the Dakota aquifer*--Continued

	Arsenic, (µg/L)	Barium, (µg/L)	Cadmium, (µg/L)	Chromium, (µg/L)	Copper, (µg/L)	Lead, (µg/L)	Mercury, (µg/L)	Selenium, (µg/L)	Silver, (µg/L)	Zinc, (µg/L)	Total alpha radia-tion, (pCi/L)	Total beta radia-tion, (pCi/L)	Radium 226, (pCi/L)	Radium 228, (pCi/L)	Radon 222, (pCi/L)
							Wiota								
Maximum	<10	300	<10	<10	50	<10	<1	<10	<10	210	3	3	--	--	65
Minimum	<10	100	<1	<10	<10	<10	<1	<10	<10	20	.4	3	--	--	65
Mean	--	192	--	--	--	--	--	--	--	70	2	3	--	--	65
Number of samples	4	4	4	4	4	4	3	3	3	4	3	2	0	0	1

Table 17. *Water use by category, 1984*

[Mgal/d, million gallons per day; gal/d, gallons per day; --, no estimate; NA, not applicable]

County and source of water	Population	Municipal and rural systems: Population served	Percent of county population	Average use (Mgal/d)	Maximum use (Mgal/d)	Estimated domestic rural use[1] (Mgal/d)	Total domestic average use (Mgal/d)
Adair	9,509	6,230	65.5	0.560	1.091	0.328	0.888
All aquifers		3,571	37.6	.314	.648	.328	.642
Alluvial aquifers		998	10.5	.070	.177	--	.070
Adams	5,731	2,473	43.2	.282	.596	.326	.608
All aquifers		534	9.3	.032	.098	.326	.358
Alluvial aquifers		534	9.3	.032	.098	--	.032
Cass	16,932	11,827	69.8	1.458	2.335	.511	1.969
All aquifers		11,827	69.8	1.458	2.335	.511	1.969
Alluvial aquifers		680	4.0	.060	.170	--	.060
Fremont	9,401	5,800	61.7	.757	1.837	.360	1.117
All aquifers		3,564	37.9	.685	1.234	.360	1.045
Alluvial aquifers		3,564	37.9	.685	1.234	--	.685
Mills	13,406	8,279	61.8	.973	3.585	.513	1.486
All aquifers		2,488	18.6	.973	.695	.513	1.486
Alluvial aquifers		1,986	14.8	.897	.433	--	.897
Montgomery	13,413	9,602	71.6	1.474	2.829	.381	1.855
All aquifers		9,484	70.7	1.464	2.829	.381	1.845
Alluvial aquifers		1,681	12.5	.276	.481	--	.276
Page	19,063	16,993	89.1	1.906	3.557	.207	2.113
All aquifers		8,079	42.4	1.002	1.879	.207	1.209
Alluvial aquifers		8,079	42.4	1.002	1.879	--	1.002
Pottawattamie	86,561	68,574	79.2	9.295	18.176	1.799	11.094
All aquifers		8,582	9.9	4.945	2.577	1.799	6.744
Alluvial aquifers		4,612	5.3	4.584	1.566	--	4.584
Taylor	8,353	4,831	57.8	.544	.874	.352	.896
All aquifers		618	7.4	.037	.063	.352	.389
Alluvial aquifers		338	4.0	.022	.048	--	.022
TOTAL:							
All counties	182,369	134,609	73.8	17.249	34.880	4.777	22.026
All aquifers		48,747	26.7	10.910	12.358	4.777	15.687
Alluvial aquifers		22,472	12.3	7.628	6.086	--	7.628

