Hydrology and Quality of Ground Water in Northern Thurston County, Washington

By B.W. Drost, G.L. Turney, N.P. Dion, and M.A. Jones

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
foot per day (ft/d)	0.0000035	meter per second
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
gallon (gal)	3.785	liter
acre	4,047	square meter
acre-foot (acre-ft)	1,233	cubic meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
ounce	28.35	grams

Temperature: Air temperatures are given in degrees Fahrenheit (°F), which can be converted to degrees Celsius (°C) by the following equation: °C = 5/9(°F-32).

Following convention, water temperatures are given in degrees Celsius, which can be converted to degrees Fahrenheit by the following equation: °F = 1.8(°C) + 32.

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

HYDROLOGY AND QUALITY OF GROUND WATER IN NORTHERN THURSTON COUNTY, WASHINGTON

By B.W. Drost, G.L. Turney, N.P. Dion, and M.A. Jones

ABSTRACT

Northern Thurston County is underlain by as much as 1,800 feet of unconsolidated deposits of Pleistocene Age that are of glacial and nonglacial origin. Iterpretation of approximately 1,140 drillers' logs led to the delineation of seven major geohydrologic units, four of which are significant aquifers.

Precipitation ranges from about 35 to 65 inches per year across the study area. Estimates of recharge indicate that the ground-water system of the Ground Water Management Area (GWMA), a subset of the study area, receives an average of about 28 inches per year. Ground water generally moves toward marine water bodies and to major surface drainage channels.

At least 33,000 acre-feet per year of ground water discharges as springs from the GWMA. Approximately 21,000 acre-feet of water was withdrawn from the ground-water system of the GWMA through wells in 1988. Total ground-water use in the GWMA in 1988 was approximately 37,000 acre-feet. About 16,000 acre-feet of water that discharges naturally through springs was used together with water withdrawn by wells for domestic supply, agricultural, commercial, industrial, institutional, and aquaculture and livestock uses.

Generally, the chemical quality of the ground water was good and 94 percent of the water samples were classified as soft or moderately hard. Of the few water-quality problems encountered, the most widespread anthropogenic problem appeared to be seawater intrusion. However, a comparison with data from 1978 indicated that the degree and extent of intrusion had not changed significantly since that time. Agricultural activities may be responsible for the presence of nitrate in ground waters at some individual wells, but septic tanks in areas of high housing density are likely responsible for elevated nitrate concentrations near the Cities of Lacey and Tumwater. The close correlation of nitrate concentrations with detergent concentrations supports the theory that the nitrate originates in septic systems, the only likely source of the detergents.

Most water-quality problems in the study area, however, are due to natural causes. Iron concentrations are as large as 21,000 micrograms per liter, manganese concentrations are as large as 3,400 micrograms per liter, and connate seawater is present in ground water in the southern part of the study area.

REVISION NOTE

The original version of the report was published in 1994. During a subsequent phase of study, while applying a numerical model to simulate the ground-water flow system, errors were discovered in the original report. These errors resulted from the method used to assign geohydrologic units to wells.

Geohydrologic unit assignments have been reevaluated for all wells. This has resulted in changes to the surficial geologic map, unit top and thickness maps, geohydrologic sections, and water-level maps, as well as revised statistics for hydraulic conductivity, water use, common constituents by geohydrologic unit, and trilinear diagrams.

Most of the data presented in this report were collected in 1988 and 1989. The discussions and conclusions in this report are based on the original field data and represent our knowledge of the hydrology and quality of the ground water at that time.

INTRODUCTION

Demand for water in the northern part of Thurston County, Wash., has increased steadily in recent years because of rapid growth in population and residential development. Thurston County lies at the southern end of Puget Sound in western Washington, and is bounded at the north by a coastline of numerous marine inlets. The northern part of the county consists of thick deposits of glacial origin, including widespread deposits of sand and gravel at land surface.

Because surface-water resources in the county have been fully appropriated for many years, Thurston County now relies almost entirely on ground water for domestic, public supply, agricultural, and industrial uses. Any additional development in the county constitutes an additional stress on the ground-water system.

State and county officials share a number of concerns about ground-water conditions in the northern part of Thurston County. These concerns include:

- The highly porous nature of the sand and gravel deposits present at land surface throughout much of the county that makes the aquifers in those areas susceptible to contamination;

- Potential contamination of the aquifers by the use and spillage of various hazardous substances in a variety of residential, agricultural, and industrial uses;

- Elevated concentrations of nitrate in the ground water upgradient from the county's McAllister Springs, which supplies water to most residents of Olympia, the State capital;

- The continual increase in demand for ground water and the lack of alternative water sources; and

- Seawater intrusion along northern coastal areas.

The United States Geological Survey (USGS) entered into a cooperative study with the Thurston County Department of Health to characterize the ground-water system in the Quaternary deposits that underlie northern Thurston County, including the designated Ground Water Management Area. The objectives of that study were to:

- Describe and quantify the ground-water system to the extent that existing or readily collectable data allow;

- Describe the general chemical characteristics of waters in the major aquifers and the areal patterns of any ground-water contamination;

- Provide guidelines for the establishment of networks to monitor ground-water levels and ground-water quality; and

- Determine the feasibility of constructing a three-dimensional ground-water-flow model for the area.

Purpose and Scope

This report summarizes the findings of the first three objectives of the study described above. The last objective, determining the feasibility of modeling, has been completed, and construction of a steady-state flow model was in progress as of the writing of this report. The topics covered in this report include the areal geometry of the aquifers and confining beds, the ground-water flow system, the relation between ground and surface waters, water-quality characteristics of the principal aquifers, and trends in ground-water levels.

The data-collection stage of this study was structured along two main premises: (1) Only those data either already available or readily collectible would be used—that is, no test drilling or borehole geophysical logging was envisioned for this study; and (2) because of the size of the study area and the heterogeneity of the subsurface deposits, a regional perspective would be used in characterizing and describing the individual geohydrologic units and the water movement and quality in each aquifer. Although the general perspective is regional, a greater density of data was collected near McAllister Springs due to its importance as the major water supply in the study area.

Description of the Study Area

The study area consists of 439 square miles in the northern part of Thurston County (fig. 1), and includes the designated Ground Water Management Area (GWMA) of the county, which covers 232 square miles. The study area is bounded on the east by the Nisqually River (pl. 1), on the north by the various marine inlets of Puget Sound, and on the west by the Black Hills. The southern and part of the eastern boundary are based partly on township and section lines, as well as geologic contacts.

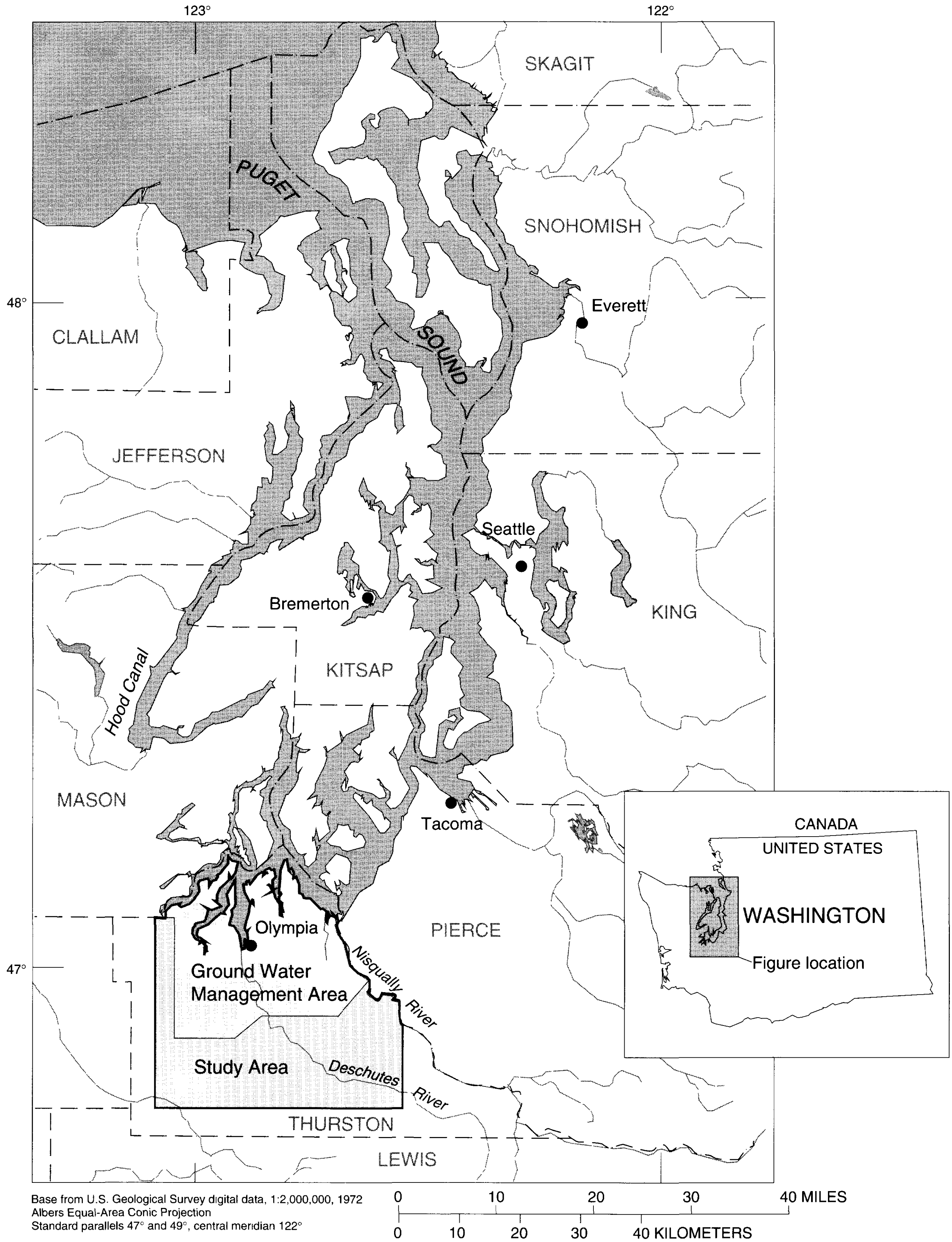


Figure 1. Location of the study area.

The topographic surface of the study area is largely the result of erosion and deposition during and since the Vashon Stade of the Fraser Glaciation (during the last 15,000 years). For the most part, the land surface is a low-lying, drift-covered glacial plain that ranges in altitude from 200 to 400 feet above sea level. Relief on the plain is generally low, but the plain terminates in steep bluffs at the shores of Puget Sound. Parts of the relatively flat plain where trees are absent are referred to locally as "prairies." The plain has been dissected by rivers and streams of small to medium size, but local closed depressions, some of which are occupied by lakes, ponds, and wetlands, are common. In particular, an area of terminal moraine in the vicinity of Lake St. Clair has numerous kettles of glacial origin (see Flint, 1971, p. 212-213). There are four major peninsulas at the northern edge of Thurston County that extend northward into Puget Sound. In this report, the four peninsulas will be referred to informally, from west to east, as the Griffin, Cooper Point, Boston Harbor, and Johnson Point peninsulas (pl. 1). The physiography of Thurston County is further described by Wallace and Molenaar (1961, pl. 1).

The climate of Thurston County, and of the study area, is of the mid-latitude, West Coast marine type, characterized by warm, dry summers and cool, wet winters. Moist air masses reaching the county originate over the Pacific Ocean, and this maritime air has a moderating influence in both winter and summer (Phillips, 1960). Prevailing winds are from the south or southwest in fall and winter, gradually shifting to the northwest or north in late spring and summer.

The long-term mean annual air temperature at Olympia is 49.6 °F; July is the warmest month and January the coldest (63.0 °F and 37.2 °F, respectively.) Afternoon temperatures are usually in the 70's in summer and from the upper 30's to lower 40's in winter.

During the wet (winter) season, rainfall is usually of light to moderate intensity and continuous over an extensive period of time. The long-term mean annual precipitation is about 51 inches at Olympia (National Oceanic and Atmospheric Administration, 1982), but ranges from about 35 inches in the northeastern part of the county to about 65 inches in the northwestern and southeastern parts of the county (fig. 2). The areas of greater precipitation are largely a result of the lifting and cooling of moist maritime air by relatively high landforms. The 51 inches of precipitation at Olympia is also the approximate mean value of the precipitation that falls throughout the GWMA.

Seventy-nine percent of the precipitation at Olympia falls in the 6-month period October to March. July has the least mean monthly precipitation and December the greatest (0.76 inch and 8.70 inches, respectively.) Total rainfall for the three driest months (June, July, and August) is less than 7 percent of the annual total. Most of the winter precipitation falls as rain at altitudes below 1,500 feet, as rain or snow between 1,500 and 2,500 feet, and as snow above 2,500 feet (Phillips, 1960).

The study area is drained by three prominent rivers—the Nisqually, Deschutes, and Black Rivers—and by numerous smaller streams such as McAllister, Woodland, Woodard, Percival, Salmon, Spurgeon, and Eaton Creeks (pl. 1). None of the drainages of the three principal rivers is completely enclosed within the study area. The principal lakes in the study area are Black, Capitol, Hewitt, Hicks, Long, Offutt, Pattison, St. Clair, Scott, Summit, and Ward; they are described by Bortleson and others (1976).

The type of native vegetation is largely dependent on the moisture-holding capacity of the soil. Poorly drained, fine-grained soils support mostly coniferous firs and cedars and deciduous alder and madrona. Beneath these trees is a lush understory of huckleberry, Oregon grape, salal, and blackberry. On the well-drained prairies, underlain by coarse-grained outwash, the vegetation consists chiefly of wild grasses, bracken fern, Scotch broom, and isolated patches of firs and oaks.

The 1988 population of the study area, which includes Olympia, Lacey, and Tumwater, is estimated to be about 136,300 (Thurston Regional Planning Council, 1989), or 91 percent of the county population. On the basis of the distribution of residences in Thurston County, approximately 41 percent of the study-area population resides within the boundaries of those three cities. The population of the GWMA was about 123,800 in 1988. Many people who work in or near the urban core of northern Thurston County live outside the study area in a rural environment or in the smaller cities and towns of Yelm, Rainier, Tenino, and Littlerock (see pl. 1). The population of Thurston County, and most likely the study area and GWMA as well, has more than tripled from 1950 to 1988. As in most metropolitan areas, the suburban and rural areas have grown at a faster rate than the more densely populated cities (fig. 3); this trend is expected to continue in the near future.

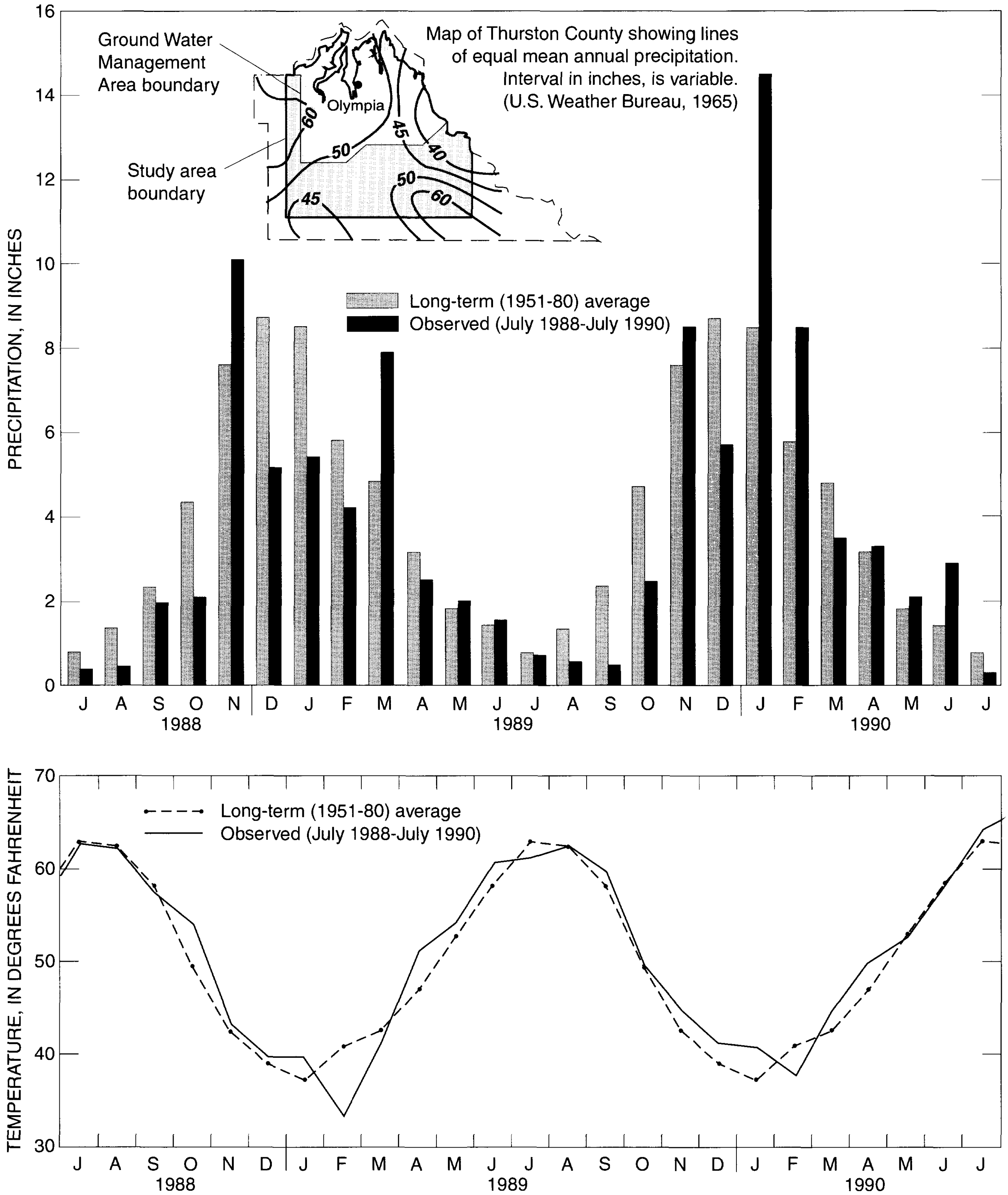


Figure 2. Long-term mean monthly (National Oceanic and Atmospheric Administration, 1982) and project-observed climatic conditions at Olympia, Washington, and areal distribution of mean annual precipitation in the study area.

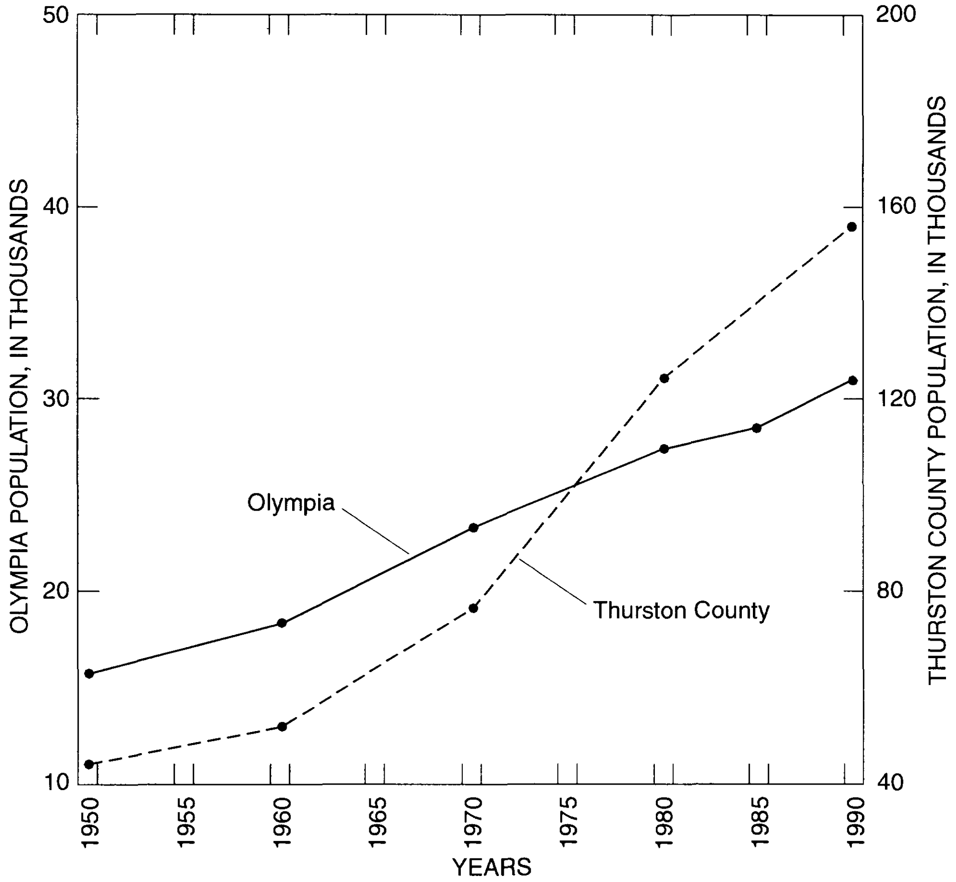


Figure 3. Population trends for Olympia and Thurston County. (Thurston Regional Planning Council, 1989)

Because Olympia is the capital city of Washington, the economy of Thurston County and the study area is dominated by State government. In 1987, State government accounted for 30 percent of the employment in the study area; by contrast, manufacturing and agriculture accounted for only 7 and 3 percent, respectively. Throughout Thurston County there are only 8 manufacturers with more than 100 employees, and only one, a brewery, with more than 400. Agricultural pursuits in the study area include dairy cattle, tree farms, wholesale nurseries, egg and poultry production, strawberries, mushrooms, and oyster harvesting.

Site-Numbering System

In Washington, wells are assigned numbers that identify their location within a township, range, section, and 40-acre tract. For example, well number 18N/01W-12J02 (fig. 4) indicates that the well is in township 18 North (N) and range 1 West (W) of the Willamette base line and meridian. The numbers immediately following the hyphen indicate the section (12) within the township; the letter following the section gives the 40-acre tract of the section, as shown on figure 4. The two-digit sequence number (02) following the letter indicates that the well was the second well in that 40-acre tract entered into the USGS data base. For springs, the sequence number is followed by the letter "S". If a well has been deepened or significantly reconstructed, the sequence number is followed by the letter "D" and a number indicating the sequence of deepenings or reconstructions.

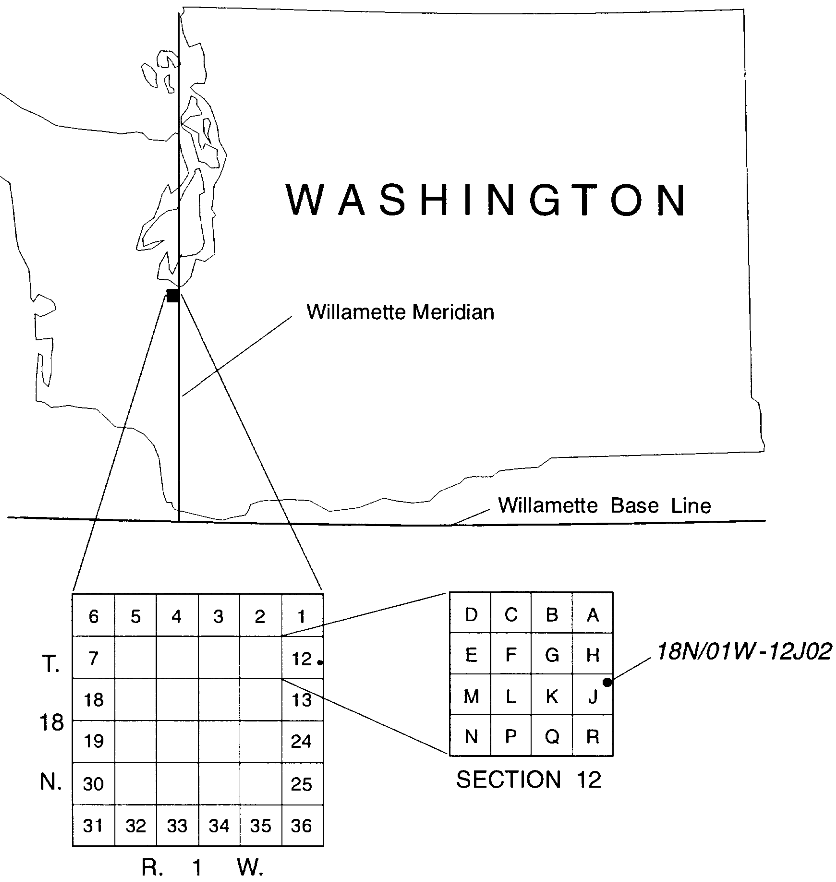


Figure 4. Site-numbering system in Washington.

Acknowledgments

The authors wish to acknowledge the cooperation of the many well owners and tenants who supplied information and allowed access to their wells and land during the field work, and the owners and managers of the water districts and companies who supplied well and water-use data. Appreciation is due in particular to the Cities of Olympia, Lacey, and Tumwater, and Mr. Gerald Petersen of the South Sound Utility Company for providing well and water-use data; Mr. Gordon White of the Thurston County Department of Planning for providing aerial photographs; Mr. Donald Tapio of the Washington State University, Thurston County Extension Service, for providing agricultural data; Ms. Lori Herman of Hart Crowser Inc. for providing data for test wells in the Lacey area; Mr. Andrew W. Hoiland of the City of Olympia for supplying discharge data for McAllister Springs; Mr. and Mrs. Larry Hansen for monitoring the stage of Lake St. Clair; and personnel of the Thurston County Department of Health for measuring the discharge of Eaton Creek. Mr. John Noble of Robinson & Noble, Inc., Mr. Robert Mead of Thurston County Environmental Health Division, and Ms. Christine Neumiller of Washington State Department of Ecology reviewed a draft of this report and provided suggestions resulting in significant improvements for the final version.

GEOLOGIC FRAMEWORK

Many studies have contributed to our current understanding of the geologic framework of the study area. Detailed descriptions of geologic conditions in Thurston County, its environs, and the Puget lowland in general are provided by Bretz (1910, 1911, 1913), Mundorff and others (1955), Snavely and others (1958), Crandell and others (1958 and 1965), Crandell (1965), Noble and Wallace (1966), Hall and Othberg (1974), Thorson (1980), Easterbrook and others (1981), Lea (1984), and Gower and others (1985). The brief summary that follows is taken largely from the work of Noble and Wallace (1966).

Continental glaciers advanced into Thurston County at least twice during the Pleistocene Epoch. The most recent glaciation of the study area, referred to as the Vashon Stade of the Fraser Glaciation, began about 15,000 years ago when the climate cooled and a great continental ice mass formed in British Columbia, Canada. The glacier slowly moved southward, blanketing the entire Puget Sound basin. The southern part of Thurston County, near Tenino (pl. 1), is generally regarded as the southernmost extent of continental glaciation in western Washington. Previous investigators have postulated that the southern advance of the glacier(s) was halted at this approximate location because of the configuration of bedrock at land surface.

As the Vashon glacier advanced southward, rivers and streams that once flowed northward, including the Nisqually and Deschutes Rivers, were blocked, and a large lake formed in front of the ice. This lake received runoff from both the blocked rivers and from the advancing glacier itself. Eventually, the rising lake breached its temporary basin and established drainage channels westward and southwestward into the valley of the Chehalis River, which drains directly to the Pacific Ocean. The Vashon Glacier remained at its maximum southern extent for a relatively short time. As the climate warmed, about 13,500 years ago, the glacier began retreating northward and drainage to the north through the Puget lowland to the Strait of Juan de Fuca eventually was reestablished. This most recent glaciation, however, left behind a characteristic sequence of glacial drift. Glacial deposits are of two general types, outwash (moderately to well-sorted sands and gravels) and till (unsorted sand, gravel, and boulders in silt and clay matrix).

As a result of the events described above, the study area of northern Thurston County is underlain by unconsolidated deposits of the Pleistocene Epoch that are of both glacial and nonglacial origin (table 1). Beneath these unconsolidated deposits, which are as much as 1,800 feet thick, are consolidated rocks of Eocene to Miocene age, which are referred to in this report as bedrock.

The youngest geologic unit in the study area consists of alluvial and deltaic sand and gravel of Holocene age. The alluvium is generally found along the valley bottoms of the principal streams and is of limited areal extent.

The Vashon recessional outwash is the next youngest unit and consists of poorly to moderately well-sorted sand and gravel laid down by streams emanating from the melting and receding glacier. A large part of the study area is mantled with this unit. Included in this unit is the glacial drift that was deposited at the terminus of the stationary or slowly retreating ice mass and labeled Vashon end moraine by Noble and Wallace (1966). Areas underlain by end moraine are characterized by hummocky terrain in which closed depressions (kettles) are common. Extensive areas of such kettled terrain are present north and southeast of Lake St. Clair and southwest of Black Lake (pl. 1b). A close examination of the bathymetric map of Lake St. Clair (Bortleson and others, 1976, p. 181-184) indicates that the lake basin most likely is formed of coalescing kettles within the end moraine. Numerous other lakes in Thurston County, such as Hewitt and Ward Lakes, are situated in closed depressions that are also kettles. Some of the smaller kettles are situated above the water table and therefore contain no water.

In most places beneath the Vashon recessional outwash is Vashon glacial till, commonly referred to as "hardpan" or "boulder clay," which consists of unsorted deposits of sand, gravel, and boulders encased in a matrix of silt and clay. The till is compact where it was laid down beneath the heavy mass of glacial ice and relatively noncompact where it formed during glacial melting. Till is exposed extensively at land surface in the northern, eastern, and south-central parts of the study area (pl. 1b).

Some materials that are found at or near the surface in the study area and resemble Vashon till may actually be part of an older till unit, the "penultimate till" of Lea (1984). Lea mapped this older till near Tenino. In the southeastern part of the study area, there are indications in some drillers' logs of a sequence of two (or more?) tills alternating with outwash. These till sequences may represent multiple Vashon tills or the deeper tills may represent older tills associated with glacial sequences prior to the Vashon.

As the Vashon Glacier advanced southward into Thurston County, large quantities of stratified sand and gravel were deposited by meltwaters at the front and sides of the ice mass. This Vashon advance outwash typically consists of fine- to coarse-grained glacially derived sand and subordinate gravel grading upward to poorly to moderately well-sorted, well-rounded gravel in a sandy matrix, interbedded with lenses of sand. Surface exposures of Vashon advance outwash are not common, but the unit is found at depth over most of the study area.

Table. 1. Lithologic and hydrologic characteristics of geohydrologic units in northern Thurston County

System	Series	Geologic unit		Geohydrologic unit, in this report[1]	Typical thickness (feet)	Lithologic characteristics	Hydrologic characteristics
Quaternary	Holocene		Alluvium	Qvr Qvrm	10-50	Alluvial and deltaic sand and gravel along major water courses. Moderately to well-sorted glacial sand and gravel, including kettled end moraine	An aquifer where saturated. Ground-water is mostly unconfined. Perched conditions occur locally.
	Pleistocene	Vashon Drift	Recessional outwash and end moraine				
			Till	Qvt[2]	20-60	Unsorted sand, gravel, and boulders in a matrix of silt and clay.	Confining bed, but can yield usable amounts of water. Some thin lenses of clean sand and gravel.
			Advance outwash	Qva	15-35	Poorly to moderately well-sorted, well-rounded gravel in a matrix of sand with some sand lenses.	Ground water mostly confined. Used extensively for public supplies near Tumwater.
		Kitsap Formation		Qf[3]	15-70	Predominantly clay and silt, with some layers of sand and gravel. Minor amounts of peat and wood.	Confining bed, but in places yields usable amounts of water.
		Salmon Springs(?) Drift (Noble and Wallace, 1966) / Deposits of "penultimate" glaciation (Lea, 1984)		Qc	15-50	Coarse sand and gravel, deeply stained with red or brown iron oxides.	Water is confined. Used extensively for industrial purposes near Tumwater.
		Unconsolidated and undifferentiated deposits		TQu	Not known	Various layers of clay, silt, sand, and gravel of both glacial and nonglacial origin.	Contains both aquifers and confining beds. Water probably confined.
Tertiary	Miocene and Eocene	Bedrock		Tb	Not known	Sedimentary rocks consisting of claystone, siltstone, sandstone, and minor beds of coal. Igneous bodies of andesite and basalt.	Poorly permeable base of unconsolidated sediments. Locally an aquifer, but generally unreliable. Water contained in fractures and joints. Well yields relatively small. Numerous abandoned wells.

[1]The identification of geohydrologic units in this report is a "best estimate" based on drillers' logs and existing surficial geology maps.

[2]Includes "late Vashon lake deposits" (Washington State Department of Ecology, 1980). May include till of "penultimate" glaciation (Lea, 1984).

[3]Includes alluvium younger than Kitsap Formation in Nisqually River delta. May include some Vashon till (where multiple tills are present). May include till of "penultimate" glaciation (Lea, 1984).

Beneath the advance outwash is a generally fine-grained assemblage of clay and silt with minor amounts of sand, gravel, peat, and wood. In many locations, this deposit is most likely the Kitsap Formation described by previous investigators. Surface exposures of this unit are found in several places along the shoreline. The unit typically occurs as high vertical bluffs above peninsular beaches. The Kitsap Formation is thought to have been deposited in shallow lakes and swamps and is probably nonglacial in origin.

Situated directly below the Kitsap Formation is a deposit of pre-Vashon glacial origin (table 1). This unit consists of coarse stratified sand and gravel that is commonly stained with iron oxides to a yellowish brown or reddish brown color. Noble and Wallace (1966) referred to this deposit as the Salmon Springs(?) Drift. However, Easterbrook and others (1981) and Lea (1984) have suggested that the Salmon Springs(?) Drift at its type locality is much older than previously assumed, and further, that it should not be correlated to more distant locations. Noble (1990) also recommended that use of the term should be discontinued in Thurston County. The unit is at the surface in several shoreline locations and in the southern part of the study area.

Beneath the Salmon Springs(?) Drift is a sequence of fine- and coarse-grained sediments extending to bedrock. These sediments are the "unconsolidated and undifferentiated deposits" of Quaternary-Tertiary age in table 1. Little is known about the lithologic character of these unconsolidated deposits, but they are believed to be of both glacial and nonglacial origin and may be similar in nature to the overlying sequence of sediments.

The consolidated rocks that make up the bedrock consist largely of Tertiary sedimentary claystone, siltstone, sandstone, and some beds of coal (Snavely and others, 1958). Associated with these sedimentary rocks are igneous bodies of andesite and basalt. In the Black Hills and near Tumwater, the bedrock is basalt. Bedrock is exposed in the southern and western parts of Thurston County, near Tumwater, and near the head of Eld Inlet. One of the components of the bedrock is the McIntosh Formation, a marine sediment of Eocene age which can have a significant effect on water quality (see section on Ground-Water Quality). The bedrock slopes downward to the northeast beneath an increasing thickness of unconsolidated deposits. Beneath the northeastern boundary of the study area, the top of bedrock is probably more than 1,800 feet below sea level (Jones, 1996).

GROUND-WATER HYDROLOGY

The bulk of the data used in this study to describe and quantify the ground-water system in the Quaternary deposits came from information associated with approximately 1,320 wells and springs that were inventoried in the field during the early stages of the study (pl. 1a). This number is estimated to represent only about 20 percent of the total number of wells and springs in the study area. Data pertaining to the inventoried sites are presented in table A1 of Appendix A. The inventory process included locating the site in the field; determining its latitude, longitude, and approximate land-surface altitude; measuring the water level in the well where practical; compiling, analyzing, and interpreting the information incorporated on the driller's report of the well construction, lithology, and testing; and then entering the information into a computerized data base. Four of the wells in table A1 were not inventoried during the field stage of the project, but were added during the report revision period. Three of these four wells are test wells or monitoring wells drilled near McAllister Springs in 1992. The fourth well is the Hawks Prairie test well (Robinson & Noble, 1984) and was added to the data base to supply needed geohydrologic information to assist in interpreting the complex geohydrology in this area.

Conceptual Model of the Ground-Water System

A generalized conceptual model of the ground-water system beneath northern Thurston County is shown on figure 5. This conceptual model shows the general nature of ground-water flow through the unconsolidated geohydrologic units.

Part of the precipitation falling on the inland glacial-drift plains infiltrates past the plant root zone and recharges the ground-water system. Ground water in recharge areas moves vertically and horizontally to discharge points such as springs, major stream channels, and Puget Sound. The directions of ground-water movement within the system are shown with arrows on figure 5. Movement is generally horizontal in aquifers and vertical in confining beds. The amount of time required for an individual particle of water to complete its journey through the system is roughly proportional to the length of the arrow. Generally, water particles with a relatively short travel path from recharge point to discharge point may be in the ground-water system for only a few weeks or months; particles with relatively long flow paths may be in the system for years or centuries.

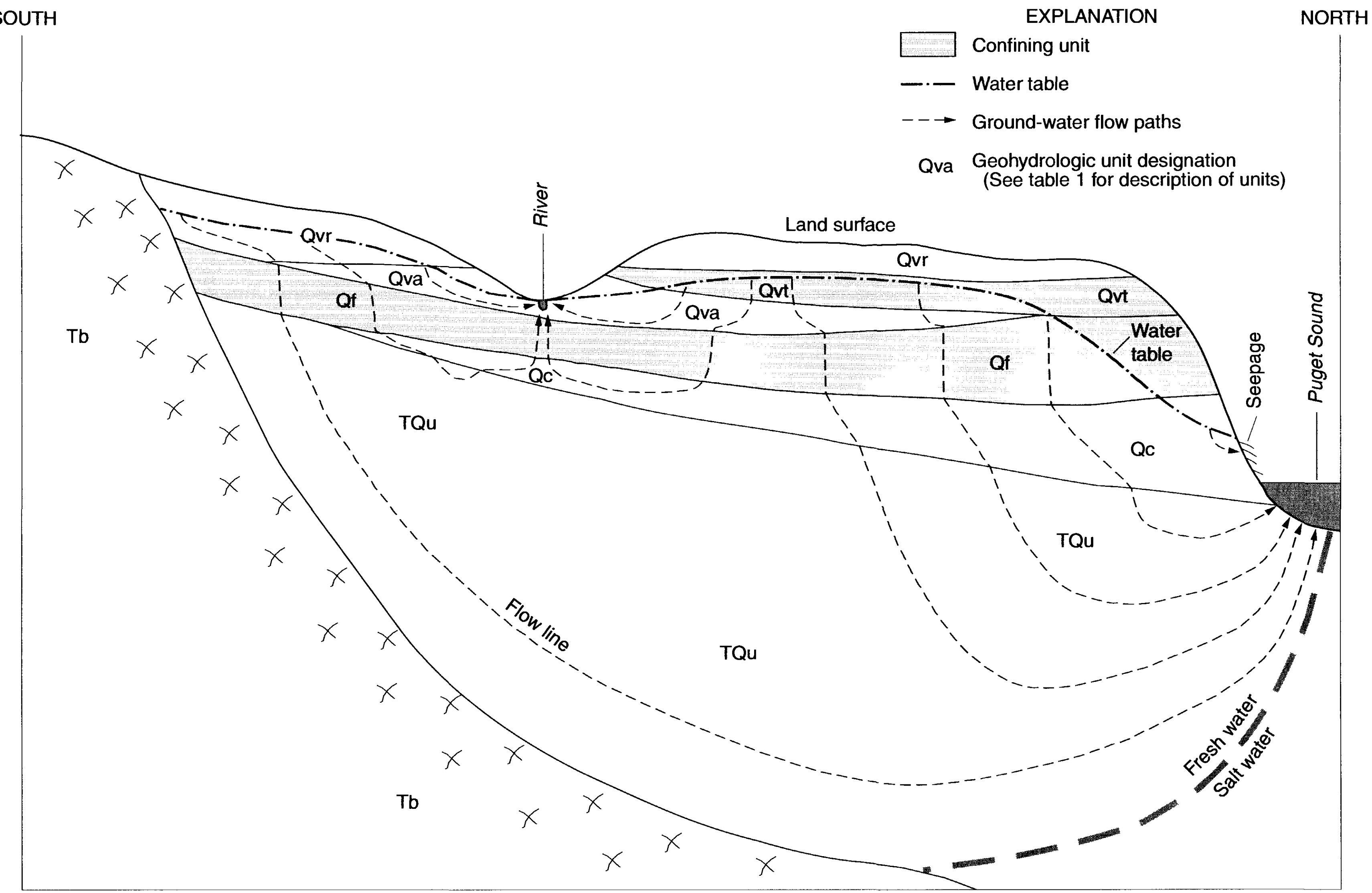


Figure 5. Conceptual model of the ground-water system beneath northern Thurston County.

Ground water in the study area occurs in aquifers under two different conditions. If water only partly fills an aquifer, the water table (the upper surface of the saturated zone) is free to rise and fall with changes in recharge and discharge. The position of the water table is represented by water levels in shallow wells. In this situation, the ground water is said to occur under unconfined or "water table" conditions.

If water completely fills an aquifer that is overlain and underlain by a confining bed, such as clay or bedrock, ground water is said to occur under confined or "artesian" conditions. Wells that tap a confined aquifer encounter water that rises in the well to a height corresponding to the potentiometric surface or "head" of the confined ground water at that point. If the head is sufficient to raise the water above land surface, the well will flow and is called a flowing artesian well. Confined ground water has a potentiometric surface analogous to the water table, but the shape of the potentiometric surface may differ greatly from that of a water table. The potentiometric surface, like the water table, fluctuates in response to changing recharge and discharge conditions.

The series of aquifers and confining beds in the study area (fig. 5) constitutes a system in which water flows vertically between layers. A stress (for instance, pumping) in an aquifer can produce responses (water-level changes) in other aquifers.

More-detailed descriptions of the recharge, movement, and discharge of water in the ground-water system of northern Thurston County are given in the later sections of the report.

Geohydrologic Units

The geologic units described previously were differentiated into aquifers and confining beds using lithologic, water-level, and well-yield data for the approximately 1,320 wells included in the study (Appendix A, table A2). The aquifers and confining beds thus defined are referred to as "geohydrologic" units in this report because they were identified based on a combination of geologic (primarily grain size and sorting) and hydrologic (hydraulic conductivity and hydraulic continuity) properties. In making the differentiation, it is important to keep in mind the heterogeneity of the sediments involved. A glacial aquifer may be composed predominantly of sand and (or) gravel, but in the small scale it will probably also contain relatively thin and discontinuous lenses of clay or silt. Conversely, a confining layer, composed predominantly of silt and (or) clay, may also contain local lenses of coarse sand or gravel. As a consequence, the general occurrence and movement of ground water may be influenced locally by these small-scale variations in lithology.

In order to increase our geohydrologic knowledge of the study area and to permit a more detailed, three-dimensional characterization of it, 17 preliminary geohydrologic sections were constructed using about 420 drillers' logs. These sections were tied to a modified version of the surficial geology map of Thurston County presented by Noble and Wallace (1966) (pl. 1b). The preliminary sections were combined with the remaining 720 drillers' logs to delineate 7 major geohydrologic units (table 1), 6 of which are in the unconsolidated deposits. Five revised final sections, considered typical of the study area, are shown on plate 1c. An examination of those sections indicated a great deal of variation in the thickness of individual units, and that not all seven units are necessarily present at any one location.

Because of its location at or near land surface, and because it is relatively undisturbed, the Vashon Drift has been more carefully studied than other, older drifts. Accordingly, previously accepted and published nomenclature associated with the Vashon Drift was used for three geohydrologic units—the Vashon advance outwash (Qva), Vashon till (Qvt), and Vashon recessional outwash (Qvr).

Because of their lithologic similarities, Holocene alluvium and Vashon recessional outwash were combined as a single geohydrologic unit (Qvr). A large part of the study area is mantled by unit Qvr (pl. 1b). This coarse-grained unit can be a productive aquifer, and is important as a water supply locally. Throughout most of the study area, however, few wells withdraw water from Qvr because the unit is thin or it lies above the water table and is unsaturated. This is especially true where the underlying till, which retards downward percolation, is absent (pl. 2b). Most of the wells that tap Qvr are in the south-central part of the study area where ground water occurs under water-table (unconfined) conditions, and they produce moderate yields for domestic purposes. Locally, perched ground-water conditions (local zones of saturation above the regional water table) may exist within the Qvr because of the low vertical permeability of the underlying till. Where present, Qvr is generally between 10 and 50 feet thick, but locally may be as much as 150 feet thick (pl. 2a).

The Vashon till, and possibly some older tills, make up geohydrologic unit Qvt. In some shoreline locations, "Late Vashon lake deposits" (Washington State Department of Ecology, 1980) were correlated with the Qvt because they tend to act as confining beds and occur at the same stratigraphic position as the Qvt. The Qvt is generally a poor source of water and is considered a confining bed. About 25 inventoried wells tap thin layers of relatively clean sand and (or) gravel that are irregularly distributed within the unit. The unit is broadly distributed (pl. 2b) and exists at land surface throughout a large part of the study area. At one time, dozens of shallow dug wells produced water from the upper, less compact part of the unit (Wallace and Molenaar, 1961). As reported by Noble and Wallace (1966), perched ground water is present near the top of the unit, and many of the shallow wells that rely on the till occasionally go dry in late summer. Where present, Qvt is generally between 25 and 60 feet thick, but locally may be as much as 180 feet thick (pl. 2b).

The Vashon advance outwash is represented as geohydrologic unit Qva, which is an important aquifer in northern Thurston County. It is present throughout a large part of the study area, mostly in the subsurface. Qva is used extensively in the Tumwater area, where it yields large quantities of water to municipal and industrial wells. It is not developed extensively in the extreme northern parts of the study area, where it is relatively thin (pl. 2c). Ground water in this aquifer typically is confined by the overlying Qvt and the underlying Qf. Where present, the unit is generally between 15 and 35 feet thick, but locally exceeds 145 feet thick (pl. 2c). The top of the Qva generally occurs between 50 and 200 feet above sea level (pl. 3a). In the vicinity of McAllister Springs, the large thickness of coarse-grained sediments was divided somewhat arbitrarily into Qvr, Qva, and Qc. That part identified as Qva was selected to be laterally continuous with Qva identified to the west and south, although its actual geologic identity is unknown.

The Kitsap Formation and other poorly permeable materials occurring beneath the Qva are represented as geohydrologic unit Qf. Included in Qf are the fine-grained deposits underlying the Nisqually River delta area. These deposits are undoubtedly much younger than the Kitsap Formation. The upper surface was mapped as Quaternary alluvium by Noble and Wallace (1966). They were included in Qf because they are of similar lithology and are, at least in part, laterally continuous with the other Qf materials adjacent to Nisqually delta. Also included in Qf, but not correlative with the Kitsap Formation, are some till units. Where multiple tills were observed, generally the uppermost was assigned to the Qvt and the lower tills to the Qf. Unit Qf confines ground water in the coarse-grained glacial deposits both above and below it. The unit is not made up solely of fine-grained materials; about 40 inventoried wells tap local, thin lenses of sand or gravel that yield relatively small quantities of water suitable for domestic use. Where the unit is present (pl. 2d), Qf is effective in retarding the downward percolation of ground water into Qc (described below), and in causing vertical head gradients between the Qva and Qc aquifer units. Where present, Qf is generally between 15 and 75 feet thick, but locally is greater than 150 feet thick (pl. 2d).

The coarse-grained Salmon Springs(?) Drift, penultimate deposits, and other deposits are represented as geohydrologic unit Qc. Qc constitutes one of the most widely used aquifers of northern Thurston County. The unit is present throughout most of the study area (pl. 3b). Ground water in this aquifer occurs under confined conditions for the most part. In some locations, such as near McAllister Springs where the overlying confining bed (Qf) is absent, Qc merges with the lithologically similar Qva above it to form a single thick and productive aquifer. Where the entire thickness of Qc has been penetrated, it is observed to be generally about 30 feet thick, with a maximum observed thickness of more than 200 feet. The top of the unit ranges from more than 50 feet below sea level to more than 600 feet above sea level and is commonly between 50 feet and 150 feet above sea level.

The unconsolidated and undifferentiated sediments beneath Qc are designated as geohydrologic unit TQu. Although there are nearly 200 inventoried wells that tap the heterogeneous unit TQu, the wells tap several different water-bearing layers that are irregularly distributed both laterally and vertically. Ground water in these layers is generally confined. TQu is an important aquifer in the study area. Deeper untapped water-bearing layers may exist within this unit, especially in the northern part of the study area where the unit is relatively thick. The unit has not been more extensively developed because sufficient quantities of ground water can usually be found at shallower depths. Few wells penetrate the entire assemblage of unit TQu in the northernmost part of the study area, and the maximum thickness of the unit in that area, therefore, is uncertain. The best estimate of maximum thickness in the study area (Jones, 1996) is somewhat in excess of 1,800 feet. Layering in TQu may be similar to that of the Vashon Drift, described previously.

The consolidated rocks of Tertiary age that constitute the bedrock are represented by geohydrologic unit Tb. This unit contains small quantities of water in fractures and joints that are more numerous near the top. In general, however, Tb is an unreliable source of ground water and many wells drilled into this unit in Thurston County have been subsequently abandoned because of insufficient yield or poor-quality water. Most of the more than 70 inventoried wells that tap bedrock are located in the southern and western parts of the study area and supply water for domestic use. Where the bedrock is exposed at land surface (pl. 1b), the ground water is likely to occur under water-table conditions; where the bedrock is covered by a significant thickness of unconsolidated deposits, especially clays and silts, the ground water is likely to be confined.

The relative importance of each of the geohydrologic units as a source of ground water can be determined from (1) a graph of the number of study wells finished in each of them (fig. 6), and (2) a comparison of the quantities of water withdrawn from each unit for various beneficial uses (see section on Discharge). The resulting information indicates that units Qvr, Qva, Qc, and TQu are the principal sources (aquifers) of water for existing wells and springs in northern Thurston County, but that usable quantities of ground water can also be obtained from units Qvt, Qf, and Tb. Even though units Qvt and Qf generally function as confining beds, numerous wells produce water from thin, local lenses of sand or gravel in these otherwise poorly permeable deposits. In areas where two or more aquifers are combined, that is, where the intervening confining bed is absent, the combined units function as a single aquifer.

At the local scale, an important geohydrologic unit has been identified, the McAllister gravel aquifer. The following description is from John Noble (Robinson & Noble, Inc., personal commun., 1998) and Pacific Groundwater Group (1997). The visible discharge point of this aquifer is McAllister Springs, which is the largest public water-supply source in the study area. The McAllister gravel aquifer is composed of pebbles to boulders that appear to be a channel fill deposited by the ancestral Nisqually River. The unit extends below McAllister Springs to at least 250 feet below sea level, is very narrow, and probably continues to the north of McAllister Springs beneath the Nisqually River delta. The southerly extent of the unit is unknown, but there are indications that the unit might extend to the existing Nisqually River just north of Yelm.

Laterally, the McAllister gravel aquifer is in contact with units Qvr, Qva, and Qc. Because of this lateral connection, and the regional perspective of this study, the McAllister gravel aquifer was divided into layers and incorporated in units Qvr, Qva, and Qc.

Hydraulic Conductivity

An estimate of the magnitude and distribution of horizontal hydraulic conductivity of each aquifer is helpful in understanding the discharge and availability of the ground water within the aquifer. Determinations of the horizontal hydraulic conductivity (a measure of permeability) for each aquifer were computed from transmissivity values that were calculated from specific-capacity data. Transmissivity is equal to an aquifer's hydraulic conductivity times its thickness. Specific capacity is a measure of a well's productivity and is equal to the pumping rate divided by the drawdown in a well. Horizontal hydraulic conductivity is a measure of a hydrologic unit's ability to transmit water horizontally. For unconsolidated materials, hydraulic conductivity depends on the size, shape, and arrangement of the particles. Horizontal hydraulic conductivity is the volume of water that will move in unit time under a unit gradient through a unit area (measured at right angles to the direction of flow). It is in units of cubic feet per square foot per day, commonly simplified to feet per day. Hydraulic conductivities were calculated for all wells that had specific-capacity information (discharge rate and drawdown) and that are open to a single geohydrologic unit; 913 of the 1,340 wells met these criteria.

Either of two methods was used to estimate hydraulic conductivity, depending on how the well was finished. For wells that had a screened or perforated interval, values of horizontal hydraulic conductivity were estimated from specific-capacity data by using the Theis method for water-table units and the Brown method for artesian units (both in Bentall, 1963). The specific-capacity data were obtained from well records and generally represent short-term (about 4-hour) pumping or bailer tests conducted by well drillers at the time the wells were originally completed. The Theis and Brown methods actually calculate a transmissivity value. These transmissivity values were divided by the length of the open interval(s) in each well to estimate hydraulic conductivity. Using the open interval of the well as being equal to the total aquifer thickness assumes that all the water flow into the well during the test was horizontal flow, although some of the flow presumably came from above or below the open interval.

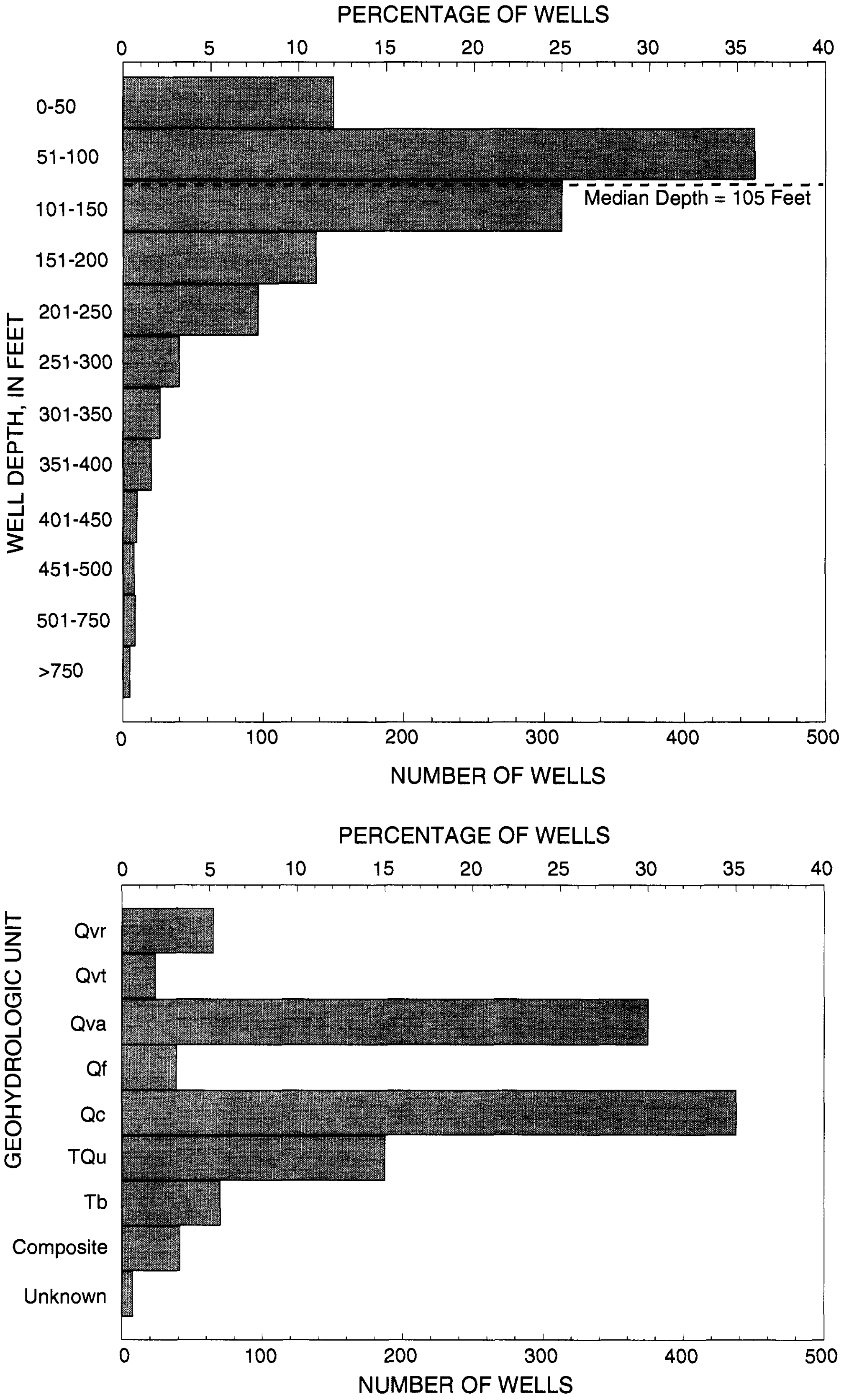


Figure 6. Frequency distributions of well depths and of geohydrologic units tapped by wells.

This may result in an overestimation of hydraulic conductivity. The amount of error caused by this assumption is probably small because layering within the geohydrologic units tends to make horizontal flow much easier than vertical flow. For wells having only an open end, and thus no vertical dimension to the open interval, hydraulic conductivity was estimated using Bear's (1979) equation for hemispherical flow to an open-ended well just penetrating a geohydrologic unit. When modified for spherical flow to an open-ended well within a unit, the equation becomes:

$$k_h = \frac{Q}{4\pi s r} \qquad (1)$$

where

k_h is horizontal hydraulic conductivity, in feet per day,

Q is discharge, or pumping rate, of the well, in cubic feet per day,

s is drawdown in the well, in feet, and

r is radius of the well, in feet

Equation 1 is based on the assumption that horizontal and vertical hydraulic conductivities are equal, which is not likely for the deposits in the study area. Violating this assumption probably results in an underestimation of k_h by an unknown factor.

The data were statistically analyzed for all geohydrologic units so that medians, ranges, and differences between units could be determined. Hydraulic conductivity data for those aquifers with sufficient data points (Qva and Qc) were examined to determine if there are distinct areal patterns of lower or higher values. Individual values of hydraulic conductivity can be found in the table of well datà (Appendix A, table A1). A summary of hydraulic-conductivity data by aquifer is given in table 2. Of significance in table 2 is the fact that the median values for the three upper aquifers (Qvr, Qva, and Qc) are remarkably similar (from 150 to 160 feet per day). The available data for the two uppermost confining units (Qvt and Qf) also indicate similar median values (14 and 17 feet per day, respectively) and are approximately an order of magnitude less than the aquifers. However, the values for Qvt and Qf represent only the coarse-grained parts of these units. True median values for these units, including the fine-grained portions, are probably much less than indicated by the available data. TQu represents a series of aquifers and confining beds and has a median value (74 feet per day) that is between the medians of the other aquifers and confining beds.

Identification of areal patterns of hydraulic conductivity is extremely difficult given the available data. The depositional nature of the units probably results in a system of "channels" of relatively coarse materials and therefore a three-dimensional distribution of hydraulic conductivity that is not readily discernible in a two-dimensional plot of the data. No areal patterns for hydraulic conductivity were observed for Qva and, although no clear areal patterns were evident for Qc, there are two areas where high values cluster and one area of low values. The areas of high hydraulic conductivity (high frequency of values equal to or greater than 1,200 ft/d) in Qc are around McAllister Springs (from Lake St. Clair to Puget Sound and from Long Lake to the Nisqually River) and near Littlerock (a 6-mile stretch along the Black River from just northeast of Littlerock to the southwest). Between these two areas of high values is a northeast-southwest trending zone of low values (high frequency of values equal to or less than 32 ft/d). Because no definitive areal trends in hydraulic conductivity were observed in any of the water-bearing geohydrologic units, no maps of the data are presented in this report.

No data are available to estimate the vertical hydraulic conductivity of aquifers or of confining layers between aquifers. Estimates made in other areas within Puget Sound with similar deposits indicate that vertical hydraulic conductivity probably ranges from 0.0001 to 0.01 ft/d for the confining layers (Vaccaro and others, 1998).

Table 2. Summary of horizontal hydraulic conductivity values estimated from specific-capacity data, by geohydrologic unit

Geohydrologic unit[1]	Number of wells tested	Hydraulic conductivity (feet per day) Range	Median
Qvr	50	14 - 2100	160
Qvt	23	5.2 - 89	14
Qva	322	6.8 - 130,000	150
Qf	42	.052 - 62	17
Qc	311	1.9 - 12,000	150
TQu	126	1.2 - 4,200	74
Tb	39	.0025 - 450	.84

[1]See table 1.

Recharge

The bulk of the recharge to the ground-water system of the study area is derived from the infiltration of precipitation. Secondary sources of recharge include seepage from septic systems, leakage from water and sewer lines, and deep percolation of irrigation water. Recharge from precipitation occurs essentially everywhere, with the possible exceptions of (1) areas of ground-water discharge and (2) those areas covered by impermeable, man-made materials such as asphalt and concrete. However, impermeable materials at land surface may only delay and redistribute the recharge process; precipitation that runs off impermeable surfaces may seep into the ground as soon as it encounters natural permeable materials. Throughout a large part of the greater Olympia area, precipitation that might otherwise recharge the aquifer(s) is diverted through storm drains to Budd Inlet, resulting in less recharge beneath Olympia than in areas without storm drains. Similarly, there is little or no recharge from septic tank filter-field leachate in the Olympia area because domestic sewage there is diverted to central sewage-treatment facilities and then to Budd Inlet. Most of the precipitation recharge in the study area occurs in the 6-month period October–March, when precipitation greatly exceeds evapotranspiration. The following calculations of recharge were made for the GWMA only, as this is the area for which a water budget is to be calculated.

The amount of precipitation recharge to the GWMA was first estimated by applying the precipitation–recharge relations derived for till and outwash units in nearby King County (Woodward and others, 1995) to similar units in the study area. These relations, graphically shown on figure 7, are based on the application to King County of a deep percolation (recharge) model developed by Bauer and Vaccaro (1987). Figure 7 also shows estimated precipitation-recharge relations for the kettled outwash and bedrock units. The kettled outwash was separated from the rest of the outwash unit(s) on the assumption that, having closed drainage, it would have somewhat greater recharge than outwash with open drainage to the sea. This incremental difference was estimated to be 10 percent. The recharge value for bedrock was estimated to be half that for till for an equivalent amount of precipitation. In addition, Qf was considered to have the same recharge characteristics as Qvt because of their somewhat similar hydrologic properties.

In order to determine the distribution of recharge in the GWMA, a map of recharge rates was prepared based on the long-term precipitation map (fig. 2), a map of the surficial distribution of the geohydrologic units (pl. 1b), and the precipitation-recharge relations shown on figure 7. The resulting recharge-rate maps were then overlaid on a map of surficial distribution of the geohydrologic units. The resulting recharge map (pl. 3c) indicates that recharge rates are higher in the west-central part of the GWMA, where relatively more precipitation falls on outwash and kettled outwash. Recharge rates are lower on the flood plains of McAllister Creek and the Nisqually River to the east, and in the basalt hills of the extreme western part of the GWMA. An integration of the resulting polygons on plate 3c indicates that the ground-water system as a whole beneath the northern Thurston County GWMA receives an average of about 28 inches of recharge in a typical year.

To corroborate the first estimate of recharge, a second estimate was made using the results of the application of a rainfall-runoff model (U.S. Environmental Protection Agency, 1984) to three drainage basins within the study area. The results of pilot studies in Percival, Woodland, and Woodard Creeks (pl. 1) by Berris (1995) were extrapolated to the entire GWMA in the form of regression equations. The independent variables for the regression analyses were precipitation, air temperature, evapotranspiration, soil type, land cover, land slope, and available water capacity of the soil. The model was run using climatological data for 28 consecutive years (1961 through 1988). Factors not considered because they were outside the scope of this study include such recharge sources as septic-tank leachate, dry-well infiltration, excessive irrigation, and influent streams and lakes. The results of this second recharge-estimation method indicated that the ground-water system beneath the northern Thurston County GWMA receives an average of about 22 inches of recharge in a typical year.

The estimates derived using both methods were considered reasonable, so the average of the two values, 25 inches per year, was used. Assuming that the GWMA covers 232 square miles, this quantity of recharge represents an annual volume of about 310,000 acre-feet.

Movement

The ground-water flow system is depicted in part by maps showing the potentiometric surface for the two principal aquifers (pl. 4a and 4b). The maps were constructed by using water levels measured in nearly 800 wells at the time of inventory, supplemented by water levels as reported by drillers for about 250 individual wells. The majority of water levels were measured between May and October 1988. The number and distribution of water levels in two of the principal aquifers were adequate (about 380 for Qva and about 410 for Qc) to allow the representation of the respective potentiometric surfaces on contour maps. The number of water-level measurements in other, less-widely-used units was more limited, and therefore contour maps were not made for these units. Vertical flow directions were estimated by comparing water levels (heads) in closely spaced wells finished in different aquifers, and by comparing the maps of the potentiometric surfaces for the two principal aquifers.

Horizontal flow directions of ground water within aquifers Qva and Qc are shown by arrows on plate 4. Flow is from areas of higher head to areas of lower head and, in general, is perpendicular to the contours of equal head. Also included on the plate are the ground-water drainage areas of McAllister Springs for the same units. Water-level data are sparse for Qva east and southeast of McAllister Springs. The boundary of the drainage area is estimated in this region based on topography.

Ground water in Qva generally moves toward marine water bodies and to major surface drainage channels; local mounds on the potentiometric surface occur beneath each of the major peninsulas (pl. 4a). In the vicinity of Lake St. Clair, ground water moves northward toward McAllister Springs. Contours along the lower reach of the Deschutes River indicate that ground-water flow is generally toward the river and that, as a result, river discharge probably increases in that area.

The configuration of the potentiometric surface for Qc (pl. 4b) is similar to that for Qva. Ground-water mounds are present on all four major peninsulas. Flow directions near Lake St. Clair and McAllister Springs are similar to those in Qva. As in the Qva, it appears that the lower reach of the Deschutes River is an area of increased discharge from the contribution of ground water.

Beneath the upland areas, water levels in Qva are generally higher than in Qc (pl. 4c), indicating that water flows vertically downward, passing through Qf where it is present. The differences in head between Qva and Qc are also shown on plate 4. The areas of greater head differential coincide largely with ground-water mounds within Qva and with areas where the intervening fine-grained unit Qf is thickest. These areas of greater water-level differential should not be interpreted as areas of greater downward flow nor as areas of greater aquifer vulnerability from surface contamination.

Discharge

Ground water in northern Thurston County discharges as seepage to lakes, streams, springs, and coastal bluffs; as transpiration by plants; as underflow (submarine seepage) to marine waters; and as withdrawals from wells. Only the amount of water withdrawn from wells and major springs was quantified as part of this study.

As mentioned previously, ground water discharges to some reaches of the principal rivers and streams of the study area, in particular the Nisqually and Deschutes Rivers, augmenting streamflow and producing what is usually referred to as a "gaining reach." Ground-water discharge sustains the late-summer flow of numerous streams in the study area. A seepage study completed in August 1988 confirmed the assumption that the lower reach of the Deschutes River is a gaining reach. According to Berris (1995), the lower reaches of Percival, Woodland, and Woodard Creeks also are generally gaining reaches. The discharge of Thompson Creek, northwest of Yelm, is greatly enhanced by spring discharge just upstream of the point where it joins the Nisqually River. The discharge of McAllister Creek, which originates at McAllister Springs, is increased by numerous other springs that issue from the base of the bluff just west of the stream.

The principal springs in Thurston County are listed in table 3 and are shown on plate 1a. The total discharge of these springs is estimated as 45 ft^3/s (33,000 acre-ft/yr). There are, in addition, probably hundreds of smaller springs scattered throughout the study area. The total spring discharge in the study area is unknown. McAllister Springs (18N/01E-19Q01S) is by far the largest in the study area in terms of both discharge and surface area. Over the period 1979-88, the mean annual discharge of McAllister Springs ranged from 21.2 to 25.6 ft^3/s (Andrew W. Hoiland, City of Olympia, written commun., 1990) and averaged 23.6 ft^3/s. During the period of this study, the discharge of the spring was below the long-term average (fig. 8) from July 1988 through December 1989, and above the long-term average from January through July 1990.

Ground-water withdrawals from wells was approximately 21,000 acre-ft in 1988 (see table 4). Subtracting the 54,000 acre-feet of water discharged to springs or withdrawn by wells from the (gross) recharge value of 310,000 acre-feet calculated previously, leaves a net unidentified discharge of 256,000 acre-feet per year. This represents the amount of water that eventually is transpired back to the atmosphere by plants, recharges deeper aquifers, or discharges naturally to seeps, lakes, streams, rivers, Puget Sound, or unidentified springs.

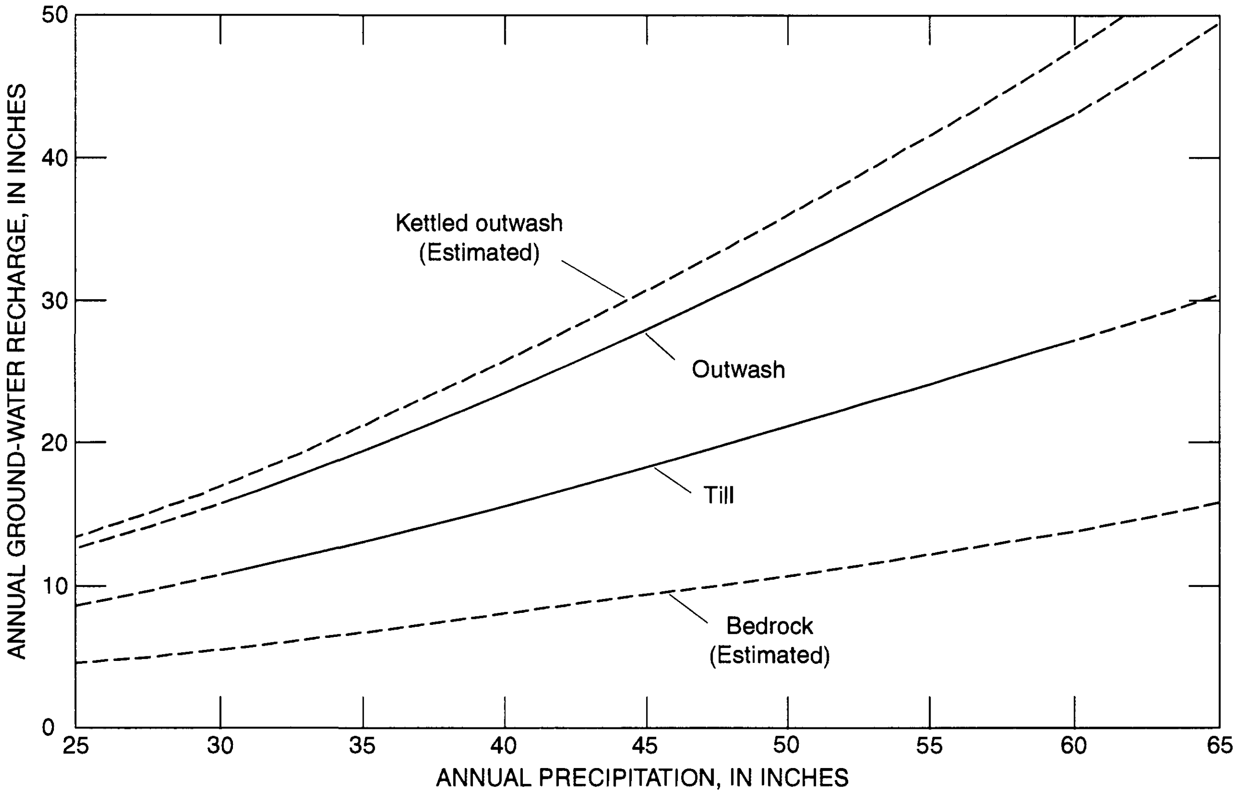


Figure 7. Precipation-recharge relations used to estimate recharge in northern Thurston County.

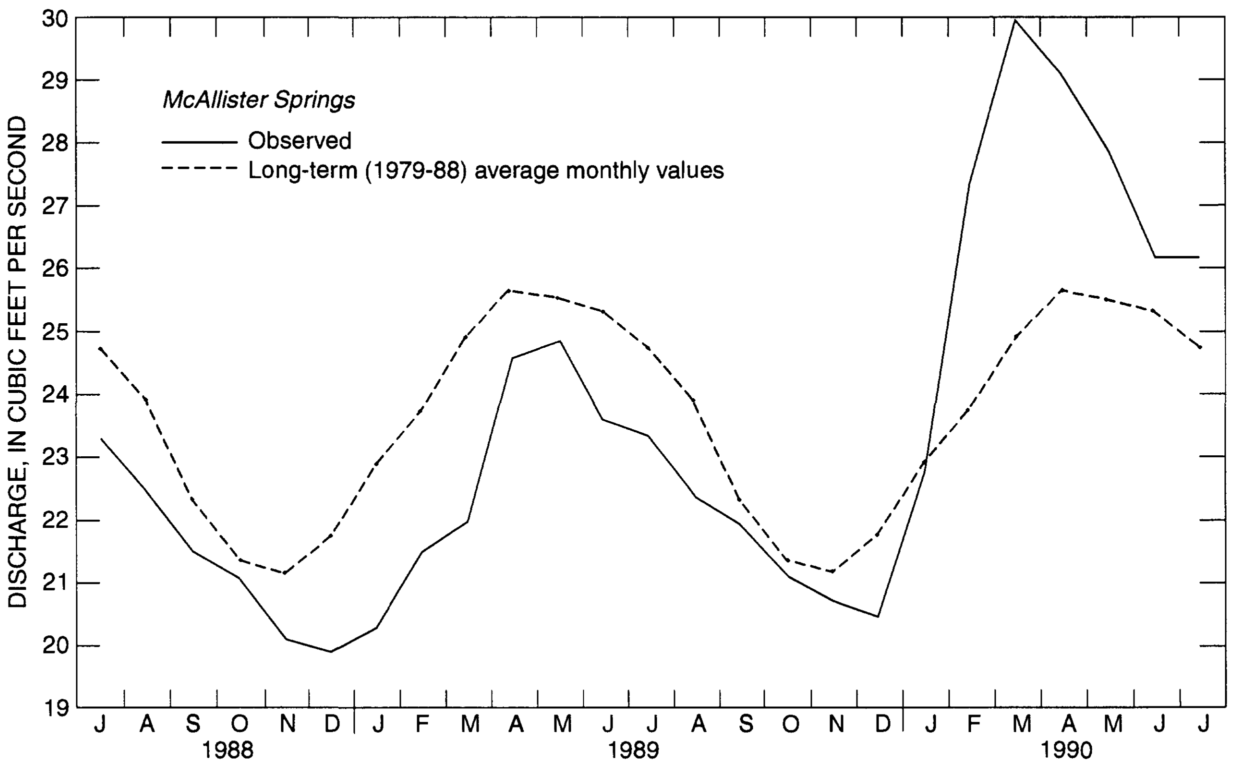


Figure 8. McAllister Springs discharge, July 1988-July 1990, and long-term average monthly discharge.

Table 3. Principal springs in northern Thurston County

[H, domestic; P, public supply; Q, aquaculture; T, institution; U, unused; ft^3/s, cubic feet per second; <, less than]

Spring number	Owner (spring name)	Altitude (feet)	Use	Discharge (ft^3/s)[1]	Geohydrologic unit[2]
16N/01W-01N01S	Schoenbachler	295	U	N/A	Qvr
17N/01E-11B01S	Unknown	135	U	<0.01 e	Qc
17N/01E-11G01S	Unknown	120	U	<1 e	Qc
17N/01E-11G02S	Unknown	140	U	1 e	Qc
18N/01E-07F01S	Nisqually Trout Farm	100	Q	1 e	Qvr
18N/01E-07F02S	Nisqually Trout Farm	100	Q	0.6 e	Qvr
18N/01E-18P01S	Unknown	15	U	N/A	Qc
18N/01E-19J01S	City of Olympia (Abbott Springs)	7	H	5-10 e	Qvr
18N/01E-19Q01S	City of Olympia (McAllister Springs)	5	P	[3]23.6 m	Qvr
18N/01W-15D01S	Nisqually Trout Farm (Beatty Spring)	75	Q	6.2 r	Qvr
18N/01W-16A01S	St. Martin's College	75	T	0.4 e	Qvr
18N/01W-34G01S	Unknown	165	U	1 e	Qvr
18N/02W-18L01S	City of Olympia	10	Q	3.1 r	Qva
18N/03W-22H01S	Unknown	325	U	N/A	Qvr
19N/01W-25F01S	Unknown	125	U	N/A	Qvt
19N/02W-33G01S	Unknown	95	U	<1 e	Qva

[1]N/A, not available; e, estimated; m, measured; r, reported.

[2]See table 1 for description of geohydrologic units.

[3]Measured annual average discharge, 1979–88.

Water-Level Fluctuations and Trends

The configuration of the water table or potentiometric surface is determined by (1) the overall geometry of the ground-water system, (2) the hydraulic properties of the aquifer, and (3) the areal and temporal distribution of recharge and discharge. Where recharge exceeds discharge, the quantity of water stored will increase and water levels will rise; where discharge exceeds recharge, the quantity of water stored will decrease and water levels will fall.

Previous studies in western Washington have shown that, in years of typical precipitation, ground-water levels in shallow wells generally rise during the wet season of October through March and fall during the dry season of April through September. Water levels in deep wells generally respond more slowly, and usually with less magnitude, than water levels in shallow wells. Near the coast, water-level fluctuations also occur in response to tidal changes; these fluctuations are superimposed on the seasonal and long-term changes that are related to changing recharge-discharge relations.

A monthly water-level-measurement network within the GWMA was started in November 1988 and wells were added gradually through June 1990 (37 wells total; [table A3, Appendix A]). Most of these wells were measured for at least a full year (May 1989 through May 1990). Water levels were generally at their seasonal highest in February-May and lowest in October–December. Hydrographs of water levels in selected observation wells (fig. 9) indicate that the highs and lows coincided in shallow and deep wells, and that the magnitude of fluctuation was controlled by more than well depth alone.

During the period May 1989 through May 1990 (when the network was most complete), most wells experienced a net water-level rise, with a median rise of nearly 1 foot. At the start of this period, the study area had been experiencing a relatively dry period. Annual water-level fluctuations in the network ranged from 2.25 to 17.08 feet, with a median of 5.36 feet. The largest fluctuations took place in bedrock wells.

The detection of long-term trends in ground-water levels requires the plotting and analysis of several years of water-level data. With the exception of a single well, those data are generally lacking in northern Thurston County. Water levels in well 18N/02W-07R01, completed in unit Qva, were monitored from 1971-80 and during this study. The hydrograph of the data from that well (fig. 10) shows that water levels declined from 1972 to early 1978, possibly because of pumping or, more likely, year-to-year differences in precipitation. Rainfall in 1972, 1974, and 1975 was above the long-term average, whereas in 1973 and 1976-80 it was below average. Climatological data, therefore, indicate that the general decline in water levels observed in well 18N/02W-07R01 from 1972 through 1977 (fig. 10) was probably due chiefly to precipitation patterns. However, the fluctuations might reflect long-term drawdown due to nearby pumping or changes in recharge that may have accompanied changes in pumping. As development has increased, some areas have become sewered, resulting in decreased recharge (compared to septic systems). The increase in the amount of impervious surface with development may have also decreased recharge.

Table 4. Summary of ground-water use in 1988 by water-use category, source, and geohydrologic unit
[--, none or negligible]

	Water use (acre-feet per year)[2]							
	Geohydrologic unit[3]							
Use category and source	Qvr	Qvt	Qva	Qf	Qc	TQu	Tb	Total
Public supply (household)								
Wells	540	110	2,900	5.6	2,400	820	--	6,800
Springs	[1]5,600	--	--	--	--	--	--	5,600
Domestic (household)								
Wells	570	100	1,900	230	1,800	510	160	5,300
Springs	--	--	--	--	--	--	--	--
Commercial-Industrial-Institutional								
Wells	200	--	2,800	530	2,300	1,100	--	6,900
Springs	[1]2,200	--	--	--	--	--	--	2,200
Irrigation								
Wells	230	39	700	--	850	240	--	2,100
Springs	--	--	--	--	--	--	--	--
Aquaculture and livestock								
Wells	--	--	6.1	--	180	--	--	190
Springs	5,700	--	2,200	--	--	--	--	7,900
Subtotal								
Wells	1,500	250	8,300	770	7,500	2,700	160	21,000
Springs	14,000	--	2,200	--	--	--	--	16,000
Total	16,000	250	10,000	770	7,500	2,700	160	37,000

[1]The discharge of McAllister Springs, shown here, may actually emanate from unit(s) Qva and(or) Qc.
[2]All values rounded to two significant figures.
[3]See table 1.

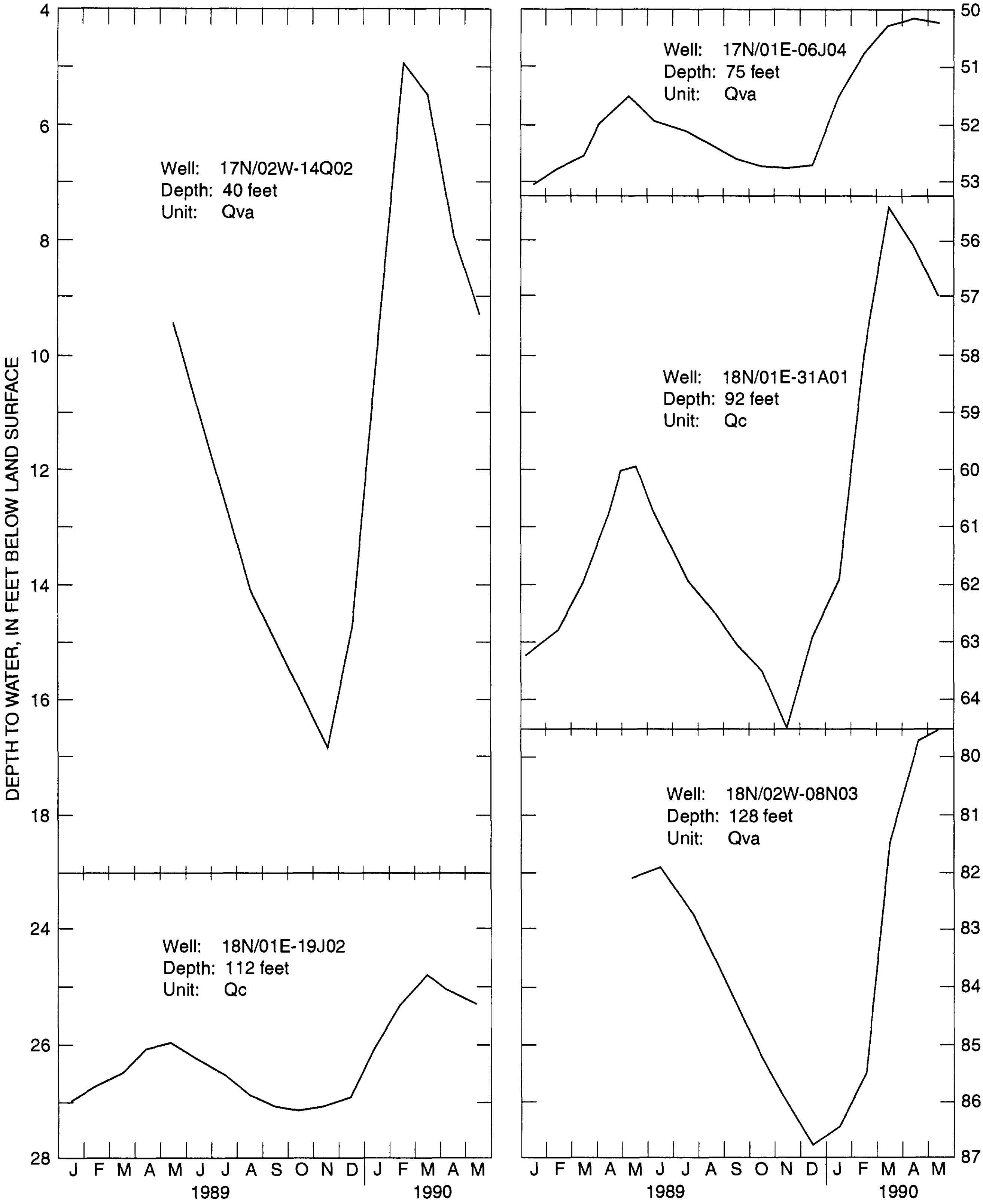


Figure 9. Water levels in selected wells in the Ground Water Management Area.

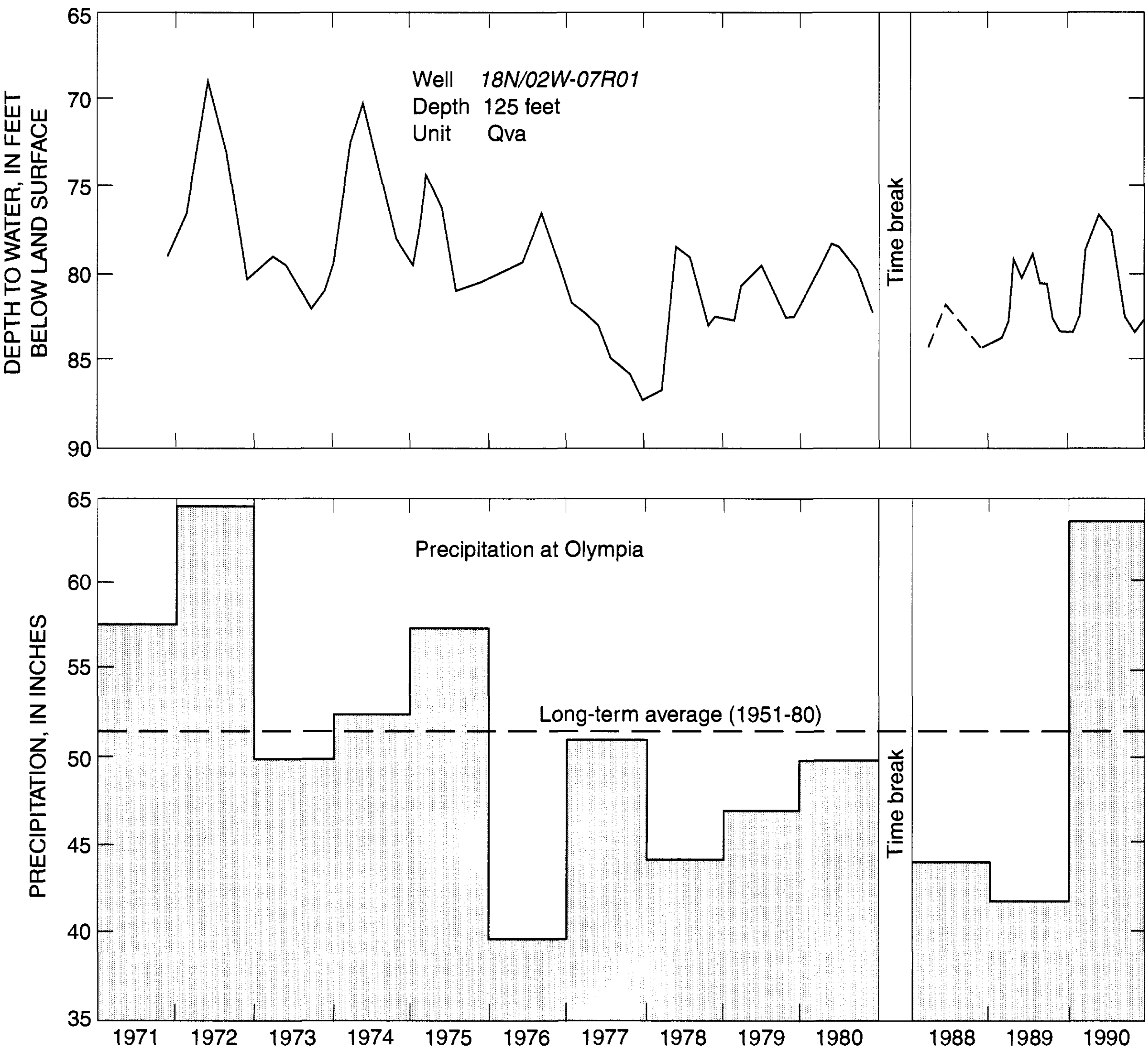


Figure 10. Long-term water-level trend in well 18N/02W-07R01 and annual precipition at Olympia.

WATER USE

Water-use data generated for this report were for calendar year 1988 and were derived from such diverse sources as the Washington State Department of Ecology (Ecology), Washington State Department of Health (WDOH), USGS, and reports from utilities and other agencies. Most of the data, however, were obtained by telephone canvassing of the major water users in the study area.

At the time of the water-use canvass, public water systems in Washington were divided into four classes (Washington Administrative Code 248-54).

- Class 1 systems had 100 or more services (a physical connection designed to serve a single family) or served a transitory population of 1,000 or more people on any one day.
- Class 2 systems had 10-99 permanent services or served a transitory population of 300-999 people on any one day.
- Class 3 systems served a transitory population of 25-299 people on any one day.
- Class 4 systems had 2-9 permanent services or served a transitory population of less than 25 people per day

Data for all Class 1 systems and some Class 2 systems were obtained by direct contact, either by telephone or letter, with each system manager or clerk. Where practical, withdrawals were determined for each well in the system. Withdrawals for most Class 2 systems generally were not metered. For the unmetered Class 2 systems, estimates of withdrawals were made based on the following equation:

$$\begin{aligned} \text{Annual withdrawal} = {} & \text{(number of connections)} \\ & \text{X (2.5 persons per connection)} \\ & \text{X (130 gallons per person per day)} \\ & \text{X (365 days)} \end{aligned}$$

For purposes of this study, persons served by Class 3 and 4 systems were considered to be supplied by privately owned wells and their domestic withdrawals were calculated accordingly.

Ground-water withdrawals from privately owned wells for domestic use were calculated by determining the population of the study area whose homes are supplied water by Class 1 or 2 public water systems (78,000) and subtracting that number from the total population of the area (124,000), then by applying a per capita rate of 100 gallons per day to the difference (46,000). The rate of 100 gallons per day is an estimate for rural homeowners, as opposed to 130 gallons per day for urban homeowners (Dion and Lum, 1977).

Ground-water withdrawals for irrigation were calculated by one of two methods: (1) by multiplying the pumping rate of the irrigation well by the owner's estimate of the duration of pumping; or (2) by applying a uniform irrigation rate of 1.5 acre-feet of water per acre per year (irrigation season) to estimates of irrigated acreage. Information about irrigated acreage was obtained by telephone and personal contact with irrigators identified either in the well-inventory process or by the county Agricultural Extension Agent.

Ground-water withdrawals for commercial, industrial, and institutional purposes are either self-supplied (private wells) or from municipal water systems. Withdrawals were estimated for private wells on the basis of telephone canvassing of water users identified in the well-inventory process and in publications such as the telephone directory and employment statistics of Thurston County (Thurston Regional Planning Council, 1989). An effort was made to contact industrial concerns with known high-water use rates or with at least 100 employees. Because of the large number of small commercial and institutional concerns in the study area, however, the canvass of these two categories was most likely incomplete. Withdrawals as part of municipal systems were reported by the system managers.

Water used for aquaculture and livestock supplies is primarily from springs. Rates of use were obtained from personnel managing the aquaculture and livestock facilities and represent both measured and estimated values.

Ground-water use in the GWMA in 1988 was compiled by water-use category, source (well or spring), and geohydrologic unit (table 4, fig. 11). Total ground-water use in 1988 was approximately 37,000 acre-feet. Approximately 21,000 acre-feet of water was withdrawn through wells. About 16,000 acre-feet of the water that discharges naturally through springs was put to beneficial use. About 48 percent of the total amount of ground water used was for household supply (public supply and "domestic"). Of the 21,000 acre-feet withdrawn from wells, 40 percent came from Qva, and the largest use was for household supply (58 percent). Of the 16,000 acre-feet of spring water used, almost half issued from McAllister Springs and was used primarily for household supply. The remainder issued from other springs and was used largely for the rearing of fish.

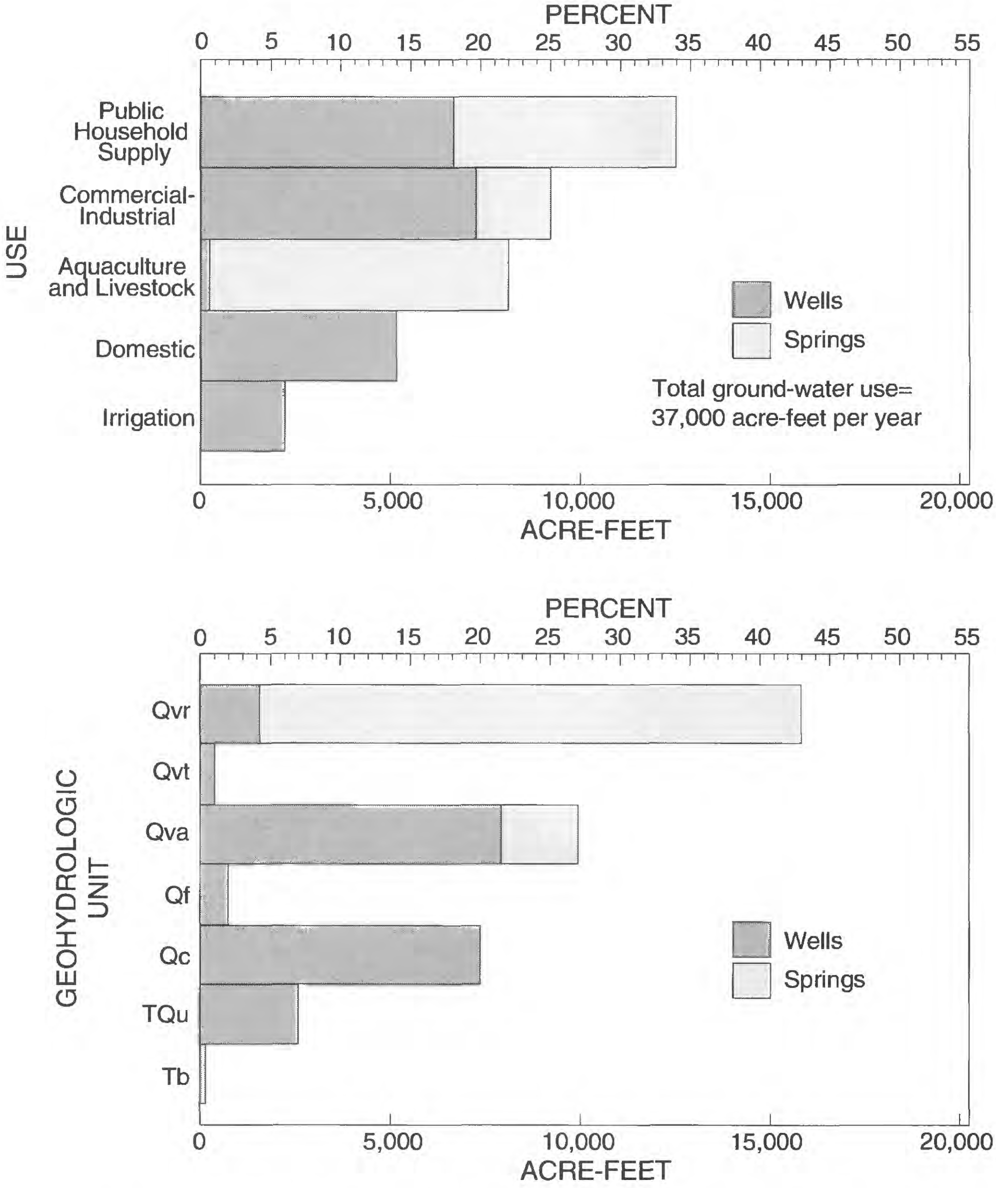
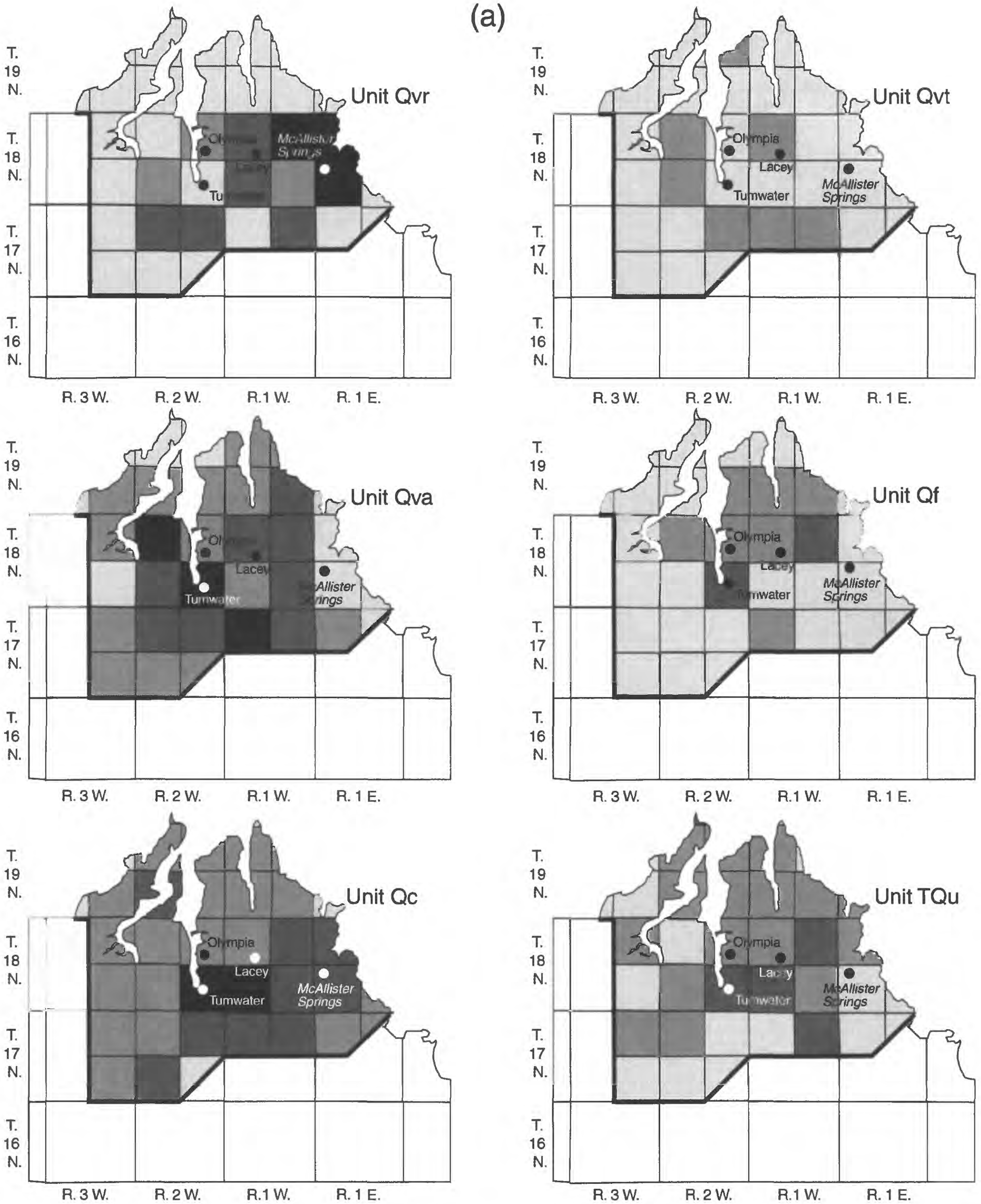


Figure 11. Ground-water use in 1988 in the Ground Water Management Area, categorized by types of use and geohydrologic unit.