Table 17. *Water use by category, 1984*--Continued

County	Total livestock (Mgal/d)	Irrigation, permitted, ground water (Mgal/d)	Irrigation, permitted, surface water (Mgal/d)	Industrial permitted, ground water (Mgal/d)	Industrial permitted, surface water (Mgal/d)	Feedlots, permitted, ground water (Mgal/d)	Feedlots, permitted surface water (Mgal/d)
Adair	1.708	0	0	0	3.655	0	0
All aquifers	--	0	NA	0	NA	0	NA
Alluvial aquifers	--	0	NA	0	NA	0	NA
Adams	.988	0	0	0	2.116	0	0
All aquifers	--	0	NA	0	NA	0	NA
Alluvial aquifers	--	0	NA	0	NA	0	NA
Cass	1.264	.521	1.435	0	4.564	0	0
All aquifers	--	.521	NA	0	NA	0	NA
Alluvial aquifers	--	0	NA	0	NA	0	NA
Fremont	.681	6.725	1.583	.241	.089	.144	0
All aquifers	--	6.725	NA	.241	NA	.144	NA
Alluvial aquifers	--	6.725	NA	.241	NA	0	NA
Mills	.661	6.075	1.039	0	.313	.145	0
All aquifers	--	6.075	NA	0	NA	.145	NA
Alluvial aquifers	--	6.075	NA	0	NA	.145	NA
Montgomery	.881	0	.193	0	.295	.085	.150
All aquifers	--	0	NA	0	NA	.085	NA
Alluvial aquifers	--	0	NA	0	NA	.085	NA
Page	1.062	0.914	1.192	0	4.104	0	0
All aquifers	--	.914	NA	0	NA	0	NA
Alluvial aquifers	--	.914	NA	0	NA	0	NA
Pottawattamie	1.983	6.056	1.179	3.534	3.096	.299	0
All aquifers	--	6.056	NA	3.534	NA	.299	NA
Alluvial aquifers	--	6.056	NA	3.534	NA	0	NA
Taylor	1.051	0	.006	0	.045	0	0
All aquifers	--	0	NA	0	NA	0	NA
Alluvial aquifers	--	0	NA	0	NA	0	NA
TOTAL:							
All counties	10.285	20.291	6.627	3.775	18.278	.673	.150
All aquifers	--	20.291	NA	3.775	NA	.673	NA
Alluvial aquifers	--	19.609	NA	3.775	NA	.230	NA

Table 17. *Water use by category, 1984*--Continued

County	Miscellaneous permitted, ground water (Mgal/d)	Miscellaneous permitted, surface water (Mgal/d)	Total, permitted use (Mgal/d)	Total permitted, without feedlots (Mgal/d)	Total water use (Mgal/d)
Adair	0	0	3.656	3.656	6.258
All aquifers	0	NA	0	0	[2].642
Alluvial aquifers	0	NA	0	0	[2].070
Adams	0	0	2.116	2.116	3.712
All aquifers	0	NA	0	0	[2].358
Alluvial aquifers	0	NA	0	0	[2].032
Cass	0	0	6.520	6.520	9.753
All aquifers	0	NA	.521	.521	[2]2.490
Alluvial aquifers	0	NA	0	0	[2].060
Fremont	.947	4.192	13.921	13.777	15.575
All aquifers	.947	NA	8.057	7.913	[2]8.958
Alluvial aquifers	.947	NA	7.752	7.752	[2]8.437
Mills	.108	.002	7.682	7.537	9.684
All aquifers	.108	NA	6.328	6.183	[2]7.669
Alluvial aquifers	.108	NA	6.328	6.183	[2]7.080
Montgomery	0	0	.723	.488	3.224
All aquifers	0	NA	.085	0	[2]1.845
Alluvial aquifers	0	NA	.085	0	[2].276
Page	0.055	0	6.265	6.265	9.440
All aquifers	.055	NA	.969	.969	[2]2.178
Alluvial aquifers	.055	NA	.969	.969	[2]1.971
Pottawattamie	.060	5.112	19.336	19.037	32.114
All aquifers	.060	NA	9.949	9.650	[2]16.394
Alluvial aquifers	.060	NA	9.650	9.650	[2]14.234
Taylor	0	0	.051	.051	1.998
All aquifers	0	NA	0	0	[2].389
Alluvial aquifers	0	NA	0	0	[2].022
TOTAL:					
All counties	1.170	9.306	60.270	59.447	91.758
All aquifers	1.170	NA	25.909	25.236	[2]40.923
Alluvial aquifers	1.154	NA	24.768	24.538	[2]32.166

[1] Domestic rural use estimated as 100 gallons per day per capita for those not served by water systems.
[2] Does not include livestock use.