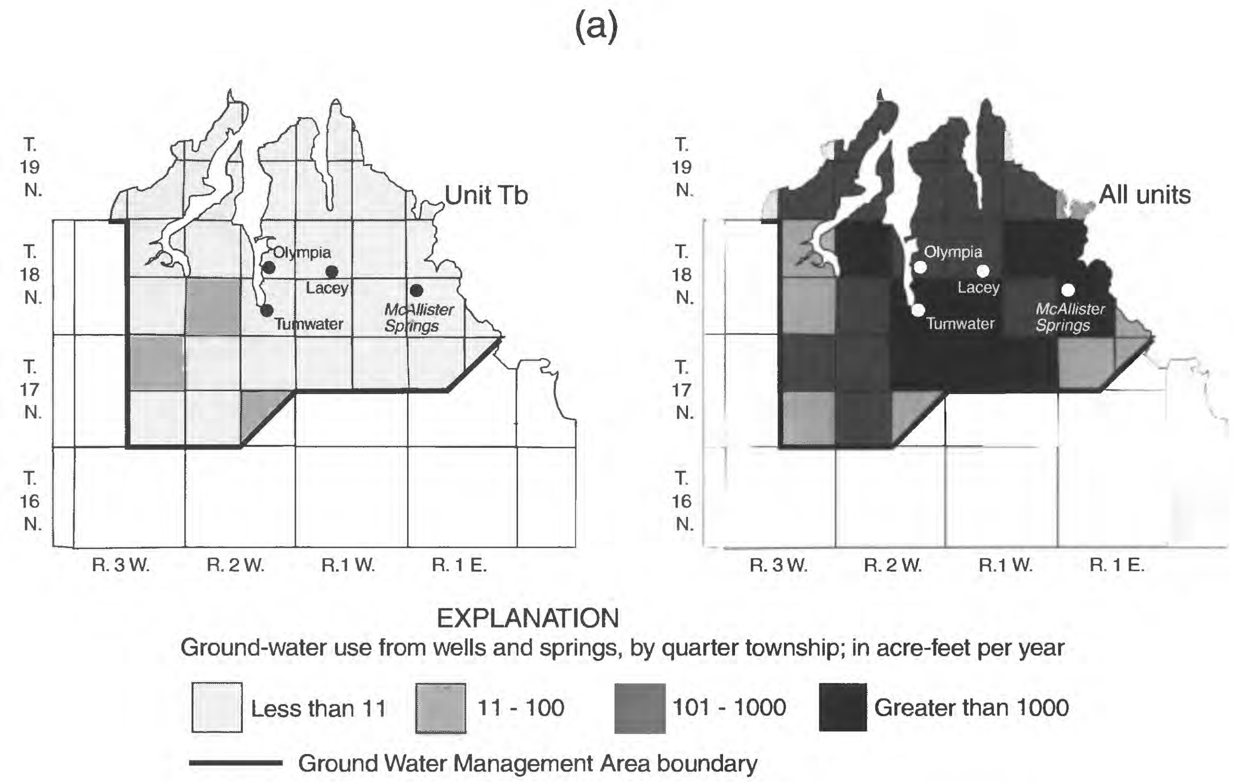
EXPLANATION

Ground-water use from wells and springs, by quarter township; in acre-feet per year

Less than 11 | 11 - 100 | 101 - 1000 | Greater than 1000

Ground Water Management Area boundary

Figure 12. Ground-water use in 1988 (a), and area served by public supply (b) in the Ground Water Management Area.



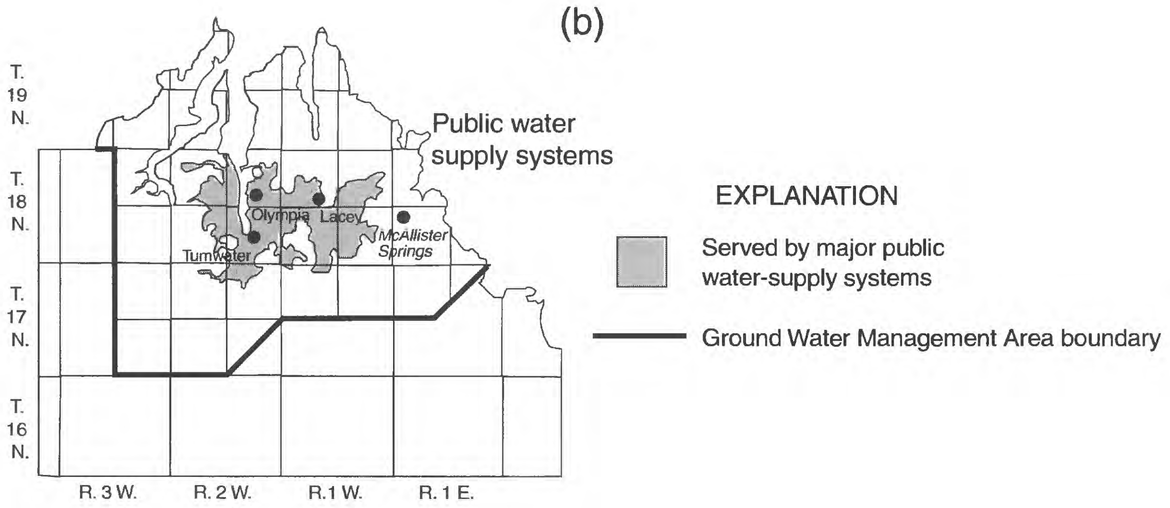


Figure 12. (continued) Ground-water use in 1988 (a), and area served by public supply (b) in the Ground Water Management Area.

Generalized maps of 1988 ground-water use (from wells and springs) are shown on figure 12 for each of the principal geohydrologic units. For the sake of clarity and simplicity, use has been aggregated for each quarter-township (9 square miles) within the GWMA. Figure 12 indicates that ground-water use was concentrated in the more populous parts of the GWMA. The greatest rates of use occured from the Qvr, Qva and Qc, and were centered around McAllister Springs and the Cities of Tumwater, Olympia, and Lacey. Most use of water from Tb occured in the southern and western parts of the study area, where more productive aquifers are generally lacking and this unit is at or close to land surface.

Of the 123,800 people estimated to have resided in the GWMA in 1988, about 78,000 (63 percent) had their household water furnished by Class 1 or Class 2 public- supply systems. The remaining 45,800 people (37 percent) relied on privately owned wells and small public-supply systems (mostly Class 4 systems). Of interest, however, is the fact that most of an estimated 23,000 people served by the City of Olympia Class 1 system were supplied by McAllister Springs water and not by well water. As shown in table 4, withdrawals of public-supply water by wells totaled 6,800 acre-feet in 1988 and most withdrawals (78 percent) were from Qva and Qc. Withdrawals for domestic use (privately owned wells and small public-supply systems) totaled 5,300 acre-feet, and most withdrawals (70 percent) were from Qva and Qc.

The single largest withdrawal of ground water through wells for commercial-industrial-institutional purposes in 1988 was in the Tumwater area. In that year, a single manufacturer withdrew an estimated 4,700 acre-feet of water, mostly from Qva and Qc. Numerous smaller industrial concerns withdrew relatively small quantities of ground water. It is unlikely that all industrial water users in the GWMA were contacted; the estimated total commercial- industrial-institutional supply of 6,900 acre-feet, therefore, probably represents a minimum value.

Irrigation water use in 1988 was relatively minor. An attempt was made to account for water being used to irrigate truck farms, tree farms, turf farms, nurseries, and pastures. The quantity of water used to sprinkle residential lawns was accounted for in the domestic water category.

In 1988, about 2,100 acre-feet of water was withdrawn for irrigation. Because not all irrigators could be contacted, this probably represents a minimum value. Irrigation supplies in 1988 were taken from all geohydrologic units except the Qf and bedrock (table 4). Small amounts of irrigation water also are taken from local streams, but this use does not constitute a major effect on the ground-water system.

The principal uses of spring water in northern Thurston County are for public supply and aquaculture-livestock (see table 4). In 1988, these two uses accounted for 5,600 and 7,900 acre-feet of spring water, respectively. The public-supply withdrawal for domestic use was from McAllister Springs and amounted to about 33 percent of its annual discharge. It should be noted that the use of spring water does not constitute withdrawal from the ground-water resource, but use of naturally occurring discharge.

The data needed to document long-term trends in ground-water withdrawal are generally lacking. One can assume, however, that withdrawals have increased over time, at least with respect to domestic water supplies, because of the relatively steady growth in population in the study area (see fig. 3).

WATER BUDGET OF THE GROUND WATER MANAGEMENT AREA

An approximate ground-water budget for a typical year in the 232-square-mile GWMA is expressed in the following equation.

$$GW_{in} + R = D + \Delta S \qquad (2)$$

where

GW_{in} is ground-water inflow to the study area,

R is recharge,

D is discharge, and

ΔS is change in ground-water storage.

Recharge to the ground-water system in the GWMA occurs primarily as recharge from precipitation and secondarily as seepage from septic systems, as leakage from water and sewer lines, and as deep percolation of irrigation water. Discharge from the system occurs as seepage to streams, springs, and coastal bluffs, as evaporation from soils and transpiration by plants, as underflow (submarine seepage to Puget Sound and flow to ground water outside the study area boundary), and as withdrawals from wells. A more detailed representation of the ground-water budget of the GWMA is

$$GW_{in} + R_{ppt} + R_{sec} = D_{sw} + D_{spr} + D_{et} + D_{un} + D_{ppg} + \Delta S \quad (3)$$

where

R_{ppt} is recharge from precipitation,

R_{sec} is secondary recharge,

D_{sw} is discharge to surface-water bodies,

D_{spr} is discharge to springs,

D_{et} is discharge by evapotranspiration,

D_{un} is discharge as underflow, and

D_{ppg} is pumping from wells.

Only some of the water-budget components can be quantified on the basis of the available data. The precipitation recharge (R_{ppt}) is equal to 310,000 acre-ft/yr (see Recharge section). The known discharge from springs is 33,000 acre-ft/yr (see Discharge section). Pumping from wells (D_{ppg}) totals 21,000 acre-ft/yr (see Water Use section). Secondary recharge (R_{sec}) and evapotranspiration from the ground water (D_{et}) are not known but are assumed to be relatively insignificant to the total budget (assume $R_{sec} = 0$ and $D_{et} = 0$). Ground-water inflow (GW_{in}) and outflow (D_{un}) are not known. On a long-term basis, a hydrologic system is usually in a state of dynamic equilibrium; that is, inflow to the system is equal to outflow from the system and there is little or no change in the amount of water stored within the system ($\Delta S = 0$).

Substituting the known values and above assumptions into equation 3 yields the following (all values in thousands of acre-feet per year).

$$GW_{in} + R_{ppt} + R_{sec} = D_{sw} + D_{spr} + D_{et} + D_{un} + D_{ppg} + \Delta S$$

(Substituting)

$$GW_{in} + 310 + 0 = D_{sw} + 33 + 0 + D_{un} + 21 + 0$$

(Rearranging)

$$GW_{in} + 256 = D_{sw} + D_{um} \quad (3)$$

This result indicates that most ground-water flow through the study area discharges to surface-water bodies and as underflow to marine waters.

Not all water that discharges naturally is available for further ground-water development. As pointed out by Bredehoeft and others (1982), any new discharge (withdrawals) superimposed on a previously stable system must be balanced by an increase in recharge, a decrease in the original discharge, a loss of storage within the aquifer, or by a combination of these factors. Considering the ground-water system of northern Thurston County in particular, the possibility of increased natural recharge on a long-term basis appears remote. In fact, the trend of increased residential development and central storm sewers may result in decreased recharge. Additional withdrawals, therefore, would result in a loss of storage (with an attendant decline in water levels) and a decrease in natural discharge. As discussed previously, not all natural discharge in the study area is to the sea; a large but undetermined quantity of ground water discharges to streams and springs. In those places, it is used both directly and indirectly for streamflow maintenance, fish propagation, waste dilution, recreation, and public supply. The magnitude of potential ground-water development, therefore, depends on the hydrologic effects on discharge that can be tolerated. Because it may take many years for a new equilibrium to become established, the full effects of additional ground-water development will most likely not be immediately apparent.

GROUND-WATER QUALITY

In this section, the methods of collecting and analyzing ground-water quality data are discussed and the quality of the ground water in the study area is described. Chemical concentrations and characteristics are discussed by geographic area and geohydrologic unit. Concentrations are compared with applicable U.S. Environmental Protection Agency (USEPA) drinking water regulations, and causes of widespread or common water-quality problems are identified.

Water-Quality Methods

The sampling and analytical methods used in this study follow guidelines presented in U.S. Geological Survey Techniques of Water-Resources Investigations (Fishman and Friedman, 1985; Friedman and Erdmann, 1982; Greeson and others, 1977; Wershaw and others, 1987; and Wood, 1981) and, where applicable, guidelines for GWMA studies as presented by Carey (1986).

Water samples were collected from 356 wells and 3 springs (pls. 5 and 6) during April, May, and June 1989. All samples were analyzed for concentrations of major ions, silica, nitrate, phosphate, iron, manganese, and fecal-coliform and fecal-streptococci bacteria. In addition, field measurements of temperature, specific conductance, pH, and dissolved-oxygen concentration were made at all sites. A subset of 47 samples, taken mostly from wells situated in areas of commercial and (or) industrial activity, was analyzed for concentrations of the trace elements arsenic, barium, cadmium, chromium, copper, lead, mercury, radon, selenium, silver, and zinc, and concentrations of volatile organic compounds. A second subset of 44 samples, chiefly from wells in unsewered areas, was analyzed for concentrations of boron, dissolved organic carbon (DOC), and methylene blue active substances (detergents).

Ten of the 365 wells sampled for complete analyses had also been sampled for chloride concentrations in 1978 as part of a regional assessment of seawater intrusion in western Washington (Dion and Sumioka, 1984). An additional 102 wells from the 1978 study, all located within a mile of the coast, were resampled for only chloride concentration, providing a total of 112 wells for comparison between 1978 and 1989.

In November 1988, 26 wells and 2 springs between McAllister Springs and Lake St. Clair were sampled to provide background data on water quality for a part of the study area where there was much concern about potential water-quality problems. The samples were analyzed for the same constituents as the 359 samples collected in spring 1989, and were also used to help determine if water chemistry varies with time. Both springs and all but 3 of the 26 wells were resampled in spring 1989.

All the wells sampled in this study had been inventoried and field-located prior to sampling. Most of the wells selected for sampling are used for domestic or, to a lesser extent, municipal purposes; a few are used for agricultural or industrial purposes. The sampled wells were selected to provide broad geographic coverage and a representation of all geohydrologic units. The number of wells selected for sampling within each of the geohydrologic units was approximately proportional to the total number of wells inventoried in each unit. Wells open to more than one geohydrologic unit were not selected. Areas of known ground-water quality problems, such as elevated nitrate concentrations or the presence of pesticides, were considered in the well-selection process. Although an effort was made to sample wells that might be representative of widespread water-quality problems, because of the regional nature of this study no attempt was made to sample wells affected by known small-scale or point-source problems. Wells from which samples were analyzed for concentrations of trace elements, volatile organic compounds, and septage-related compounds were selected largely on the basis of the predominant land use in the general vicinity of the wells. If a selected well could not be sampled for any reason, a substitute well with similar characteristics was selected using the same criteria.

Water samples were usually collected from a hose bib in the well's distribution system as close to the wellhead as possible. All samples were collected prior to any water treatment, such as chlorination, fluoridation, or softening. Where feasible, samples were collected upstream of any holding tank. Water was directed from the hose bib through nylon tubing to a flow-directing stainless-steel manifold mounted in a mobile water-quality laboratory (fig. 13). At a flow chamber, pH, temperature, and dissolved-oxygen concentration were monitored continuously. Specific conductance was also measured every 5 minutes. When these readings were constant for 10 minutes, indicating that the water monitored was being drawn from the aquifer, raw and filtered samples were collected from the appropriate manifold outlet. Raw samples to be analyzed for concentrations of organic compounds and bacteria were collected last, directly from the hose bib. All sampling equipment was rinsed and cleaned as appropriate before subsequent samples were collected.

After collection, samples were treated and preserved according to standard USGS procedures (Feltz and others, 1985). Samples requiring laboratory analysis were sent to the USGS National Water Quality Laboratory (NWQL) in Arvada, Colo. Dissolved concentrations were determined for all inorganic constituents, and total concentrations were determined for all organic compounds except dissolved organic carbon. Analytical procedures used at the NWQL are described by Fishman and Friedman (1985), Thatcher and others (1977), and Wershaw and others (1987).

Determinations of pH, specific conductance, dissolved-oxygen concentration, and temperature were made onsite using methods outlined by Wood (1981). Dissolved-oxygen concentrations were determined using a meter, and concentrations of 1.0 mg/L (milligrams per liter) or less were verified by collecting samples to be analyzed at the end of the field day using the Winkler titration method (American Public Health Association and others, 1985; Wood, 1981). Samples were also analyzed in the field for concentrations of fecal-coliform bacteria and fecal-streptococci bacteria using membrane filtration methods outlined by Greeson and others (1977).

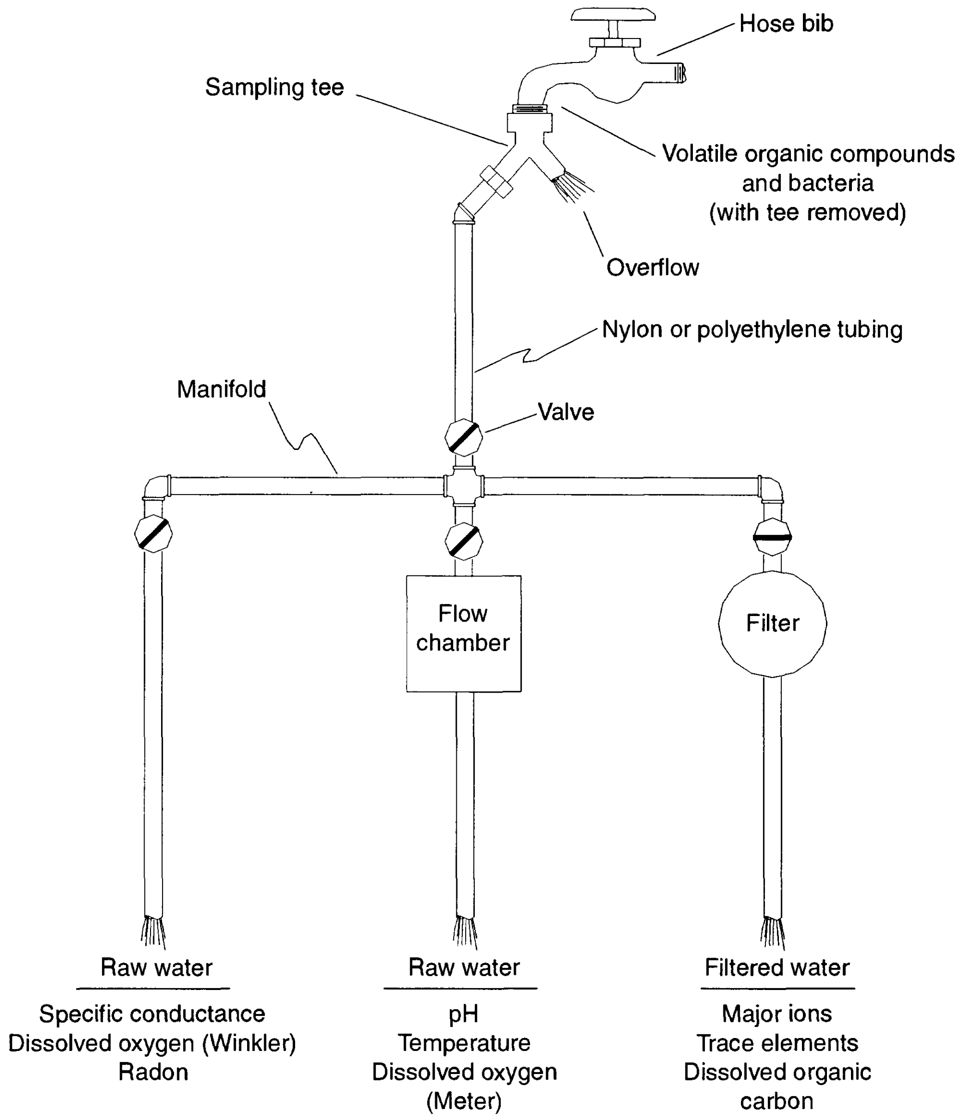


Figure 13. Water-sampling apparatus and locations of sampling points.

As part of the study's quality-assurance program, accuracy of field measurements of pH and specific conductance was ensured by daily calibration of meters to known standards. Dissolved-oxygen meters were also calibrated daily, using the water-saturated air technique. Field analyses of bacteria concentration were performed in duplicate for 1 in every 20 wells sampled.

Samples for analysis by the NWQL were collected in duplicate on a random basis. One duplicate sample for major inorganic analysis was collected for every 20 wells sampled, and one duplicate sample for trace elements and organic analysis was collected for every 15 wells sampled. Blank samples, prepared from deionized water, were analyzed at the same frequencies. Duplicates and blanks were processed in the same manner as ordinary ground-water samples and were submitted to the laboratory disguised as normal ground-water samples.

No standards or spiked samples were submitted from the field to the laboratory, but standards for most inorganic constituents were inserted routinely as blind samples into the sample stream at the NWQL. Appropriate standards were spiked into each sample for organic analysis to determine the percentage of constituent recovered.

Standard quality-assurance procedures were used at the NWQL (Friedman and Erdman, 1982). The resulting analytical data were reviewed by laboratory personnel, then released to the USGS district office in Tacoma, Wash., by computerized data transfer. The data were then further reviewed by district personnel in the context of the geohydrologic setting. Computer programs and statistical techniques were used to assist in all stages of the reviews. Additional details of laboratory quality-assurance procedures and data review are discussed in a project quality-assurance plan by G. L. Turney (U.S. Geological Survey, written commun., 1988) and in a general plan by Friedman and Erdmann (1982). A detailed review of the quality-assurance data for the project is included in Appendix B of this report. All water-quality data that resulted from this study are presented in Appendix C.

General Chemistry

Most of the data that describe the general chemistry of the ground water are presented statistically in summary tables. Table 5 presents the minimum, median, and maximum values of the common constituents determined; table 6 shows median values for each of the common constituents by geohydrologic unit. Similar summary tables are presented for other constituents and chemicals as needed for the discussion. All supporting basic data are presented in Appendix C.

For many constituents, some concentrations may be reported as "less than" (<) a given value, where the value given is the detection limit or reporting limit for the analytical method. For example, the concentrations of many organic compounds are reported at <0.2 μg/L, (micrograms per liter) where the detection limit is 0.2 μg/L. The correct interpretation of such concentrations is that the constituent was not detected at or above that particular concentration. The constituent could be present at a lower concentration, such as 0.1 μg/L, or it may not be present at all, but that is impossible to tell with certainty with the analytical method used.

pH, Dissolved Oxygen, and Specific Conductance

The acidity or basicity of a substance is measured by pH, which in water is measured on a scale from 0 to 14. A pH of 7.0 is considered neutral; smaller values are acidic and larger values are basic. The scale is logarithmic; therefore, a pH of 5.0 indicates that a water is 10 times as acidic as water with a pH of 6.0.

The pH values of the samples collected as part of this study ranged from 6.0 to 9.9 and the median was 7.1 (table 5). The median pH by aquifer increased steadily from 6.7 in Qvr to 7.9 in Tb (table 6). The variation in pH values is natural and is due largely to alterations of the water composition by chemical reactions with minerals in the aquifer material. Some of these reactions and the effects they have on water chemistry are discussed in the section on Water Types.

Dissolved-oxygen concentrations are useful in determining the types of chemical reactions that can occur in water. Small dissolved-oxygen concentrations indicate that a chemically reducing reaction can occur, and large concentrations indicate that a chemically oxidizing reaction can occur. In some instances, though, large dissolved-oxygen concentrations may have been caused by the introduction of air into plumbing systems by pumps, leaking tanks, or pipes. Caution was taken to avoid aeration of the samples, but sometimes it was unavoidable or undetectable.

Dissolved-oxygen concentrations ranged from 0.0 to 12.6 mg/L, and the overall median concentration was 3.9 mg/L (table 5). Median concentrations varied considerably by unit, ranging from 6.7 mg/L in Qvr to 0.2 and

0.5 mg/L in TQu and Tb (table 6). However, there was much variation within individual units; the maximum value for each unit was at least 7.8 mg/L and the minimum value was either 0.0 or 0.1 mg/L. Much of this variation is natural and results from reactions between the water and minerals or the water and organic matter.

Specific conductance is a measure of the electrical conductance of the water (corrected for water temperature), which increases with the concentration of dissolved minerals. Because of this, specific conductance is a good indication of the concentrations of those dissolved minerals, usually called dissolved solids. The median specific conductance of the samples from 359 wells was 142 µS/cm (microsiemens per centimeter at 25°Celsius), and overall the values ranged from 32 to 2,100 µS/cm (table 5).

Dissolved Solids

The concentration of dissolved solids is the total concentration of all the minerals dissolved in the water. The components of dissolved solids present depend on many factors, but usually include calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, nitrate, and silica. Other constituents, such as carbonate and fluoride, or metals such as iron and manganese, are also common but are rarely dissolved in natural waters in large enough concentrations to be a significant contribution to the dissolved-solids concentration.

Dissolved-solids concentrations ranged from 28 to 1,140 mg/L with a median concentration of 112 mg/L (table 5), and the concentrations tended to be larger in the lower (older) units. The median concentration in Qvr was

Table 5. Summary of concentrations of common constituents

[Concentrations in milligrams per liter unless otherwise noted. All are dissolved concentrations. Statistics are for samples from 359 wells and springs unless noted; µS/cm, microsiemens per centimeter at 25°Celsius; <, not detected at the given concentration; µg/L, micrograms per liter]

Constituent	Concentrations		
	Minimum	Median	Maximum
pH (standard units)	6.0	7.1	9.9
Dissolved oxygen[1]	.0	3.9	12.6
Specific conductance (µs/cm)	32	142	2,100
Hardness (as $CaCO_3$)	1.0	54	600
Calcium	.13	11	170
Magnesium	.01	5.8	55
Sodium	2.0	6.5	260
Percent sodium	10	20	99
Potassium	.1	1.6	11
Alkalinity (as $CaCO_3$)	7.0	56	464
Sulfate	<1.0	4.0	52
Chloride	1.3	3.4	600
Fluoride	<.1	.1	.4
Silica	5.7	35	66
Dissolved solids (calculated)	28	112	1,140
Nitrate (as nitrogen)	<.10	.33	19
Phosphorus	<.01	.04	1.6
Iron (µg/L)	<3	23	21,000
Manganese (µg/L)	<1	5	3,400

[1]Statistics based on 357 samples.

100 mg/L, and there was a general increase to TQu, where the median concentration was 127 mg/L (table 6). Some of this variation is because of different minerals in the units (Noble and Wallace, 1966), but some likely is due to increased residence time of water in the lower units. Water that has been in the ground for a longer time generally has had the opportunity to dissolve more minerals than water with a shorter residence time.

A map of dissolved-solids concentrations (pl. 5) shows some areal variation. Concentrations in the southwest, near Black Lake and Littlerock, tended to be less than 100 mg/L; concentrations in the northern and eastern areas were generally more than 100 mg/L. Ground-water residence times would tend to be longer in the north and east, leading to larger dissolved-solids concentrations. Dissolved-solids concentrations exceeding 200 mg/L were observed in the northern parts of all of the peninsulas (especially Boston Harbor and Johnson Point peninsulas), just south of Mud Bay, and east of Offutt Lake. Most of these large concentrations are from samples of wells near coastal shorelines and are probably associated with seawater intrusion.

Major Ions

Most of the major components of the dissolved-solids concentrations are ions, meaning they have an electrical charge. Cations are ions with a positive charge and include calcium, magnesium, sodium, potassium, and most metals. Anions are ions with a negative charge and include bicarbonate, sulfate, chloride, nitrate, carbonate, and fluoride. Silica has no charge and is the only major component that is not a cation nor an anion.

Table 6. Median concentrations of common constituents by geohydrologic unit

[Concentrations in milligrams per liter (mg/L) unless otherwise noted. All are dissolved concentrations; µS/cm, microsiemens per centimeter at 25°Celsius; <, not detected at the given concentration; µg/L, micrograms per liter]

	Geohydrologic unit (Number of samples[1])						
Constituent	Qvr (19)	Qvt (11)	Qva (120)	Qf (12)	Qc (122)	Tqu (52)	Tb (19)
pH (standard units)	6.7	6.8	6.8	7.2	7.2	7.8	7.9
Dissolved oxygen	6.7	.8	5.7	4.9	3.3	.2	.5
Specific conductance(µS/cm,)	129	137	124	176	144	162	184
Hardness (as $CaCO_3$)	50	54	48	72	55	57	64
Calcium	11	11	10	12	12	13	21
Magnesium	5.2	6.0	5.2	6.0	6.6	6.2	3.9
Sodium	6.1	6.7	5.9	7.6	6.4	7.8	23
Percent sodium	21	20	20	20	20	24	32
Potassium	1.1	1.4	1.4	2.2	1.9	2.1	.4
Alkalinity (as $CaCO_3$)	42	52	49	81	58	74	64
Sulfate	6.0	6.7	4.0	5.4	4.0	2.0	5.5
Chloride	4.2	3.6	3.4	2.8	3.4	3.0	3.9
Fluoride	.1	.1	.1	.1	.1	.1	.1
Silica	31	33	31	40	37	40	27
Dissolved solids (calculated)	100	110	101	130	113	127	118
Nitrate (as nitrogen)	1.7	.34	.78	.20	.34	<.10	<.10
Phosphorus	.02	.03	.02	.04	.05	.14	.03
Iron (µg/L)	7	43	14	49	20	110	10
Manganese (µg/L)	<1	14	2	12	4	61	6

[1]Total is 355 because four wells open to multiple units were not included.

In Thurston County ground water, the median concentration of calcium (table 5) was 11 mg/L, the largest of any cation. Magnesium and sodium had median concentrations of 5.8 and 6.5 mg/L, respectively, and accounted for most of the remaining cations. Concentrations of potassium, iron, and manganese were generally small compared with calcium, magnesium, and (or) sodium. Maximum concentrations of all these cations were about an order of magnitude larger than the median concentrations.

The major anion was bicarbonate, as indicated by the median alkalinity concentration of 56 mg/L. Although bicarbonate, carbonate, and hydroxide all contribute to alkalinity, at all pH values observed bicarbonate is by far the major component of alkalinity. Thus, at these pH values the concentration of bicarbonate is 0.61 times the alkalinity concentration, which is expressed as calcium carbonate. The largest alkalinity concentration observed in the study area was 464 mg/L, in a sample from well 19N/01W-32B01. The median concentrations of sulfate, chloride, nitrate, and fluoride were very small compared with alkalinity, and as such they are generally negligible as major components of the water. The maximum concentration of chloride, however, was 600 mg/L, and chloride was the major anion in some samples. Chloride and nitrate are discussed in more detail in the next two subsections because of their local effect on water quality.

Silica was also a major component of the dissolved solids, with a median concentration of 35 mg/L. The maximum silica concentration observed was 66 mg/L.

Hardness is calculated from the concentrations of calcium and magnesium. The most familiar effect of increased hardness is a decreased production of lather from a given amount of soap introduced into the water. Hard water may also cause a scale deposit on the inside of plumbing pipes. Most water samples were classified as soft or moderately hard, as defined by the following scheme (Hem, 1985).

Description	Hardness range (milligrams per liter of $CaCO_3$)	Number of samples	Percentage of samples
Soft	0-60	229	64
Moderately hard	61-120	108	30
Hard	121-180	10	3
Very hard	Greater than 180	12	3
		359	100

Median concentrations of calcium and sodium were considerably larger in Tb than in the other units (table 6). This is likely a reflection of the different minerals in the bedrock. The variations in calcium and sodium, along with variations in alkalinity and silica, account for most of the differences in dissolved-solids concentrations between geohydrologic units. Variations in median concentrations of magnesium, potassium, sulfate, chloride, fluoride, and nitrate were not large enough to account for much of the variation in dissolved-solids concentrations between units. In fact, median magnesium and potassium concentrations were smallest in Tb, and the median sulfate concentration was smallest in TQu. Median chloride and fluoride concentrations were essentially the same for all units, but median nitrate concentrations decreased from Qvr to Tb.

Chloride

Chloride concentrations for the 359 samples analyzed for common constituents are shown areally on plate 6, along with results from an additional 102 samples collected from coastal wells as a follow-up to a seawater intrusion study in 1978. Chloride concentrations of the 461 samples ranged from 1.2 to 600 mg/L, with a median concentration of 3.3 mg/L. Median concentrations for each unit varied little, ranging from 2.8 to 4.2 mg/L. These results are very similar to those in tables 5 and 6 for the 359 complete analyses only.

Chloride concentrations of 3.0 mg/L or less were most common in samples from wells in the western part of the study area. However, samples with concentrations exceeding 3.0 mg/L were found throughout the study area. Of particular note is an area southeast of Lacey, in the vicinity of Long Lake and Lake St. Clair, where chloride concentrations for virtually all samples ranged from 3.1 to 5.0 mg/L. Because chloride is a common constituent of septic-tank effluent, these slightly elevated concentrations may have been caused by the large number of homes that rely on such systems in parts of that area.

The highest chloride concentrations exceeded 50 mg/L, and were found mostly along the northeastern and western shores of Johnson Point peninsula, the northern shore of Boston Harbor peninsula, the northern half of Cooper Point peninsula, the northern end of Griffin peninsula, and the area around the south end of Mud Bay. Concentrations as large as 570 mg/L, in a sample from well 19N/01W- 04G01, were found in these areas. Such concentrations in coastal areas are suggestive of seawater intrusion. However, as shown on plate 6, there are many coastal regions in the study area that had chloride concentrations of 3.0 mg/L or less.

Connate seawater seeping from marine rocks of Tertiary age is a likely source of chloride concentrations exceeding 50 mg/L for wells located east of Offutt Lake. Concentrations as large as 600 mg/L were found in that area. The Tertiary McIntosh Formation is exposed near this area and may also lie at shallow depth beneath other nearby areas, where it is not exposed at land surface. Weigle and Foxworthy (1962, p. 19) and Noble and Wallace (1966, p. 83, 103) pointed out that numerous wells tapping the McIntosh Formation have produced connate water that is salty or has otherwise undesirable quality.

Chloride concentrations exceeding 5 mg/L in samples collected from wells located away from a shoreline also may be due to contamination from anthropogenic sources such as septic tanks or industry. Road salt is rarely used in Thurston County during the winter and is likely an insignificant source of chloride.

Nitrate

Nitrate, although not a major component of most water samples, is a concern in some areas of Thurston County because of elevated concentrations and the associated implications of ground-water contamination. Concentrations ranged from <0.10 to 19 mg/L, with a median concentration of 0.33 mg/L (table 5). The actual analysis for nitrate includes both nitrite and nitrate; however, nitrite concentrations in ground water are usually negligibly small (National Research Council, 1978). The values determined are therefore considered to be entirely nitrate.

Concentrations of nitrate were 1.0 mg/L or less throughout most of the study area (pl. 6); 71 percent of the samples analyzed fell in this range. The most notable exception is the area east and southeast of Lacey, where virtually all samples had nitrate concentrations above 1.0 mg/L and about half had concentrations exceeding 2.0 mg/L. Concentrations in this area were as large as 7.8 mg/L and likely were due to a high housing density and the extensive use of septic tanks. Agricultural activities south of Lake St. Clair may also contribute nitrate to the ground-water system. However, nitrate concentrations were generally small in the agricultural areas themselves, suggesting that the contribution of nitrate from agriculture may be minimal in the area southeast of Lacey. Nitrate concentrations in the range of 2.1 to 5.0 mg/L, south of Lacey and south of Tumwater, were also likely caused by residentially developed areas with septic systems.

The largest nitrate concentration observed was 19 mg/L, in a sample from well 17N/01W-16E02. This well is only 31 feet deep and located in a pasture, therefore animals or fertilizers are the likely source of the nitrate in this particular well. All other wells sampled in the immediate vicinity had concentrations of 1.0 mg/L or less, so the problem is not likely widespread. Relatively large nitrate concentrations of 8.3 and 9.9 mg/L were found in samples from wells 17N/01E-11R02 and 17N/01E-13MO2, respectively. These wells are located about a mile northwest of Yelm, where elevated nitrate concentrations in ground water are common. There is considerable local debate as to whether the large nitrate concentrations there are due to septic tanks, nearby chicken ranches, or some yet unknown source. Investigating the problem further was beyond the scope of this study because the Yelm area is outside the GWMA.

Nitrate concentrations were generally largest in the shallowest aquifers. The median concentration was 1.7 mg/L in samples in Qvr and generally decreased downward to median concentrations of <0.10 mg/L in both TQu and Tb (table 6). This would be expected, because nitrate sources are typically at or near the surface. Where Qvr is not present or is not saturated, large concentrations may be found in other, older, units.

Water Types

Another way to interpret major ion data is to determine the water types (defined by the dominant ions) of the samples from the analytical results. First, concentrations of the major ions are converted from milligrams, which are based on mass, to milliequivalents, which are based on the number of molecules and electrical charge. A milliequivalent is the amount of a compound, in this case one of the ions, that either furnishes or reacts with a given amount of H^+ or OH^-. When expressed as milliequivalents, all cations or anions are equivalent for the purpose of balancing equations. A milliequivalent of sulfate will combine with a milliequivalent of calcium, as would a milliequivalent of chloride. The milliequivalents of all the cations and anions are then summed separately to obtain a cation sum and anion sum, in milliequivalents. Because the water is electrically neutral, the cation and anion sums should be close in value. The contribution of each ion to the appropriate sum is then calculated as a percentage.

The cation(s) and anion(s) that are the largest contributors to their respective sums define the water types. For example, the water type of seawater is sodium/chloride.

To make the determination of water types easier, the percentages of cations and anions for a given sample are plotted on a trilinear, or Piper, diagram (Hem, 1985). The water type is then determined from the area of the diagram in which the sample is plotted (pl. 5). One plot defines the dominant cation, another the dominant anion. Combined water types, where more than one cation or anion dominate, are possible and are quite common. The diagram shows that to be defined as a sole dominant ion, an ion must account for 60 percent or more of the cation or anion sum, and the analysis will be plotted near one of the corners. On the other hand, an ion that accounts for less than 20 percent of the sum will not be included in the water type. An exception to the latter case occurs when two ions are included on a single axis of the plot, such as chloride and nitrate. If both together contribute 20 percent, then the sample will plot as though chloride and nitrate together are dominant anions, even though individually chloride and nitrate contributions may be less than 20 percent. For this study, the actual percentages were used to determine the water type, and if both were less than 20 percent neither was considered dominant. Also, for combined water types, the ions are listed in order of dominance. For example, a calcium-magnesium/bicarbonate type has more calcium than magnesium, and a magnesium-calcium/bicarbonate type has more magnesium than calcium; however, both plot in the same section of the diagram. Note that the diagram, which is based on percentages, does not show actual concentrations.

For this study, all of the samples from a unit were plotted on a common trilinear diagram for each unit (pl. 5); this allowed trends and anomalies to be more easily discerned. Samples that plotted away from the majority of samples for the unit were considered anomalies. They are listed, along with comments, on plate 5. Perhaps the most notable anomalies are the calcium/chloride and sodium/chloride water types; they were observed primarily in the lower units. Also, a few samples that at first appeared to have bicarbonate-chloride as the dominant anions actually had large nitrate concentrations, which increased the apparent chloride contribution. Most of these samples were from wells in the upper units.

Samples with calcium and (or) magnesium as the dominant cations and bicarbonate as the dominant anion were the most common throughout the study area, and were most common from wells finished in Qvr, Qvt, Qva, Qf, and Qc. Such water types are characteristic of the glacial deposits of western Washington (Van Denburgh and Santos, 1965; Turney, 1986a). Freeze and Cherry (1979) attribute those water types to the interaction of dilute, slightly acidic recharge water with aluminosilicate minerals. These minerals dissolve slowly, resulting in low concentrations of dissolved solids and pH values that commonly do not exceed 7.0.

Sodium/bicarbonate and (or) sodium-calcium/bicarbonate water types were common in TQu and Tb. The source of the elevated sodium and bicarbonate concentrations in some of the water samples from TQu is uncertain, but there are at least two possibilities. The first is that TQu has more sodium-rich minerals than do the overlying younger units. The second is that sodium-rich water flows upward from the underlying Tb. The elevated sodium concentrations in Tb could be caused by geochemical reactions of ground water with basalt, which makes up part of that unit. These reactions have been described by Hearn and others (1985) and by Steinkampf and others (1985) for basalts in eastern Washington, and similar reactions probably occur in the basalts of Thurston County.

Water types in which chloride is the dominant anion are readily attributed to seawater intrusion if the sample is from a well near a marine water body and finished below sea level. This is obvious for sodium/chloride water types, but even applies to calcium/chloride types and mixed cation types, where the proportion of sodium is not as large as would be expected from the proportion of chloride (Piper and others, 1953; Poland and others, 1959).

Chloride water types in samples from wells away from marine shorelines may be attributed to connate seawater in Tertiary marine rocks, such as the McIntosh Formation of Eocene age. These saline waters likely were trapped in the rock as it was deposited.

Iron and Manganese

Iron concentrations ranged from <3 μg/L to 21,000 μg/L, with a median concentration of 23 μg/L (table 5). Median concentrations for individual units were from 7 to 49 μg/L for all units except TQu, which had a median concentration of 110 μg/L (table 6). Even so, concentrations exceeding 1,000 μg/L were observed in samples from every unit except Qvt and Tb. Areal distributions of iron concentrations varied, but some patterns are apparent (pl. 6). Large numbers of samples with iron concentrations of 10 μg/L or less were collected from wells located east and southeast of Lacey, east of Black Lake, and near the town of Rainier. Conversely, large iron concentrations, some exceeding 300 µg/L, were found in samples from wells on the peninsulas and around Lake St. Clair. In general, however, these delineations are subtle, and the concentration of iron is geographically highly variable.

Manganese concentrations ranged from <1 µg/L to 3,400 µg/L, and the median concentration was 5 µg/L. Like iron, the median concentration for individual units was largest (61 µg/L) for samples from TQu; median concentrations for all other units ranged from 1 µg/L to 12 µg/L. The distribution of areal manganese concentrations followed the same general pattern as iron concentrations.

The variation and range of iron and manganese concentrations seen in Thurston County are typical of western Washington ground waters (Van Denburgh and Santos, 1965; Turney, 1986a, 1990), and are due largely to natural processes. These processes depend on ambient geochemical conditions, one of which is the concentration of dissolved oxygen. Water that is depleted of oxygen can dissolve iron from the surrounding minerals as the chemically reduced ferrous (Fe^{2+}) form of iron. Iron is highly soluble under these conditions and large concentrations can result. If the water is reoxygenated, then the iron is oxidized to the ferric (Fe^{3+}) form, which is much less soluble than the ferrous form and will precipitate as an oxide or a carbonate, resulting in a lower dissolved-iron concentration (Hem, 1985). Manganese undergoes a similar set of reactions. Because these reactions are oxygen-sensitive and the oxygen content of the ground water may vary considerably in a given area, dissolved iron and manganese concentrations may also vary greatly.

The large median iron and manganese concentrations in TQu are due in part to the small dissolved-oxygen concentrations in that unit. Water samples from TQu had a median dissolved-oxygen concentration of only 0.2 mg/L, the smallest of any unit (table 6). Although dissolved oxygen is an obvious factor, this unit may also have more iron- and manganese-rich minerals than do the other unconsolidated units.

Trace Elements

Concentrations of most trace elements were small. Median concentrations of all trace elements except zinc and radon were less than 5 µg/L (table 7). Only three samples had concentrations of any trace element other than zinc or radon larger than 10 µg/L. A sample from well 18N/01W-22K01 had a copper concentration of 80 µg/L, which may have leached from the plumbing. The sample from well 18N/01W- 31R02 had an arsenic concentration of 21 µg/L, and the sample from well 19N/02W-22D02 had a barium concentration of 12 µg/L. The sources of these latter two large concentrations are unknown.

Concentrations of zinc varied the most, ranging from <3 µg/L to 900 µg/L (table 7). The areal distribution of zinc concentrations had no discernible geographic trend, and no correlation could be made to geohydrologic units. This is because the most likely source of the zinc is galvanized pipe used in wells and in some home plumbing systems. Zinc may be leached from the pipes, especially if the water is slightly acidic and low in dissolved-solids concentration, as is much of the ground water in Thurston County

Table 7. Summary of concentrations of selected trace elements

[Concentrations in micrograms per liter unless otherwise noted. All are dissolved concentrations. Statistics are for samples from 47 wells and springs except where noted; <, not detected at the given concentration; pCi/L, picocuries per liter]

	Concentrations		
Element	Minimum	Median	Maximum
Arsenic	<1	1	21
Barium	<2	4	12
Cadmium	<1	<1	2
Chromium	<1	<1	5
Copper	<1	1	80
Lead	<1	<5	<5
Mercury	<.1	<.1	.5
Selenium	<1	<1	<1
Silver	<1	<1	7
Zinc	<3	36	900
Radon (pCi/L)[1]	<80	410	660

[1]Statistics based on samples from 46 wells.

Radon concentrations ranged from <80 pCi/L (picocuries per liter) to 660 pCi/L, with a median concentration of 410 pCi/L. The picocurie is a measure of radioactivity, not mass. Radon is a naturally occurring element and is part of the radioactive decay chain of uranium. Radon concentrations showed no areal or geohydrologic patterns. The radon concentrations observed in Thurston County are similar to those found in ground water in Clark County (about 75 miles south of Thurston County), where concentrations ranged from <80 to 820 pCi/L, with a median concentration of 315 pCi/L (Turney, 1990). The concentrations are not large compared with some other areas of the Nation, such as Maine, where concentrations in excess of 10,000 pCi/L have been observed in water from granitic formations.

Volatile Organic Compounds

Volatile organic compounds were detected in samples from only 6 of the 46 wells sampled in spring 1989. Several individual volatile organic compounds were detected, but the median concentration of all compounds was less than the detection limit (table 8). The presence of any volatile organic compound is generally considered to represent some type of anthropogenic source. Concentrations of all the detected compounds and the wells from which the samples were taken are listed in table 9.

The largest concentration of any volatile organic compound detected was 1.5 µg/L of 1,2-dichloropropane in a sample from well 17N/01W-02L02. This was the only volatile organic compound detected in the sample collected from this well in May 1989. The sample from nearby well 17N/01W-02E03 contained 0.8 µg/L of 1,2-dichloropropane, as well as 0.9 µg/L of 1,2-dibromoethane (commonly known as EDB) and lesser concentrations of several other organic compounds. Both wells are located just southwest of Pattison Lake and within 0.5 mile of a strawberry farm and other agricultural activities. Because 1,2-dichloropropane and 1,2-dibromoethane are used as pesticides, agricultural activities are suspected as the source of these two compounds. To confirm the results of the May 1989 sampling, and to investigate the presence of an associated pesticide, 1,2-dibromo-3-chloropropane, both wells were resampled in December 1989. A more sensitive analysis was used for the December samples and 1,2-dichloropropane was detected again in both samples, as was 1,2-dibromoethane. The December sample from well 17N/01W-02L02 also contained 1,2-dibromo-3-chloropropane. The several other organic compounds originally detected in the sample from well 17N/01W-02E03 were not detected in the December 1989 sample. This may be related to instrument problems that occurred during the analysis of the original sample and is discussed in Appendix B.

Small concentrations of trichloromethane and bromodichloromethane were found in samples from well 18N/01W-02G02, as were trace concentrations of trichloromethane in the sample from well 18N/01W-17H05. These compounds are usually associated with industrial or commercial activities or the chlorination of drinking water. The samples were not chlorinated, however. Trace concentrations of 1,1,1-trichloroethane were found in samples from well 18N/01W-11P05 and are likely related to commercial activities, such as automotive repair or dry cleaning. Benzene, dimethylbenzene, and ethylbenzene were detected in samples from well 18N/01W-06A03 and are characteristic of gasoline contamination. None of these wells were resampled as part of this study to verify the small concentrations because they are public-supply wells that will be monitored by another agency in the future.

Septage-Related Compounds

Concentrations of boron, DOC (dissolved organic carbon), and MBAS (methylene blue active substances) were determined for samples from 44 wells located mostly in areas with septic systems. Boron and MBAS are present in household wastewater as detergent residues and have been identified in septage-contaminated ground water (LeBlanc, 1984). Large concentrations of DOC may suggest the presence of several types of organic compounds, including septage compounds, oil and grease, and solvents.

The median concentration of MBAS in the samples was 0.03 mg/L, and the maximum concentration was 0.21 mg/L (table 10). The median concentration is larger than the median concentration of 0.01 mg/L reported for ground waters in Clark County (Turney, 1990) and southwestern King County (Woodward and others, 1995). The median value is also slightly larger than the concentration of 0.02 mg/L, above which ground-water quality can be considered degraded, as suggested by Hughes (1975). All MBAS concentrations in Thurston County exceeding 0.04 mg/L were in samples from wells in unsewered areas, and half of these were in areas with more than 250 residential units per square mile. Water from well 18N/01W-11P05, which had an average MBAS concentration of 0.08 mg/L, also contained 1,1,1-trichloroethane. All wells with water samples having MBAS concentrations exceeding 0.04 mg/L are listed in table 11.

Table 8. Summary of concentrations of volatile organic compounds

[Concentrations in micrograms per liter (μg/L). All are total concentrations. Statistics are for samples from 46 wells and springs except where noted; <, not detected at given concentration]

Constituent	Concentrations Minimum	Concentrations Median	Concentrations Maximum	Number of wells where compound was detected
Chloromethane	<0.2	<0.2	<0.2	0
Dichloromethane	<.2	<.2	<.2	0
Trichloromethane	<.2	<.2	.3	2
Tetrachloromethane	<.2	<.2	<.2	0
Bromomethane	<.2	<.2	<.2	0
Dibromomethane	<.2	<.2	<.2	0
Tribromomethane	<.2	<.2	<.2	0
Bromodichloromethane	<.2	<.2	.2	1
Dibromochloromethane	<.2	<.2	<.2	0
Trichlorofluoromethane	<.2	<.2	<.2	0
Dichlorodifluoromethane	<.2	<.2	<.2	0
Chloroethane	<.2	<.2	<.2	0
1,1-dichloroethane	<.2	<.2	<.2	0
1,2-dichloroethane	<.2	<.2	<.2	0
1,1,1-trichloroethane	<.2	<.2	.2	1
1,1,2-trichloroethane	<.2	<.2	<.2	0
1,1,1,2-tetrachloroethane	<.2	<.2	<.2	0
1,1,2,2-tetrachloroethane	<.2	<.2	<.2	0
1,2-dibromoethane	[1].12	<.2	.9	2
Chloroethene	<.2	<.2	<.2	0
1,1-dichloroethene	<.2	<.2	.5	1
cis 1,2-dichloroethene	<.2	<.2	<.2	0
trans 1,2-dichloroethene	<.2	<.2	<.2	0
Trichloroethene	<.2	<.2	.4	1
Tetrachloroethene	<.2	<.2	<.2	0
1,2-dichloropropane	<.2	<.2	1.5	2
1,3-dichloropropane	<.2	<.2	<.2	0
2,2-dichloropropane	<.2	<.2	<.2	0
1,2,3-trichloropropane	<.2	<.2	<.2	0
1,2-dibromo-3-chloropane[2]	<.03	<.03	.16	1
1,1-dichloropropene	<.2	<.2	<.2	0
cis 1,3-dichloropropene	<.2	<.2	<.2	0
trans 1,3-dichloropropene	<.2	<.2	<.2	0
Benzene	<.2	<.2	.3	1
Chlorobenzene	<.2	<.2	.5	1
1,2-dichlorobenzene	<.2	<.2	<.2	0
1,3-dichlorobenzene	<.2	<.2	<.2	0
1,4-dichlorobenzene	<.2	<.2	<.2	0
Bromobenzene	<.2	<.2	<.2	0
Toluene	<.2	<.2	.4	1
2-chlorotoluene	<.2	<.2	<.2	0
4-chlorotoluene	<.2	<.2	<.2	0
Dimethylbenzene	<.2	<.2	.2	1
Ethylbenzene	<.2	<.2	.3	1
Ethenylbenzene	<.2	<.2	<.2	0

[1]Two samples collected in December 1989 had a minimum concentration of 0.12 μg/L because a more sensitive method was used. The detection limit of the method used to analyze the samples collected in the spring of 1989 was 0.2 μg/L.

[2]Based on samples from two wells.

Table 9. Concentrations of volatile organic compounds in samples where they were detected

[Concentrations in micrograms per liter; <, not detected at given concentrations; --, compound not analyzed for]

Local well number	Date	Tri-chloro-methane, total	Bromo-dichloro-methane, total	1,1,1-Tri-chloro-ethane, total	1,2-Di-bromo-ethane, total	1,1-Di-chloro-ethene, total	Tri-chloro-ethene, total
17N/01W-02E03	05-16-89	<0.2	<0.2	<0.2	0.9	0.5	0.4
	12-13-89	<.2	<.2	<.2	.68	<.2	<.2
17N/01W-02L02	05-16-89	<.2	<.2	<.2	<.2	<.2	<.2
	12-13-89	<.2	<.2	<.2	.12	<.2	<.2
18N/01W-02G02	06-08-89	.3	.2	<.2	<.2	<.2	<.2
18N/01W-06A03	04-28-89	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-11P05	06-21-89	<.2	<.2	.2	<.2	<.2	<.2
	06-21-89	<.2	<.2	.2	<.2	<.2	<.2
18N/01W-17H05	05-03-89	.2	<.2	<.2	<.2	<.2	<.2

Local well number	Date	1,2,-Di-chloro-propane, total	1-2-Di-bromo-3-chloro-propane, total	Benzene, total	Chloro-benzene, total	Toluene, total	Di-methyl-benzene, total	Ethyl-benzene, total
17N/01W-02E03	05-16-89	0.8	--	<0.2	0.5	0.4	<0.2	<0.2
	12-13-89	.9	<0.03	<.2	<.2	<.2	<.2	<.2
17N/01W-02L02	05-16-89	1.5	--	<.2	<.2	<.2	<.2	<.2
	12-13-89	.9	.16	<.2	<.2	<.2	<.2	<.2
18N/01W-02G02	06-08-89	<.2	--	<.2	<.2	<.2	<.2	<.2
18N/01W-06A03	04-28-89	<.2	--	.3	<.2	<.2	.2	.3
18N/01W-11P05	06-21-89	<.2	--	<.2	<.2	<.2	<.2	<.2
	06-21-89	<.2	--	<.2	<.2	<.2	<.2	<.2
18N/01W-17H05	05-03-89	<.2	--	<.2	<.2	<.2	<.2	<.2

Table 10. Summary of concentrations of septage-related compounds

[Concentrations are in milligrams per liter unless noted. All except methylene blue active substances are dissolved concentrations. Statistics based on samples from 44 wells and springs except where noted; <, not detected at given concentration; µg/L, micrograms per liter]

Constituent	Concentrations Minimum	Median	Maximum
Methylene blue active substances (MBAS, or detergents)	<0.02	0.03	0.21
Boron (µg/L)	<10	10	70
Organic carbon[1]	.2	.4	3.1

[1]Statistics based on samples from 43 wells.

The major source of the MBAS concentrations observed is believed to be septic tanks. The only other potential source is surfactants, which are also detected as MBAS and are used in pesticide applications for agricultural activities. The typical agricultural usage, though, is only a few ounces per 100 gallons of pesticide/water solution, which is spread over several acres. Because applications are generally made only once or twice a year, a reasonable estimate of agricultural application is about 1 ounce per acre per year. This is a small amount compared with the amount of laundry detergent used in just one household. Conservatively assuming 8 ounces of detergent used per week per household and a density of 250 residential units per square mile, the load of detergents from septic tanks could easily be as large as 160 ounces per acre per year.

In samples analyzed for concentrations of both nitrate and MBAS, the correlation coefficient between these two constituents is 0.85 (fig. 14). This degree of correlation implies that sources of nitrate and MBAS are similar. Whereas nitrate may have several sources including agricultural activities and septic systems, the only large source of MBAS is septic systems. Therefore, much, but not necessarily all, of the nitrate in the ground water of the unsewered, densely populated areas is also likely to be from septic systems.

The median concentration of boron was 10 µg/L. Samples from only 7 of the 44 wells had concentrations exceeding 20 µg/L (table 11). Six of the 7 wells were located in high-density residential unsewered areas with more than 250 residences per square mile. It would seem, therefore, that even these slightly elevated boron concentrations might be associated with septic systems. However, boron concentrations correlated poorly with nitrate and MBAS concentrations; good correlations would have been expected if septic systems were the true source. It is possible that boron may be transported by ground water differently than nitrate and MBAS, or that the elevated boron concentrations are merely due to natural causes. Natural boron concentrations in excess of 100 µg/L are not uncommon (Hem, 1985).

Most DOC concentrations were 1.0 mg/L or less. The median concentration was 0.4 mg/L, smaller than the value of 0.7 mg/L given by Thurman (1985) as the median concentration of DOC in ground waters throughout the United States. Samples from only four wells had concentrations exceeding 1.0 mg/L (table 11) and the maximum concentration was 3.1 mg/L. Of these four samples, one from well 18N/02W-04J08 also had a large boron concentration (70 µg/L), but boron concentrations in the other three samples, and nitrate and MBAS concentrations in all four samples, were not large (table 11). Overall, the correlations of DOC with nitrate, MBAS, and boron were poor. Given the diversity of sources and the lack of correlation with other septage-related compounds, it is difficult to attribute these few large concentrations of DOC to septic systems. In addition to the anthropogenic sources of DOC mentioned, there are several natural sources, including recent surficial organic matter and kerogen, the fossilized organic matter present in most aquifer materials (Thurman, 1985).

Bacteria

Bacteria were present in samples from 20 of the 359 wells and springs. Fecal coliform were present in 2 samples and fecal streptococci in 15 samples; 3 samples contained both types of bacteria. Median concentrations of fecal coliform and fecal streptococci bacteria were both less than 1 colony per 100 milliliters (table 12). Both types of bacteria are merely indicators; that is, they are not pathogenic themselves, but can occur in conjunction with pathogenic bacteria. Fecal coliform are the only bacteria for which a quantitative relation with a pathogen (salmonella) has been observed (Geldreich and Van Donsel, 1970).

Table 11. Analyses of samples containing elevated concentrations of septage-related compounds

[Concentrations are in milligrams per liter unless noted.. All except methylene blue active substances are dissolved. Wells shown had samples with concentrations exceeding one or more of the indicated "threshold" concentrations; µg/L, micrograms per liter; <, not detected at given concentration; --, not applicable]

Local well number	Date	Nitrate, dissolved, (mg/L as N)	Methylene blue active substances	Boron, dissolved (µg/L as B)	Carbon, organic, dissolved
Threshold concentration [1]		--	0.04	20	1.0
17N/01E-07H01	06-12-89	0.17	<.02	<10	1.7
17N/01E-14P01	06-16-89	1.5	.06	<10	.4
17N/01W-04E01	06-08-89	2.1	.05	10	.3
17N/02W-08L01	04-13-89	2.7	.05	<10	.5
17N/02W-11J01	04-13-89	2.8	.06	<10	.2
17N/02W-22A02	04-13-89	3.7	.07	<10	.3
17N/02W-29R01	04-13-89	<.10	<.02	20	1.2
18N/01W-07C01	04-28-89	3.1	.05	20	.3
18N/01W-11P05	06-21-89	5.6	.09	30	.5
	06-21-89	5.4	.07	40	.5
18N/01W-12F01	06-08-89	1.1	.04	30	.3
18N/01W-14L02	06-15-89	7.8	.21	30	.5
18N/01W-23B02	06-15-89	3.2	.05	10	.3
18N/01W-32P01	06-07-89	3.5	.04	30	.4
18N/01W-35G02	05-10-89	<.10	<.02	<10	3.1
18N/01W-36M02	05-10-89	5.0	.07	20	.3
18N/02W-04J08	04-26-89	<.10	.03	70	1.6
18N/02W-31J03	04-14-89	2.3	.03	40	.3
19N/02W-33K08	04-18-89	<.10	<.02	30	1.0
	04-18-89	<.10	<.02	20	.9

[1] Concentration above which the septage-related compounds were considered elevated. This was an arbitrary concentration based on the distribution of overall concentrations.

Table 12. Summary of concentrations of bacteria

[All concentrations in colonies per 100 milliliters; <, not detected at given concentration; >, concentration is greater than the given value]

Bacteria type	Concentrations: Minimum	Concentrations: Median	Concentrations: Maximum	Number of wells sampled	Number of wells with bacteria present	Number of springs with bacteria present
Fecal coliform	<1	<1	99	359	3	2
Fecal streptococci	<1	<1	>100	349	16	2

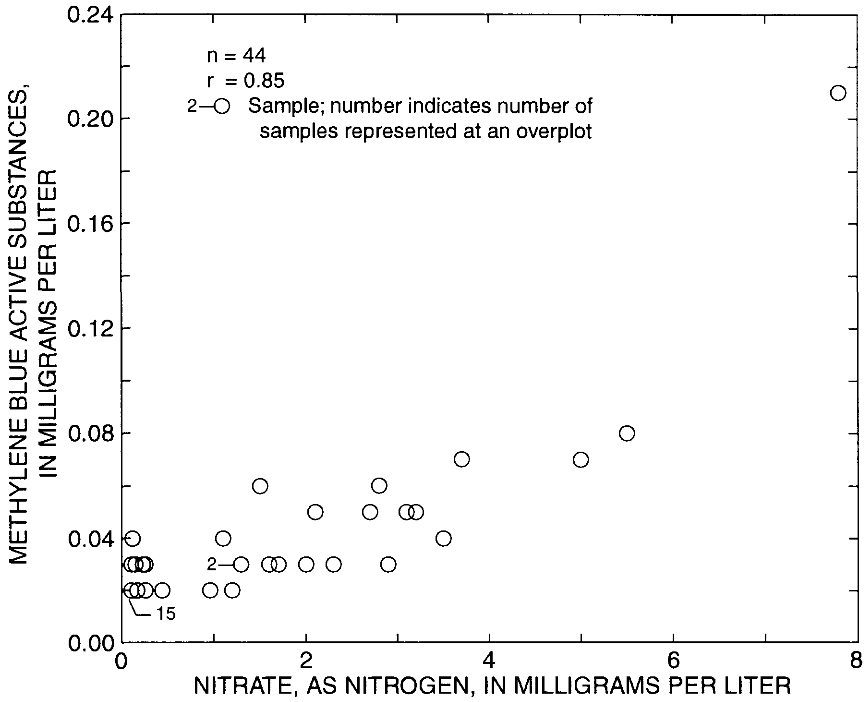


Figure 14. Comparison of nitrate and methylene blue active substances (MBAS).

The sites that contained bacteria are listed in table 13. The only results that are readily explainable are those for Abbott Springs (18N/01E-19J01S) and Allison Springs (18N/02W-18L01S). Samples from both springs were collected from ponds into which the springs discharge. These ponds are easily accessible to and extensively used by wildlife such as ducks, which are prolific sources of bacteria. The sources of bacteria in wells are more difficult to determine. Some of the wells containing bacteria, including 16N/02W-27H02, 19N/01W-18F01, and 19N/01W-29C02, are located near barns, which suggests that farm animals may be the source of the bacteria. Other wells may be near septic tanks, another potential source of bacteria. However, nitrate concentrations in most bacteria-contaminated wells were less than 1.0 mg/L, suggesting a source other than septic systems or animal wastes. Regardless of the source(s), the presence of bacteria in ground water in Thurston County was limited, and no areal patterns were evident.

Drinking Water Regulations

The USEPA has established drinking water regulations with several sets of laws and legislation. These regulations may be considered in two groups. Primary drinking water regulations generally concern chemicals that affect human health. The maximum concentration allowed for each constituent is referred to by USEPA as the maximum contaminant level, or MCL (U.S. Environmental Protection Agency, 1988a, 1988b, 1989), and is legally enforceable by the USEPA or State regulatory agencies. Secondary drinking water regulations (U.S. Environmental Protection Agency, 1988c) pertain to the esthetic quality of water and are guidelines only. A secondary maximum contaminant level, or SMCL, is not enforceable by a Federal agency. Both sets of regulations legally apply only to public supplies, but can also be used to help assess the quality of private systems.

Table 13. Concentrations of bacteria in samples where they were present

[mg/L, milligrams per liter; cols. per 100 mL, colonies per 100 milliliters; K, value based on non-ideal plate count; <, not detected at given concentration; >, concentration is greater than the given value; --, not applicable]

Local well number	Date	Geo-hydro-logic unit	Depth of well (feet)	Nitrate, dissolved, (mg/L as N)	Coli-form, fecal (cols. per 100 mL)	Strep-tococci, fecal (cols. per 100 mL)
16N/01E-18N01	06-20-89	Tb	100	0.98	<1	1
16N/02W-27H02	04-04-89	Qva	47	1.0	2	1
17N/01E-07H01	06-12-89	Qva	40	.17	<1	8
17N/01W-34E01D1	06-30-89	TQu	138	.11	<1	1
17N/02W-31H01	04-07-89	TQu	112	<.10	<1	<1
	04-07-89	TQu	112	<.10	<1	1
17N/03W-01G02	04-13-89	Qva	93	.93	<1	1
17N/03W-26F01	04-07-89	Qc	96	.63	<1	10
18N/01E-19J01S	06-19-89	Qvr	--	.15	>60	>100
18N/01W-03H02	06-14-89	Qc	233	1.4	<1	1
18N/01W-09J01	05-03-89	Qc	195	.44	<1	1
18N/01W-19M05	05-03-89	Qva	70	1.3	<1	1
18N/01W-33F01	05-04-89	Qva	62	1.3	<1	2
18N/01W-35L02	05-08-89	Qva	56	1.7	<1	19
18N/02W-18L01S	06-19-89	Qva	--	.74	K99	46
18N/03W-07L02	06-19-89	Tb	420	.60	1	<1
19N/01W-18F01	04-06-89	Qf	64	<.10	<1	47
19N/01W-20H01	04-13-89	Qc	178	.39	<1	1
19N/01W-29C02	04-06-89	Qc	152	.43	<1	11
19N/03W-12Q01	05-04-89	TQu	199	<.10	1	<1
	05-04-89	TQu	199	<.10	<1	<1
20N/01W-33L02	04-19-89	TQu	500	<.10	<1	>100

The drinking water regulations for all constituents determined in this study are shown in table 14. Because the regulations are subject to revision, this report uses the MCL or SMCL in effect at the time the samples were collected. Along with each MCL or SMCL, the number of wells from which samples did not meet the regulation is also shown in table 14.

The only primary MCL that was not met was the one for nitrate, in one sample from well 17N/01W-16E02, which had a nitrate concentration of 19 mg/L. Although less than the MCL of 10 mg/L, the nitrate concentration in well 17N/01E-13M02 was 9.9 mg/L. The nitrate MCL is based on the concentration that can cause methemoglobinemia in infants. This disease can result in suffocation because the oxygen-carrying capacity of hemoglobin is impaired by large concentrations of nitrate in the blood. Older children and adults generally are not affected at these levels.

Although total coliform bacteria were not analyzed for, the presence of fecal coliform bacteria in samples from five sites implies that the MCL for total coliform was exceeded. The presence of fecal coliform bacteria suggests some type of fecal contamination, and as such is considered a drinking water problem.

Table 14. Drinking-water regulations and the number of samples not meeting them

[mg/L, milligram per liter; µg/L, micrograms per liter; cols. per 100 mL, colonies per 100 milliliters]

Constituent	Maximum contaminant level (MCL) or secondary MCL (SMCL)	Number of wells with samples not meeting MCL or SMCL	Percentage of wells not meeting MCL or SMCL	Total number of wells sampled
	Primary drinking-water regulations			
Inorganic				
Fluoride	4 mg/L	0	0	359
Nitrate (as nitrogen)	10 mg/L	1	.3	359
Arsenic	50 µg/L	0	0	47
Barium	1,000 µg/L	0	0	47
Cadmium	10 µg/L	0	0	47
Chromium	50 µg/L	0	0	47
Lead	50 µg/L	0	0	47
Mercury	2 µg/L	0	0	47
Selenium	10 µg/L	0	0	47
Silver	50 µg/L	0	0	47
Organic				
Trihalomethanes[1]	100 µg/L	0	0	46
Tetrachloromethane	5 µg/L	0	0	46
1,2-dichloroethane	5 µg/L	0	0	46
1,1,1-trichloroethane	200 µg/L	0	0	46
Chloroethene	2 µg/L	0	0	46
1,1-dichloroethane	7 µg/L	0	0	46
Trichloroethene	5 µg/L	0	0	46
Benzene	5 µg/L	0	0	46
1,4-dichlorobenzene	75 µg/L	0	0	46
Microbiological				
Total coliform[2]	0 cols. per 100 mL	5	1	359
	Secondary drinking-water regulations			
Inorganic				
pH	6.5-8.5 units	34	9	359
Sulfate	250 mg/L	0	0	359
Chloride	250 mg/L	11	2	461
Fluoride	2 mg/L	0	0	359
Dissolved solids	500 mg/L	6	2	359
Iron	300 µg/L	57	16	359
Manganese	50 µg/L	107	30	359
Copper	1,000 µg/L	0	0	47
Zinc	5,000 µg/L	0	0	47
Organic				
MBAS (methylene blue	0.5 mg/L	0	0	44

[1]Includes trichloromethane, tribromomethane, bromodichloromethane, and dibromochloromethane.

[2]The presence of fecal coliform bacteria constitutes an implied violation of this MCL.

The most important SMCL's that were not met may be those for chloride and dissolved solids, because large concentrations of these constituents in ground waters in the study area usually suggest seawater intrusion. The chloride SMCL of 250 mg/L was not met in samples from 11 of 461 wells, or 2 percent. Of these, 5 wells were from the group of 359 sampled for all common constituents, and 6 were from the 102 coastal wells sampled for chloride only. Only one of the 11 wells, 16N/02W-05R01, was located far enough from the coast that intrusion was unlikely. This is the well believed to be affected by connate seawater from the McIntosh Formation. The SMCL for chloride is the level at which the taste of the water may be affected.

Of the six water samples that did not meet the dissolved-solids SMCL of 500 mg/L, five also did not meet the chloride SMCL. The large dissolved-solids concentration in the sixth well, 19N/01W-32B01, most likely was due to a large alkalinity concentration. Four of the five wells that also did not meet the chloride SMCL were probably intruded with seawater. The exception was well 16N/02W-05R01, likely affected by connate seawater. Like chloride, the SMCL for dissolved solids is based largely on taste, although other undesirable properties such as corrosiveness or hardness may be associated with large dissolved-solids concentrations.

More samples did not meet the SMCL for manganese (50 μg/L) than for any other constituent: samples from 107, or 30 percent, of the 359 wells sampled. However, as described elsewhere, these large manganese concentrations occur naturally and are common. The SMCL for manganese is based on the level at which staining of laundry and plumbing fixtures may occur; the stain is usually black or purple. The taste of the water may also be affected at concentrations greater than 50 μg/L. Extremely large concentrations of manganese may cause human health problems, but no such instances have ever been reported in the United States (U.S. Environmental Protection Agency, 1986).

Concentrations of iron in samples from 57 wells, or 16 percent, did not meet the SMCL for iron of 300 μg/L. As with manganese, these large concentrations are likely due to natural causes. Iron concentrations exceeding the SMCL may cause objectionable tastes and may stain plumbing fixtures a characteristic red or brown color. Some industrial applications, such as paper production, food processing, and chemical production, may require concentrations less than 300 μg/L.

Samples from 34 wells, or 9 percent, had pH values outside the acceptable range of 6.5 to 8.5 (U.S. Environmental Protection Agency, 1986). Of these, 29 had values less than 6.5 and 5 had values greater than 8.5. Samples from another 19 wells had pH values equal to 6.5. A broader pH range from 5 to 9 is often considered acceptable for domestic supplies because water in this range is readily treatable (U.S. Environmental Protection Agency, 1986). Samples from only four wells were above this range and none had a pH value below this range. Small pH values may be corrosive to pipes and plumbing and can increase copper, lead, zinc, and cadmium concentrations. Large pH values may adversely affect the chlorination process and may cause carbonate to deposit in pipes.

All other applicable USEPA drinking water regulations were met. Note, however, that even though the MCL for a particular regulation was met, the constituent may have been present in concentrations smaller than the MCL, indicating a potential water-quality problem. This is especially true for the organic compounds 1,1,1-trichloroethane, 1,1-dichloroethene, trichloroethene, benzene, and MBAS. As discussed previously in this report, the nature of these compounds is such that their mere presence indicates some degree of contamination.

For more information on drinking water regulations, the reader is referred to documents of the U.S. Environmental Protection Agency (1976, 1986, 1988a, 1988b, 1988c, 1989).

Variations of Water Quality at Times of High and Low Water Levels

Samples were collected from 26 wells and 2 springs in the area between McAllister Springs and Lake St. Clair during November 1988, before the entire study area was sampled in spring 1989. These samples were collected to provide background data from the McAllister Springs area for the Thurston County Health Department. Because 23 of the 26 wells and the 2 springs (Abbott and McAllister) were resampled in the 1989 effort, the variation of water quality at times of high and low water levels can be examined for this area.

In general, there were no large differences between constituent concentrations in samples collected in late 1988 and in early 1989. Most of the paired concentrations (from 1988 and 1989) differed by less than 10 percent. For some constituents, such as dissolved oxygen, sulfate, nitrate, and iron, concentration pairs from several wells differed by more than 10 percent, but for most of these cases, concentrations were small and the absolute difference in concentration also was small. Even when the differences were considered large, such as for the nitrate data (table 15), the differences appear to be limited to specific wells, and no areal trend could be discerned. The data from each well sampled in November 1988, along with data collected from these same wells in spring 1989, are listed in Appendix C.

Although differences in these samples are few, there still may be some unobserved seasonal variations or long-term trends in the study area. Only two data points have been considered for each of the wells discussed, and usually more data are needed to discern seasonal variations. Many more data over several years are needed to determine trends.

Table 15. Wells with samples that had large differences in nitrate concentrations between 1988 and 1989

[mg/L, milligrams per liter]

Local well number	Date	Nitrate, dissolved, (mg/L as N)
17N/01W-01F01	11-14-88	2.3
	05-16-89	1.6
18N/01E-30C01	11-19-88	1.3
	06-24-89	2.2
18N/01W-36M02	11-14-88	3.7
	05-10-89	5.0

Water-Quality Problems

Several occurrences of large concentrations of certain constituents in the ground waters of Thurston County have been identified and attributed to one or more sources. Some of these large concentrations are a health concern; others affect only the esthetic qualities of the water. In either instance, a water-quality problem or concern exists, and to understand the problem it is helpful to understand its source, if known, and how it affects water quality and water chemistry. A complete description of all the sources of water-quality problems in Thurston County is beyond the scope of this report. However, brief discussions of the more important ground-water quality problems are presented below. The extent and severity of water-quality problems depend not only on the source, but on many geohydrologic conditions, including aquifer mineralogy, ground-water flow direction and rate, depth to water, recharge rate, and water chemistry.

Seawater Intrusion

Wells in coastal areas are at risk of pumping some seawater because the ground water at depth in these areas may consist partly, or wholly, of water from Puget Sound. In addition to larger concentrations of sodium and chloride, intrusion of seawater into wells can also lead to increased concentrations of calcium, magnesium, potassium, sulfate, barium, and some trace elements. Once seawater intrudes an aquifer, it may be difficult and expensive to control or reverse the condition. Because ground water moves slowly, remedial measures may require years or decades to take effect.

In about 1900, hydrologists working along coastal areas of Europe observed that seawater occurred beneath fresh ground water not at sea level, but at a depth below sea level of about 40 times the height of the freshwater above sea level. The freshwater appeared to "float" on the seawater as a lens- or wedge-shaped body. This relation, known as the Ghyben-Herzberg principle after the two scientists who first described it, occurs because the density of freshwater is slightly less than the density of seawater. The principle assumes static ground-water conditions and a sharp boundary between freshwater and saltwater.

The result of this effect is somewhat different for Puget Sound, where the water is slightly more dilute and less dense (1.020 grams per milliliter) than typical seawater (1.025 grams per milliliter) due to freshwater inflow (Wagner and others, 1957). Applying the Ghyben-Herzberg principle to locations along Puget Sound, for every 1 foot of altitude that the water table is above sea level, fresh ground water will extend about 50 feet below sea level. For example, if the water table at a given site is 3.0 feet above sea level, the freshwater-seawater boundary is theoretically 150 feet below sea level. The thickness of the freshwater body is, therefore, 153 feet at that site. The principle also implies that if the water table in an aquifer is lowered 1 foot, the boundary will rise 50 feet, thereby reducing the total thickness of the freshwater layer by 51 feet.

In addition to the relative densities of freshwater and seawater, the position of the boundary at any one time is also affected by tides, the seasonal position of the water table, the hydraulic characteristics of the aquifer, and recharge-discharge relations within the aquifer. The boundary is seldom sharp, but rather is a "zone of transition" in which the chloride concentration gradually increases from that of freshwater to that of the surrounding salt water body. This zone may be narrow or broad, depending on the hydraulic characteristics of the aquifer and other factors. Because the position of the boundary is a function of recharge, discharge, and the spatial variation of aquifer hydraulic characteristics, the Ghyben-Herzberg principle should only be used to provide an approximate position of the transition zone.

Under natural conditions, the altitude of the water table in a coastal area is higher than sea level and decreases toward the shoreline; if recharge and discharge are in equilibrium, the boundary (zone of transition) is maintained in a relatively constant position (fig. 15). Freshwater under these conditions will move downgradient toward the sea and eventually, if not intercepted by pumping wells, discharge to low-lying coastal areas and to the sea. When the freshwater gradient is decreased or reversed, such as by pumping from wells, the seaward flow of freshwater is decreased and the boundary moves landward and upward. Conversely, when water levels increase, the boundary moves seaward and downward.

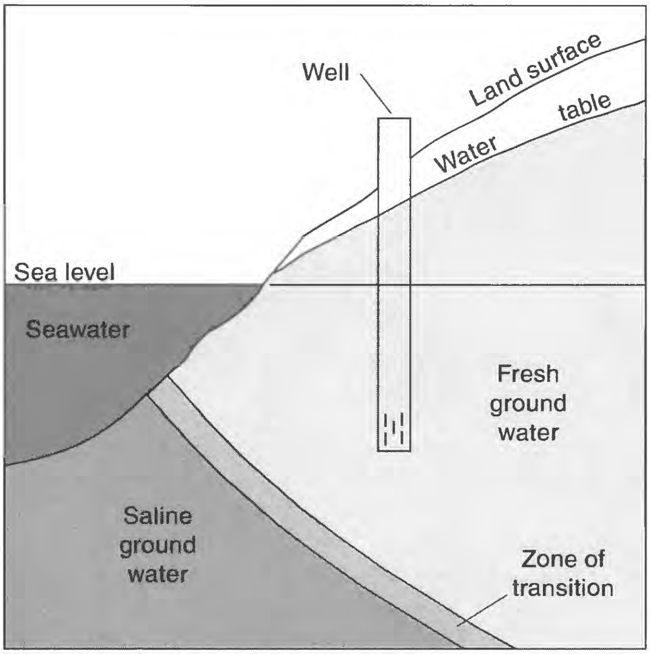
The saline water surrounding the Thurston County shoreline typically contains about 15,000 mg/L of chloride (Wagner and others, 1957); uncontaminated ground water in most coastal areas of Washington generally contains less than 10 mg/L of chloride (Dion and Sumioka, 1984). Chloride is chemically stable and will move through the saturated zone of an aquifer at virtually the same rate as intruding seawater. For this reason, chloride serves as a good indicator of seawater intrusion.

In this study, chloride concentrations were 5 mg/L or less in samples from 77 percent of all wells. This concentration can be considered a maximum "background" level. Concentrations in excess of 5 mg/L may be due to intrusion, but only if the samples are from wells completed below sea level and located along the coast. Twenty-nine of 73 samples with chloride concentrations from 5.1 to 50 mg/L can be attributed to such coastal wells; the other 44 samples came from wells too far inland to be intruded. The chloride concentration at which a well is intruded is uncertain but is likely within this range. Thus a chloride concentration of 50 mg/L was conservatively selected as the level above which a coastal well can be considered intruded. Of 32 samples with chloride concentrations larger than 50 mg/L, 25 were from coastal wells.

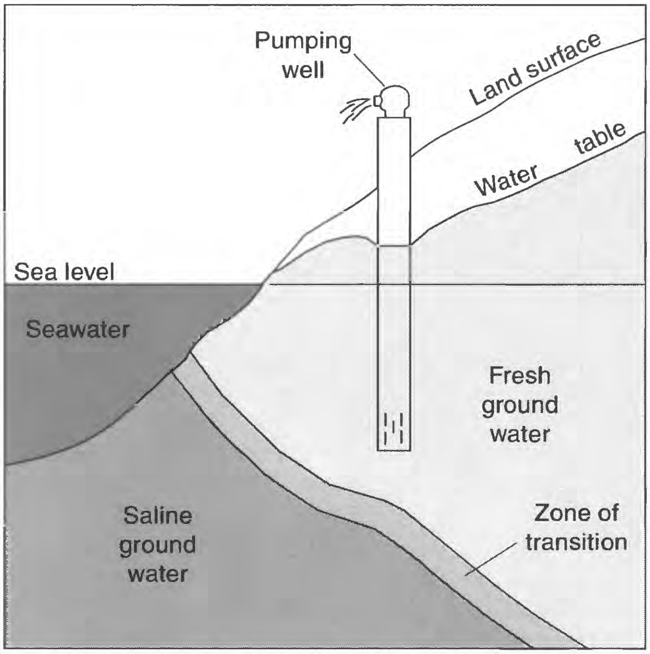
The coastal areas where chloride concentrations in some wells exceeded 50 mg/L were identified previously as the northeastern and western shores of Johnson Point peninsula, the northern shore of Boston Harbor peninsula, the northern half of Cooper Point peninsula, the northern end of Griffin peninsula, and the area around the southern end of Mud Bay (pl. 6). Seawater intrusion does not appear to occur selectively in any particular geohydrologic unit (among the units present along the shorelines) or at any particular depth or altitude. Intrusion occurs in both Qc and TQu, the units most heavily pumped along the coast. Chloride concentrations larger than 50 mg/L occurred in wells completed at altitudes (horizons) of -12 to -235 feet (relative to sea level).

Samples from coastal wells completed at similar altitudes and near each other were found to have widely varying chloride concentrations. Samples from wells 19N/01W-10L02 and 19N/01W-10Q02 had chloride concentrations greater than 300 mg/L; however, the sample from well 19N/01W-15G01, which is about half a mile south, had a concentration of only 3.0 mg/L. All three wells are completed at altitudes of -40 to -55 feet, the first two in Qc and the latter in TQu. Likewise, a sample from well 19N/01W-20G01 had a chloride concentration of 92 mg/L, but a sample from well 19N/01W-20R03 had a concentration of only 1.2 mg/L. Both wells are completed in Qc at altitudes 19 feet apart. It is evident that the occurrences of intrusion can vary widely and are probably affected more by pumping patterns and (or) heterogeneities in local geologic conditions than by regional geohydrologic features.

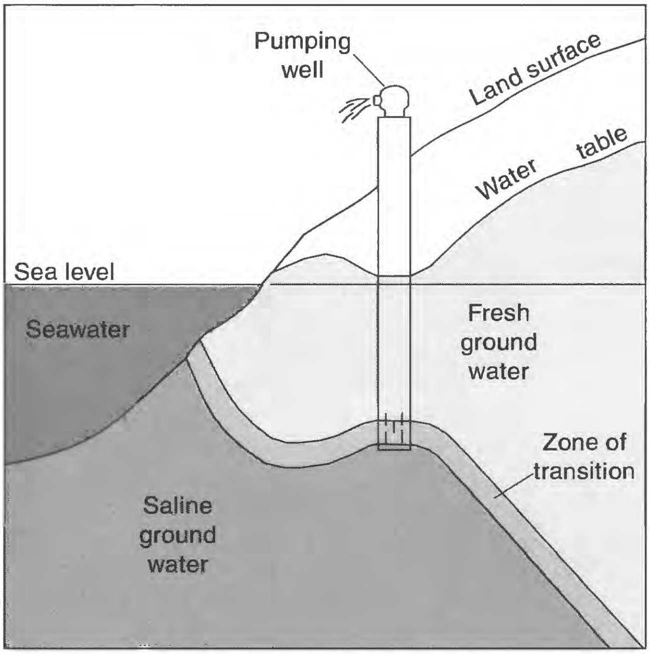
The degree of intrusion does not appear to be changing significantly with time over widespread areas. Except for Johnson Point peninsula, all of the areas identified as being intruded in this study were also identified by Noble and Wallace (1966) as being intruded in 1961. A comparison of chloride concentrations in samples collected from 112 wells sampled during this study and in 1978 (Appendix C, table C6) showed that concentrations in samples from 57 wells differed by 10 percent or less (table 16). The differences for another 29 wells were greater than 10 percent, but chloride concentrations were 5.0 mg/L or less for both samples, so the actual concentration differences were small. Only 26 pairs differed by more than 10 percent and had concentrations larger than 5.0 mg/L. Interestingly, of these 26, 12 showed an increase from 1978 to 1989 and 14 showed a decrease. Of 17 pairs where concentrations were more than 50 mg/L, signifying seawater intrusion, 11 differed by more than 10 percent; however, 7 showed an increase and 10 showed either a decrease or no change. Overall, samples from 57 wells showed an increase and samples from 55 wells either a decrease or no change. No clear direction or magnitude of change is apparent. This comparison does not take into consideration any natural seasonal, tidal, or other cyclical variations in concentration. Changes in the degree of intrusion for an individual well may be more or less than that determined by this limited comparison.



Nonpumping well in an unconfined (water-table) aquifer under conditions of equilibrium--no intrusion has occurred.



Well pumping from an unconfined (water-table) aquifer--seawater intrusion not affecting salinity of pumped water.



Well pumping from an unconfined aquifer--seawater intrusion affecting salinity of pumped water.

Figure 15. Hypothetical hydrologic conditions before and after seawater intrusion.

Table 16. Summary of comparison of chloride concentrations for samples collected in 1978 and 1989 from 112 coastal wells

[≤, less than or equal to, >, greater than]

Difference between 1978 and 1989 chloride concentrations, in percent	Number of wells	Number of wells where chloride		
		Increased	Decreased	Unchanged
≤10	57	24	27	6
>10, but concentrations <5.0 milligrams per liter	29	21	8	0
11-20	9	3	6	0
21-50	9	5	4	0
>50	8	4	4	0
Totals	112	57	49	6
Difference between 1978 and 1989 chloride concentrations, in percent, where one or both values exceeded 50 milligrams per liter, and therefore likely indicate intrusion by seawater				
≤10	6	4	0	2
11-20	4	0	4	0
21-50	5	3	2	0
>50	2	0	2	0
Totals	17	7	8	2

Agricultural Activities

Agricultural activities can lead to several types of water-quality problems, most commonly the presence of various nitrogen species, pesticides and associated compounds, and bacteria. Sulfate, chloride, and phosphorous also may be present. Most problems are related to fertilizers, pesticides, or barnyard wastes.

Virtually all fertilizers include some type of nitrogen in the form of ammonia or nitrate. In some, the nitrogen is part of a solid organic compound and is released over several days or weeks to the soil; in others an aqueous solution of nitrogen, usually as ammonia, is injected directly into the soil and is released immediately. Any ammonia is usually converted by bacteria to nitrite and then to nitrate in the process of nitrification. Nitrate, whether applied or converted from ammonia, then is taken up by the crops. Any remaining nitrate can be transported by water percolating down through the soil and the unsaturated zone to the water table. Nitrate generally does not sorb, or attach, to the aquifer material, therefore it is transported at a rate similar to that of the ground water. In some instances, unconverted ammonia may be transported to the ground water also, either as ammonium ion or as an organic ammonia compound. Ammonia tends to sorb to soil particles, so it may not be transported as quickly as nitrate. Usually, any ammonium or ammonia compound reaching the ground water ultimately will be converted to nitrate. Fertilizers also contain other chemicals that may be introduced into the ground water, such as potassium, sulfate, and phosphorous, but the resulting concentrations are usually small compared with those of nitrate.

Barnyard wastes, including those from dairies and feedlots, contain urea, chloride, and bacteria, along with other constituents in smaller quantities. Urea eventually is converted to nitrate, which is transported in the aquifer in a manner similar to nitrate from fertilizers. Chloride is generally unreactive and will also be transported to the water table. Many different types of bacteria are present in barnyard wastes, including the indicator bacteria (fecal coliform and fecal streptococci) analyzed for in this study. Their viability while being transported to and within the ground water depends greatly on such factors as water temperature and depth to water. Sodium, potassium, sulfate, and phosphorous are among the other constituents that may also be transported to the ground water from barnyard wastes, but natural sources generally mask these contributions.

The transport of pesticides and their associated compounds to the ground water is complex. Most pesticides undergo chemical and biological transformations as part of one or more of the following processes: biodegradation, photolysis, hydrolysis, or oxidation. The products of these reactions may be as great a contamination problem as the original pesticide. Also, solvents or carriers, such as toluene, are applied with pesticides to assure an even application of the pesticide. The transport of all these pesticide-related compounds is affected by physical processes such as dissolution in the water, sorption to aquifer material, and volatilization to the atmosphere as soil gas. Because of these factors of pesticide transport and all of the geohydrologic variables, the occurrence of pesticides in ground water can vary widely over both space and time. Additionally, pesticides can remain a water-quality problem for many years.

The most serious agriculture-related water-quality problem identified during this study was the presence of pesticides in ground water. The pesticides 1,2-dibromoethane (EDB), 1,2-dichloropropane, and 1,2-dibromo-3-chloropropane were detected in samples from wells along the southwestern shore of Pattison Lake. These same pesticides were previously reported in samples from wells about 3 miles east, just south of Lake St. Clair, in an area where the pesticides had been applied on strawberry fields. In this latter case, alternative water supplies were required for several residences with contaminated wells. (The presence of EDB near Lake St. Clair was not investigated as part of this study because it had been addressed as part of another study and was under litigation at the time.)

Barnyard wastes probably contributed to elevated nitrate concentrations in some small areas. However, large areas of elevated nitrate concentrations, such as those east and southeast of Lacey, are not likely due to agricultural sources, but rather to septic systems. Isolated bacterial problems in the general study area may also be due to barnyard wastes.

A group of agricultural activities that was outside the scope of this study and is not included in the above assessment is sometimes referred to as "hobby farming." This includes agricultural activities similar to those discussed, but on a smaller scale for private rather than commercial use. Examples include backyard gardens, pet pens or corrals, and lawns. Most hobby farms are in suburban or urban areas, and as such are not considered commercial agricultural activities. However, pesticide and fertilizer use is extensive and these chemicals are often overapplied because of a lack of knowledge, experience, or motive for cost effectiveness. Little documentation has been done on hobby farming, but researchers have reported that urban lawn fertilizers may contribute as much nitrate to ground water as do septic systems (Porter, 1980).

Septic Systems

A septic system, consisting of a septic tank and drainfield, can be a source of several constituents in groundwater. The most familiar of these is nitrate, but others include sodium, potassium, sulfate, chloride, phosphorous, ammonia, boron, MBAS, and bacteria. Because septic systems are used virtually everywhere that central sewer systems are not available, they are a widespread source of these constituents and may remain so long after they are abandoned.