Table 18. *Water source and use for municipal and rural-water systems in southwest Iowa*

[Mgal/d, million gallons per day; --, no data]

Municipal water use	Water source	Source (percent of total)	Population served during 1980	Average use during 1984 (Mgal/d)	Maximum use during 1984 (Mgal/d)
		Adair County			
Adair	Cambrian/Ordovician aquifer	90	883	0.094	0.181
	Silurian/Devonian aquifer	10	--	--	--
Bridgewater	West Fork Middle Nodaway River alluvium	100	233	.019	.096
Fontanelle	West Fork Middle Nodaway River alluvium	95	805	.054	.085
	Albany channel	5	--	--	--
Greenfield	Lake Nodaway and Lake Greenfield	100	2,243	.203	.388
Orient	Lake Orient	100	416	.044	.055
Stuart	Cambrian/Ordovician aquifer	90	1,650	.147	.286
	Inter-till sand and gravel aquifer	10	--	--	--
		Adams County			
Corning	Lake Binder, city reservoir, and Lake Icaria	100	1,939	.250	.498
Nodaway	East Nodaway River alluvium	100	185	.011	.048
Prescott	East Nodaway River alluvium	100	349	.021	.050
		Cass County			
Anita	Dakota aquifer	100	1,153	.139	.239
Atlantic	Dakota aquifer	100	7,789	.919	1.35
Cumberland	Dakota aquifer	75	351	.026	.070
	Inter-till sand and gravel aquifer	25	--	--	--
Griswold	Dakota aquifer	100	1,176	.250	.400
Lewis	Glacial drift aquifer	100	497	.042	.080
Marne	Camp Creek alluvium	100	162	.013	.018
Massena	West Nodaway River alluvium	100	518	.047	.152
Wiota	Dakota aquifer	100	181	.023	.025

Table 18. *Water source and use for municipal and rural-water systems in southwest Iowa*--Continued

Municipal water use	Water source	Source (percent of total)	Population served during 1980	Average use during 1984 (Mgal/d)	Maximum use during 1984 (Mgal/d)
		Fremont County			
Farragut	East Nishnabotna River alluvium	100	603	0.055	0.404
Hamburg	Missouri River alluvium	100	1,597	.240	.475
Imogene	Nodaway River; from Page I Rural Water Association	100	188	.052	--
Randolph	West Nishnabotna River alluvium	100	223	.037	.167
Riverton	East Nishnabotna River alluvium	100	342	.006	.103
Sidney	West Nishnabotna River alluvium	100	1,308	.184	.360
Tabor	West Nishnabotna River alluvium	100	1,088	.125	.200
Thurman	Missouri River alluvium	100	221	.038	.110
Page I Rural Water Association	Nodaway River; from Clarinda	100	230	.020	--
		Mills County			
Emerson	Basal sand and gravel aquifer	100	502	.076	.262
Glenwood	Missouri River alluvium	100	5,280	.711	2.89
Hastings	West Nishnabotna River alluvium	100	215	.010	.065
Henderson	West Nishnabotna River alluvium	100	236	.022	.103
Malvern	West Nishnabotna River alluvium	90	1,244	.123	.229
	Silver Creek alluvium	10	--	--	--
Pacific Junction	Missouri River alluvium; from Glenwood	100	511	--	--
Silver City	Silver Creek alluvium	100	291	.031	.036
		Montgomery County			
Elliott	East Nishnabotna River alluvium	50	493	.099	.079
	Dakota aquifer	50	--	--	--
Red Oak	Dakota aquifer	100	6,810	1.049	2.19
Stanton	Dakota aquifer	100	747	.089	.120
Villisca	West Nodaway River alluvium	100	1,434	.226	.441