In the operation of a septic system, household sewage is piped into a tank that typically has a capacity of approximately 1,000 to 1,500 gallons for a single household unit. In the tank, solids settle to the bottom and liquids discharge to a drainfield, which is a subsurface trench filled with permeable material such as sand or gravel. The drainfield allows the liquid to infiltrate the natural soil or geologic formation over a large area. Ultimately, the effluent percolates down through the unsaturated zone. Where septic tanks are used in densely populated areas, the combined discharge from them may be a large component of the total ground-water recharge.

Once in the unsaturated zone, the individual constituents in the effluent are susceptible to the same chemical and biological transformations as constituents that originate at land surface. Urea is transformed by bacteria to ammonia and eventually to nitrate. The nitrate, along with chloride, then flows through the aquifer at virtually the same rate as the ground water. Sodium, potassium, sulfate, MBAS, and other constituents, however, may undergo sorption, ion exchange, or degradation reactions that can hinder their transport to and within the ground-water body.

The good correlation between MBAS and nitrate concentrations (fig. 14) suggests that septic systems were the source of much of the nitrate found in Thurston County ground water. As discussed in previous sections, the large areas where nitrate concentrations were in excess of 2.0 mg/L are, for the most part, densely populated areas where septic systems are common. Isolated concentrations of nitrate in excess of 1.0 mg/L may be from individual septic systems, but could also be from local agricultural activities.

Commercial and Industrial Activities

Many widespread commercial and industrial activities in Thurston County use chemicals that are potential sources of ground-water contaminants. Service stations are potential sources of benzene and other hydrocarbon compounds from fuels and oils. Dry cleaners and paint shops are potential sources of solvents such as 1,1,1-trichloroethane and trichloroethene. Solvents, along with metals such as chromium, copper, zinc, and lead, can come from electronic, machine, and automotive-repair shops. Parking lots and roads may also be sources of many of these chemicals. In general, most of the chemicals are volatile organic compounds or trace elements. Industrial activities such as shipping, manufacturing, and food processing can also be sources of these chemicals, but there are few of these activities in Thurston County.

Chemicals are sometimes spilled or dumped onto the ground, where they are dissolved or otherwise incorporated into the recharge water. In the case of large spills of liquids, such as fuels or oils, the chemical itself may travel into the unsaturated zone unaltered. In other instances the chemical may reach the ground water only after being subjected to physical or chemical transformation processes, such as volatilization, sorption, biodegradation, hydrolysis, or oxidation. As a result, the contaminants in ground water may eventually include any of the initially spilled compounds or their transformation products.

Contamination of ground water in Thurston County by commercial and industrial activities was apparently minimal at the time these samples were collected. Of six samples found to contain volatile organic compounds, four were from wells located north and east of Lacey in commercial or industrial areas. Potential sources of the chemicals are different for each well and were likely from the types of activities described in this section. No large concentrations of trace elements were associated with these activities.

Because this study was designed to determine large-scale areal variability, it is unlikely that all areas of contamination by commercial and (or) industrial activity in northern Thurston County were discovered. Sources are generally isolated, therefore areas contaminated as a result of commercial or industrial activity are typically small. On the scale of this study, the areal density of sampled wells was too low to detect small contaminated areas.

Natural Conditions

Most of the water-quality problems in the study area were attributable to natural conditions. Large concentrations of iron and manganese are the most widespread natural problems. Connate water with large chloride concentrations is another naturally occurring water-quality problem. Fortunately, most of these problems are esthetic and not health threatening.

BENEFITS OF MONITORING AND POSSIBLE ADDITIONAL STUDIES

The long-term effects of various ground-water management alternatives and of changing land-use conditions in northern Thurston County could be monitored by the establishment of a water-level measurement and water-sampling network. Water-level declines beyond those expected for seasonal or climatic reasons could provide an early warning of ground-water overdrafts; water-quality degradation could indicate the need to revise land-use controls or other management practices.

A long-term cost-effective monitoring program would include measuring water levels in selected wells every 2–3 years in spring and autumn, corresponding to times when water levels in shallow wells are at their seasonal highs and lows, respectively. One-third of the wells could be measured annually. More frequent measurements could be made as desired or needed. The aquifers of greatest concern would be those that are the most heavily used for ground-water supplies. Observation wells could be selected to provide broad geographic coverage of the aquifers of concern, with emphasis on the areas of greatest ground-water withdrawal.

A minimum water-quality monitoring program would include the periodic collection of samples for the analysis of nitrate, chloride, and bacteria. An expanded program could include analyses for concentrations of common ions, trace elements, and organic compounds (including pesticides). Samples would be collected from the areas east and southeast of Lacey, immediately upgradient of McAllister Springs, and in rapidly growing residential areas that depend on septic systems, to determine the temporal trends of nitrate concentrations.

Samples from coastal wells finished below sea level would be analyzed for chloride concentrations in order to detect incipient seawater intrusion. A gradual increase in chloride concentrations with time, or concentrations in excess of normal seasonal highs, could be interpreted as evidence of seawater intrusion.

The monitoring program proposed above would be reviewed periodically to evaluate the number and locations of wells and the frequency of their measurement and sampling. This evaluation would reflect changing cultural, managerial, and hydrologic conditions. Modifications could be made, but ideally would be kept to a minimum because the long-term success of a monitoring program depends in part on continuity.

The large chloride concentrations thought to be associated with marine rocks could be investigated further. In particular, additional wells in the vicinity of Offutt Lake could be sampled to determine the extent of the large chloride concentrations, and a more thorough study made to determine the cause.

The occurrences of moderate concentrations of volatile organic compounds in samples from six wells in the eastern part of the study area could be investigated in greater detail. Individual, focused studies would be needed for each occurrence.

Although excessive concentrations of iron and manganese pose no health risk and are controlled primarily by natural geochemical reactions, their presence is annoying and considerable time and money is spent by well owners to avoid or minimize their effects. A study to determine the specific conditions and processes that contribute to large iron and manganese concentrations in western Washington would be of interest.

SUMMARY AND CONCLUSIONS

Northern Thurston County is underlain by as much as 1,800 feet of unconsolidated glacial and nonglacial deposits of Pleistocene age. Beneath these unconsolidated deposits is bedrock, composed of consolidated rocks of Eocene to Miocene age. Interpretation of 17 preliminary geologic sections and about 1,140 drillers' logs led to the delineation of 7 major geohydrologic units. Six of the geohydrologic units are in the unconsolidated deposits. In general, the unconsolidated deposits are lithologically varied and most geohydrologic units have limited vertical and lateral extent. More than 90 percent of the wells used to collect geologic and hydrologic data for this study are completed in the uppermost 250 feet of the Quaternary deposits.

Although four coarse-grained geohydrologic units (Qvr, Qva, Qc, and TQu) function as the principal aquifers of the study area, usable quantities of ground water can also be obtained from units Qvt, Qf, and the bedrock (Tb). Even though the fine-grained units generally function as confining beds, numerous wells produce water from thin, local lenses of sand or gravel within them.

Water-level data indicate that ground water in the principal aquifers of the study area generally moves laterally to the marine shoreline and to major surface drainage channels. Beneath the upland areas, ground water has a downward vertical component; along the marine shorelines and the major drainage channels, ground water has an upward vertical component.

Discharge from the ground-water system occurs as seepage to streams, springs, and coastal bluffs; as evaporation from soils and transpiration by plants; as underflow (submarine seepage to Puget Sound and flow to ground water outside of the study-area boundary); and as withdrawals from wells.

More than 33,000 acre-ft/yr of ground water discharges as springs from the GWMA. Approximately 21,000 acre-feet of water was withdrawn from the ground-water system of the GWMA through wells in 1988. Total ground-water use was approximately 37,000 acre-ft. About 16,000 acre-feet of the water that discharges through springs was used together with water withdrawn by wells for domestic supply, agricultural, commercial, industrial, institutional, and aquaculture and livestock uses.

The chemical quality of ground water in the study area is generally good, and 94 percent of the water samples were classified as soft or moderately hard. Dissolved-solids concentrations tended to be higher in the lower units as is typical of glacial deposits in western Washington. The major cations were calcium and magnesium and the major anion was bicarbonate. Calcium/bicarbonate and calcium-magnesium/bicarbonate were the most common water types.

Perhaps the most widespread anthropogenic water-quality problem is seawater intrusion, which has resulted in local chloride concentrations as large as 570 mg/L. For this study, areas in which seawater has intruded were defined as coastal areas where concentrations of chloride exceeded 50 mg/L. Such concentrations were found on the northeastern and western shores of Johnson Point peninsula, the northern shore of Boston Harbor peninsula, the northern half of Cooper Point peninsula, the northern tip of Griffin peninsula, and near the southern end of Mud Bay. However, there are many coastal areas where no intrusion is evident. A comparison with data from 1978 gives no indication that the degree and extent of intrusion have changed significantly in the sampled wells since that time.

Agricultural activities may be responsible for the presence of pesticides in samples from two wells southwest of Pattison Lake. The pesticides detected were 1,2-dibromoethane (EDB), 1,2-dichloropropane, and 1,2-dibromo-3-chloropropane, and are the same ones previously detected in samples from wells about 3 miles east, south of Lake St. Clair. Barnyard wastes may contribute to elevated nitrate concentrations locally and to isolated bacteria problems. However, large areas of elevated nitrate concentrations likely are not a result of agricultural activities.

Septic systems are probably the largest contributors of nitrate to the ground-water system of northern Thurston County. Even though the median nitrate concentration was 0.33 mg/L, some areas have nitrate concentrations in excess of 2.0 mg/L. These areas are east, southeast, and south of Lacey, and south of Tumwater, and all areas of relatively high housing density and septic tank use. Concentrations of detergents correlated well (correlation coefficient of 0.85) with nitrate concentrations, implying a common source. Because septic tanks are the only major source of detergents, this correlation is evidence that much of the nitrate likely comes from septic systems.

Most water-quality problems in northern Thurston County result from natural causes. Iron concentrations were as large as 21,000 µg/L, and manganese concentrations were as large as 3,400 µg/L. At these levels, the taste of water may be adversely affected and plumbing fixtures may be stained red, brown, or black. These problems were evident throughout the county and are common in western Washington ground waters. These large concentrations are due largely to the dissolution of naturally occurring iron and manganese in the aquifer minerals.

Another natural water-quality problem is the presence of connate seawater in the southern part of the study area. There, Tertiary marine rocks of the McIntosh Formation, which are naturally high in chloride, are exposed or are just beneath the surface. Water from this formation probably flows into the overlying unconsolidated deposits, causing varying degrees of salinity in some wells.

Concentrations of selected constituents were compared with maximum contaminant levels, or MCLs, for applicable USEPA drinking water regulations. The only primary MCL that was not met in all cases was the one for nitrate, which is 10 mg/L. The secondary maximum contaminant level (SMCL) of 250 mg/L for chloride was not met in samples from 11 of 461 wells (2 percent), 10 of which were from wells most likely affected by seawater intrusion. More samples did not meet the SMCL for manganese than for any other standard. Some 30 percent of all wells had samples that did not meet the manganese SMCL of 50 µg/L. Likewise, 16 percent did not meet the SMCL of 300 µg/L for iron.

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Appendix A. Physical and hydrologic data for the wells and springs used in this study

Table A1. Well and spring records for the study area

EXPLANATION

Land surface altitude:	Reported in feet above sea level.
Well depth:	Reported in feet below land surface.
Water use:	Primary water use: C, commercial; F, fire protection; H, domestic; I, irrigation; N, industrial; P, public supply; Q, aquaculture; S, stock; T, institutional; U, unused.
Geohydrologic unit:	Geohydrologic unit tapped by well (see table 1): Mlt, well taps multiple units; --, unit tapped not determined.
Water level:	Reported in feet below land surface. Minus sign indicates water level above land surface. Water levels measured by U.S. Geological Survey are reported to nearest 0.1 foot for electric tapes and to nearest 0.01 foot for steel tapes. Reported water levels to nearest foot. Water-level status; F, flowing; P, pumping; R, recently pumped; S, nearby well pumping; Z, status uncertain.
Date:	Date of water-level measurement. See table A3 for additional water-level data.
Hydraulic conductivity:	Reported in feet per day. Calculated from specific-capacity data.
Remarks:	D, driller's log available; G, geologist's log available; X, used in constructing geologic section (plate 1); W, project observation well for water level; I, sampled for major ions, bacteria: M, sampled for major ions, bacteria, trace metals; O, sampled for major ions, bacteria, trace metals, volatile organic compounds; S, sampled for major ions, bacteria, detergents, boron, dissolved-organic carbon; C, sampled for chloride and specific conductance only.

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
16N/01E-02B01	KRONENBERG, BOB	390	80	H	Qva	57	05-00-89	--	D
16N/01E-02F01	ROCHESTER, DALE & SHARON	420	235	H	Qc	130	02-09-89	--	D
16N/01E-02N02	CROSBY, GENE	440	183	U	Qc	141	09-07-88	--	D
16N/01E-04D01	ASCHENBRENNER, DAN	490	223	H	Qc	190	09-06-85	71	D
16N/01E-04E02	MCFERRON, GARY	490	246	H	Qc	210	10-00-87	--	D
16N/01E-05F01	BAKER, ROBERT	518	274	H	Qc	220.92	11-09-88	37	D,I
16N/01E-05F02	DURHAM, THOMAS	515	240	H	Qc	211.05	10-28-88	120	D
16N/01E-05K02	DRUTHER, EDWARD	507	280	H	Qc	203	03-01-78	41	D
16N/01E-05M01	MCDANIELS	500	260	H	Qf	205	04-02-79	17	D
16N/01E-06J02	GLENNWINKLE, BILL	480	240	H	Qc	178.56	08-04-89	--	D
16N/01E-07C01	ZAHN, EARL	460	223	H	Tb	160.59	11-19-88	.69	D
16N/01E-07E02	FROST, M.	442	220	U	Tb	118	06-04-52	.25	D
16N/01E-07E04	FROST, FLOYD	442	226	H	Tb	133	01-11-73	6.5	D
16N/01E-07H01	MAITLAND, ROBERT	458	203	H	Tb	145	07-19-74	3.7	D
16N/01E-07J02	STURGIS, CLAYTON	455	119	H	Tb	95	11-24-80	450	D
16N/01E-07P02	SICKLER, BILL	434	215	H	Tb	101	03-01-74	.54	D,I
16N/01E-08C02	LENZI	480	203	H	TQu	170	07-11-78	49	D
16N/01E-08L01	FAIRLEY, CAROLYN	471	220	H	Tb	147	11-14-74	33	D
16N/01E-08N01	SPROUFFSKE, JERRY	500	100	H	TQu	59.80	10-26-88	>3,700	D
16N/01E-09E01	TOWN OF RAINIER, WELL NO. 3	425	323	P	Mlt	94	06-18-70	--	D
16N/01E-09F01	TOWN OF RAINIER, WELL NO. 2	428	120	P	Qva	100	00-00-60	--	-
16N/01E-09F02	TOWN OF RAINIER, WELL NO. 1	428	120	P	Qva	115	00-00-50	1,800	-
16N/01E-09K01	TOWN OF RAINIER, WELL NO. 4	419	219	P	Qc	85	01-30-75	--	D,I
16N/01E-10D01	WHALEN, JIMMIE	520	260	H	Qc	210	04-03-79	>1,200	D
16N/01E-14G03	HAGGERTY, JOHN	450	120	H	Qc	83.42	01-25-89	--	D,I
16N/01E-16E01	OLYMPIC PIPELINE	461	182	C	Tb	106.79	11-09-88	2.6	D,I
16N/01E-16L03	HUNSINGER, DENNIS	463	203	H	Mlt	136.72	11-09-88	--	D
16N/01E-17G01	REICHEL, HUGH	398	200	H	Tb	52.41	11-07-88	1.1	D
16N/01E-18N01	JOHNSON, ROGER	340	100	H	Tb	20	12-04-87	--	D,I
16N/01E-18Q01	SMITH, ELMER	311	76	H	Qvt	9.77	10-27-88	11	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
16N/01E-18Q02	REICHEL, MICHAEL	350	60	H	Qvt	-- F	10-27-88	--	D,I
16N/01W-01N01S	SCHOENBACHLER, HERMAN	295	--	U	Qvr	--	--	--	-
16N/01W-06F01	LARSON, NORM	240	134	H	Qva	15.06	03-21-89	28	D
16N/01W-06G01	WOLF HAVEN	250	53	C	Qva	36	10-14-85	310	D
16N/01W-06L01	GEER, GALE & JUANITA	243	58	H	Qva	25	07-21-88	1,100	D,I
16N/01W-13H01	JEWELL, MIKE	340	75	U	Qva	39.74	10-17-89	--	D
16N/01W-14Q02	MOORE, JOHN	355	60	H	Tb	20.16	08-04-89	--	D
16N/01W-19A02	PETERSON, CHARLES A.	280	115	U	Tb	28.43	08-09-88	--	D
16N/01W-19G02	TOWN OF TENINO, WELL NO. 1	272	94	P	Qva	32.54	10-11-88	190	D
16N/01W-21D04	SO. SOUND UTIL.	304	34	P	Qva	14	02-22-74	210	D,I
16N/02W-03F01	CASCADE MATERIALS	223	125	U	Mlt	18	05-23-69	--	D
16N/02W-04N01	ANDERSON, CHRIS	194	39	H	Qc	15.30	10-20-88	2,200	D
16N/02W-05N01	CHRISTENSON, MEL	270	149	H	TQu	91.50	08-05-88	--	D,I
16N/02W-05R01	WEYERHAEUSER CO.	195	330	F	Tb	4.13	08-05-88	.36	D,X
16N/02W-05R02	WEYERHAEUSER CO.	190	33	C	Mlt	8.00	10-14-88	--	D
16N/02W-06E01	LARSON, CRAIG	230	152	H	TQu	62.41	03-21-89	--	D
16N/02W-09A01	GIRTON, WALLACE	235	200	H	Tb	38	03-00-89	--	D
16N/02W-10C01	SLIVA, MIKE	220	35	H	Qva	1.73	09-26-88	330	D
16N/02W-12N01	MCCLINTOCK, CHUCK	300	116	H	TQu	88	12-04-79	49	D
16N/02W-20Q02	PRAIRIE VILLA WATER SYSTEM	231	159	P	TQu	41.85	08-18-88	--	D,X
16N/02W-26M01	DANDAR FARMS	260	200	U	Mlt	34.22	08-08-88	--	D
16N/02W-27H01	WIENS, PERRY	260	180	U	Tb	25	03-23-88	--	D
16N/02W-27H02	WIENS, PERRY	260	47	H	Qva	12	03-28-88	--	D,I
16N/03W-01D01	HEAY, ADA	156	68	H	Qc	32.89	09-27-88	620	D
16N/03W-01J01	JENKINS, HERBERT	190	135	H	Mlt	23.90	10-04-88	--	D
16N/03W-02E01	SNOBAR, BEN	200	119	H	Qc	88.68	09-28-88	>1,200	D,I
16N/03W-02H01	BRYANT, PEGGY	155	88	H	Qva	40.52	09-27-88	620	D,O
16N/03W-02J01	TALCOTE, SHIRLEY	143	46	H	Qva	31	06-30-77	>1,200	D
16N/03W-02M02	TIEDE, KEITH	197	110	U	Qva	79.70	10-12-88	180	D
16N/03W-09B02	PAYNE, GARY	220	164	U	Tb	30.25	10-12-88	.10	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
16N/03W-09B03	PAYNE, GARY	220	356	H	Tb	29.28	10-12-88	--	-
16N/03W-10B01	KLOOZ, RICHARD	212	115	H	Qc	102.20	10-04-88	>920	D
16N/03W-10K01	DAVIS, JOHN	180	110	H	Qc	76.01	10-04-88	410	D
16N/03W-10Q01	VOSS, DELBERT	168	99	H	Qc	64.90	10-30-88	>1,200	D
16N/03W-12M01	MCKIM, DAVE	184	39	H	Qc	2.91	10-30-88	--	D
16N/03W-12Q01	TALMAGE, RON	217	80	H	TQu	28	08-24-78	2.4	D,I
16N/03W-12Q02	LANDRY, BOB	202	52	H	TQu	13.30	09-26-88	88	D
16N/03W-14B01	CAPITOL CITY GUN CLUB	240	164	C	Qc	125.78	10-14-88	>1,000	D
16N/03W-15F01	BOYD, LYLE	160	80	H	Qc	56.93	10-19-88	--	D
16N/03W-16K01	WEYERHAEUSER CO.	148	78	H	Qc	47.05	09-28-88	>1,800	D
16N/03W-16L03	WEYERHAEUSER CO.	144	67	U	Qc	42	06-13-68	580	D
16N/03W-16R01	WEYERHAEUSER CO., WELL NO. 5	130	120	I	Qc	32.28	09-28-88	5,400	D
16N/03W-21F01	BLACK RIVER RANCH	107	82	S	Qc	17	03-01-78	450	D
17N/01E-05D01	SAARINEN	222	219	H	Qc	183	08-00-83	1.9	D
17N/01E-05D02	TROCHE, MARIO	240	220	H	Mlt	186.30	05-17-88	--	D
17N/01E-05D03	WARE, JAMES	155	149	H	Qc	111.9	06-23-88	190	D
17N/01E-05E01	WALNER, WARREN	221	218	H	Qc	171.93 Z	06-30-88	46	D,X,I
17N/01E-05F01	CITY OF LACEY, FIRE DEPT.	245	180	I	Qva	147.72	06-23-88	700	D
17N/01E-05N01	SPOONER, KENNETH M.	225	305	I	Qc	88.99	06-23-88	62	D,X,I
17N/01E-06A01	MCBURNEY, ROBERT	115	120	H	Qc	87	09-30-87	400	D,X
17N/01E-06C01	STRONG, HUGH	100	52	H	Qvr	41.70	05-18-88	510	D,W
17N/01E-06J03D1	SUMMER SHORES WATER CO.	205	425	P	TQu	66.30	06-23-88	--	D,X,I
17N/01E-06J04	TOBINSKI, FRANK	175	75	U	Qva	52.12	05-16-88	250	D,W
17N/01E-06M02	METZ, DOUGLAS	210	172	H	Qc	87.35	05-18-88	200	D
17N/01E-07A01	DRAPER, CONRAD	210	154	H	Qc	55	07-01-88	59	D
17N/01E-07B04	DUNBAR, RALPH	215	42	U	Qvr	28.95	06-23-88	47	D
17N/01E-07B05	COOPER, RICHARD	213	190	H	Qc	45	01-04-87	65	D
17N/01E-07C01	DUFF, RICHARD	215	131	H	Qc	71	10-06-78	86	D
17N/01E-07D01	ANDERSEN, JIM	208	138	H	Qc	48.55 R	09-12-79	44	D
17N/01E-07F01	KEGLEY, C.A.	208	104	H	Qva	30.60	06-27-88	200	D,I

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
17N/01E-07H01	WALTERS, VIC	204	40	H	Qva	24.57	06-28-88	--	D,X,S
17N/01E-07L01	TIMM, MELVIN W.	215	72	H	Qva	30	01-15-78	390	D,I
17N/01E-07P02	WELLS, CLIFFORD	226	74	H	Qf	16.86	06-27-88	7.3	D
17N/01E-07P03	CARSON, LARRY	212	260	H	TQu	10.14	06-28-88	160	D
17N/01E-07Q02	PARSHALL, STEVE	210	35	H	Qva	13.83 Z	06-27-88	--	-
17N/01E-07Q03	EMMONS, MIKE	211	35	H	Qva	7.48	06-29-88	59	D,I
17N/01E-08L02	SCHOEPFER, JACK	218	258	I	TQu	28	04-10-70	7.2	D,X
17N/01E-08L03	SCHOEPFER, JACK	250	171	H	Qc	67.89	06-28-88	68	D,I
17N/01E-11B01S	UNKNOWN	135	--	U	Qc	--	--	--	-
17N/01E-11G01S	UNKNOWN	120	--	U	Qc	--	--	--	-
17N/01E-11G02S	UNKNOWN	140	--	U	Qc	--	--	--	-
17N/01E-11H01	LONGNECKER, CARL	140	120	H	TQu	28.40	07-07-88	30	D
17N/01E-11Q02	MILLER, RICHARD D.	309	139	H	Qc	106.97	07-01-88	95	D
17N/01E-11R01	INDIAN HEALTH SERVICE	315	193	H	TQu	93.94	07-06-88	120	D,I
17N/01E-13D04	CLARY WATER ASOC	322	160	P	Qc	103.94	07-19-88	270	D
17N/01E-13D05	LIVERNASH, LYLE	324	118	H	Qc	94.20	07-07-88	180	D
17N/01E-13E03	LONGNECKER, CARL	332	139	H	Mlt	42.31	07-07-88	--	D
17N/01E-13G02	HOUSTON, DON	330	114	H	Qc	--	--	--	D
17N/01E-13K01	SARIAINS, KEVIN	345	110	H	Qf	58	03-10-77	52	D
17N/01E-13L01D1	WALKER, RANDALL	337	140	H	Qc	59.86	07-05-88	41	D
17N/01E-13M02	JONES, FLOYD E.	334	98	H	Qc	51.25	07-05-88	46	D,I
17N/01E-14A03	ANDERSON, DONALD	322	198	H	Mlt	120	04-07-80	--	D
17N/01E-14A04	ANDERSON, DONALD	320	160	I	Qc	91.03	06-30-88	60	D
17N/01E-14D01	GRANTHAM, EARL	375	158	H	Qc	146.46	07-05-88	920	D,I
17N/01E-14L01	POWELL, LINDA	420	200	H	Qc	186.53	07-15-88	77	D
17N/01E-14M02	ARMSTRONG, C.	375	168	H	Qc	145	04-19-79	66	D
17N/01E-14N02	BROWN, LOREN	370	162	H	Qf	148.42	07-11-88	50	D
17N/01E-14P01	NEWBERRY ROBERT	376	200	H	Qc	144.13	07-07-88	31	D,S
17N/01E-14R01	KNIGHT, JASIE	332	115	H	Qva	57.31	06-30-88	180	D
17N/01E-18N01	UNKNOWN	228	77	H	Qc	7	06-00-85	300	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
17N/01E-23B01	DALLAS	348	157	H	Qc	83.65 R	08-18-88	74	D
17N/01E-23H01	PURVIS, JOHN B.	370	151	P	Qc	109.60 Z	08-08-88	70	D
17N/01E-24K02	AMERICAN SAVINGS BANK	350	97	H	Qc	30.68	09-08-88	--	D
17N/01E-25G01	FORRESTER, JAMES	415	137	H	Qva	92	11-08-88	--	D
17N/01E-25Q03	JONES, GEORGE	410	115	H	Qva	62.54	10-06-89	29	D
17N/01E-26R01	BOSEQUETT, JERRY	400	72	H	Qva	43	08-06-88	--	D
17N/01E-33J01D1	WHITNEY, RICHARD	505	247	H	Qva	206.67	07-05-88	210	D
17N/01E-34M01	CRAIG, STEVE	470	196	H	Qva	179.90	07-07-88	210	D,I
17N/01E-35H01	AULTMAN, JAMES	420	80	H	Qva	56.95	07-11-88	210	D,I
17N/01E-36L01	STANHOPE, LEE	400	86	U	Qva	52.94	08-03-89	--	D
17N/01E-36L02	STANHOPE, LEE	410	112	U	Qva	59.58	08-03-89	--	D
17N/01W-01B01	COLONIAL MANOR	230	205	P	Qc	140	11-17-70	71	D
17N/01W-01B03	GRABHORN, LYNN	222	182	H	Qc	149.30 R	07-27-88	--	I
17N/01W-01B04	CRAIN, BILL	222	191	H	Qc	147.54	07-27-88	83	D,I
17N/01W-01F01	MACDONALD, WILLIAM H.	230	160	H	Qc	144.14	08-02-88	310	D,I
17N/01W-01G01	DNR, SOUTHWEST WELL	235	229	I	Qc	159.63	07-27-88	1,900	D
17N/01W-01G02	DNR, FORKS WELL	215	212	I	Qc	140.60 S	07-27-88	240	D
17N/01W-01H01	DNR, CENTRAL WELL	213	236	H	Mlt	117	03-06-52	--	D
17N/01W-01H02	DNR, NORTHWEST WELL	225	222	I	Qc	153.96	07-27-88	3,000	D
17N/01W-01H03	DNR, SOUTH PUGET COAST WELL	214	220	I	Qc	126.50	07-27-88	15	D
17N/01W-01J03	SUMMERSET WATER ASSOC.	190	179	P	Qc	67.47 R	05-23-88	30	D
17N/01W-01L01	SWENSON, PHIL	210	157	H	Qc	87.69	08-02-88	13	D
17N/01W-01Q01	GLACIER VIEW MOBILE HOME PARK	205	97	P	Qva	70.68	05-23-88	290	D,I
17N/01W-01Q03	FRENCH, DONALD	200	58	H	Qvr	45.01	08-01-88	--	D
17N/01W-01Q04	GLACIER VIEW MOBILE HOME PARK	205	108	P	Qva	71.00	05-23-88	800	D
17N/01W-01R01	HIRCOCK, JERRY	217	122	H	Qc	70.87	07-26-88	30	D,I
17N/01W-02A03	SO. SOUND UTIL., WINWOOD WELL	216	231	P	TQu	140.82	05-16-88	55	D
17N/01W-02A04	PATTISON WATER CO.	202	166	P	TQu	129.81	08-02-88	--	-
17N/01W-02E03	DEEGAN, W.E.	178	49	H	Qva	25.31 R	08-01-88	410	D,O
17N/01W-02E04	RICHARDSON WATER CO.	215	542	P	TQu	81.03	07-22-88	39	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
17N/01W-02K01	THOMAS, STEVE	222	146	H	Qc	85	10-00-77	1,100	D
17N/01W-02L02	ZIMMERMAN, BILL	216	78	H	Qva	55.34	08-01-88	230	D,O
17N/01W-02L03	ORR, DAVID S.	211	67	H	Qvr	32	07-09-80	48	D
17N/01W-02Q03	VAN LIEROP, PETER	210	144	I	Qva	33	04-19-88	90	D
17N/01W-02Q04	BURKE, BRIAN	208	79	H	Qva	32.21	08-01-88	650	D
17N/01W-02R02	MAHURIN, HOWARD	209	158	I	Mlt	41.40	07-19-88	--	D
17N/01W-03A05	MONTOYA, ERNIE	206	80	H	Qva	48.04	08-08-88	620	D
17N/01W-03D01	MYINT, LWIN	188	46	I	Qva	15.59	08-02-88	2,600	D
17N/01W-03E01	WARD FARMS, WELL NO. 1	197	68	I	Mlt	32	08-00-47	--	D
17N/01W-03E02	WARD FARMS, WELL NO. 2	199	80	I	Qvr	18	06-15-67	530	D
17N/01W-03Q01	WARD, MERVIN	201	114	I	Mlt	28	05-16-55	--	D
17N/01W-04E01	CITY OF LACEY	210	84	I	Qvr	25	04-00-46	840	D,S
17N/01W-04E02	CITY OF LACEY, WELL NO. 4	210	111	P	Qva	37	09-12-73	--	-
17N/01W-04F01	CITY OF LACEY	214	72	I	Mlt	25	04-19-46	--	D,X
17N/01W-04G01	CAPITOL CITY GOLF CLUB	207	243	I	Mlt	21	05-04-48	--	D
17N/01W-04L01	ROWE, W.R.	198	87	U	Mlt	22	11-13-57	--	D
17N/01W-05H02	PUST, WES	210	68	I	Qvr	41.74	08-09-88	270	D,I
17N/01W-06B02	CITY OF OLYMPIA, SHANNA PARK WEL	185	80	U	Qva	--	--	--	D
17N/01W-06K05	SPAHR, JIM	190	83	H	Qvt	34.62	08-04-88	13	D
17N/01W-07F02	RIVERLEA WATER SYSTEM	205	163	P	Qc	58	05-03-74	36	D
17N/01W-07G02	BAUER	209	104	H	Qf	54.03 R	08-04-88	18	D
17N/01W-07R03	CARLSON, WILLIAM R.	210	120	H	Qc	48.63	08-08-88	--	I
17N/01W-08B01	MCGRAW, MIKE	216	59	U	Qva	37.36 Z	08-08-88	75	D
17N/01W-08B02	GIFFORD	211	54	H	Qva	29	03-26-75	2,100	D,I
17N/01W-08C02	TOPPS, LES	210	52	H	Qva	22	08-24-87	--	D
17N/01W-08D03	HOLCOMB & CEDERSTROHM	209	48	H	Qvr	31.49	08-04-88	--	D
17N/01W-08D04	HAMSIK, RANDAL	210	62	H	Qva	32	04-00-82	660	D
17N/01W-08J01	REESE, DAVE	220	84	H	Qva	35.9	08-03-88	--	D
17N/01W-08L02	HOLLADAY, JIM	200	85	H	Qva	32	06-12-79	16	D,I
17N/01W-08N01	NESBIT, JERRY	210	90	H	Qf	43.32 R	08-08-88	27	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
17N/01W-08P03	KLAASEN, TONY	220	94	U	Qc	38	04-04-78	--	D
17N/01W-08P04	BROWN, D.	215	94	H	Qc	45.43	08-30-88	--	D
17N/01W-08Q02	VAN DERVORT, JUDY	220	180	H	Qc	40	07-30-75	48	D
17N/01W-09B01	HARPER, MIKE	210	38	H	Qvr	18.25	08-02-88	920	D
17N/01W-09D01	LEWIS, E.M.	190	41	H	Qva	9	08-09-86	110	D
17N/01W-09G02	IVERSON, GARY	216	55	H	Qvt	20.50	08-02-88	33	D,I
17N/01W-09G03	BUSCHE, RON	206	90	H	Qc	20.34	07-20-88	180	D,X
17N/01W-09J02	JOHNSON, BILL	205	100	H	Qc	15	06-28-76	150	D,I
17N/01W-10N02	SENN, HARRY	236	78	H	Qva	39.56	07-20-88	--	D,I
17N/01W-11H03	HANSEN, CORKY	220	65	H	Qva	33.24 R	07-26-88	230	D
17N/01W-11J01	OBERT, WILLIAM	218	34	H	Qva	12.45	07-25-88	250	D,I
17N/01W-11K03	DENZLER, GUS	264	96	H	Qva	70.94 R	07-02-88	620	D
17N/01W-11K04	DUSSAULT	217	28	U	Qvr	10.74	07-26-88	430	D
17N/01W-11K05	SUNWOOD LAKES	224	301	P	TQu	44.17 R	09-01-88	2,000	D
17N/01W-11M01	SUNWOOD LAKE, WELL NO. 3	270	334	P	TQu	87.50 R	07-26-88	49	D,I
17N/01W-12B02	LAWYER NURSERY, WELL NO. 2	232	146	I	Mlt	60.85	05-20-88	--	D
17N/01W-12C01	LAWYER NURSERY, WELL NO. 1	214	90	I	Qva	38.30	05-20-88	180	D
17N/01W-12D01	INDEP FORESTRY ASSOC, WELL NO. 3	209	129	U	Mlt	28.10	05-20-88	--	D
17N/01W-12D02	LAWYER NURSERY, WELL NO. 4	206	174	I	Mlt	29.00	05-20-88	--	D
17N/01W-12J02	PATTISON WATER CO., WELL NO. 1	270	186	P	Qc	79.27	10-06-89	--	-
17N/01W-13H01	HEBEL, JOSEPH	340	160	H	Qc	136.57	07-22-88	92	D,I
17N/01W-14B01	BENLINE, LORI	270	85	H	Qva	64.59 Z	07-26-88	310	D
17N/01W-14H01	CONNOLLY, BILLIE	218	50	H	Qva	4.92	07-25-88	--	D,O
17N/01W-14K01	FULKERSON, RICHARD	218	29	H	Qvr	6.56	07-25-88	150	D,I
17N/01W-15A01	SIGMAN, KIM	264	91	H	Qva	56.37	07-20-88	1,200	D,I
17N/01W-15C01	COOLEY, DANIEL H.	256	99	H	Qva	50.24 Z	07-25-88	16	D
17N/01W-15F02	FLYING CARPET MOBILE ESTATES	245	120	P	Qc	56	09-03-81	76	D
17N/01W-15G01	MITCHELL, CHARLES	265	121	H	Qc	56	02-23-86	46	D
17N/01W-15H01	BURRELL, LLOYD	220	39	H	Qva	8	09-18-80	22	D
17N/01W-15H02	GASPER, MARCINE	265	80	H	Qva	56.17	08-26-88	--	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
17N/01W-15K01	WEGE, JIM	220	32	H	Qvr	12.00	07-15-88	88	D
17N/01W-15N01	MUSTIN, GEORGE & HOLLY	209	39	H	Qva	5.14	07-27-88	36	D
17N/01W-15N02	ADAIR, GERALD A.	211	32	H	Qva	4.98	07-25-88	200	D,I
17N/01W-15P01	HODGE, RON	210	40	H	Qva	6	02-22-86	100	D,I
17N/01W-15P02	HODGE, RON	210	46	H	Qva	3.52	07-25-88	150	D
17N/01W-15P03	CLEVENGER, MELISSA	213	30	H	Qva	6.00	07-25-88	310	D
17N/01W-16D01	HALL, LESLIE L.	220	110	H	Qc	37.15	07-22-88	19	D,X
17N/01W-16D02	SLADE, MIKE	220	71	H	Qva	24.16	07-15-88	65	D
17N/01W-16E02	BOUCHEE, BILL	220	31	H	Qva	15.89	07-14-88	51	D,I
17N/01W-16F02	CADYL, THEODORE S.	230	86	H	Qf	27.50	07-14-88	42	D
17N/01W-16F03	ASCHENBRENNER, ARRON	250	82	H	Qva	45.67	07-14-88	29	D
17N/01W-16F04	WESTERN, TEX	250	122	H	TQu	40.50	07-14-88	94	D,X
17N/01W-16L01	JAMES, ROBERT	210	51	H	Qva	9.40	07-14-88	17	D,X,W,O,S
17N/01W-16M02	CASEBIER, DAVID	220	47	H	Qva	24.53	07-15-88	>790	D
17N/01W-17A01	KLEIN, WALTER	215	78	H	Qf	24.46 R	07-07-88	16	D
17N/01W-17B03	VANSYCKLE, RON	215	39	H	Qva	27.52	07-07-88	--	D
17N/01W-17G02	MAHLUM, STAN	215	148	H	TQu	31.76	07-14-88	200	D,I
17N/01W-17J02	SCHUMACHER, CLIFF	220	120	H	Qc	23	02-26-73	30	D
17N/01W-17K01	WRIGHT, MICHAEL	215	41	H	Qva	20.40	07-08-88	180	D
17N/01W-17N02	BARTLETT, DON	205	80	H	Qc	29.67	07-15-88	--	D
17N/01W-18B02	BICKLE, MALCOLM	210	103	H	Qc	59.58	07-07-88	48	D
17N/01W-18B03	ELWANGER, JOHN	200	300	U	TQu	53.41	10-11-89	--	D
17N/01W-19C02	THURSTON COUNTY, FIRE DEPT. 6	220	119	H	TQu	45	10-14-85	--	D,O
17N/01W-19M02	MCCUE, ROBERT	340	270	H	Tb	93.59	07-22-88	.13	D,I
17N/01W-19P01	SANDERS, VALERIE	210	60	H	Qva	21.06 R	06-29-88	190	D
17N/01W-21K01	MILES, MARK	360	507	H	Tb	153.29	07-07-88	--	D,X,I
17N/01W-21P01	BODECKER, D.L.	250	78	H	TQu	46.40	08-02-89	68	D
17N/01W-28B01	BREEDLOVE, MORRIS	295	167	H	Tb	12.80	06-29-88	--	D,X
17N/01W-28C02	LUND	240	72	H	TQu	44.81	07-07-88	22	D
17N/01W-28G02	PARKER, LARRY	400	342	H	Tb	132	11-23-87	.020	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
17N/01W-28H01	TEMPO LAKE CORP.	260	140	P	Tb	27.95 R	07-08-88	1.4	D,X
17N/01W-30F02	GRUNENFELDER, DOUG	260	405	U	Tb	118	01-21-88	--	D
17N/01W-30F03	LAPORTE, WILLIAM H.	250	66	H	Qva	57	04-01-75	130,000	D
17N/01W-31C01	DOYLE, DON	260	52	H	Qva	34.56	06-28-88	400	D
17N/01W-32C01	OFFUTT LAKE COMMUNITY WELL	230	140	P	Qc	--	--	--	-
17N/01W-32F01	ROBINSON, HERB G.	250	244	H	Qc	47.66 R	07-08-88	180	D
17N/01W-32F02	FARIS, DAVID	250	265	H	TQu	62.30	07-14-88	180	D
17N/01W-32K04	BURNS, VERONICA	265	158	H	TQu	46.35	07-01-88	--	D
17N/01W-32P02	ISOM, CECIL	260	143	H	TQu	50.05	06-28-88	--	D,I
17N/01W-33B03	GREENWELL, THOMAS	245	59	H	Qvr	29	10-12-82	49	D
17N/01W-33E02	NYHOLM, ROBERT	245	81	H	Qc	30	02-26-85	74	D,I
17N/01W-33E03	MCINTYRE, ART D.	230	32	H	Qva	8.10	06-29-88	92	D,I
17N/01W-33E04	CARR, WILLIAM JR.	230	54	H	Qva	7.95	06-29-88	35	D,I
17N/01W-33K02	HYDE, DAVID	260	40	H	Qva	15.62	07-01-88	63	D
17N/01W-34D01	BREWER, RALPH	400	57	H	TQu	38.67	06-28-88	--	D,X
17N/01W-34E01D1	CAMP FIRE COUNCIL OF OLYMPIA	280	138	H	TQu	52.25 R	06-29-88	65	D,X,I
17N/01W-34J02	REISTER, PHILIP	290	61	H	Qc	23.17	07-01-88	620	D
17N/01W-34L01	MILLER, DENNIS	290	70	H	Qc	55	05-16-76	150	D,I
17N/01W-34L02	GARDENER	280	125	H	Tb	38.16	06-29-88	.84	D,X,W,I
17N/01W-34M01	WEYERHAEUSER CO.	290	58	H	Qvr	44.48	06-28-88	1,200	D,I
17N/02W-01C01	FINNEGAN	110	32	H	Qvr	7.15	08-04-88	14	D
17N/02W-01E02	DALRYMPLE, WAITE	175	92	H	Qva	65.99	07-18-88	--	D,W,I
17N/02W-02B02	NELSON, DON	175	200	H	Qc	73.86 R	08-26-88	11	D
17N/02W-02E03	CAPITOL PARK CARE CENTER	185	104	I	Qva	30.18	07-26-88	18	D
17N/02W-02E04	KILDOW, JIM & STAN	183	61	H	Mlt	35.26	07-26-88	--	D
17N/02W-02K01	LLOYD, BILL	170	60	H	Qvr	21.89	07-26-88	--	D,I
17N/02W-02N01	ASBACH, DONALD	185	68	H	Qvr	23.12	08-03-88	62	D
17N/02W-02Q06	LUHR, MERLYN	175	67	H	Qvr	34.51	07-26-88	130	D
17N/02W-02R01	SO. SOUND UTIL., BRIDGEWATER 1	191	106	P	Qva	45.20	12-13-88	95	-
17N/02W-02R02	SO. SOUND UTIL., BRIDGEWATER 2	191	97	P	Qva	45.26	09-14-88	220	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
17N/02W-02R03	SO. SOUND UTIL., MONACO PARK	180	87	P	Qva	46	05-15-81	>580	D
17N/02W-03D01	CUTSINGER, M.D.	178	30	H	Qvr	21	05-14-79	--	D
17N/02W-03D02	CONNELLY, JIM	178	45	H	Qvr	18	11-20-86	77	D
17N/02W-03J02	LEAL, TOM & CATHERINE	190	111	U	Qva	22	05-01-67	44	D
17N/02W-03R02	CITY OF TUMWATER, WELL NO. 7	190	333	F	TQu	61	07-01-68	77	D,I
17N/02W-04A01	STEINER, GLYNN	175	43	H	Qvr	10	07-06-72	410	D,X
17N/02W-04E07	VESS, R.	180	45	H	Qvr	14	07-23-86	15	D
17N/02W-04H01	UNWIN, D.J.	188	72	H	Qva	25	06-19-79	180	D,X
17N/02W-04H02	UNWIN, E.R.	188	60	U	Qvr	20	10-12-78	130	D
17N/02W-04K04	JONES, RICK	190	44	H	Qvr	23.10	07-28-88	170	D
17N/02W-04L01	JENSON, MORRIS	190	50	H	Qvr	15.88	07-29-88	77	D
17N/02W-04N04	MCCROSKY, WENDALL	188	40	H	Qvr	15.35	07-29-88	280	D
17N/02W-04N05	MCCROSKY, WENDALL	188	44	H	Qvr	15.72	07-29-88	250	D
17N/02W-04N06	SMITH, PAT	190	50	H	Qvr	21	09-22-78	37	D
17N/02W-04P02	ANDERSON PUD	189	46	P	Qva	19.19	07-29-88	460	D
17N/02W-05A02	MINKLER, JACK	172	33	H	Qvr	4.32	07-28-88	110	D,W,I
17N/02W-05F01	SO. SOUND UTIL.	165	71	U	Qva	12	04-29-82	--	D
17N/02W-05J01D1	UNWIN, NAT	190	106	H	Qc	18	02-06-78	31	D,I
17N/02W-06A04	DOOLEY, LLOYD	142	48	H	Qva	7.49	08-01-88	24	D
17N/02W-06A05	SANFORD, RON	150	27	H	Qva	4.09	08-03-88	180	D
17N/02W-06F03	MAY, ED	143	27	H	Qva	20.66 S	09-14-88	920	D,I
17N/02W-06G02	COFFEY, FORREST	140	332	U	TQu	4	11- -78	85	D
17N/02W-06N01	VANSYCKEL, CONNIE	143	55	H	Qc	-5	05-20-86	--	D
17N/02W-06P02	KELLY, PHIL	137	59	H	Qc	8.08 R	08-08-88	13	D,I
17N/02W-06R01	HOWARD, BARRY	140	205	H	TQu	5	09-27-86	41	D,I
17N/02W-08D03	QUENTIN, KEITH	155	75	U	Qf	18.32	08-04-89	11	D
17N/02W-08E01	SO. SOUND UTIL., BLACK LAKE 1	183	200	P	TQu	68.53	09-14-88	--	D
17N/02W-08K02	FONTENOT, MICHAEL	190	37	H	Qvr	15	03-15-77	>980	D
17N/02W-08L01	DECKERT, C.E.	188	40	H	Qvr	17.35	08-01-88	130	D,S
17N/02W-08L02	ELLIOTT, DOUG, WELL NO. 1	182	38	H	Qvr	7	05-25-77	>1,500	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
17N/02W-08L03	ELLIOTT, DOUG, WELL NO. 2	181	40	U	Qvr	9.24	08-02-88	>1,200	D
17N/02W-08R06	GRUNENFELDER, LOREN	195	65	H	Qva	17.05	07-19-88	820	D,X,I
17N/02W-09A02	PILES, DAVID	190	40	P	Qva	14.46	07-27-88	350	D
17N/02W-09C02	SO. SOUND UTIL., SUMMER HILL	195	56	P	Qva	19.15	07-07-88	540	D,X,I
17N/02W-09E03	PARR, WILLIAM	195	77	I	Qva	16.86	07-29-88	78	D,X
17N/02W-09G02	HARRIETHA, DUANE	190	56	P	Qva	13.94	09-29-88	240	D,O
17N/02W-09K01	KOSHE, DON	188	44	H	Mlt	13.58	07-29-88	--	D
17N/02W-09M04	EYLENFELDT	195	47	H	Qva	16.59	08-02-88	>1,500	D
17N/02W-09Q01	MAY, CLAUDE	190	62	I	Qva	14	12-22-65	290	D
17N/02W-10B01	CITY OF TUMWATER, WELL NO. 10	195	96	N	Qva	3	04-01-72	380	D
17N/02W-10B02	CITY OF TUMWATER, WELL NO. 9	195	111	N	Qva	17.07 R	01-06-89	150	D,I
17N/02W-10N01	DAPAUL, INC.	190	56	N	Qva	10.97	07-29-88	100	D,I
17N/02W-11G08	WYTCO, RICHARD	195	135	H	Qc	29.64	07-18-88	14	D
17N/02W-11G09	KAUFMAN CONSTRUCTION	200	60	C	Qvr	26	07-26-79	32	D
17N/02W-11J01	KAUFMAN CONSTRUCTION	198	79	C	Qvr	39	03-10-77	160	D,S
17N/02W-11R01	HOFERT CORP.	200	255	I	Mlt	46.07	07-27-88	--	D
17N/02W-12E02	ESTATE OF HELEN SHANKS	185	130	H	Qc	58	04-19-74	23	I
17N/02W-12L02	TRAILS END UTILITIES	195	157	P	Qc	62.86	07-27-88	30	D,I
17N/02W-13Q02	MELODY PINES MOBILE HOME ESTATES	225	73	P	Qvt	55.64	08-04-88	77	D
17N/02W-13R02	PARKS, HAROLD	177	73	U	Qva	10.65	10-11-88	6.8	D
17N/02W-14H02	ALLSUP, RANDY	200	39	H	Qva	20.38	08-04-88	>740	D
17N/02W-14H03	KILBURG, GLEN	196	50	H	Qva	18.48	08-09-88	380	D
17N/02W-14Q01	LONGHORN COUNTRY ESTATES	198	65	P	Qva	22.34 R	06-16-88	35	D,I
17N/02W-14Q02	ELWANGER, EUGENE & PAT	200	40	H	Qva	14.25	08-15-88	--	D,W,I
17N/02W-15C02	HECK, EDWARD	196	--	C	--	--	--	--	-
17N/02W-15C03	HECK, EDWARD	196	--	C	--	--	--	--	-
17N/02W-15D02	GREENUP, BILL	195	43	H	Qva	15.61	08-12-88	1,100	D
17N/02W-15E01	BALCOM, JOHN & VIRGINIA	195	50	H	Qva	16.76	08-10-88	>1,500	D
17N/02W-15L04	STRAWDER	200	58	I	Qva	18.54	08-10-88	140	D
17N/02W-16M02	LUHR, MERLYN	191	38	H	Qva	15	02-05-88	460	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
17N/02W-16P02	COX, TED	193	77	H	Qva	13.51	08-08-88	150	D
17N/02W-16P03	KAUFMAN, MARVIN	194	58	U	Qva	14	03-20-80	>980	D
17N/02W-16Q02	MCKAY, STAN	196	54	U	Qva	20	08-22-79	--	D
17N/02W-17E01	RADER, CAREY	175	115	H	Qc	7.57	08-03-88	150	D,I
17N/02W-17F02	SHAW, EARL	186	60	H	Qva	5	05-12-76	>3,700	D
17N/02W-17H01	PYPER, WILLIAM	190	39	H	Qva	13.56	09-08-88	620	D,X,O
17N/02W-17J01	DNR, WELL NO. 7	195	136	I	Qva	13.82	07-18-88	140	D,X
17N/02W-17L02	FRIEDEL, RUDY	189	80	H	Qva	10.37	09-30-88	120	D
17N/02W-17N02	INGLIN, DAVE	185	83	H	Qva	5.81	08-09-88	310	D,I
17N/02W-17R02	LONEGRAN, GEORGE	195	54	H	Qva	18.14	08-02-88	>1,700	D
17N/02W-17R03	DNR, WELL NO. 6	192	119	I	Qva	10.74	07-18-88	66	D
17N/02W-17R04	DNR, WELL NO. 5	192	93	I	Qva	11.86	07-18-88	400	D,X
17N/02W-18H03	PARKS, HAROLD	175	109	P	Qf	20.16	08-18-88	27	D
17N/02W-19A01	BROWN, JOHN	175	57	H	Qvt	8.93	08-11-88	10	D
17N/02W-19F01	HARRISON, TODD	164	100	H	Qc	10	08-19-86	20	D,I
17N/02W-19G04	CLOVIS, GEORGE	174	60	H	Qva	12.51	08-25-88	20	D
17N/02W-19L03	THURBER, WILLARD	164	67	H	Qf	11.90	08-23-88	3.4	D
17N/02W-20B05	DNR, WELL NO. 9	188	71	I	Qva	11.59	09-20-88	730	D
17N/02W-20B06	DNR, WELL NO. 4	191	91	I	Qva	17.48	09-20-88	320	D
17N/02W-20H02	DNR, WELL NO. 8	191	64	I	Qva	13.95	09-20-88	260	D,X
17N/02W-20J02	BAILEY, WESLEY	190	123	H	Qf	8	01-04-80	44	D,X
17N/02W-20J03	PARKS, HAROLD	188	60	H	Qvr	7.48	08-12-88	--	D,I
17N/02W-20K01	MICHAELS, KIRBY	186	53	H	Qva	12.48	08-15-88	>1,200	D
17N/02W-21A01	ADAIR HOMES	196	63	C	Qva	15.59	09-08-88	29	D
17N/02W-21F01	NACOTTA, LARRY	195	178	U	Qc	39.15	09-21-88	--	D
17N/02W-21J01	MCLAIN, MIKE	193	26	H	Qvr	8.65	09-21-88	620	D
17N/02W-22A01	TOBINSKI, FRANK & ASSOC.	200	80	H	Qva	20.49	09-30-88	620	D
17N/02W-22A02	SHOAF, WILLIAM	197	60	H	Qva	10	09-08-80	92	D,S
17N/02W-22B04	MOORE, TOM	205	53	P	Qva	24	11-24-78	>1,100	D
17N/02W-22D02	TAYLOR, DICK	200	86	C	Qva	15.78	10-07-88	38	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
17N/02W-22E02	HECK, EDWARD, WELL NO. 2	200	117	C	Mlt	14	08-16-73	--	D
17N/02W-22E03	HECK, EDWARD, WELL NO. 1	200	87	C	Qvt	18	07-20-73	5.2	D
17N/02W-22F03	DELANEY, GEORGE	198	66	H	Qva	13.34	08-26-88	7.7	D
17N/02W-22H02	THURSTON CO., MAINTENANCE SHOP	196	67	C	Qva	15.51	08-22-88	--	D,W,I
17N/02W-22H03	ROGERS, DARRELL	200	57	H	Qva	23	07-19-88	180	D
17N/02W-22Q03	BOCK, FRED	200	45	H	Qva	18.74	10-19-88	120	D
17N/02W-23B01	RIDLEY, WILLIAM	215	57	H	Qva	23.80	10-03-88	41	D
17N/02W-23B02	REXUS, FRANK	200	40	H	Mlt	15.01	09-06-88	--	D
17N/02W-23K01	GUNDERSON, GEORGE	196	59	H	Qva	14.75	08-22-88	120	D,I
17N/02W-24B01	GROVER, TOM	224	100	H	Qc	60	08-04-87	62	D
17N/02W-24C02	NOE, BILLY	210	243	H	Mlt	48.26	08-25-88	--	D
17N/02W-24D01	HAWKINS, HARRY	220	120	H	Tb	30	10-10-79	1.1	D,I
17N/02W-24D02D1	BANTER, JEANETTE	200	70	U	Tb	38.23	08-12-88	--	D
17N/02W-25N02	LINCOLN, RICHARD	216	104	H	Tb	8.84	08-17-88	--	-
17N/02W-25N03	LINCOLN, RICHARD	217	80	U	Tb	--	--	--	D
17N/02W-25Q01	BLAKE, TIM	243	155	H	Tb	46.04 R	08-26-88	.91	D
17N/02W-25Q02	STODDARD, PATRICK	274	113	H	TQu	52.19	08-15-88	14	D,I
17N/02W-25Q03	SCHMITT, EVAN	276	280	H	Mlt	40.23	08-15-88	--	D,I
17N/02W-26D02	PUCKETT, DALLAS	380	186	H	Tb	71.41	08-17-88	7.7	D
17N/02W-26E01	CARNEY, EDWARD & CYNTHIA	200	58	H	Qc	14.57	08-23-88	44	D,I
17N/02W-27J01	EDMINSTER, ED	310	110	U	Tb	44	06-24-80	.087	D
17N/02W-27J02	EDMINSTER, GEORGE	200	212	H	Tb	--	--	--	D
17N/02W-27P01	SKYE	195	35	H	Qc	12.47	08-22-88	62	D
17N/02W-28J01	ROBERTS, STEPHEN	200	62	U	TQu	--	--	--	D
17N/02W-28J02	ROBERTS, STEPHEN	200	45	H	Qc	10	09-26-80	3,000	D
17N/02W-28R01	TELLERS, JOSEPH & CHERIE	198	28	H	Qc	10.90	09-15-88	470	D
17N/02W-29A01	VAN BUSKIRK, GEORGE	188	44	H	Qva	10.52	09-07-88	62	D
17N/02W-29A02	BALUKOFF, TONY	190	50	H	Qva	9.60	08-23-88	>1,200	D,X,I
17N/02W-29D01	PETERSON, TODD	180	56	H	Qva	7.23	09-30-88	250	D
17N/02W-29D02	CRAYPO, SARAH	180	60	H	Qva	8	05-23-84	62	D,I

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
17N/02W-29F01	HURST, J.J.	186	57	C	Qva	7.73	08-26-88	130	D
17N/02W-29G01	TURCOTTE, BILL	195	50	H	Qva	14	10-27-77	--	D,I
17N/02W-29R01	DEEDS, NORMAN	195	100	H	Qc	25	07-19-88	--	D,X,S
17N/02W-30D02D1	LEE, BOB	163	70	H	Qc	15.73 R	08-24-88	--	D
17N/02W-30E02	H. & R. WATER WORKS	180	146	P	Tb	22	10-00-73	3.8	D
17N/02W-30E03	CAMPBELL, JIM	186	146	H	Tb	22.37	09-19-88	1.4	D,W,I
17N/02W-30E04	KNIERIM, EUGENE & ALBERTA	180	86	H	Qc	12	05-18-84	6.8	D
17N/02W-30F01	STEWART, RICHARD	185	148	H	Tb	25	09-27-78	--	D
17N/02W-30P02	BLUE RIBBON TURF	178	31	I	Qc	4.85	09-23-88	74	D
17N/02W-31E01	BRIGGS, DAVID	181	80	H	TQu	10	11-16-77	--	D
17N/02W-31H01	MONTGOMERY, GEORGE	220	112	H	TQu	32.78	08-24-88	41	D,O
17N/02W-32E01	COLEMAN, CARROLL	193	24	I	Qc	10	06-14-80	>2,800	D
17N/02W-32K01	ROGERS, DIANA	188	38	H	Qf	8	08-25-87	2.4	D,X
17N/02W-33K02	SCOTT LAKE WATER SYSTEM	205	41	P	Qc	16.19	09-14-88	--	D
17N/02W-34J02	WASHINGTON STATE PARKS	212	97	C	Qc	17.14	08-25-88	480	D
17N/02W-35C01	DAY, MARGARET	268	201	H	Tb	15	01-07-88	.0047	D,I
17N/02W-36C02	HIGHFILL	290	170	H	Tb	70	01-24-78	.021	D
17N/02W-36C03	BROWNE, BONNIE	310	95	H	Tb	27	12-27-79	.0028	D
17N/02W-36D01	FEDEN, DAVID	250	--	H	--	64.40	07-22-88	--	-
17N/03W-01B01	MCCARTY, BEATRICE	240	117	H	Qva	86.23	01-27-89	180	D
17N/03W-01G02	PATCH, TOM	220	93	H	Qva	46.89	08-23-88	240	D,I
17N/03W-01J01	SMITH, XAVIER	210	83	H	Qva	50.00	08-23-88	100	D
17N/03W-01L02	HILL, LEON	220	95	H	Qva	50.46	08-24-88	250	D
17N/03W-01R03	LONGNECKER, DAVID W.	205	113	H	Qc	67.60	08-23-88	--	D
17N/03W-02G01	ARNESEN, WILLIAM	340	166	H	Tb	18	09-15-85	1.7	D
17N/03W-02H01	ARNESEN, DALE	290	84	H	Mlt	52.65 Z	10-19-88	--	D
17N/03W-02J01	DELPHI WATER SYSTEM	260	165	P	TQu	76	12-11-71	39	D
17N/03W-02J02	DELPHI COUNTRY CLUB, WELL NO. 2	260	165	I	Mlt	88.29	08-24-88	--	D
17N/03W-02J03D1	BUTCHKO, STEPHEN	260	113	H	Qva	95.63	09-13-88	--	D
17N/03W-02K01	PEKOLA, JERRY	275	46	H	Qva	33.22	08-23-88	400	D,I

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
17N/03W-02K03	SO. SOUND UTIL., ALPINE HILLS	300	196	U	TQu	49.18	12-13-88	6.7	-
17N/03W-02K04	SO. SOUND UTIL., ALPINE HILLS 1	300	113	P	Qva	24.70	12-13-88	54	D
17N/03W-02K05	SO. SOUND UITL., ALPINE HILLS 2	300	105	P	Qva	49.01 R	12-13-88	--	I
17N/03W-02Q01	GAMBLE, DON	270	78	H	Qva	27.16	07-21-88	89	D
17N/03W-10B01	ERNSTES, BECKY	510	74	H	Tb	15.70	08-24-88	--	D
17N/03W-10C01	POTTER, JEFF	600	110	H	Mlt	15.71	08-24-88	--	D,I
17N/03W-10D01	KIEFER, JIM	620	42	H	TQu	18.25 R	09-13-88	41	D
17N/03W-11A03	GRAHAM, JAMES	240	94	H	Qva	79.97	10-19-88	74	D
17N/03W-11G01	TAYLOR, BOB	240	97	U	Qva	58.78	08-24-88	100	D
17N/03W-11H01	MCMURRY, LARRY & LINDA	240	100	H	Qva	78	06-22-87	65	D
17N/03W-11K01	ELLIOTT, R. LINDSAY	180	58	H	Qva	22.52	08-26-88	67	D,I
17N/03W-11Q01	BECKMAN, JAMES	140	35	H	Qva	4.65	08-24-88	46	D
17N/03W-12A02	SO. SOUND UTIL., EVRGRN SHORES 1	185	109	P	Qc	37.58 S	07-07-88	62	D
17N/03W-12A03	SO. SOUND UTIL., EVRGRN SHORES 2	180	107	P	Qc	30	07-28-73	72	D
17N/03W-12A04	SO. SOUND UTIL., EVRGRN SHORES 3	185	113	P	Qc	24	06-11-76	45	D
17N/03W-12B02	BERKENKAMP, WILLIAM	240	103	H	Qva	80	09-02-80	180	D
17N/03W-12E01	FOLLETT, DOUGLAS	200	56	H	Qva	44.86	10-20-88	92	D
17N/03W-12F01	BUDINSKI, ROBERT	220	119	H	Qva	74.01	08-26-88	41	D,O
17N/03W-14C02	MACDUFF, JAMES	140	52	H	Qva	9	12-00-71	11	D
17N/03W-14F03	LARSEN, BRUCE	170	402	H	Tb	3	07-20-87	--	D
17N/03W-14R02	GIBBONS, JOANNE	200	101	H	Qva	65.98	08-26-88	94	D
17N/03W-15A01	FOSTER, MIKE	240	310	H	Tb	5	01-17-84	.0025	D,O
17N/03W-15B01	STENBERG, ROGER	390	124	H	Tb	51.98 R	09-13-88	.024	D
17N/03W-15F01	HILDEN, JERRY	580	48	U	TQu	--	--	--	D
17N/03W-15N01	DRUCQUER, CEDRIC	580	129	H	TQu	109.49 P	09-14-88	--	D
17N/03W-15P01	SCHULTZ, LEROY	400	282	U	Tb	159.06	08-26-88	--	D
17N/03W-15P02	RENFROE, JACK	360	47	U	Tb	42.34	10-25-88	--	D
17N/03W-17A01	CRONIN, MIKE	515	38	H	Tb	5	01-08-88	--	D,I
17N/03W-17B01	REDECKER, CRAIG	420	109	H	Tb	2.19	10-03-88	7.0	D
17N/03W-17D01	GARY, THOR	485	75	H	TQu	16.32	09-14-88	23	D,I

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
17N/03W-17G01	MCRAE, SUSAN	420	81	H	TQu	-- F	10-19-88	--	D
17N/03W-17R01	MCKINNON, CAMERON	380	79	H	TQu	--	--	--	D
17N/03W-22J01	SANFORD, GARY	200	98	H	Qva	38.13	10-21-88	>310	D,W,I
17N/03W-22L01	OLIVER, ROBERT	290	243	H	Tb	15.70	10-20-88	--	D
17N/03W-23L02	MILLER, THOMAS	250	136	H	Qva	94.94	10-20-88	--	D
17N/03W-23P01	CRUMLEY, LONNIE	245	98	H	Qva	74.54	10-20-88	--	D
17N/03W-23Q02	BENNETT, GORDON	230	111	H	Qva	69	06-19-78	95	D,I
17N/03W-23R02	THURSTON CO., FIRE DIST. NO. 11	170	70	H	Qva	26.41	10-05-88	50	D
17N/03W-24D01	BODINE, DAVID	200	97	H	Qva	68	06-10-76	44	D,I
17N/03W-24E02	SALAZAR, LEO	200	89	H	Qva	63.61	10-03-88	92	D
17N/03W-24E03	WILSON, MICHAEL	190	84	H	Qva	56.30	10-05-88	150	D
17N/03W-25D01	DELPHI MOBILE HOME PARK	160	113	P	Qc	26	11-00-86	190	D,I
17N/03W-25D02	ROSS, DEWEY	160	74	U	Qc	26.86	10-12-88	73	D
17N/03W-25G01	BUMFORD, MARGARET	150	50	H	Qc	14.30 R	10-05-88	>740	D
17N/03W-25H02	JOHNSON, JOHN	155	60	H	Qc	10.40	10-20-88	46	D
17N/03W-25J02	STEELE, RALPH	180	45	H	Qc	20	08-15-83	37	D,I
17N/03W-25K01	PETTY, RUSSELL	155	43	H	Qc	10	03-05-76	>1,200	D
17N/03W-25R04	BOOTH, JAMES	165	44	H	Qc	7.98	08-03-88	19	D,I
17N/03W-25R05	BAKER, JACK	170	94	H	Qc	6	07-29-87	180	D,I
17N/03W-26A01	DENMAN, LARRY	160	94	H	Qc	24.86	10-15-88	28	D
17N/03W-26F01	WILDBERGER, PAUL	200	96	H	Qc	52.65	10-18-88	31	D,I
17N/03W-26G01	GADD, GREG	180	66	H	Qva	16.32	10-18-88	>1,700	D
17N/03W-26H01	HILL, RON	160	89	H	Qc	22.11	10-21-88	36	D
17N/03W-26H02	BAFARO, GARY	158	88	H	Qc	21.86	09-21-88	62	D
17N/03W-26J02	WHITE, CLAYTON	140	30	H	Qvr	8	11-17-78	1,100	D
17N/03W-27N01	HATCHER, TIM	300	156	H	TQu	110.68	10-25-88	--	D,I
17N/03W-34E03	WALTERS, ROY	250	90	H	Qvt	29.79	10-17-88	13	D
17N/03W-34E04	DAHL, KIM	250	120	H	Mlt	29.00	10-25-88	--	D
17N/03W-34F01	NAPPI, AMEDES	250	288	U	Tb	74.93	10-17-88	.070	D
17N/03W-34J01	ZIRBES, LARRY	170	55	H	Qva	33.38	10-13-88	62	D,I

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
17N/03W-34M01	BRYENTON, KEITH	200	400	H	Tb	29.78	10-13-88	--	D
17N/03W-35B02	WILLIAMS, JANET	140	54	H	Qva	7.27	10-12-88	--	D
17N/03W-35R01	BURKE, DAVE E.	140	47	H	Qc	24.89	10-13-88	110	D
17N/03W-36A01	REED, PAUL & BEVERLY	171	55	H	Qc	9.61	09-27-88	92	D
17N/03W-36C01	JUDY, STEVE	160	248	H	Tb	15	10-20-83	2.6	D
17N/03W-36F01	JUDY, STEVE	160	34	H	Qc	11.61 R	10-25-88	99	D
17N/03W-36N05	DOWN, GENE	160	40	H	Qc	12.02	10-17-88	410	D,I
17N/03W-36Q02	HEPPE, RUBY	180	185	H	Tb	15.12	10-17-88	.33	D
17N/03W-36R01	COLLINS, KELVIN	230	91	H	TQu	33.23	10-17-88	29	D,I
18N/01E-05M01	U.S. FISH & WILDLIFE SERVICE	10	900	H	TQu	-- F	--	--	C
18N/01E-06N01	PARKS, HAROLD	230	253	P	Qc	223	07-01-62	--	D
18N/01E-06R01	U.S. FISH & WILDLIFE SERVICE	18	250	U	Qc	-- F	06-22-88	1,600	D,X,S
18N/01E-07A01	BALCOM, BILL	15	130	P	Qc	-2	08-03-88	2,500	D
18N/01E-07A02	ELWESS, GENE	10	120	H	Qc	-1	04-01-54	11,000	-
18N/01E-07D01	WEBB, PAUL	238	260	H	Qc	205	06-29-76	43	D
18N/01E-07E01	BUCK, VIRGINIA	230	223	H	Qc	204	-60	--	-
18N/01E-07F01S	NISQUALLY TROUT FARM	100	--	Q	Qvr	--	--	--	-
18N/01E-07F02S	NISQUALLY TROUT FARM	100	--	Q	Qvr	--	--	--	-
18N/01E-07L01	THOMSEN, TORDEN	15	100	H	Qc	-- F	06-22-88	51	D
18N/01E-08B03	MARTIN, STUART	18	86	H	Qc	9.06 Z	06-22-88	150	D
18N/01E-08C01	KOENIG, W.	20	75	H	Qc	--	--	--	-
18N/01E-08D03	INDEPENDENT FORESTRY ASSOC.	10	110	I	Qc	1.30	05-08-78	3,700	D,I
18N/01E-08F02	DAHL, LEWIS G.	18	100	H	Qc	6.70	05-08-78	--	C
18N/01E-08H01	ATTWOOD, LARRY	20	72	H	Qc	10.99	06-23-88	880	D
18N/01E-08J01	DORMAN, DALE	22	96	H	Qc	12	08-22-88	--	-
18N/01E-09M01	CITY OF LACEY, WELL NO. 19C	25	96	P	Qc	13.87	07-08-88	2,500	-
18N/01E-09M02	CITY OF LACEY, WELL NO. 19A	25	107	P	Qc	13.50	07-08-88	170	D
18N/01E-16E01	NISQUALLY SPORTSMAN CLUB	33	109	P	Qc	9.89	06-22-88	2,000	D
18N/01E-17D02	LACHANCE, TED	15	110	H	Qc	--	--	--	-
18N/01E-17Q01	WYNN, DONALD	181	260	C	Qc	176.60 R	06-28-88	>330	D,I

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
18N/01E-18A01	SCHOLS, HERMAN	15	120	H	Qc	-- F	--	--	D,I
18N/01E-18A02	SCHOLS, HERMAN	10	123	I	Qc	2.17	07-15-88	300	D
18N/01E-18B01	BRAGET, P.H.	15	84	H	Qc	-- F	--	240	D
18N/01E-18G01	WASH. DEPT. FISHERIES	20	135	Q	Qc	-- F	10-06-89	--	-
18N/01E-18H01	JESS THOMSEN, INC.	10	130	I	Qc	1.90 Z	06-23-88	--	D,X
18N/01E-18P01S	UNKNOWN	15	--	U	Qc	--	--	--	-
18N/01E-19J01	LOFTIN, FRED	70	68	H	Qc	61.87 Z	10-11-88	--	-
18N/01E-19J01S	CITY OF OLYMPIA, ABBOTT SPRING	7	--	H	Qvr	--	--	--	-
18N/01E-19J02	CITY OF OLYMPIA, ABBOTT EXPL WELL	39	92	U	Qc	27.11	11-15-88	--	D,W
18N/01E-19Q01	CITY OF OLYMPIA	70	134	H	Qc	60.99	07-13-90	390	D
18N/01E-19Q01S	CITY OF OLYMPIA, MCALLISTER SPR	5	--	P	Qvr	--	--	--	-
18N/01E-19R01	CITY OF OLYMPIA, MCALSTR TST WELL	95	312	U	Qc	86.2	08-04-92	3,700	D,X
18N/01E-20M01	THOMPSEN, JOHN	120	130	H	Qc	109.9 P	08-22-88	--	-
18N/01E-20R02	IYALL, JACK	221	205	H	Qc	175.87	05-16-88	140	D,X
18N/01E-21N01	FEATHERS	230	352	P	TQu	184	01-19-71	58	D,X
18N/01E-21N02	AGUILLARD, DALE	220	200	H	Qc	185.98	06-23-88	74	D,I
18N/01E-21P01	SO. SOUND UTIL., CUYAMACA NO. 2	230	236	P	Qc	197.14	05-24-88	--	D
18N/01E-21P02	SO. SOUND UTIL., CUYAMACA NO. 1	230	408	P	TQu	189.79	05-24-88	38	D,X
18N/01E-21P03	SO. SOUND UTIL., CUYAMACA NO. 3	230	235	P	Qc	196.63	05-24-88	120	D,I
18N/01E-21Q02	IYELL, ART	238	225	H	Qc	201.86 Z	06-24-88	>850	D,X
18N/01E-28M01	NISQUALLY SAND & GRAVEL	238	194	N	Qc	176.6	05-24-88	2,700	D,I
18N/01E-28N01	NOYET, MIKE	244	197	P	Qc	175	12-09-71	--	D
18N/01E-29B01	CITY OF OLYMPIA, MCALSTR SPR MW3	94	261	U	Qc	74	09-23-92	--	G
18N/01E-29E01	CITY OF OLYMPIA, MCALSTR SPR MW4	112	259	U	Qc	93	09-21-92	--	G,X
18N/01E-29N04	CITY OF OLYMPIA, MCALSTR SPR MW2	130	206	U	Qc	111	09-22-92	--	G
18N/01E-30C01	THOMSEN, HANS	160	26	H	Qvr	1.81	05-25-88	920	D,I
18N/01E-30D02	THOMSEN, HANS	160	153	U	Qc	114.52	05-25-88	--	D,X
18N/01E-30M01	NISQUALLY HOG RANCH	175	170	U	Qc	124.40	05-10-88	--	-
18N/01E-30N01	SO. SOUND UTIL., HOLIDAY NO. 1	212	194	P	Mlt	154.50	05-10-88	--	D
18N/01E-30N02	SO. SOUND UTIL., HOLIDAY NO. 2	212	190	P	Qc	155.07	05-10-88	3,000	D,I

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
18N/01E-30P01	ADAMS, VIRGIL	212	220	U	Mlt	170	12-18-75	--	D
18N/01E-31A01	OBRIEN, C.F.	83	92	H	Qc	60.72	05-11-88	--	D,X,W,I
18N/01E-31E02	LUBITZ, JAMES	221	167	H	Qc	--	--	--	-
18N/01E-31F01	ENFIELD/RACE WATER SYSTEM	222	214	P	Qc	183.74	06-27-88	470	D,I
18N/01E-31F02	AKEHURST, CAROL	216	213	H	Qc	164.57	05-12-88	80	D
18N/01E-31G01	WILLIAMS, E.V.	103	76	H	Qc	66	01-17-58	--	-
18N/01E-31H01	PETERSON, WILLIAM	108	101	H	Qc	70.33	05-11-88	350	D
18N/01E-31H02	ZURFLUHS	111	119	P	Qc	75.45 Z	06-30-88	54	D
18N/01E-31H03	LANDROM, BRUCE	160	193	H	Qc	135.84	06-24-88	>5,500	D,X,I
18N/01E-31J01	CALVERT, R.D.	94	80	P	Qc	60.56	10-06-88	--	-
18N/01E-31M01	SO. SOUND UTIL., TRIPLE G NO. 1	215	190	P	Qc	147.13	05-12-88	650	D
18N/01E-31M02	SO. SOUND UTIL., TRIPLE G NO. 2	215	192	P	Qc	143 R	06-14-84	330	D
18N/01E-31N01	ACTON, GLEN	212	139	H	Qva	84	01-30-79	>2,700	D,I
18N/01E-31P01	KAGY, ROBERT	138	106	H	Qc	94.42	05-13-88	--	-
18N/01E-31Q01D1	BARNES, DAVID	156	373	P	TQu	117.11	05-13-88	27	D,I
18N/01E-31R01	SEAUNIER, PHIL	82	91	H	Qc	46.40	07-05-88	550	D
18N/01E-31R02	DOYLE, RICHARD	78	85	H	Qc	39.46	05-13-88	460	D
18N/01E-32C02	FRANKLIN, MICHAEL G.	140	128	H	Qc	108	08-04-80	410	D,I
18N/01E-32D04D1	WELLS, V.	80	76	H	Qc	51.08 Z	06-29-88	>1,100	D
18N/01E-32D05	CUDNEY ROBERT	100	98	H	Qc	77.27 R	06-28-88	120	D
18N/01E-32D09	ROMPA, WILLIAM	73	93	U	Qc	57.91	05-11-88	>1,000	D
18N/01E-32E02	KRUEGER, JEFF	100	83	H	Qc	73.89	05-16-88	920	D
18N/01E-32E03	MCKECHNIE, DON	97	98	H	Qc	69.70	05-16-88	410	D
18N/01E-32E04	RUIZ, J.R.	80	67	H	Qc	41	06-12-75	450	D
18N/01E-32H02	CASEBOLT, G.C.	253	216	P	Qc	175.48	05-11-88	360	D,W,O
18N/01E-32M01	ERNST	121	112	H	Qc	97.12 R	08-23-88	>920	D
18N/01E-32N01	RYAN, JAMES G.	115	92	H	Qc	81.30 R	07-06-88	1,100	D,O
18N/01E-32N02	HALL, JACK	76	81	H	Qc	42.69	06-28-88	180	D
18N/01E-32N03	LAKE SAINT CLAIRE WATER	162	158	P	Qc	131.76	05-17-88	>850	D
18N/01E-32P02	PETERSON, LEE	75	81	H	Qc	44.50	07-06-88	400	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
18N/01E-34F03	NISQUALLY INDIAN TRIBE	260	255	P	Qc	192	05-18-76	35	D,I
18N/01E-34F04	NISQUALLY INDIAN TRIBE	260	280	P	Qc	195.83 S	05-25-88	28	D,I
18N/01E-34J01	SIMMONS	264	229	H	Qc	198	07-16-71	--	D,I
18N/01E-34K01	SMITH, CARMEN	273	232	H	Qc	195.38	10-17-88	--	D
18N/01E-34R01	MCCLOUD, JACK	280	208	H	Qc	178.22	01-15-72	--	D
18N/01E-34R02	MCCLOUD, GEORGE	280	218	H	Qc	181	08-16-81	--	D
18N/01E-35P02	NISQUALLY INDIAN TRIBE	90	220	Q	TQu	--	--	--	-
18N/01W-01H01	CHRISTOPHERSON, CURTIS	225	120	H	Qva	91.21	06-07-88	44	D
18N/01W-01H02	SO. SOUND UTIL., WHITE FIRS WELL	225	255	P	Qc	222	10-28-78	>2,700	D,I
18N/01W-01R01	KNAPP, RONALD H.	245	236	H	Qc	212	06-30-73	68	D
18N/01W-02G01	OLYMPIA CHEESE CO.	235	131	U	Qva	93	05-29-64	72	D
18N/01W-02G02	OLYMPIA CHEESE CO.	237	241	N	Qc	176	10-05-74	51	D,O
18N/01W-02H01	MCCARTHY, J. JR.	245	139	P	Qva	107.87	06-07-88	--	D,O
18N/01W-02H02	OLYMPIA CHEESE CO.	235	319	N	TQu	200	02-26-77	4,200	D
18N/01W-02L01	BETTI, BRUNO	235	212	U	Qc	168.9	06-07-88	--	D
18N/01W-02M02	BETTI, BRUNO	240	218	H	Qc	148	10-19-72	82	D
18N/01W-02R01	TOM MARTIN CONSTRUCTION	220	256	H	Qc	166.9	06-07-88	--	D
18N/01W-03B01	LENARD, WILBUR	234	204	H	Qc	155.92	08-23-88	49	D
18N/01W-03B02	PARKS, HAROLD	238	280	P	TQu	210	04-21-79	110	D
18N/01W-03E01	POND, RANDY	95	63	H	Qva	37.87	06-08-88	480	D,I
18N/01W-03G01	ANTHONY, DONALD	195	151	H	Qva	123	06-27-84	500	D
18N/01W-03H02	TOLMIE COVE ASSOC.	205	233	P	Qc	146.0 R	06-08-88	97	D,I
18N/01W-04M01	GALLAGER, THOMAS	70	77	H	Qva	43.60	06-08-88	150	D,I
18N/01W-04M02	HALL, DON	65	158	H	Qc	14.63	06-13-88	75	D,X
18N/01W-04N01	KELLEHER, JOHN	80	326	H	TQu	34.27	06-08-88	95	D,X,I
18N/01W-04P01	MIDDAGH, NANCY	50	75	H	Qf	3.24	07-14-88	39	D
18N/01W-05E02	ESTES, ROBERT	165	50	H	Qva	30.72	06-13-88	410	D
18N/01W-05E03	LOVIEN, MARK	165	46	H	Qva	31.55	06-15-88	270	D,S
18N/01W-05G01	JACKSON	90	75	H	Qva	44.82	07-14-88	49	D
18N/01W-05G02	SCOTT, J.W.	110	56	H	Qva	23.40	06-20-88	360	D,W,I

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
18N/01W-05L02	RUGGIERO, LEN	160	40	H	Qva	25.74	07-13-88	310	D
18N/01W-05L03	SCHMITKE, LARRY	165	40	H	Qva	11	09-06-86	320	D
18N/01W-05L04	RUGGIERO, LEN	160	--	U	--	26.02	06-13-88	--	-
18N/01W-05L05	BROWN, GARY	136	153	H	Qc	50	08-04-78	--	D
18N/01W-06A03	SPURR, MAHLON	160	118	H	Qc	51.04	06-14-88	380	D,O
18N/01W-06D01	SCHAFFER, JOHN L.	145	72	H	Qva	30.55	06-14-88	--	D
18N/01W-06E02	CONWAY, HAROLD	165	79	H	Qvt	21.24	06-14-88	13	D,O
18N/01W-06G02	FULTON, FRANK	160	50	H	Qvr	28.74	06-14-88	140	D
18N/01W-06H03D1	MILLS, RAY	160	157	H	TQu	114.10	06-15-88	110	D
18N/01W-06P03	GODAT, TONY	170	86	H	Qva	35.92	07-14-88	59	D
18N/01W-06Q04	MORRIS, JUANITA	160	65	H	Qvr	35.51	06-16-88	260	D
18N/01W-06R03	HANNA, LAWRENCE J.	165	72	H	Qva	19.15	06-16-88	120	D
18N/01W-07A06	COHN, JACK	175	67	H	Qva	25.00 R	06-16-88	88	D
18N/01W-07C01	DRESSER, ROD F.	175	63	H	Qvt	40.72	06-16-88	17	D,W,S
18N/01W-07E02	SWANSON, RICK	180	64	H	Qvr	46.61	06-16-88	2100	D
18N/01W-07E04	WILLIAMS, CHRIS	175	80	H	Qvt	47.77	09-06-88	11	D,I
18N/01W-07H04	CROSLEY, LARRY	195	141	P	Qc	66.46	06-20-88	120	D,S
18N/01W-07K03	NORTHCOTT, JAY	185	91	H	Qvr	59.41 R	08-24-88	65	D
18N/01W-07L04	WILD, DONALD	180	91	H	Qva	45.81	06-16-88	56	D
18N/01W-07M02	REYNOLDS, BERNICE	185	79	H	Qva	38.36	06-16-88	76	D
18N/01W-07N03	GRANT, RICHARD	195	98	H	Qva	52.30 R	06-20-88	22	D,O,S
18N/01W-07P02	STUART, JEAN	181	53	P	Qva	51.51	09-07-88	430	D
18N/01W-08C02	MASON, COLLEEN	150	140	H	Qf	45.77	07-14-88	15	D
18N/01W-08E01	ROBINSON, JOHN	190	77	H	Qva	33.69	06-20-88	77	D
18N/01W-08G02	SLEATER KINNEY BAPTIST CHURCH	150	67	H	Qva	9.80R	06-22-88	140	D,I
18N/01W-08H03D1	CITY OF LACEY, PLEASANT GLADE	124	570	P	TQu	55	09-22-88	23	D,X
18N/01W-08L01	CHRISTIANSON, HARRY	202	97	P	Qf	41.86 R	07-13-88	24	D
18N/01W-08L03	CHRISTIANSON, HARRY	202	100	H	Qva	50	07-10-67	37	D
18N/01W-08L04	CHRISTIANSON, HARRY	202	101	P	Qva	40.70	07-13-88	--	-
18N/01W-09D01	FISHER, DON	85	71	H	Qf	39.88	06-15-88	60	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
18N/01W-09G01	PARKS, HAROLD	82	345	P	TQu	15.49	07-20-88	--	D
18N/01W-09J01	SELNESS, DARRELL	105	195	H	Qc	36.76	06-22-88	49	D,W,S
18N/01W-09K03	MECONI, R.F.	93	83	P	Qva	7.11	07-07-88	40	-
18N/01W-09K04	MECONI, R.F.	92	88	P	Qva	8.47	07-07-88	54	D
18N/01W-09K05	MECONI, R.F.	95	--	P	--	7.44	07-07-88	--	-
18N/01W-10F01	OLYMPIA SAND & GRAVEL, WELL NO 1	150	195	N	Qf	70.70	07-14-88	11	D
18N/01W-10R02	THOMPSON, ALVIN H.	208	171	U	Qc	136	10-20-58	1,000	D
18N/01W-10R03	MOON, J.K.	210	178	U	Qc	120	09-06-51	880	D
18N/01W-11A01	LAKESIDE INDUSTRIES, INC.	217	481	N	Mlt	190	08-28-70	--	D
18N/01W-11J01	DEPT. OF NATURAL RESOURCES	215	165	U	Qc	128	-38	--	-
18N/01W-11P05	MILLS, GARY	205	73	C	Qva	36.36	06-23-88	--	D,O,S
18N/01W-12D01	THURSTON CO., PUBLIC WORKS DEPT.	220	200	U	Mlt	168	01-05-89	--	D
18N/01W-12F01	CITY OF LACEY, WELL NO. 8	215	380	P	TQu	187	08-28-87	100	D,O,S
18N/01W-12J02	RICHARDSON, PAUL	240	230	H	Qc	209.06	07-07-88	--	D
18N/01W-12L04	LANDRAM, DREW	218	112	P	Qva	108.16 R	08-19-88	36	-
18N/01W-12M01D1	NORTH END MANOR & RENTALS	218	239	P	Qc	190	11-05-64	1,800	D,O,S
18N/01W-12R02	DUTERROW, JAMES	237	231	H	Qc	205	04-24-78	>1,200	D
18N/01W-12R03	SMITH, SYLVIA	235	145	H	Qf	54.11 R	06-23-88	62	D,I
18N/01W-13A01	BONTEMPS, JEFF	225	228	H	Qc	165	02-16-80	--	D
18N/01W-13A02	CITY OF LACEY, WELL NO. MA 1	235	240	P	Qc	198.55	07-08-88	380	D,I
18N/01W-13A03	CITY OF LACEY, WELL NO. MA 2	235	292	P	Qc	197.46	07-08-88	340	-
18N/01W-13B01	BROWN, HAROLD	230	259	H	TQu	206.64	06-23-88	310	D
18N/01W-13C01	BOONE & BOONE PROP. MANAGERS	200	16	H	Qvr	10	01-28-58	--	S
18N/01W-13F01	OWEN, BOYD	200	16	H	Qvr	8	03-06-58	--	-
18N/01W-13G02	WASH. LAND YACHT HARBOR, NO. 1	210	259	P	Qc	175.99	06-23-88	42	D,I
18N/01W-13G03	WASH. LAND YACHT HARBOR, NO. 2	223	275	P	Qc	180	04-04-69	1,300	D
18N/01W-13J01D1	MEADOWS WATER CO., WELL NO. 3	240	321	P	TQu	238.65	05-26-88	52	D
18N/01W-13J02	MEADOWS WATER CO., WELL NO. 5	245	336	U	TQu	223.79 R	06-01-88	8.2	D
18N/01W-13J03	MEADOWS WATER CO., WELL NO. 4	240	292	P	TQu	217.34	05-25-88	1,200	D
18N/01W-13J04	MEADOWS WATER CO., WELL NO. 6	240	324	U	TQu	220	03-30-89	1,400	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
18N/01W-13N01	SO. SOUND UTIL., ROLLING FIRS 2	265	284	P	Qc	236.95	06-27-88	2,200	D
18N/01W-14D04	TANGLEWILDE PUD	203	226	U	Qc	162	05-12-62	52	D
18N/01W-14H02	OSTROM MUSHROOM FARM	235	64	U	Qva	49.39	08-19-88	160	-
18N/01W-14H04	OSTROM MUSHROOM FARM	232	260	I	Qc	199	01-12-56	4,800	D
18N/01W-14L02	HOPKINS, BRAD	218	53	H	Qva	36.99	07-06-88	820	D,S
18N/01W-14R01	SO. SOUND UTIL., ROLLING FIRS 1	225	254	P	Qc	191	02-08-69	870	D,I
18N/01W-15B04	MINELGA, ANTANAS	180	149	U	Qc	108	06-30-62	45	D
18N/01W-15D01S	NISQUALLY TROUT FARM	75	--	Q	Qvr	--	--	--	-
18N/01W-15H01	TANGLEWILDE PUD	175	177	U	Qc	135	07-00-57	118	D
18N/01W-16A01S	ST. MARTINS COLLEGE	75	--	T	Qvr	--	--	--	-
18N/01W-16Q03	REINHARDT, HERMAN	160	137	I	Qf	--	--	--	D,O
18N/01W-17C01	CITY OF OLYMPIA, NO. 1	199	187	U	Qc	85	03-26-63	133	D
18N/01W-17C02	CITY OF OLYMPIA, NO. 2	199	190	U	Qc	84	01-01-67	50	D
18N/01W-17G02	UNION OIL CO.	200	62	U	Qvt	18	04-29-67	18	D
18N/01W-17H05	DAWSON, DAN	202	101	P	Qva	51	06-11-66	270	D,X,O
18N/01W-19A01	FEELY, DEL	195	92	U	Qva	21	09-02-62	77	D
18N/01W-19C02	WOODSUM, CHRISTOPHER	145	42	H	Qva	18.20	07-25-88	48	D
18N/01W-19D05	PALMER, NELDA	162	75	H	Qf	22.41	07-19-88	7.5	D
18N/01W-19F02	CRAIG, LAURA	182	42	P	Qva	23.49	09-06-88	180	D
18N/01W-19G02	WEISS, OSKAR	202	60	H	Qva	44.62	08-02-88	--	D
18N/01W-19H02	DETRAY, PAUL	198	82	P	Qva	35.00	09-07-88	330	D
18N/01W-19L03	STIMMEL, BOB	185	78	H	Qva	30.64	07-25-88	58	D
18N/01W-19M05	WILLOWS, WALT	210	70	H	Qva	43.75	08-10-88	300	D,O,S
18N/01W-21B04	THURSTON CO., WATER DIST. NO. 2	175	120	P	Qva	64	04-27-59	650	D
18N/01W-21B05	CITY OF LACEY, FIRE DEPT.	182	107	U	Qva	60	10-29-54	62	D
18N/01W-21B06	CITY OF LACEY, WELL NO. 7	178	481	P	TQu	52	08-14-76	140	D,X,O
18N/01W-21D03	HUNTAMER, TOM	194	153	U	Qc	60	04-14-53	--	D
18N/01W-21H02	CITY OF LACEY, PARKS & REC.	150	340	U	TQu	15	06-13-77	210	D
18N/01W-21P01	CITY OF LACEY, WELL NO. 6B	228	119	U	Qva	85	11-19-59	1,100	D
18N/01W-21P02D1	CITY OF LACEY, WELL NO. 6C	235	380	P	Mlt	94	08-25-88	--	D,X

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
18N/01W-22K01	DOTSON	199	56	H	Qvr	47	04-30-64	52	D,O
18N/01W-23B02	SMITH, WESLEY M.	167	32	H	Qvr	15.87	08-18-88	830	D,O,S
18N/01W-23Q01	ERIKSON, RICHARD L.	181	161	H	Qc	142.62	07-29-88	620	D
18N/01W-24A02	MEADOWS WATER CO., WELL NO. 1	213	797	P	TQu	162.36	05-26-88	55	D
18N/01W-24A03	MEADOWS WATER CO., WELL NO. 2	214	103	P	Qva	44.18 R	05-26-88	24	D
18N/01W-24B01	EVERGREEN BALLROOM	222	85	H	Qva	50	01-15-58	--	-
18N/01W-24B02	TEXACO	242	103	H	Qva	53.44	07-28-88	56	D,W,I
18N/01W-24D02	CONLY, DONNA	226	96	H	Qva	48.65	08-02-88	--	D
18N/01W-24E01	TRAVIS, DAVID	230	82	H	Qva	--	--	--	-
18N/01W-25B01	SO. SOUND UTIL., EVERGREEN ESTAT	260	239	P	Qc	216	07-14-66	12,000	D,I
18N/01W-25P02	DRAPER, T.W.	181	57	H	Qva	23.01	07-29-88	--	D,X,I
18N/01W-26A02	MAY, ROBERT	230	118	H	Qva	80.79 R	07-29-88	620	D,S
18N/01W-26C02	EVERETT, JOEL	189	65	H	Qva	38.91	08-02-88	130	D
18N/01W-26G01	LAKERIDGE WATER CO.	187	73	P	Qva	38.72	08-17-88	3,000	D
18N/01W-26N01	HUNTAMER WATER SERVICE	182	85	U	Qva	34	03-11-57	--	D,X
18N/01W-26N02	CITY OF LACEY, LONG LAKE TEST	185	386	U	TQu	103	12-13-88	13	D
18N/01W-27A03	GLASS, RAY	166	78	H	Qva	24.03 R	07-29-88	23	D
18N/01W-27K01	CITY OF LACEY, WELL NO. 5	205	84	U	Qva	50.78	10-03-88	960	D
18N/01W-27M02	GUILES, JAMES	190	388	H	TQu	43.27 Z	08-24-88	24	D,I
18N/01W-28E01	CITY OF LACEY, WELL NO. 1	232	217	P	Qc	65.60	07-08-88	67	D,I
18N/01W-28J01	HANSON, BOB	185	127	H	Qc	26.93 Z	08-17-88	--	D,W,I
18N/01W-28M01	CITY OF LACEY, WELL NO. 2	232	227	P	Qc	76.98	07-08-88	29	D
18N/01W-28M02	CITY OF LACEY, WELL NO. 3	232	225	P	Qc	74.70 R	07-08-88	70	-
18N/01W-28P01	JACKSON, E.A.	235	121	U	Qva	54	11-27-53	170	D,X
18N/01W-29E01	NICKERSON, CARL	212	100	H	Qva	50	05-20-67	92	D
18N/01W-29Q02	ROSS, DEWEY	238	137	U	Qva	72.93	07-25-88	17	D,X
18N/01W-30A01	CITY OF OLYMPIA, WELL NO. 3	278	362	P	TQu	145	08-27-84	--	D
18N/01W-30E04	MACKEY, LANNY	202	75	H	Qva	51.98 S	07-26-88	490	D,I
18N/01W-30L02	BELL, KEITH	235	61	P	Qva	43	08-01-65	370	D
18N/01W-30M02	BELL, KEITH	228	105	U	Qva	91	08-24-59	150	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
18N/01W-31A02	WARNER, JOHN	210	140	H	Qva	67.40 R	07-27-88	>1,200	D,X,I
18N/01W-31A03	DIXON, BETTY	209	139	H	Qva	64.88	08-08-88	280	D,S
18N/01W-31G01	JACOBSEN, HAROLD	205	84	U	Qva	22	02-08-72	63	D
18N/01W-31G02	JACOBSEN, HAROLD	204	102	U	Qva	38.52	09-07-88	340	D
18N/01W-31G03	JACOBSEN, HAROLD	205	80	U	Qva	25	04-01-71	29	D
18N/01W-31K03	BOE SAND & GRAVEL	185	64	H	Qva	31.77	08-05-88	36	D,I
18N/01W-31R02	CITY OF OLYMPIA, WELL NO. 14	200	154	P	Qc	40	03-26-75	--	D,O
18N/01W-32D02	BENNETT, JAMES	203	91	H	Qva	54.90	08-08-88	31	D,X
18N/01W-32L01	HUTSON, JERRY	215	79	H	Qva	43.70	08-05-88	62	D
18N/01W-32N02	SKAIFE, LARRY	212	98	H	Qva	41.25	08-05-88	--	D
18N/01W-32P01	CITY OF OLYMPIA, WELL NO. 4	202	56	P	Qvr	25	05-02-58	>1,500	D,S
18N/01W-32P02	CITY OF OLYMPIA, WELL NO. 10	200	194	U	Qc	29.24	12-13-88	50	D
18N/01W-32P03	CITY OF OLYMPIA, WELL NO. 11	200	88	U	Mlt	29.00	12-13-88	--	D
18N/01W-32P04	CITY OF OLYMPIA, WELL NO. 5	200	47	P	Qvr	21	02-15-75	310	D
18N/01W-32P05	CITY OF OLYMPIA, NO. 6/ABANDONED	200	170	U	Qc	31	12-21-79	20	D
18N/01W-33B01	WOODLAWN CEMETERY	212	118	I	Qva	40	04-02-59	44	D
18N/01W-33C01	TRABER, JOHN E.	208	73	I	Qva	40.29	08-05-88	46	D,X,W,S
18N/01W-33F01	PARKER, REBECCA	208	62	H	Qva	34	10-17-62	--	D,X,S
18N/01W-33G02	JACKSON, ERVIN	212	102	U	Qva	33	04-30-59	--	D,X
18N/01W-33J02	ROSENTHAL, ROSS	201	60	H	Qvr	36.29	08-25-88	--	D
18N/01W-33N01	CITY OF LACEY, WELL N0. 9	197	283	P	TQu	22	10-19-81	38	D,X
18N/01W-33P01	CITY OF LACEY, WELL NO. 10	198	208	P	Qc	33.35	07-08-88	270	D,S
18N/01W-34G01	HANSEN & ITTNER	175	59	U	Qvr	20.45	09-22-88	72	D
18N/01W-34G01S	UNKNOWN	165	--	U	Qvr	--	--	--	-
18N/01W-34J01	GRONKA, WALTER	172	54	H	Qva	21.35	08-02-88	180	D
18N/01W-34J02	CITY OF LACEY	200	461	U	TQu	58	09-25-65	18	D
18N/01W-34M03	COX, WALT	202	80	H	Qva	45.10	08-04-88	380	D,I
18N/01W-34Q01	RUMAC FUND WATER ASSOC.	194	109	P	Qva	39.00	08-24-88	200	D
18N/01W-35A04	STEFFENS, JIM	161	32	H	Qva	10.41	08-02-88	31	D,X,W
18N/01W-35B02	SOUTH SHORE WATER CO.	176	82	P	Qva	25.78	08-08-88	--	D,X