Table 18. *Water source and use for municipal and rural-water systems in southwest Iowa*--Continued

Municipal water use	Water source	Source (percent of total)	Population served during 1980	Average use during 1984 (Mgal/d)	Maximum use during 1984 (Mgal/d)
		Montgomery County--Continued			
Page I Rural Water Association	Nodaway River; from Clarinda	100	118	0.011	--
		Page County			
Blanchard	Tarkio River alluvium	100	101	.007	0.030
Braddyville	Nodaway River alluvium	100	199	.016	.063
Clarinda	Nodaway River	100	5.458	.625	1.68
Coin	Nodaway River; from Page I Rural Water Association	100	316	--	--
College Springs	Inter-till sand and gravel aquifer	100	307	.020	.020
Essex	East Nishnabotna River alluvium	100	1,001	.122	.220
Shambaugh	West Nodaway River alluvium	100	197	.014	.046
Shenandoah	East Nishnabotna River alluvium	100	6,274	.824	1.50
Page I Rural Water Association	Nodaway River; from Clarinda	100	3,140	.279	--
		Pottawattamie County			
Avoca	West Nishnabotna River alluvium	100	1,650	.215	.392
Carson	West Nishnabotna River alluvium	100	716	.098	.218
Carter Lake	from Omaha, Nebraska	100	3,438	.350	1.05
Council Bluffs	Missouri River	50	56,449	8.000	4.5
	Missouri River alluvium	50	--	--	--
Crescent	Pigeon Creek alluvium	100	547	.043	.089
Hancock	West Nishnabotna River alluvium	100	254	.025	.076
Macedonia	West Nishnabotna River alluvium	100	279	.009	.063
Minden	Inter-till sand and gravel aquifer	100	419	.038	.088
Neola	Dakota aquifer	93.3	839	.093	.154
	Mosquito Creek alluvium	6.7	--	--	--
Oakland	West Nishnabotna River alluvium	87.5	1,552	.156	.450
	Silurian/Devonian aquifer	12.5	--	--	--

Table 18. *Water source and use for municipal and rural-water systems in southwest Iowa*--Continued

Municipal water use	Water source	Source (percent of total)	Population served during 1980	Average use during 1984 (Mgal/d)	Maximum use during 1984 (Mgal/d)
		Pottawattamie County--Continued			
Treynor	Fremont channel aquifer	100	981	0.076	0.225
Underwood	Mosquito Creek alluvium	33.4	448	.068	.617
	Inter-till sand and gravel aquifer	33.3	--	--	--
	Basal sand and gravel aquifer	33.3	--	--	--
Walnut	Ordovician aquifer	66.5	897	.095	.204
	Cambrian/Ordovician aquifer	33.5	--	--	--
Shelby County Rural Water District	West Nishnabotna River alluvium in Shelby County	99.5	105	.028	.048
	Mississippian aquifer in Shelby County	.5	--	--	--
		Taylor County			
Bedford	East Fork One Hundred and Two River, East Branch One Hundred and Two River, and Lake of Three Fires	100	1,692	0.176	0.383
Blockton	Albany channel aquifer	100	280	.015	--
Clearfield	Platte River alluvium	100	433	.092	.127
Conway	East Fork One Hundred and Two River alluvium	100	93	.010	.024
Gravity	Middle Fork One Hundred and Two River alluvium	100	245	.012	.024
Lenox	East reservoir, West reservoir, and Mahary Lake	100	1,338	.188	.203
New Market	Nodaway River; from Page I Rural Water Association	100	554	.035	.050
Clearfield Rural Water District	Platte River alluvium	100	84	.011	.049
Page I Rural Water Association	Nodaway River; from Clarinda	100	112	.010	--

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