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
18N/01W-35G02	ROBERTS, JAMES L.	181	139	H	Qc	101.22	08-08-88	220	D,S
18N/01W-35L02	WARICK, SKIP	193	56	H	Qva	43.75 R	08-08-88	370	D,I
18N/01W-35N01	BIENICH, JOE	185	76	H	Qva	36	01-02-63	140	D
18N/01W-36C01	CITY OF LACEY, SEASONS NO. 1	195	230	U	TQu	130.42	07-08-88	39	D
18N/01W-36C02	CITY OF LACEY, SEASONS NO. 2	195	336	U	TQu	126.87	07-08-88	11	D,W
18N/01W-36E01	BAYNE, SID	210	150	H	Qc	--	--	--	-
18N/01W-36H02	SWANSON, KENNETH	221	188	H	Qc	164.45 R	08-02-88	140	D,I
18N/01W-36J01	TRI LAKES COUNTRY HOME ESTATES	228	260	P	TQu	155	05-18-79	>590	D
18N/01W-36L01	CHAPMAN, WILLIAM K.	222	163	H	Qc	154.18 R	07-28-88	250	D
18N/01W-36L02	BAUGHN, EARL	223	90	H	Qva	--	--	--	-
18N/01W-36M02	TOWER & MCCULLOCK	225	160	H	Qc	146	09-27-66	--	D,S
18N/01W-36N01	PATTISON WATER CO.	218	217	P	Qc	149.11	08-17-88	9,700	D,W
18N/01W-36N02	PATTISON WATER CO.	210	217	P	Qc	--	--	--	-
18N/02W-01E06	LAPP, ORVILLE	120	37	H	Qva	18.45 Z	09-30-88	62	D
18N/02W-01F04	PLESHA, JERRY	150	92	H	Qf	42.69	09-15-88	10	D,I
18N/02W-01G02	RADONOVICH, MIKE	168	97	H	Qva	11.72 R	09-14-88	46	D
18N/02W-01G03	RADONOVICH, MIKE	168	178	U	Qc	135.32 Z	09-30-88	310	D
18N/02W-01Q03	DEVOE, DAN	178	71	H	Qva	19.60	09-14-88	34	D
18N/02W-01R05	LUNDMARK, MORRIS	165	164	H	Qc	105.47	09-14-88	310	D
18N/02W-02A03	THOMPSON, PHIL	110	47	H	Qvt	27.91	09-29-88	15	D,I
18N/02W-02A04	GOHEEN, GREG	115	111	H	Qc	100.43	08-18-88	89	D
18N/02W-02A05	ALDERBROOK KENNELS	119	133	H	Qc	108.14	06-28-88	100	D
18N/02W-02B05	HINCHCLIFFE, RON	130	74	H	Qva	19.09	06-24-88	--	D
18N/02W-02C04	BLOOM, LEWIS	100	143	H	Qc	95	05-26-59	--	C
18N/02W-02C07	DANIELS, BILL	55	43	H	Qva	22.16	06-28-88	46	D
18N/02W-02C08	CONSER, DORIS	102	126	H	Qc	92	08-10-68	590	D
18N/02W-02C09	KEEGAN, ROBERT	35	60	H	Qc	33	10-16-76	140	D
18N/02W-02E02	LOCKWOOD, CALVIN	5	200	H	TQu	-- F	--	--	C
18N/02W-02F04	MOTTMAN, MIKE	105	83	H	Qva	39.82 Z	09-15-88	45	D
18N/02W-02H04	ALEXANDER, GARY	110	81	H	Qf	39.67	11-04-88	8.3	D,S

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
18N/02W-03N06	SHAWLER, DAVID	159	159	I	Qc	140	03-11-80	--	D
18N/02W-04D01	RUSH, FRANK	145	69	H	Qva	31.62 Z	09-27-88	48	D,I
18N/02W-04F02	WINDOLPH WATER ASSOC.	20	400	P	TQu	-- F	--	--	C
18N/02W-04F03	MOTT, FREDRICK R.	98	419	H	TQu	40	06-26-62	740	D,X,I
18N/02W-04G03	THOMPSON, STEVE	156	97	H	Qva	10.97	09-15-88	14	D
18N/02W-04J08	HEGGEN, RICHARD	170	125	H	Qf	33	12-27-78	13	D,S
18N/02W-05B02	WINKELMAN, JIM	182	79	H	Qva	62.34 Z	09-13-88	--	-
18N/02W-05B03	BRACKEN, CANDY	150	59	H	Qva	33.37	06-29-88	--	D
18N/02W-05C03	KELLY, DAN	145	57	H	Qva	28.24	06-29-88	--	D
18N/02W-05D02	SACRE, MARY	160	110	H	Qf	55.05	09-13-88	14	D
18N/02W-05D03	SO. SOUND UTIL., RAINWOOD WELL	180	106	P	Qva	68.84	06-23-88	280	D,I
18N/02W-05D04	HARTLEY, JAMES R.	168	100	H	Qva	63.88	09-27-88	34	D
18N/02W-05H01	HARPER, LARRY	140	60	H	Qva	12	05-18-79	--	D,S
18N/02W-06E02	BROWER, HAL	35	45	H	Qc	--	--	--	C
18N/02W-06N01	THORKILDSEN, ARNT	150	165	P	Qc	86	11-20-87	56	D
18N/02W-07D01	SO. SOUND UTIL., SIMMONS CT.	160	99	P	Qva	82.03	06-14-88	--	D,I
18N/02W-07E01	RUTZ, JERRY	163	101	H	Qva	82.38	06-14-88	280	D
18N/02W-07J03	CONWELL WATER SUPPLY	195	149	H	Qva	115.87	06-14-88	79	D
18N/02W-07L02	NOBLE, CAROL	145	73	H	Qva	59.98	06-14-88	290	D
18N/02W-07N02	MUNRO, RALPH	40	39	H	Qva	>-12.5 F	06-23-88	59	D,I
18N/02W-07N03	MCKEEHAN, SUZAN	40	40	H	Qva	0	01-15-87	210	D
18N/02W-07R01	MCBRIDE, KENNETH	155	125	U	Qva	83.43	04-04-88	75	D,W
18N/02W-08E03	MCBRAYER, CLYDE	172	64	H	Qva	39.05	09-15-88	340	D,I
18N/02W-08N03	SWIGERT, MIKE	160	120	H	Qva	86.97	09-03-88	110	D,W,I
18N/02W-09D01	KANDA, DEVIN	178	67	H	Qva	29.56	09-13-88	>1,100	D,X
18N/02W-09D02	WOODLAND PARK WATER ASSOC.	250	104	P	Qvt	20.47 R	09-06-88	9.6	-
18N/02W-09G01	CARLSON, JAMES D.	248	191	H	Qva	110	07-12-82	31	D,X,I
18N/02W-12A03	KVERNVIK, ANDREA	165	84	H	Qva	7.75 Z	09-30-88	35	D
18N/02W-12E01	RIDLEY, TIM	160	70	H	Qva	15.03	11-04-88	61	D
18N/02W-12G04	PEACE LUTHERAN CHURCH	173	164	H	TQu	91.67	06-24-88	220	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
18N/02W-12G05	OLYMPIA FROSTED FOODS	180	194	N	Qc	--	--	--	-
18N/02W-12H01	HUBER, KAISER	171	138	H	Qc	96.64 R	06-21-88	80	D,I
18N/02W-12J01	NORRIS, DEAN	165	28	H	Qvr	3.45	09-30-84	26	D
18N/02W-12K04	CHILDRESS, BILL	165	145	H	Qc	89.25 Z	09-14-88	11	D
18N/02W-12Q03	KNUDSON, DEL	165	44	H	Qva	5	06-17-82	120	D,I
18N/02W-12Q04	JONES, TOM	180	28	H	Qvr	17.48	07-21-88	--	-
18N/02W-12R01	BROWN, ADRIAN	158	139	H	Qc	66.50	09-30-88	1,000	D
18N/02W-16A01	CURLS, TILDEN	193	140	H	Qva	102.97	09-27-88	1,800	D,X
18N/02W-17B02	UNKNOWN	165	117	P	Qva	78	09-26-77	180	D
18N/02W-17B03	UNKNOWN	166	123	P	Qva	79	10-13-77	78	D
18N/02W-17B04	CITY OF OLYMPIA, WELL NO. 1	155	111	P	Qva	59	10-07-88	--	-
18N/02W-17D05	LINDERMAN, KEN	175	125	H	Qvt	95	03-08-87	15	D,O
18N/02W-17H02	BARK & GARDEN CENTER	185	119	I	Qva	90	07-14-78	510	D
18N/02W-17H03	BARK & GARDEN CENTER	183	109	I	Qva	80.56	06-17-88	560	D
18N/02W-17M02	THURSTON CO., FIRE DEPT. NO. 9	150	131	H	Qva	84.88	05-23-68	520	D,I
18N/02W-17M04	CITY OF OLYMPIA, MCLANE TEST	155	160	U	Qva	91.40	06-17-88	>230	D
18N/02W-17Q04	LEIGHT & NELSON	175	153	H	Qc	94.94	06-17-88	490	D
18N/02W-18A02	UNKNOWN	184	140	H	Qva	98.76	06-17-88	--	D
18N/02W-18G04	SUNDAY, DALE	160	100	H	Qva	81	04-01-82	160	D
18N/02W-18K01	MCLANE SCHOOL	175	180	U	Qc	117.85	05-18-78	--	-
18N/02W-18K02	CITY OF OLYMPIA, TEST WELL NO. 4	120	160	U	Qc	84.00	06-17-88	370	D
18N/02W-18K03	CITY OF OLYMPIA, EXPL WELL NO. 2	145	200	U	Qc	117	01-17-88	--	D
18N/02W-18L01	CITY OF OLYMPIA, WELL NO. 2	10	229	U	TQu	-- F	06-17-88	47	D,I
18N/02W-18L01S	CITY OF OLYMPIA, ALLISON SPRINGS	10	--	Q	Qva	--	--	--	-
18N/02W-18L02	CITY OF OLYMPIA, WELL NO. 13	130	185	U	Qc	109.53	08-02-89	540	D
18N/02W-20C01	KAISER ROAD INDUSTRIAL PARK	170	71	H	Qva	62.84	06-17-88	>530	D,O,S
18N/02W-21Q01	WASHINGTON STATE, HIGHWAY DEPT.	135	75	H	Qva	9	02-20-68	65	D,X,O
18N/02W-22D01	WASHINGTON STATE, WORK RELEASE	210	149	U	Qva	123	02-27-78	23	D,X
18N/02W-22E01	DAIGNEAULT, MAURICE	210	200	H	Qf	127.27	09-19-88	32	D,X,O,S
18N/02W-24B01	MALLINGER, JOHN	100	51	H	Qva	5	04-15-85	62	D,O,S

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
18N/02W-25A03	PORTER, WILLIAM	188	73	H	Qva	65.79	07-26-88	56	D
18N/02W-28J01	WICKETT, RUSS	198	184	H	Tb	129	05-07-87	.017	D,X
18N/02W-28J02	DANIELSON, JAMES	135	83	H	Qva	18.10	09-20-88	1,100	D,I
18N/02W-29N01	MILLS, GARY	199	98	H	Tb	29.71	09-21-88	--	D
18N/02W-30Q02	VOVI FRIENDSHIP ASSOC.	175	163	H	Tb	21.68 Z	09-29-88	--	D
18N/02W-31G01	MARTINI, DICK	150	50	H	Qvt	12	06-06-85	16	D
18N/02W-31J03	HOROWITZ, HARRY	135	67	H	Qva	1.22	09-29-88	620	D,S
18N/02W-31L01	WILLIAMS, NANCY	164	68	H	Qva	35.66 Z	09-20-88	25	D
18N/02W-31P02	COLUMBUS PARK	167	105	P	Qc	45.36	09-20-88	81	D
18N/02W-31P03	COLUMBUS PARK	160	106	P	Qc	36.68 Z	10-11-89	22	D
18N/02W-31R02	WESTHOFF, LYLE	150	28	H	Qva	10.95	09-15-88	310	D,I
18N/02W-32A06	REINKER, ROBERT	181	80	H	Qva	30	05-00-80	97	D,X,O
18N/02W-32B02	ROLLMAN, DICK	175	37	H	Qva	22.90	09-21-88	40	D,X,I
18N/02W-32D02	MILLS, GARY	138	140	U	Tb	107	12-14-87	--	D,X
18N/02W-32D03	WOSKI, L.F.	180	173	H	TQu	38	05-19-78	--	D,X
18N/02W-32K01	SIEGLER, JACOB	177	67	H	Qva	7	02-16-79	51	D
18N/02W-32K02	BOYSEN, LINDA S.	177	61	H	Qva	20	08-08-81	44	D
18N/02W-33A03	SCOTT, GARY	155	46	H	Qva	14	02-09-81	13	D,X
18N/02W-33C01	HARRISON, NORMAN	270	304	H	Tb	65	08-10-88	--	D,W
18N/02W-33M01	FUNK, BILL	181	120	H	Tb	9.77	09-21-88	1.2	D,O
18N/02W-33R02	GRONMYER, LEE	163	60	H	Qvr	12.55 Z	09-29-88	20	D,X
18N/02W-34B01	MEAD, BETTY	170	37	H	Qvr	20.07	09-20-88	63	D,X,O,S
18N/02W-34C02	ROGERS, SANDY	170	61	H	Qvr	17.62	09-21-88	280	D,X
18N/02W-35B02	PABST BREWING CO., WELL NO. 35	185	258	N	Qc	98	05-23-89	70	D,O,S
18N/02W-35B04	PABST BREWING CO., WELL NO. 37	170	228	N	Mlt	46	02-09-89	--	D,X
18N/02W-35B05	PABST BREWING CO., WELL NO. 38	185	294	N	Qc	98	08-23-89	90	D
18N/02W-35F06	PABST BREWING CO., WELL NO. 11	100	134	N	Mlt	16	02-09-89	--	D
18N/02W-35F08	PABST BREWING CO., WELL NO. 18	95	147	N	Qva	--	--	--	D
18N/02W-35F11	PABST BREWING CO., WELL NO. 22	100	152	N	Qva	13	02-09-89	--	D
18N/02W-35F12	PABST BREWING CO., WELL NO. 23	95	132	N	Qva	38	02-09-89	--	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
18N/02W-35K01	PABST BREWING CO., WELL NO. 29	105	318	I	TQu	-- F	01-05-89	--	D
18N/02W-35K02	PABST BREWING CO., WELL NO. 31	105	344	I	TQu	-- F	01-05-89	--	D
18N/02W-35K03	PABST BREWING CO., WELL NO. 39	110	390	N	TQu	-- F	--	150	D,I
18N/02W-35M01	CITY OF TUMWATER, WELL NO. 1	110	80	P	Qva	8	03-00-48	61	I
18N/02W-35M02	CITY OF TUMWATER, WELL NO. 2	110	92	P	Qva	9.27	01-06-89	250	D
18N/02W-35M03	CITY OF TUMWATER, WELL NO. 3	110	96	P	Qva	8	05-01-65	97	D
18N/02W-35M04	CITY OF TUMWATER, WELL NO. 4	110	90	P	Qva	8	00-00-60	210	D
18N/02W-35M05	CITY OF TUMWATER, WELL NO. 5	110	115	P	Qva	9.94	01-06-89	53	D
18N/02W-35M06	CITY OF TUMWATER, WELL NO. 6	110	120	P	Qva	8.22	01-06-89	75	D
18N/02W-35M08	CITY OF TUMWATER, WELL NO. 8	110	90	P	Qva	5.93	01-06-89	110	D
18N/02W-36D01	BRIGGS NURSERY	183	319	I	TQu	82.08 Z	09-29-88	84	D,X
18N/02W-36L01	CRAWFORD, DALE	185	124	H	Qva	80	10-02-78	44	D,I
18N/03W-01D02	VOIGT, L.C.	10	64	H	Qc	-- F	--	--	D,C
18N/03W-01D04	HOLZ, TOM & LYNN	65	136	H	Qc	46	-77	140	D
18N/03W-01J02	HICKS, BILL	70	75	U	Qc	34.26	06-14-88	330	D,W
18N/03W-01K04	NEAT, DARRELL	20	72	H	Qc	-- F	07-18-82	160	D,I
18N/03W-01L01	HOGAN, DAVE	50	53	H	Qc	43.49	07-11-88	330	D,I
18N/03W-02A02D1	TALLMAN, RON	130	179	H	Qc	126.50	07-14-88	320	D
18N/03W-02B05	GRIFFIN SCHOOL	165	117	H	Qva	91.43	06-16-88	270	D,I
18N/03W-02B06	PETERS, WILLIAM	165	100	H	Qva	87.14	08-22-88	260	D,I
18N/03W-02C02	BAKER, STEVEN	180	180	H	Tb	6.93	08-18-88	--	D
18N/03W-02H02	SEXTON, L.W.	6	71	P	Qc	-- F	05-02-67	--	D
18N/03W-02H05	SMITH, GARY	135	178	H	Qc	133.18	07-15-88	--	D,I
18N/03W-02J01	SMITH, JAMES M.	35	55	H	Qc	--	--	--	C
18N/03W-03J02	WYNNE, TOM	180	24	H	Qva	5	05-19-66	88	D
18N/03W-04R02	WYNNE, HENRY	180	60	H	Mlt	1.40	06-22-88	--	D
18N/03W-04R03	WYNNE, HENRY	180	60	H	Qc	1.87	06-22-88	20	D,I
18N/03W-07L02	HILLS, DWAYNE	490	420	U	Tb	13.05	06-22-88	--	D,I
18N/03W-08C01	HILLIARD, GLENN	525	460	H	Tb	77.73	06-22-88	--	D
18N/03W-11C01	CAMPBELL, WOODIE	150	138	H	Tb	12.35	07-21-88	--	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
18N/03W-11D01	BORCHERDING, DAVE	440	60	U	Tb	1.80	07-21-88	.83	D
18N/03W-11P02	STRASSBURGER, JIM	230	40	H	TQu	-- F	07-11-88	57	D,I
18N/03W-11Q01	CONNELL, WILLIAM	250	72	H	TQu	56	02-01-79	47	D
18N/03W-12D01	HOY, DAVID	50	106	U	TQu	67.88	07-14-88	330	D
18N/03W-12G01	EKAR, KEVIN	80	56	H	Qva	26.00	07-11-88	180	D
18N/03W-12H01	SO. SOUND UTIL., INLET HGHTS 1	160	207	P	TQu	120	10-21-79	180	D,I
E8N/03W-12H02	GARRETT, BOB	170	121	H	Qva	99.73	07-11-88	--	D
18N/03W-12H03	SO. SOUND UTIL., INLET HGHTS 2	165	114	P	Qva	88.09	08-03-89	--	D
18N/03W-12K01	LAFLER, JOHN	80	78	H	Qf	31.81	08-04-88	21	D
18N/03W-12L01	WHITE, BARRY & SUE	30	49	H	Qc	10.87	07-14-88	--	D,I
18N/03W-12R01	OSBORNE, A.F.	12	27	H	Qc	-- F	--	--	C
18N/03W-13B01	HIVELY, H.	15	50	H	--	--	--	--	C
18N/03W-13G02	DORSETT, LESTER	20	90	H	Qc	-- F	--	--	C
18N/03W-13G06	PISANI, NICK	20	69	U	Qc	4.72	08-04-88	--	D
18N/03W-13H02	CONNOR, BILL	20	300	U	Tb	161	01-05-88	--	D
18N/03W-13K01	MOOK, M.L.	50	85	H	Qc	21	06-30-60	--	I
18N/03W-13K03	WEST OLYMPIC BAPTIST CHAPEL	75	79	H	Qc	29.31	06-14-88	160	D
18N/03W-13Q01	WILDER, F.E.	60	83	H	--	--	--	--	C
18N/03W-14J01	SIMPSON, SAM	195	38	H	Qva	17	05-01-87	32	D
18N/03W-16E01	GRAVES, RAY	540	415	U	Tb	6.00 Z	07-15-88	--	D
18N/03W-16N01	NIXON, MARGARET	510	300	H	Tb	49.24 Z	07-21-88	.018	D
18N/03W-16P02	JEWELL, DAVE	460	80	H	Mlt	15	04-14-77	--	D,I
18N/03W-16Q01	GUNTER, ROBERT	425	47	U	Tb	5.38	07-20-88	40	D
18N/03W-17R01	MACLACHLAN	490	88	H	TQu	24.33	07-12-88	8.5	D
18N/03W-18A01	DANIEL, DANIEL E.	670	400	H	Tb	84.67 R	05-11-89	--	D,I
18N/03W-18E01	LAMSON, EARL	490	215	H	Tb	178	06-10-75	--	D
18N/03W-19C01	CUYLE, JACK	670	115	H	Tb	-- F	07-21-88	--	D,I
18N/03W-19E01	HUGHES, WAYNE	490	28	H	TQu	24	05-10-78	--	D
18N/03W-19F01	PERSON, JERRY	525	103	U	TQu	8.78	07-15-88	15	D
18N/03W-22A01	OLETZKE, MARK	410	290	H	Tb	--	--	--	D,I

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
18N/03W-22H01S	UNKNOWN	325	--	U	Qvr	--	--	--	-
18N/03W-22J01	ROTH, RAY	320	47	H	Qva	24.34	06-22-88	430	D
18N/03W-23A01	CEDAR FLATS, WELL NO. 1	210	53	U	Qvt	1.65	06-22-88	13	D,I
18N/03W-23A02	CEDAR FLATS, WELL NO. 2	210	53	U	Qvt	5.48	06-22-88	5.4	D
18N/03W-23B02	KIBIT, ROBERT	230	40	H	Qvt	1.63 R	07-15-88	8.8	D
18N/03W-23F01	BRIGGS, ROBERT	295	160	U	Mlt	38.86 Z	07-20-88	--	D
18N/03W-23G01	SMITH, LESLIE	260	65	H	Qc	21.95	06-16-88	--	D
18N/03W-23H04	CEDAR FLATS, WELL NO. 3	170	48	U	Qva	21.60	06-22-88	27	D
18N/03W-23H05	CEDAR FLATS, WELL NO. 4	170	48	U	Qva	26.51	06-22-88	15	D
18N/03W-23J01	LEE, STEVE	200	55	H	Qvt	27	02-15-79	21	D
18N/03W-23K02	ULERY, GEORGE	225	59	H	Qva	5.69	06-16-88	19	D
18N/03W-23N01	ZIESEMER, GEORGE	330	41	H	Qva	2.08	07-12-88	31	D,W,I
18N/03W-23N02	ASH, MARK	355	63	H	Qva	36.98 R	07-12-88	280	D
18N/03W-23P01	SHAFFER, BILL	310	59	H	Qva	27.09 Z	06-15-88	140	D
18N/03W-23Q01	OLSON, WILLIAM	245	88	H	Qc	27.65 R	06-15-88	120	D
18N/03W-24H01	KING, FRANK	20	207	H	TQu	-- F	--	190	D,I
18N/03W-24H02	MCGRAW, MIKE	35	44	P	Qc	16.11	07-12-88	680	D,I
18N/03W-24J01	FRANK, W.L.	20	116	H	TQu	-- F	--	--	C
18N/03W-24J02	RAMSAVER, R.J.	20	105	H	Tb	4.77	06-16-88	17	D,I
18N/03W-24J03	JONES, JACK	35	29	H	Qc	16.09	06-14-88	400	D,I
18N/03W-24M01D1	JONES, JACK	197	100	H	Qva	77.25 Z	06-17-88	--	D
18N/03W-24P01	HOUSE, STEVE	180	135	H	Qc	118.33R	06-15-88	>610	D
18N/03W-24R04	WEEKS, CLARENCE	20	115	H	TQu	-- F	05-17-78	--	C
18N/03W-24R06	SHOEMAKER, RICHARD	30	138	H	TQu	-- F	--	280	D
18N/03W-25A02	MEREDITH, MARK	30	65	H	Tb	1.17	06-17-88	5.5	D,I
18N/03W-25J01	DUNHAM, FLOYD	120	90	H	Qc	50.89	06-16-88	45	D
18N/03W-25P01	COLEMAN, RAY	65	100	H	Qc	2.82	07-11-88	1,500	D,I
18N/03W-25R04	HANNA, LLOYD	125	130	H	Mlt	37.06	07-12-88	--	D,X
18N/03W-36B01	THOMAS, BEN	65	79	H	Qc	.98	07-12-88	--	D,X,I
19N/01E-30E01	NATIONAL FISH & OYSTER CO.	10	34	C	Qc	-- F	--	--	C

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
19N/01E-30M01	FOREMAN, ZETTA M.	55	72	H	TQu	56.72	05-08-78	100	D
19N/01E-30P06	CONNER, ANN	155	186	H	Qc	154.90	07-13-88	62	D,X,I
19N/01E-30P07	JOHNSON, ROBERT	150	60	H	Qva	7.24	07-08-88	--	D
19N/01E-30Q01	KREIDER, C.D.	62	107	H	TQu	71	04-20-86	--	D
19N/01E-30Q02	IVEY, CURTIS	80	104	H	TQu	80.15	07-08-88	130	D
19N/01E-31C03	RAMEZ, MARIA	200	238	H	Qc	--	--	--	C
19N/01E-31C04	SMITH, DICK	190	38	H	Qvr	18	09-09-85	150	D,I
19N/01E-31C05	JOHANSEN, NORVAL	208	--	I	Qvr	39.84	07-08-88	--	-
19N/01W-03N01	MANOR, RON	30	98	H	TQu	72.95	04-10-89	480	D,C
19N/01W-04D03	JOHNSON POINT WATER SYSTEM	120	134	P	Qc	102	06-20-86	630	D
19N/01W-04F02	ZITTLE, MIKE	100	116	H	Qc	93.46	05-02-89	--	C
19N/01W-04G01	PINKERTON & LYSACK	55	90	H	Qc	69	07-00-56	--	C
19N/01W-04J02	WAKKURES, DAVID	55	66	H	Qc	56	10-12-57	--	D,C
19N/01W-04P01	EICHELSER	165	215	H	Qc	159.65	07-15-88	63	D,I
19N/01W-05H01	SHUMWAY, S.E.	60	99	H	Qc	55.81	05-09-78	61	D,X,I
19N/01W-05J01	CUSHMAN, KENT	5	337	H	TQu	-- F	05-09-78	--	C
19N/01W-05J04	ANTIPA, ROSS	45	--	H	--	42.22	07-21-88	--	-
19N/01W-05N02	BRABECK, E.D.	45	50	H	Qc	43	10-19-59	--	-
19N/01W-05R04	WICK, R.H.	40	139	H	TQu	36	12-01-64	41	D,C
19N/01W-05R05	TREECE, STEVE	10	203	H	TQu	30.22	07-21-88	9.9	D,X,I
19N/01W-05R06	CARLSON, WENDELL	20	194	H	TQu	37	12-07-81	16	D
19N/01W-06H01	WARD, J.M.	30	144	H	Qc	25.42	05-01-89	--	C
19N/01W-06J06	TREMBLAY, LAURIE	22	37	H	Qc	11.07	07-21-88	120	D
19N/01W-06J07	OLIVER, SCOTT	45	50	U	Qf	--	--	--	D
19N/01W-06K04	APP, H.F.	40	65	H	Qc	27.47	05-02-89	--	C
19N/01W-06K05	HOONAN, KEVIN	80	70	H	Qf	38.21	09-25-88	.052	D
19N/01W-06L01	JOHNSON, HARRY	61	190	H	TQu	69.24 R	08-08-88	250	D,W,I
19N/01W-06M03	CRABB, M.J.	65	300	H	TQu	--	--	--	C
19N/01W-07A01	SO. SOUND UTIL., LIBBY ROAD WELL	85	82	P	Qc	45.13	06-21-88	6,600	D,I
19N/01W-07N01	WRIGHT, L.W.	120	133	H	Qc	--	--	--	C

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
19N/01W-07N02	DUNHAM, DENNIS	125	138	H	Qc	95	04-15-77	180	D,I
19N/01W-07R01	LINSCOTT, ROBERT	40	1,000	P	TQu	36.10 R	12-22-88	1.2	I
19N/01W-08A03	BUDINICH, HENRY	60	137	H	TQu	--	--	--	C
19N/01W-08J01	BAIN, LEONA	40	87	H	Qc	--	--	--	C
19N/01W-08K01	MEYER, ERNEST	80	89	H	Qc	64.13	12-22-88	180	D
19N/01W-08R01	COATES, DON	50	79	H	Qc	38.33	09-14-88	33	D,X
19N/01W-09L01	BERNDT, RICHARD	230	146	H	Qva	55	10-20-77	10	D
19N/01W-09L02	CHASE, MILTON	190	90	H	Qva	54.52	08-29-88	150	D,W,O
19N/01W-09R03	LIBBY, NICK	157	65	H	Qva	25.28	07-13-88	380	D
19N/01W-09R04	HENDERSHOT, KEN	162	56	H	Qva	47.76 R	07-25-88	180	D
19N/01W-10C02	REED, RICHARD	65	90	H	Qc	65	-60	--	C
19N/01W-10F04	SMIRCICH, JULIUS	62	74	H	Qc	60.31	08-29-88	310	D,I
19N/01W-10L02	BENNETT, DON	30	85	H	Qc	30	07-28-47	--	I
19N/01W-10L04	COKER, LYNN	70	83	H	Qc	67.97	08-30-88	>680	D
19N/01W-10N01	THAYER, MARSHALL	161	73	H	Qva	57	03-11-88	620	D
19N/01W-10N02	SKOGEN, KEVIN	148	56	H	Qva	30.88	08-30-88	150	D,I
19N/01W-10P01	ERICKSON, A.C.	85	88	H	Qc	73.60	07-14-88	86	D
19N/01W-10Q02	TOUMEY, JIM	70	119	H	Qc	70.11 R	08-29-88	32	D,I
19N/01W-15C01	GRIMES, JACK	110	55	H	Qva	32.73	07-15-88	410	D
19N/01W-15C02	MCCULLOUGH, JERRY	145	100	H	Qc	--	--	--	D
19N/01W-15C03	SORTIAS, J.	144	80	H	Qva	56.87	08-09-88	--	D
19N/01W-15E01	JENKINSON, DAVID	165	69	H	Qva	54.73	07-14-88	600	D
19N/01W-15G01	COLE, KENNETH	40	80	H	TQu	38.97	05-09-78	--	C
19N/01W-15K03	MICHAEL, GEORGE	80	82	H	Qf	45	04-16-76	4.9	D,X,I
19N/01W-15L01	HEINEMANN, ED	137	134	H	Qf	100	08-04-86	.11	D,X
19N/01W-16K01	FAUST, JOHN	160	90	H	Qva	53.58	07-14-88	87	D,X,W,I
19N/01W-16K02	SPARLING, MARY	155	71	H	Qva	34.22	08-18-88	440	D
19N/01W-16L01	MICHAEL, JOHN	165	80	H	Qva	46	02-02-79	--	D,X
19N/01W-16N02	FEERO, STAN	121	78	H	Qva	27.27	07-13-88	54	D
19N/01W-16R01	SPRAGLUNG, MIKE	158	149	H	Qc	113.20	07-25-88	53	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
19N/01W-17A03	RUSSELL, MONTGOMERY	30	128	H	TQu	--	--	--	C
19N/01W-17A05	CHERVENKA, FRANCIS	40	174	H	TQu	40.97	07-15-88	47	D,X,I
19N/01W-17J02	PRINCE, LOUIS	43	95	H	TQu	44.29	08-24-88	100	D,X,I
19N/01W-17K01	MADDEN, W.C.	5	38	H	Qc	-- F	--	--	C
19N/01W-17M01	WEYERHAEUSER CO.	10	995	H	TQu	-- F	--	3,100	D,X,C
19N/01W-17N01	KOCH, R.M.	9	20	H	Qc	--	--	--	-
19N/01W-17N02	ZORN, MIKE	70	102	H	Qc	65.32	07-20-88	20	D,I
19N/01W-17R02	ROBINSON, H.E.	15	130	H	TQu	9	09-22-58	--	-
19N/01W-18E01	WALKER, HARLAN	101	46	H	Qf	27	01-00-88	3.6	D
19N/01W-18F01	HOOVER, ALAN	90	64	H	Qf	28.73	07-25-88	28	D,I
19N/01W-18M02	CREELEY, CHRIS	85	49	H	Qf	27	08-00-83	5.1	D,X,I
19N/01W-18P01	HALE, CHARLES	70	108	H	Qc	66.60	07-20-88	160	D,X,I
19N/01W-19B01	MYERS, L.O.	50	85	H	Qc	--	--	--	C
19N/01W-19L02	SEIBOLD, BILL	70	98	H	Qf	25	06-00-83	35	D
19N/01W-19P03	LEDGERWOOD, KELLY	120	105	H	Qc	68.31	09-14-88	1,100	D,I
19N/01W-20G01	GLENN ALDER WATER & IMPROVEMENT	125	159	P	Qc	113	06-01-64	68	D,C
19N/01W-20G04	MCMINN, JIM	110	124	H	Qc	102.74	08-19-88	550	D,X
19N/01W-20H01	HUSK, RICHARD	150	178	I	Qc	147	01-08-64	610	D,X,I
19N/01W-20L01	SNUG HARBOR OWNERS CLUB	15	377	P	TQu	-- F	10-17-88	--	D
19N/01W-20Q01	WRIGHT, J.M.	95	116	H	Qc	96	03-00-54	310	D
19N/01W-20R03	LONG, R.R.	15	68	H	Qc	11	09-23-58	--	C
19N/01W-21C03	GILBERY, EARL	162	67	H	Qva	49.28	07-28-88	260	D,I
19N/01W-21K01	BRUNS, DAVID W.	130	126	H	Qf	72	07-16-75	10	D,M,S
19N/01W-21L02	WILMOUTH, WILLIAM J.	115	78	H	Qva	26.18	07-28-88	35	D,I
19N/01W-21M01	GREEN, BILL	90	116	H	Qc	19.50	07-20-88	120	D,X
19N/01W-21M02	SMITH, CHARLES	90	123	H	Qc	85.74	08-18-88	220	D
19N/01W-21N01	FLAHAUT, FLORENCE	125	218	H	TQu	--	--	--	C
19N/01W-22A01	WHITTAKER, DALE	65	143	H	TQu	57.43 Z	09-30-88	4.2	D,W,I
19N/01W-22G01	JOACHIM, JEFF	120	128	H	Qc	92	03-06-78	150	D
19N/01W-23D02	HOVANCSEK, DON	104	133	H	Qf	92.28	09-14-88	2.9	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
19N/01W-23D03	SYBEN, PETER H.	60	114	H	Qf	81.34	09-15-88	23	D
19N/01W-23F02	ASHLEY, K.R.	40	388	H	TQu	--	--	--	C
19N/01W-23G02	SCMIDT, CLIFFORD	84	108	H	Qc	60	09-29-81	40	D,I
19N/01W-23L01	TOLMIE STATE PARK	100	344	P	TQu	72	06-15-71	--	D
19N/01W-23N01	MANCE & SON	181	103	P	Qva	72.70	08-17-88	200	D
19N/01W-25F01S	UNKNOWN	125	--	U	Qvt	--	--	--	-
19N/01W-25P01	CITY OF LACEY, WELL NO. BC 1	225	140	P	Qva	77	06-28-76	360	I
19N/01W-25P02	CITY OF LACEY, WELL NO. BC 2	225	138	P	Qva	84.63	07-08-88	420	-
19N/01W-27A01	MANCE & SON	200	118	P	Qva	77.62	07-12-88	87	D,I
19N/01W-27N01	SO. SOUND UTIL., FOXHALL NO. 3	225	250	U	TQu	97.40	06-17-88	--	D
19N/01W-27N02	SO. SOUND UTIL., FOXHALL NO. 4	225	148	P	Qva	96.03	06-17-88	46	D
19N/01W-28A02	ALLEN, ROGER	90	117	H	Qc	40.15 P	09-06-88	160	D
19N/01W-28C02	GILSON, JOHN	170	146	H	Qc	101.96	08-19-88	520	D
19N/01W-28D04D1	THERIN, LANEY	150	228	H	TQu	110	01-05-79	3.3	D,X
19N/01W-28F02	SAYLOR, JOHN	120	99	H	Qc	64.17	07-28-88	160	D,W,I
19N/01W-28F04	LAUR, N.	140	110	H	Qc	72.60	10-27-88	--	D,X
19N/01W-28L02	KANEEN	82	78	H	Qc	31.27	10-03-78	73	D
19N/01W-28M01	CARTER, RAY	60	84	H	Qc	12	07-16-76	33	D,X
19N/01W-28M02	STILLMAN, CHARLES	30	393	U	TQu	-- F	11-02-88	--	D
19N/01W-28N02	SADLER, RONALD	60	112	H	Qc	--	--	--	C
19N/01W-29A01	WESTERN OYSTER CO.	12	225	H	TQu	-- F	--	--	C
19N/01W-29C02	FAILOR, RICHARD	145	152	H	Qc	137.17	09-06-88	>690	D,I
19N/01W-29N01	SPRINGER, BILL	135	120	H	Qc	37.63	09-07-88	120	D,I
19N/01W-30H03	VANNOY, RANDY	120	88	H	Qva	48	11-00-83	89	D
19N/01W-30J02	PARSONS, KEN	115	74	H	Qva	35	02-26-80	47	D
19N/01W-30P04	CANFIELD, ROGER	115	122	H	TQu	98.09	10-28-88	830	D,I
19N/01W-30R02	GALIVAN, HARRY	115	67	H	Qva	23.38	09-08-88	620	D,I
19N/01W-31B03	COLLINS, MIKE	126	78	H	Qf	26.94	09-13-88	40	D,I
19N/01W-31F01	CARPENTER, DENNY	140	130	H	TQu	115	02-03-88	230	D
19N/01W-31K04	SO. SOUND UTIL., RED CEDAR ESTAT	155	77	P	Qvt	39.35	06-21-88	27	D,I

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy- drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
19N/01W-31Q01	CRIST, BRIAN	145	46	H	Qva	17	04-06-84	26	D
19N/01W-31R01	HAZEL, JOHN	165	164	H	TQu	126.92	07-20-88	120	D
19N/01W-32B01	WESTON, MIKE	50	211	H	TQu	39.14	09-06-88	160	D,I
19N/01W-32C04	BERGVALL, JOHN	145	94	H	Qva	46	03-26-87	130	D,I
19N/01W-32D03	KIRKLAND, KENNETH	157	70	H	Qva	52.17	09-15-88	130	D
19N/01W-32K03	SODDEN, ED	90	38	H	Qva	16.04	09-08-88	76	D
19N/01W-32K04	HOCHGRAEF, RON	128	62	H	Qva	54.45	07-11-88	73	D
19N/01W-32N03	ROSE, CLYDE	157	70	H	Qva	52.20	08-31-88	1,100	D,I
19N/01W-32P03	TOPPER	142	75	H	Qva	50.08	09-13-88	--	D
19N/01W-32Q03	TABER, RON	100	63	H	Qva	29.44	06-20-88	43	D
19N/01W-32R01	ROBB, STEVE	80	86	H	Qvt	.56	11-01-88	15	D,I
19N/01W-33D03	GRETCHMAN, A.G.	25	70	H	Qc	16	04-18-67	--	C
19N/01W-33E01	LOHRER, E.M.	5	150	H	TQu	-- F	--	--	C
19N/01W-33K03	SO. SOUND UTIL., FOXHALL NO. 1	160	110	P	Qva	80.00	06-17-88	--	I
19N/01W-33K04	SO. SOUND UTIL., FOXHALL NO. 2	160	163	P	Qc	79.41	06-17-88	36	D,I
19N/01W-33K05	JACOBSEN, MAURICE	150	122	H	Qva	52.55	09-08-88	38	D,W,I
19N/01W-34B01	DROHMAN, ROBERT	298	174	P	Qva	157.40 P	07-20-88	--	D
19N/01W-34M02	WILLIS, MIKE	151	111	H	Qva	84.99	08-31-88	--	D
19N/01W-34N03	HEUSMAN, LEE	151	112	H	Qva	77.89	09-06-88	--	D
19N/01W-34P01	BEAIRD, PAT	170	148	H	Qva	88.81	08-31-88	23	D
19N/01W-34Q02	KUHNAU, DAVE	232	--	H	Qvt	94	07- -68	--	-
19N/01W-35G01	GLACIER PARK CO.	250	590	P	TQu	201	08-23-84	170	G
19N/01W-35M01	CITY OF LACEY, HAWKS PRAIRIE TST	290	643	U	TQu	259	12-15-88	52	D
19N/02W-01Q01	WOLDFORD, L.W.	80	118	H	Qc	--	--	--	C
19N/02W-01R03	KINCY, R.F.	85	90	H	Qc	--	--	--	C
19N/02W-03E02	OLSON, JEFF	90	90	H	Qc	65.40	08-17-88	270	D,I
19N/02W-03F04	PRECHT, CORRINE	30	--	H	--	--	--	--	-
19N/02W-03M02	RONNE, C.J.	60	104	H	Qc	--	--	--	C
19N/02W-04F03	STEEGES, TED	115	156	H	TQu	110	09-10-59	61	D,C
19N/02W-04F05	BEEHLER, MICHAEL & SALLY	125	156	H	TQu	--	--	--	D,X,I

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
19N/02W-05J01	MONDAU, FRITZ	85	110	H	Qc	73.20 R	08-02-88	830	D
19N/02W-05Q01	ADAMS, CARL	60	78	H	TQu	--	--	--	-
19N/02W-07L02	RAWDING, JACK	15	120	H	TQu	10	06-11-59	--	C
19N/02W-07P01	SCHABEN, NORVAL	90	102	H	Qc	71.82	07-29-88	160	D,W,I
19N/02W-07P02	CLAWSON, RANDY	80	99	H	Qc	65.90	08-01-88	410	D
19N/02W-07R01	BORK, MIKE	40	205	H	TQu	53.82	08-12-88	>1,200	D
19N/02W-08A01	WILLIAMS, JACK	105	59	H	Qva	12	09-30-79	--	D
19N/02W-08B01	CAMUS, DAMON	50	130	H	TQu	30.45 R	07-28-88	6.0	D
19N/02W-08C01	SANDERS, MILFORD	60	85	P	TQu	--	--	--	C
19N/02W-08C02	OLYMPIA VIEW WATER ASSOC.	60	160	P	TQu	53.64 R	07-28-88	78	D
19N/02W-08F02	OVIATT, LORRAINE	40	172	H	TQu	30.75	08-10-88	190	D
19N/02W-08F03	BAKER, TED	60	156	H	TQu	38.86	08-17-88	--	D,I
19N/02W-08G01	MEACH, TOM	100	144	U	TQu	112.31	08-02-88	>1,200	D
19N/02W-08G02	MOORE	120	147	H	TQu	131	04-19-76	78	D
19N/02W-08H01	MILLER, DALE	110	79	H	Qc	50	05-10-77	1,200	D,I
19N/02W-08K01	OSTERBERG, STAN	100	130	H	TQu	35	01-20-78	120	D,I
19N/02W-08M01	CLEVELAND, DAVID M.	10	80	H	TQu	-- F	--	--	C
19N/02W-08N03	ST. JULIEN, JOSEPH	40	221	H	TQu	36.90	07-18-88	26	D
19N/02W-08P01	CHOATE, JAMES	125	87	H	Qc	56.41 Z	08-12-88	180	D,I
19N/02W-08Q01	TANNER, JAMES	90	140	H	TQu	102.15	08-01-88	--	D
19N/02W-09F02	NORWOOD, RANDY	100	139	H	TQu	99	12-30-83	620	D,X
19N/02W-09F03	PEGG, LLOYD	70	79	H	TQu	59	06-11-85	320	D
19N/02W-09G01	EDGEWATER BEACH WATER CO.	75	120	P	TQu	87	02-28-75	130	D
19N/02W-09H01	EDGEWATER BEACH WATER CO.	70	102	P	TQu	70.55	08-10-88	99	D
19N/02W-09L05	MCCONNELL, RACHEL	15	37	H	Qc	13.90 R	04-24-89	--	C
19N/02W-09L06	SALEWSKY, BEN	30	43	H	Qc	26	02-04-86	230	D,X
19N/02W-09N01	CAMUS, MORRIS	30	37	H	Qc	26.50	05-19-78	--	-
19N/02W-09N02	PICKERING, CHRIS	30	56	H	Qc	23.85	06-23-89	720	D,C
19N/02W-09N03	HUECKEL	80	105	H	Qc	69.24 R	08-11-88	120	D
19N/02W-09R01	COOPERS POINT WATER CO.	10	360	P	TQu	-- F	--	--	D,C

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
19N/02W-11P02	PARSONS	60	351	H	TQu	61.44	08-03-89	120	D
19N/02W-12C02	LAPHAM, H.H.	50	120	H	Qc	--	--	--	C
19N/02W-12F02	ROSS, ANN	35	40	H	Qc	--	--	--	-
19N/02W-12F03	HILL, G.E.	60	65	H	Qc	52.76	04-28-89	--	C
19N/02W-12L02	SHAW, LEWIS	98	148	H	Qc	--	--	--	D
19N/02W-12M02	KLUH, FREDERICK	80	621	H	TQu	--	--	--	C
19N/02W-13N03	CUSHMAN, BOB	140	107	H	Qva	71.40	10-24-88	880	D,X
19N/02W-14H03	BOSTON HARBOR WATER SYSTEM	130	36	P	Qvt	-- F	01-05-89	89	D,I
19N/02W-14H04	AMES, MARTIN	125	430	H	TQu	125.49	10-24-88	4.6	D,I
19N/02W-14J01	JOHNSON, LEE	146	116	H	Qf	77	-77	16	D,X,I
19N/02W-14K01	HAMMAR, BILL	110	68	H	Qva	36.10	11-01-88	130	D
19N/02W-14P02	RADCLIFF, BILL	175	232	H	Qc	153.63	08-03-88	110	D,X,I
19N/02W-14Q03D1	MCGILL, BILLY	140	130	H	Qc	--	--	--	D
19N/02W-15N01	CLEARWELL WATER CO.	90	117	P	Qc	--	--	400	D,X,C
19N/02W-16A01	LEWIS WATER SYSTEM	10	552	P	TQu	-- F	--	--	C
19N/02W-16J02	FINLEY, J.M.	140	10	U	Qvt	7	07-08-58	--	-
19N/02W-16J06	LESNICK, A.J.	80	105	H	Qc	--	--	--	C
19N/02W-16J08	STEWART, MICHAEL	40	83	H	Qc	63.69R	09-09-88	--	D
19N/02W-16J09	MYERS, BILL	85	114	H	Qc	80	09-11-78	--	D
19N/02W-16K02D1	VISTA HOME OWNERS ASSOC.	55	382	P	TQu	35	11-00-79	31	D,I
19N/02W-16P01	STONE, F.C.	40	70	H	Qc	--	--	--	C
19N/02W-16Q04D1	KUS, ROY	140	225	H	TQu	155	02-28-84	9.8	D,X
19N/02W-16Q05	SKUBE, MARY	140	151	H	Qc	139.32 Z	08-10-88	250	D,I
19N/02W-17A01	BOULDEN, O.O.	60	64	H	Qc	48	01-01-66	--	C
19N/02W-17C01	FREEZE, ROBERT	120	240	H	TQu	111.36 Z	08-01-88	--	D
19N/02W-17D02	BRYANT, BILL	100	345	H	TQu	93.88R	08-01-88	--	D
19N/02W-17F01	PEREZ, TONY	120	335	U	TQu	95.54	08-04-88	--	D
19N/02W-17G01	CLARK, KEITH	105	210	H	TQu	70	06-00-70	620	D,C
19N/02W-18A02	VANNELLI, JIM	120	67	H	Mlt	39.36	07-29-88	--	D,I
19N/02W-18B01	DAHLBERG, GEOFFREY	25	100	H	TQu	--	--	--	C

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
19N/02W-18C01	REED, DOROTHY	35	120	H	TQu	--	--	--	C
19N/02W-18F01	BAYNESS, E.R.	40	73	H	TQu	--	--	--	C
19N/02W-18G01	PALMER, FRED	120	207	H	TQu	94	02-02-88	120	D
19N/02W-18K02	ROBBINS, LES	130	166	H	TQu	104.51	05-10-89	16	D,W,I
19N/02W-18K03	NIEMI, GEORGE	120	150	H	TQu	97	04-30-77	120	D
19N/02W-18M01	FITZTHUM, ALAN	80	70	H	Qc	37.70	07-29-88	34	D,W,I
19N/02W-18N04	PARKS, JAMES	140	138	H	Qc	110	01-15-79	44	D
19N/02W-19H01	ELD INLET WATER ASSOC.	100	112	H	TQu	56.43	08-12-88	22	D,X,I
19N/02W-20D01	RUDNICK, TERRY & SANDY	110	299	U	TQu	90.93	08-17-88	370	D,X
19N/02W-20E01	FROHBOES, K.H.	85	138	H	TQu	20	-60	--	C
19N/02W-20E02	MAPLE SHORES COMMUNITY HOMEOWNRS	120	233	P	TQu	111.90 R	07-20-88	23	D
19N/02W-21C02	ST. MARTINS ABBEY	60	89	H	Qc	54.45	09-30-88	--	D,X,I
19N/02W-21F01	MURRAY, R.M.	85	306	H	TQu	75	-60	--	D,C
19N/02W-21L01	STUART, DEAN	50	84	H	Qc	50	08-00-59	--	C
19N/02W-21Q03	BIDLAKE	60	275	H	TQu	--	--	--	C
19N/02W-21Q04	GEHRING, WALTER	48	231	H	TQu	49.72	09-08-88	82	D,X,I
19N/02W-21R02	SMITH, SHERWOOD	125	161	P	Qc	135	10-07-79	100	D
19N/02W-22D01	SOLLARS, KEN	80	90	H	Qc	--	--	--	C
19N/02W-22D02	TAMO O SHAN WATER	40	258	P	TQu	14	11-02-88	62	D,O
19N/02W-22M06	BEVERLY BEACH COMMUNITY	10	439	P	TQu	-- F	--	--	D,C
19N/02W-22N01	WARDEN, JOHN	50	65	H	Qc	47	08-10-59	--	C
19N/02W-23K01	LYNCH, W.J.	20	385	H	TQu	-- F	--	--	D,C
19N/02W-24F01	SIMS, RORY	105	80	H	Qf	57	03-27-88	18	D,I
19N/02W-24F02	MOORE, VICTOR	120	86	H	Qva	64.56	10-27-88	120	D,I
19N/02W-24H01	LEMON, BOB	120	110	H	Qf	67.03	10-24-88	26	D
19N/02W-24K01	HARRY, RAY	120	93	H	Qf	65.49	11-01-88	20	D
19N/02W-25A02	JOHNSON, DAVID	100	212	H	TQu	34.25 Z	10-27-88	6.9	D,I
19N/02W-25C07	BURDICK, ELDIE	118	140	H	Qc	110.46	07-25-88	250	D
19N/02W-25D01	SEARS, DONALD	90	123	H	Qc	82.90	05-12-78	84	D,C
19N/02W-25F01	NORTH OLYMPIA FIRE DIST.	145	91	H	Qva	56.48	11-01-88	82	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
19N/02W-25N01	SOLLARS, KEN	140	158	H	Qc	131.88	11-02-88	330	D
19N/02W-25R01	MERRILEES, CHARLES	165	74	H	Qva	41.19 Z	10-31-88	62	D
19N/02W-26B01	CUSHMAN, DAN	20	116	H	Qc	-- F	05-12-78	160	D
19N/02W-26J01	AMES, MEL	125	147	H	Qc	120	08-00-87	11	D,O
19N/02W-26K02	STIGGLEBOUT, HENDRICK	80	173	H	TQu	--	--	--	C
19N/02W-26Q01	DEPT. OF NATURAL RESOURCES	15	--	H	--	-- F	--	--	C
19N/02W-26Q05	SEASHORE VILLA	20	118	P	TQu	--	--	--	-
19N/02W-27D03	MANNING	78	114	H	Qc	61.75 Z	08-09-88	--	D,I
19N/02W-27D04	WEHRLI, CRAIG	50	115	H	Qc	34.58	08-11-88	--	D,W
19N/02W-27D05	SMYTH, D.W.	10	240	H	TQu	-- F	--	--	C
19N/02W-28B02	WIEG, D.	60	390	U	TQu	57.64	10-28-88	--	D,X
19N/02W-28J01	DUNN, CHARLES	10	213	P	TQu	-- F	--	--	D,C
19N/02W-28L02	LAYTON, M.J.	80	146	H	Qc	70.10	05-23-89	--	C
19N/02W-28L05	ALLEN, JOHN	135	54	H	Qva	30.79	08-08-88	41	D,O
19N/02W-28L06	LAW, DON	108	460	H	TQu	108.51 Z	08-09-88	2.1	D
19N/02W-28N02	HAYNES, HERBERT L.	30	75	H	Qc	--	--	--	C
19N/02W-28N08	BAKER, DON	50	88	H	Qc	43.28	08-09-88	23	D
19N/02W-29B02	BLACKMER, C.L.	35	44	H	Qc	33	-60	100	D,C
19N/02W-29B03	LABRECK, CLAYTON	30	74	H	Qc	28	03-28-77	66	D
19N/02W-29B04	LABRECK, CLAYTON	58	90	H	Qc	57.03	08-02-88	82	D
19N/02W-29C01	COLEMAN, MURRY	40	76	H	Qc	35.16 R	08-03-88	32	D,I
19N/02W-29F01	ROHR, ROBERT	75	114	H	Qc	65.10 Z	08-04-88	140	D
19N/02W-29G02	ROE, F.D. & CAROL	20	43	H	Qc	16.06	08-11-88	120	D
19N/02W-29M01	BREIDNBACH, F.J.	90	150	H	Qc	--	--	--	C
19N/02W-30B01	VOGT, FRANK	100	79	H	Qva	61.78 R	08-01-88	--	D,O
19N/02W-30E01	MUSTARD, RICK	25	84	H	Qc	3.94	08-02-88	78	D
19N/02W-30F01	COX, G.S.	70	70	H	Qva	38	-60	--	C
19N/02W-30J02	MCLEAN, R.B.	25	79	H	TQu	17.54 Z	08-10-88	15	D,I
19N/02W-30K03	STEERE, E.F.	60	110	H	Qc	45	05-02-67	--	C
19N/02W-30L03	KISSICK, GARY	20	109	P	TQu	35	04-10-69	270	D

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
19N/02W-30N01	BARRETT, DOUGLAS	65	45	H	Qva	26	05-03-78	300	D
19N/02W-30N02	YATES, RICHARD	35	62	H	Qc	30	01-00-87	56	D
19N/02W-31E03	MARTIN, MEL	60	109	H	Qc	36.25	08-03-88	260	D,I
19N/02W-31M01	NISBET, CHARLES & SANDRA	40	86	H	Qva	--	--	--	C
19N/02W-31M03	CRATSENBERG, STEVE	20	104	H	Qc	15.97	08-03-88	15	D
19N/02W-31N01	ALBERTI	40	50	H	Qc	35	--	--	C
19N/02W-31R03	EVERGREEN STATE COLLEGE	25	58	H	Qc	10	04-08-59	--	C
19N/02W-32A04	BISCAY, JOHN H.	80	120	H	Qc	59.32	05-23-89	--	C
19N/02W-32A06	OLYMPIA OIL & WOOD PRODUCTS CO.	30	224	H	TQu	-- F	08-08-88	690	D,I
19N/02W-32A07	HAVENS, JOHN	130	70	H	Qva	31.92	08-11-88	310	D
19N/02W-32B05	BEEMAN, P.J.	5	228	H	TQu	-- F	--	--	C
19N/02W-32F02	WALBRIDGE, FRANK	30	60	H	Qc	7	-60	--	C
19N/02W-32G02	REESE, OWEN	175	158	H	Qva	83.90	08-11-88	74	D
19N/02W-32G03	BRENNER, BYRON	158	122	H	Qva	68.59	09-22-88	35	D
19N/02W-32G04	SKOV, NIELS	195	210	H	Qc	153.17 R	08-11-88	33	D,I
19N/02W-32H03	SO. SOUND UTIL., BISCAY VILLA	182	158	P	Qc	132.85	09-15-88	77	D,I
19N/02W-32M03	ASPINWALL, R.C.	35	90	H	Qc	--	--	--	C
19N/02W-32M05	DOLBY, TIMOTHY	60	52	H	Qc	27	10-15-86	--	D
19N/02W-32M06	KILDOW, BEVERLY	65	65	H	Qc	25.78 Z	08-11-88	78	D
19N/02W-33B02	COCKRALL & PECKLER	192	134	H	Qva	111.01	09-15-88	60	D,I
19N/02W-33D01	BURMER, FRED	70	107	H	Qc	65.15	08-10-88	130	D
19N/02W-33F02	SAGER, ROGER	135	112	H	Qc	70.57	09-30-88	150	D
19N/02W-33G01S	UNKNOWN	95	--	U	Qva	--	--	--	-
19N/02W-33G02	LAZAR, DAVID	130	--	H	Qva	58.12	09-29-88	--	-
19N/02W-33G03	KORMANDY, MRS. ED	130	143	H	Qc	116.08	09-09-88	--	D
19N/02W-33H02	BRUNO	150	165	H	Qc	142	-60	130	C
19N/02W-33H03	STIVERS-SCHMIDT, ZUA	120	139	H	Qc	101.76	09-08-88	170	D
19N/02W-33K05	BREUER, W.J.	140	150	H	Qc	--	--	--	C
19N/02W-33K08	RAMSEY, WILMONT	19	120	H	Qc	-- F	09-08-88	140	D,X,S
19N/02W-33M03	ADEE, DON	165	84	H	Qva	59.93 Z	09-09-88	32	D,S

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
19N/02W-33Q01	BUTLER COVE WATER CO., NO. 3	10	355	P	TQu	-- F	--	--	D,C
19N/02W-33Q03	OLYMPIA COUNTRY & GOLF CLUB	30	227	P	TQu	10	06-24-77	73	D,X
19N/02W-35B01	DEHART, GLENN	110	173	H	Qc	--	--	--	C
19N/02W-35B03	PUTSCHER, LARRY	118	160	H	Qc	110.17	07-25-88	220	D
19N/02W-35G02	ANDERSON, JOHN	120	160	H	Qc	115	05-28-59	--	C
19N/02W-35K05	BUNN, LARRY	70	107	H	Qc	68.48 Z	11-04-88	240	D
19N/02W-35P02	HANNA, W.S. JR.	120	132	H	Qc	114	-60	--	C
19N/02W-35P03	STEHR, EVERETT	123	208	H	TQu	111.90	07-21-88	120	D,I
19N/02W-36A03	THORP, MICHAEL	160	68	H	Qva	30.06	11-04-88	370	D
19N/02W-36H02	HAGLUND, JIM	160	75	H	Qva	33.84 R	10-27-88	22	D
19N/02W-36J01	NELSON, DAVID	160	73	H	Qva	23.45	10-27-88	77	D,I
19N/02W-36M02	BOYER, TOM	160	160	H	Qc	139	03-30-88	270	D
19N/02W-36N02	FANTONI, ALDO	152	69	H	Qva	18	08-00-86	180	D
19N/02W-36N03	WYER, ROY	155	157	H	Qc	140	03-18-81	--	D,I
19N/03W-12Q01	RODGERS, DUANE	100	199	P	TQu	--	--	--	D,I
19N/03W-13K01	TAYLOR, JUSTIN	15	86	H	Qc	4	-60	--	D,C
19N/03W-24D03	DOBSON, M.W.	100	120	H	Qc	98.23	05-23-78	--	I
19N/03W-24L01	COX, HENRY W.	130	71	H	Qva	--	--	--	D,X
19N/03W-24M01	JACOB, KEN	130	163	H	Qc	129.17	07-22-88	46	D,X,I
19N/03W-25C01	PAGE, ALICE	135	118	H	Qc	87	08-06-80	47	D
19N/03W-25E02	GRIGGS, JIM	150	120	H	Qc	85	06-04-86	--	D
19N/03W-25E03	COLLINS, MIKE	130	118	H	Qc	72	07-03-79	>3,700	D,I
19N/03W-25J01	SCHMIDT, GARY	145	128	H	Qc	89.16	08-15-88	43	D
19N/03W-25K01	ONEILL, TOM	175	41	H	Qvr	13.85	08-15-88	770	D,I
19N/03W-25M03	EDINGTON, MARY	150	123	H	Qva	80	02-07-79	180	D
19N/03W-25N02	SAVAGE, FLOYD R.	150	106	H	Qc	67.65	08-15-88	62	D,I
19N/03W-26E01	KLONTZ, THOMAS	40	62	H	Qc	19	06-17-59	--	-
19N/03W-26F01	SMITH, PAUL	130	101	H	Qc	72.02	08-16-88	130	D,I
19N/03W-26H02	ALEXANDER, FORREST	150	179	H	Qc	89.92	08-15-88	--	D
19N/03W-27E03	BURNS POINT UTIL. CO.	50	123	P	Qc	47	11-15-74	--	-

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
19N/03W-27K01	HOFFMAN, HUBERT H.	35	70	H	Qc	33.41	05-23-78	--	C
19N/03W-27L01	DICKENSON, COL. HARRY	40	103	I	TQu	32.12 R	10-05-88	53	D,I
19N/03W-27M02	SALMI, FRANK	165	103	H	Qc	75.45	08-15-88	230	D
19N/03W-27N01	BARNHART, ROBERT	165	83	H	Qva	65.08 R	08-18-88	>920	D,I
19N/03W-27R01	DEMICH, GARY	140	106	H	Qc	65	08-30-78	79	D
19N/03W-27R02	WILSON, JIM	125	113	H	Qc	52	12-01-78	45	D
19N/03W-28H02	COX, CHELLO	150	79	H	Qva	60	10-18-84	180	D
19N/03W-28J01	MASON, WILLIAM	215	160	H	Qc	141	03-02-88	330	D
19N/03W-28K01	CROWLEY, W.D.	100	135	H	Qc	--	--	--	-
19N/03W-28L01	MCCOOL, H.L.	25	70	H	Qc	13	-60	--	-
19N/03W-34A01	WARD, HUGH	130	47	H	Qva	19.06	08-16-88	610	D,I
19N/03W-34H01	COOK, WILLIAM	150	103	H	Qc	85	05-17-77	920	D,I
19N/03W-34K01	HOLIDAY VALLEY ESTATES, NO. 1	140	127	P	Qc	74	04-02-68	290	D
19N/03W-34K02	HOLIDAY VALLEY ESTATES, NO. 2	140	134	P	Qc	72	05-25-81	200	D
19N/03W-35J02	CREEL, C.O.	165	113	H	Qc	73	03-30-83	82	D
19N/03W-36B04	BASHAM, TANIA	160	111	H	Qc	91	05-23-86	250	D
19N/03W-36D03	KELLY, TOM	150	92	H	Qc	72	09-19-86	620	D
19N/03W-36E03	BROWN, PHIL	150	94	H	Qc	63.55	08-22-88	210	D
19N/03W-36M02	EHRESMANN, ADOLPH	150	105	H	Qc	69.59	08-22-88	>2,800	D,I
19N/03W-36P01	KOCH, W.A.	135	142	H	Qc	117	-60	--	C
19N/03W-36P03	HELMER, MARIE	30	45	H	Qc	18	06-12-78	71	D
19N/03W-36R03	GRANT, GREGORY	30	78	H	Qc	30	05-02-81	--	D
20N/01W-33L02	BROWN, DR. R.C.	5	500	H	TQu	-- F	--	130	I
20N/01W-33N01	HURLEY, JOHN	91	119	H	Qc	84.04	07-15-88	>1,200	D,X,W,S
20N/02W-28P01	STEAMBOAT ISLANDERS, INC.	10	425	P	TQu	-- F	--	2,600	D,X,C

Table A1. Well records for the study wells--Continued

Well or spring identifer	Owner	Land surface altitude (feet)	Well depth (feet)	Water use	Geohy-drologic unit	Water level (feet)	Date	Hydraulic conductivity (feet per day)	Remarks
20N/02W-33F01	SABIN, HOWARD	40	98	H	TQu	71	08-30-87	76	D,X
20N/02W-33L01	GAFFNEY, ARTHUR	65	107	H	Qc	63	06-02-59	--	C
20N/02W-33L02	BELLA VISTA WATER CO.	55	455	H	TQu	46	11-15-60	790	C
20N/02W-33L03	MURPHY	25	500	H	TQu	-- F	10-10-78	--	C
20N/02W-33Q01	CARLYON BEACH CLUB, WELL NO. 1	70	736	P	TQu	53.16	08-12-88	6.8	D
20N/02W-33Q02	CARLYON BEACH CLUB. WELL NO. 2	80	757	P	TQu	56	11-25-81	64	D,X,I

Table A2. Depths to top of geohydrologic units in the wells used in this study

EXPLANATION

[NP, unit not present; ?, log incomplete at surface (depth = 0) or unit top not apparent in log; -, well does not penetrate to stratigraphic position where unit may or may not be present]

Latitude and longitude	Most well locations are believed to be accurate to within 1 second of latitude and longitude. The least accurate locations are probably still within 10 seconds of latitude and longitude.
Land-surface altitude:	Reported in feet above sea level. Most altitudes were obtained from topographic maps (scale of 1:24,000; with 10- or 20-foot contour intervals) and are generally accurate to within 10 feet. In steep terrain, or where the precise location of the well is in doubt, the error may be as great as 50 feet. Altitudes of some wells (less than 10 percent) have been surveyed and are accurate to within 1 foot.
Hole depth:	Total depth penetrated during drilling; does not necessarily equal finished depth of the well.

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
16N/01E-02B01	4654241223827	390	80	0	6	40	-	-	-	-
16N/01E-02F01	4654071223848	420	235	0	2	16	60	160	-	-
16N/01E-02N02	4653501223906	440	183	0	12	36	40	173	-	-
16N/01E-04D01	4654311224130	490	223	0	54	130	147	213	-	-
16N/01E-04E02	4654071224131	490	246	0	NP	71	NP	179	-	-
16N/01E-05F01	4654131224228	518	274	0	18	122	165	238	-	-
16N/01E-05F02	4654081224240	515	263	0	81	<221	<221	221	-	-
16N/01E-05K02	4653551224219	507	283	0	36	107	178	258	-	-
16N/01E-05M01	4654051224259	500	263	0	2	125	156	-	-	-
16N/01E-06J02	4653561224319	480	243	0	2	20	110	220	-	-
16N/01E-07C01	4653351224350	460	223	0	<39	39	90	94	NP	167
16N/01E-07E02	4653221224405	442	220	0	38	NP	74	90	99	160
16N/01E-07E04	4653201224407	442	286	0	24	NP	77	91	107	158
16N/01E-07H01	4653201224315	458	203	0	12	48	86	94	122	168
16N/01E-07J02	4653131224314	455	126	NP	0	37	88	NP	NP	109
16N/01E-07P02	4652571224342	434	215	0	5	30	NP	NP	105	123
16N/01E-08C02	4653311224229	480	203	0	NP	72	109	116	196	-
16N/01E-08L01	4653101224231	471	220	0	NP	61	84	118	125	175
16N/01E-08N01	4653001224259	500	103	NP	NP	NP	NP	NP	0	-
16N/01E-09E01	4653241224127	425	430	0	64	107	121	170	222	417
16N/01E-09K01	4653061224057	419	305	0	NP	19	84	120	200	-
16N/01E-10D01	4653351224016	520	263	0	12	110	113	252	-	-
16N/01E-14G03	4652221223826	450	120	NP	0	25	NP	80	-	-
16N/01E-16E01	4652211224136	461	182	0	2	NP	NP	NP	NP	113
16N/01E-16L03	4652181224127	463	205	0	2	NP	NP	NP	NP	143
16N/01E-17G01	4652331224210	398	200	0	10	NP	NP	NP	70	118
16N/01E-18N01	4652091224405	340	100	0	22	NP	NP	NP	NP	23
16N/01E-18Q01	4652031224335	311	76	0	2	-	-	-	-	-
16N/01E-18Q02	4651571224337	350	140	0	3	NP	NP	NP	NP	110
16N/01W-06F01	4654051225121	240	147	0	4	55	NP	NP	134	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
16N/01W-06G01	4654101225059	250	53	0	10	51	-	-	-	-
16N/01W-06L01	4653581225126	243	58	0	2	39	-	-	-	-
16N/01W-13H01	4652231224425	340	75	0	20	40	-	-	-	-
16N/01W-14Q02	4652041224608	355	60	NP	NP	NP	NP	NP	NP	0
16N/01W-19A02	4651511225047	280	120	0	NP	11	NP	NP	65	72
16N/01W-19G02	4651411225054	272	94	0	14	23	-	-	-	-
16N/01W-21D04	4651441224902	304	95	0	16	28	NP	NP	35	83
16N/02W-03F01	4654081225519	223	125	0	NP	NP	NP	NP	41	46
16N/02W-04N01	4653501225643	194	39	0	18	NP	NP	26	-	-
16N/02W-05N01	4653541225806	270	149	NP	NP	NP	NP	NP	0	-
16N/02W-05R01	4653451225704	195	330	0	16	NP	NP	NP	38	160
16N/02W-05R02	4653451225715	190	33	0	5	NP	NP	18	NP	29
16N/02W-06E01	4654091225919	230	152	NP	NP	NP	NP	0	60	-
16N/02W-09A01	4653351225544	235	200	NP	NP	NP	NP	NP	0	28
16N/02W-10C01	4653291225508	220	35	NP	0	25	-	-	-	-
16N/02W-12N01	4652531225257	300	118	NP	0	NP	NP	NP	21	-
16N/02W-20Q02	4651151225729	231	159	0	NP	NP	NP	NP	20	-
16N/02W-26M01	4650251225414	260	202	0	NP	<62	NP	NP	NP	62
16N/02W-27H01	4650381225437	260	185	0	NP	<47	NP	NP	NP	47
16N/02W-27H02	4650381225437	260	47	0	NP	<47	NP	NP	47	-
16N/03W-01D01	4654321230043	156	68	0	26	36	44	47	-	-
16N/03W-01J01	4654001225942	190	135	0	NP	NP	NP	13	53	-
16N/03W-02E01	4654161230155	200	119	0	NP	<60	60	106	-	-
16N/03W-02H01	4654171230050	155	89	0	14	58	-	-	-	-
16N/03W-02J01	4654061230058	143	46	0	18	44	-	-	-	-
16N/03W-02M02	4654051230158	197	110	0	<94	94	-	-	-	-
16N/03W-09B02	4653391230348	220	164	0	7	NP	NP	NP	NP	41
16N/03W-10B01	4653341230231	212	116	0	35	55	85	112	-	-
16N/03W-10K01	4653031230221	180	110	0	15	55	NP	107	-	-
16N/03W-10Q01	4652541230232	168	100	0	NP	<100	NP	<100	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
16N/03W-12M01	4653111230028	184	39	NP	0	NP	NP	37	-	-
16N/03W-12Q01	4652571225959	217	80	NP	NP	NP	NP	NP	0	-
16N/03W-12Q02	4653001230002	202	52	NP	NP	NP	NP	NP	0	-
16N/03W-14B01	4652451230107	240	164	NP	0	NP	NP	103	-	-
16N/03W-15F01	4652341230250	160	80	0	NP	NP	NP	<80	-	-
16N/03W-16K01	4652191230337	148	78	0	NP	NP	NP	<78	-	-
16N/03W-16L03	4652181230405	144	67	0	NP	NP	NP	<67	-	-
16N/03W-16R01	4651571230332	130	127	0	NP	NP	NP	<125	NP	127
16N/03W-21F01	4651381230356	107	82	0	NP	NP	NP	<82	-	-
17N/01E-05D01	4659381224247	222	226	0	NP	97	132	190	-	-
17N/01E-05D02	4659451224241	240	226	0	NP	122	NP	215	220	-
17N/01E-05D03	4659411224254	155	149	0	NP	<135	135	143	-	-
17N/01E-05E01	4659281224256	221	218	0	NP	<180	180	200	-	-
17N/01E-05F01	4659311224229	245	182	0	102	154	180	-	-	-
17N/01E-05N01	4659021224256	225	306	0	NP	92	190	212	304	-
17N/01E-06A01	4659401224307	115	120	0	NP	55	NP	87	-	-
17N/01E-06C01	4659371224345	100	54	0	-	-	-	-	-	-
17N/01E-06J03D1	4659171224305	205	427	0	NP	80	NP		180 <387	-
17N/01E-06J04	4659161224317	175	75	0	NP	65	-	-	-	-
17N/01E-06M02	4659121224411	210	174	0	NP	68	NP	170	-	-
17N/01E-07A01	4658441224317	210	154	0	NP	44	113	143	-	-
17N/01E-07B04	4658521224331	215	43	0	-	-	-	-	-	-
17N/01E-07B05	4658491224333	213	190	0	NP	49	NP	110	-	-
17N/01E-07C01	4658451224349	215	132	0	NP	48	NP	126	-	-
17N/01E-07D01	4658441224358	208	138	0	NP	72	107	127	-	-
17N/01E-07F01	4658391224339	208	105	0	NP	35	-	-	-	-
17N/01E-07H01	4658351224310	204	41	0	NP	30	-	-	-	-
17N/01E-07L01	4658161224354	215	72	0	NP	40	-	-	-	-
17N/01E-07P02	4658061224350	226	84	0	NP	46	47	-	-	-
17N/01E-07P03	4658091224344	212	260	0	NP	36	<172	<172	172	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
17N/01E-07Q03	4658021224329	211	36	0	NP	29	35	-	-	-
17N/01E-08L02	4658181224238	218	258	0	NP	56	63	88	178	-
17N/01E-08L03	4658191224229	250	171	0	17	40	92	126	-	-
17N/01E-11H01	4658281223800	140	120	NP	NP	NP	NP	NP	0	-
17N/01E-11Q02	4658121223815	309	139	0	<18	44	NP	79	-	-
17N/01E-11R01	4658051223806	315	193	0	2	NP	<109	109	185	-
17N/01E-13D04	4657581223747	322	183	0	27	NP	<120	120	161	-
17N/01E-13D05	4657531223751	324	118	0	68	75	78	98	-	-
17N/01E-13E03	4657421223751	332	139	?	?	<88	103	126	-	-
17N/01E-13G02	4657411223713	330	114	0	<100	NP	<100	100	-	-
17N/01E-13K01	4657241223659	345	111	0	12	42	73	-	-	-
17N/01E-13L01D1	4657331223719	337	140	0	12	57	60	94	-	-
17N/01E-13M02	4657231223737	334	98	0	14	NP	46	90	-	-
17N/01E-14A03	4657551223803	322	203	0	12	78	81	121	165	-
17N/01E-14A04	4657551223803	320	160	0	7	60	80	105	-	-
17N/01E-14D01	4657501223909	375	160	0	21	40	57	152	-	-
17N/01E-14L01	4657321223842	420	200	0	8	64	143	184	-	-
17N/01E-14M02	4657301223906	375	168	0	6	52	110	162	-	-
17N/01E-14N02	4657181223908	370	162	0	40	<112	142	-	-	-
17N/01E-14P01	4657131223843	376	200	0	10	54	100	172	-	-
17N/01E-14R01	4657201223754	332	115	0	18	74	-	-	-	-
17N/01E-18N01	4657211224402	228	79	0	2	32	42	69	77	-
17N/01E-23B01	4657071223826	348	157	NP	0	74	101	156	-	-
17N/01E-23H01	4656531223800	370	153	NP	0	78	82	150	-	-
17N/01E-24K02	4656311223705	350	97	0	12	30	32	89	-	-
17N/01E-25G01	4655541223704	415	137	NP	0	111	-	-	-	-
17N/01E-25Q03	4655361223704	410	115	NP	0	94	-	-	-	-
17N/01E-26R01	4655301223811	400	72	NP	0	56	-	-	-	-
17N/01E-33J01D1	4654561224041	505	247	?	?	<203	-	-	-	-
17N/01E-34M01	4654551224010	470	196	NP	0	180	-	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
17N/01E-35H01	4655001223804	420	80	0	2	65	-	-	-	-
17N/01E-36L01	4654541223729	400	86	0	10	85	-	-	-	-
17N/01E-36L02	4654551223729	410	112	0	20	100	-	-	-	-
17N/01W-01B01	4659431224435	230	205	0	70	NP	96	172	-	-
17N/01W-01B04	4659451224447	222	196	0	35	NP	98	174	196	-
17N/01W-01F01	4659261224510	230	160	0	36	81	NP	141	-	-
17N/01W-01G01	4659321224440	235	235	0	56	NP	97	145	-	-
17N/01W-01G02	4659201224438	215	215	0	NP	<140	NP	140	-	-
17N/01W-01H01	4659261224421	213	236	0	45	96	101	143	145	-
17N/01W-01H02	4659321224427	225	225	0	49	NP	65	157	-	-
17N/01W-01H03	4659211224430	214	250	0	NP	60	105	172	-	-
17N/01W-01J03	4659141224429	190	179	0	NP	65	136	146	-	-
17N/01W-01L01	4659111224510	210	157	0	2	40	73	152	-	-
17N/01W-01Q01	4658581224435	205	105	0	NP	70	-	-	-	-
17N/01W-01Q03	4658581224447	200	58	0	-	-	-	-	-	-
17N/01W-01Q04	4658581224436	205	110	0	78	100	-	-	-	-
17N/01W-01R01	4658551224415	217	123	0	NP	<112	112	121	-	-
17N/01W-02A03	4659431224532	216	235	0	2	NP	80	NP	<235	-
17N/01W-02E03	4659321224638	178	49	0	NP	35	-	-	-	-
17N/01W-02E04	4659251224638	215	542	0	26	90	120	138	184	-
17N/01W-02K01	4659151224558	222	146	0	72	85	88	145	-	-
17N/01W-02L02	4659191224621	216	78	0	59	73	-	-	-	-
17N/01W-02L03	4659171224614	211	67	0	-	-	-	-	-	-
17N/01W-02Q03	4659011224605	210	154	0	58	92	145	-	-	-
17N/01W-02Q04	4658531224559	208	79	0	38	70	-	-	-	-
17N/01W-02R02	4659011224533	209	158	0	43	86	109	139	-	-
17N/01W-03A05	4659351224654	206	80	0	17	68	-	-	-	-
17N/01W-03D01	4659331224758	188	48	0	37	42	-	-	-	-
17N/01W-03E01	4659191224753	197	68	0	66	-	-	-	-	-
17N/01W-03E02	4659201224750	199	81	0	80	-	-	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
17N/01W-03Q01	4659051224712	201	126	0	51	60	-	-	-	-
17N/01W-04E01	4659331224909	210	84	0	76	-	-	-	-	-
17N/01W-04F01	4659321224851	214	72	0	62	-	-	-	-	-
17N/01W-04G01	4659321224832	207	243	0	57	76	113	121	159	-
17N/01W-04L01	4659191224845	198	87	0	59	65	82	-	-	-
17N/01W-05H02	4659271224921	210	68	0	-	-	-	-	-	-
17N/01W-06B02	4659391225110	185	80	0	9	28	-	-	-	-
17N/01W-06K05	4659111225111	190	83	0	54	-	-	-	-	-
17N/01W-07F02	4658321225114	205	163	0	NP	26	80	122	162	-
17N/01W-07G02	4658321225104	209	104	0	NP	27	81	-	-	-
17N/01W-08B01	4658451224948	216	59	0	6	51	-	-	-	-
17N/01W-08B02	4658461224952	211	54	0	3	45	-	-	-	-
17N/01W-08C02	4658461225014	210	52	0	20	49	-	-	-	-
17N/01W-08D03	4658461225031	209	48	0	-	-	-	-	-	-
17N/01W-08D04	4658421225025	210	64	0	28	50	62	-	-	-
17N/01W-08J01	4658181224927	220	84	0	8	68	82	-	-	-
17N/01W-08L02	4658221225008	200	85	0	8	69	-	-	-	-
17N/01W-08N01	4658151225018	210	95	0	28	>55	90	-	-	-
17N/01W-08P03	4658051224959	220	94	0	8	57	59	88	-	-
17N/01W-08P04	4658131225008	215	94	0	2	64	80	90	-	-
17N/01W-08Q02	4658041224953	220	181	0	7	63	99	118	-	-
17N/01W-09B01	4658421224836	210	40	0	-	-	-	-	-	-
17N/01W-09D01	4658531224907	190	41	0	12	33	-	-	-	-
17N/01W-09G02	4658371224832	216	55	0	23	-	-	-	-	-
17N/01W-09G03	4658401224838	206	91	0	2	53	69	86	-	-
17N/01W-09J02	4658251224810	205	100	0	20	62	75	95	-	-
17N/01W-10N02	4658081224752	236	79	NP	0	75	-	-	-	-
17N/01W-11H03	4658371224544	220	65	0	8	55	-	-	-	-
17N/01W-11J01	4658261224543	218	36	0	19	25	-	-	-	-
17N/01W-11K03	4658221224607	264	96	NP	0	51	-	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
17N/01W-11K04	4658201224550	217	28	0	-	-	-	-	-	-
17N/01W-11K05	4658201224601	224	302	NP	0	51	60	111	180	-
17N/01W-11M01	4658261224630	270	334	NP	0	79	93	169	203	-
17N/01W-12B02	4658461224440	232	166	0	27	89	117	137	146	-
17N/01W-12C01	4658441224503	214	100	0	NP	53	-	-	-	-
17N/01W-12D01	4658471224521	209	180	0	13	40	NP	104	155	-
17N/01W-12D02	4658471224511	206	174	0	15	24	NP	115	157	-
17N/01W-13H01	4657351224434	340	160	0	8	40	NP	140	-	-
17N/01W-14B01	4657541224557	270	85	NP	0	42	-	-	-	-
17N/01W-14H01	4657471224544	218	50	0	NP	10	-	-	-	-
17N/01W-14K01	4657291224558	218	29	0	-	-	-	-	-	-
17N/01W-15A01	4657511224659	264	91	NP	0	16	-	-	-	-
17N/01W-15C01	4657501224733	256	99	NP	0	41	99	-	-	-
17N/01W-15F02	4657401224729	245	120	0	15	20	40	105	-	-
17N/01W-15G01	4657411224713	265	121	0	17	58	62	118	-	-
17N/01W-15H01	4657381224658	220	39	0	3	34	39	-	-	-
17N/01W-15H02	4657411224659	265	83	0	55	60	-	-	-	-
17N/01W-15K01	4657271224710	220	33	0	-	-	-	-	-	-
17N/01W-15N01	4657181224743	209	39	0	2	14	-	-	-	-
17N/01W-15N02	4657161224748	211	32	0	2	15	-	-	-	-
17N/01W-15P01	4657171224731	210	40	0	NP	31	-	-	-	-
17N/01W-15P02	4657181224738	210	46	0	15	39	-	-	-	-
17N/01W-15P03	4657151224728	213	33	0	11	29	-	-	-	-
17N/01W-16D01	4657521224913	220	110	0	10	45	55	105	-	-
17N/01W-16D02	4657571224908	220	72	0	24	64	71	-	-	-
17N/01W-16E02	4657411224911	220	31	0	6	25	-	-	-	-
17N/01W-16F02	4657391224856	230	89	0	6	43	59	-	-	-
17N/01W-16F03	4657481224847	250	89	0	4	79	82	-	-	-
17N/01W-16F04	4657431224853	250	122	0	4	50	74	103	121	-
17N/01W-16L01	4657221224853	210	52	0	20	31	51	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
17N/01W-16M02	4657271224910	220	49	0	2	36	-	-	-	-
17N/01W-17A01	4657531224921	215	79	0	2	38	70	-	-	-
17N/01W-17B03	4657531224953	215	39	0	1	37	-	-	-	-
17N/01W-17G02	4657431224953	215	148	0	10	20	60	NP	100	-
17N/01W-17J02	4657301224935	220	123	0	16	27	42	48	-	-
17N/01W-17K01	4657281224943	215	41	0	20	40	-	-	-	-
17N/01W-17N02	4657111225026	205	80	0	17	39	40	68	-	-
17N/01W-18B02	4658011225056	210	103	0	25	NP	45	74	-	-
17N/01W-18B03	4657501225105	200	300	0	20	NP	NP	60	120	-
17N/01W-19C02	4656581225123	220	120	0	4	56	68	80	85	-
17N/01W-19M02	4656371225142	340	270	NP	0	NP	NP	NP	NP	76
17N/01W-19P01	4656191225116	210	60	0	NP	15	46	-	-	-
17N/01W-21K01	4656421224833	360	507	NP	NP	NP	NP	NP	0	14
17N/01W-21P01	4656241224854	250	78	NP	NP	NP	NP	NP	0	-
17N/01W-28B01	4656041224821	295	167	NP	NP	NP	NP	NP	0	9
17N/01W-28C02	4656171224859	240	72	NP	NP	NP	NP	NP	0	-
17N/01W-28G02	4655581224838	400	342	NP	NP	NP	NP	0	30	90
17N/01W-28H01	4655571224813	260	140	NP	NP	NP	NP	NP	0	26
17N/01W-30F02	4656001225130	260	405	NP	0	NP	NP	NP	NP	18
17N/01W-30F03	4655521225123	250	67	0	NP	<67	NP	NP	NP	67
17N/01W-31C01	4655221225126	260	52	0	24	36	-	-	-	-
17N/01W-32F01	4655091224955	250	250	0	8	19	35	97	248	-
17N/01W-32F02	4655051225001	250	270	0	9	32	41	82	236	-
17N/01W-32K04	4654461224947	265	168	0	NP	NP	65	NP	100	168
17N/01W-32P02	4654431225002	260	143	0	NP	NP	55	NP	70	-
17N/01W-33B03	4655141224826	245	59	0	-	-	-	-	-	-
17N/01W-33E02	4655091224907	245	81	0	23	29	52	74	-	-
17N/01W-33E03	4655071224905	230	32	0	8	22	-	-	-	-
17N/01W-33E04	4655061224902	230	55	0	15	39	-	-	-	-
17N/01W-33K02	4654521224829	260	41	0	8	37	-	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
17N/01W-34D01	4655211224751	400	80	NP	NP	NP	NP	NP	0	-
17N/01W-34E01D1	4655071224744	280	142	0	5	17	63	NP	94	138
17N/01W-34J02	4654491224703	290	61	0	12	40	50	60	-	-
17N/01W-34L01	4654501224733	290	70	0	22	43	55	61	-	-
17N/01W-34L02	4654581224735	280	125	0	21	NP	NP	NP	NP	45
17N/01W-34M01	4654551224752	290	68	0	60	-	-	-	-	-
17N/02W-01C01	4659461225245	110	32	0	-	-	-	-	-	-
17N/02W-01E02	4659321225255	175	148	0	22	45	-	-	-	-
17N/02W-02B02	4659401225327	175	200	0	NP	<105	105	166	-	-
17N/02W-02E03	4659231225415	185	106	0	24	80	104	-	-	-
17N/02W-02E04	4659291225406	183	62	0	41	61	-	-	-	-
17N/02W-02K01	4659091225337	170	60	0	-	-	-	-	-	-
17N/02W-02N01	4659021225410	185	70	0	-	-	-	-	-	-
17N/02W-02Q06	4658571225336	175	67	0	-	-	-	-	-	-
17N/02W-02R01	4658561225312	191	106	0	NP	<106	-	-	-	-
17N/02W-02R02	4658561225313	191	97	0	NP	<97	97	-	-	-
17N/02W-02R03	4659081225311	180	88	0	20	32	88	-	-	-
17N/02W-03D01	4659361225520	178	30	0	-	-	-	-	-	-
17N/02W-03D02	4659341225521	178	45	0	-	-	-	-	-	-
17N/02W-03J02	4659101225428	190	111	0	45	103	-	-	-	-
17N/02W-03R02	4659071225433	190	334	0	49	106	108	128	153	-
17N/02W-04A01	4659401225546	175	43	0	-	-	-	-	-	-
17N/02W-04E07	4659241225652	180	45	0	-	-	-	-	-	-
17N/02W-04H01	4659241225542	188	73	0	55	72	-	-	-	-
17N/02W-04H02	4659231225542	188	60	0	-	-	-	-	-	-
17N/02W-04K04	4659201225615	190	45	0	-	-	-	-	-	-
17N/02W-04L01	4659081225624	190	50	0	-	-	-	-	-	-
17N/02W-04N04	4658581225640	188	40	0	-	-	-	-	-	-
17N/02W-04N05	4658581225643	188	44	0	-	-	-	-	-	-
17N/02W-04N06	4659041225647	190	53	0	-	-	-	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
17N/02W-04P02	4659001225617	189	47	0	16	37	-	-	-	-
17N/02W-05A02	4659391225659	172	33	0	-	-	-	-	-	-
17N/02W-05F01	4659261225746	165	71	0	10	55	71	-	-	-
17N/02W-05J01D1	4659171225656	190	106	0	43	67	72	104	-	-
17N/02W-06A04	4659451225818	142	51	0	15	24	51	-	-	-
17N/02W-06A05	4659411225821	150	27	0	20	25	-	-	-	-
17N/02W-06F03	4659251225852	143	27	0	2	27	-	-	-	-
17N/02W-06G02	4659291225848	140	332	0	20	NP	26	NP	<158	-
17N/02W-06N01	4658571225910	143	60	0	NP	NP	30	44	-	-
17N/02W-06P02	4659001225905	137	62	0	NP	NP	19	58	-	-
17N/02W-06R01	4658571225822	140	205	0	NP	NP	40	NP	90	-
17N/02W-08D03	4658441225802	155	76	0	26	NP	34	-	-	-
17N/02W-08E01	4658321225809	183	200	0	25	NP	72	115	139	-
17N/02W-08K02	4658181225722	190	37	0	-	-	-	-	-	-
17N/02W-08L01	4658241225739	188	41	0	-	-	-	-	-	-
17N/02W-08L02	4658191225738	182	38	0	-	-	-	-	-	-
17N/02W-08L03	4658171225739	181	40	0	-	-	-	-	-	-
17N/02W-08R06	4658071225657	195	65	0	21	62	-	-	-	-
17N/02W-09A02	4658521225554	190	40	0	19	32	-	-	-	-
17N/02W-09C02	4658451225620	195	56	0	46	49	-	-	-	-
17N/02W-09E03	4658291225639	195	77	0	32	52	77	-	-	-
17N/02W-09G02	4658341225607	190	56	0	19	46	-	-	-	-
17N/02W-09K01	4658271225606	188	44	0	12	43	-	-	-	-
17N/02W-09M04	4658241225652	195	47	0	35	43	-	-	-	-
17N/02W-09Q01	4658081225607	190	70	0	4	40	-	-	-	-
17N/02W-10B01	4658471225446	195	105	0	52	56	98	-	-	-
17N/02W-10B02	4658421225452	195	111	0	47	52	99	-	-	-
17N/02W-10N01	4658091225539	190	57	0	NP	<57	-	-	-	-
17N/02W-11G08	4658341225336	195	136	0	51	70	83	129	-	-
17N/02W-11G09	4658311225337	200	60	0	60	-	-	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
17N/02W-11J01	4658221225324	198	79	0	79	-	-	-	-	-
17N/02W-11R01	4658131225307	200	300	0	NP	90	105	<265	<265	-
17N/02W-12L02	4658241225246	195	157	0	31	62	<130	130	-	-
17N/02W-13Q02	4657201225220	225	73	0	6	-	-	-	-	-
17N/02W-13R02	4657191225154	177	107	0	4	48	73	NP	104	-
17N/02W-14H02	4657391225319	200	39	0	3	34	-	-	-	-
17N/02W-14H03	4657411225309	196	50	0	6	47	50	-	-	-
17N/02W-14Q01	4657231225344	198	150	0	8	50	65	97	143	-
17N/02W-14Q02	4657121225338	200	40	0	22	30	-	-	-	-
17N/02W-15D02	4657591225529	195	43	0	4	31	-	-	-	-
17N/02W-15E01	4657471225526	195	50	0	4	45	50	-	-	-
17N/02W-15L04	4657321225518	200	58	0	42	51	-	-	-	-
17N/02W-16M02	4657241225651	191	39	0	17	31	-	-	-	-
17N/02W-16P02	4657121225636	193	77	0	30	60	-	-	-	-
17N/02W-16P03	4657121225621	194	58	0	27	57	-	-	-	-
17N/02W-16Q02	4657141225559	196	55	0	NP	<55	-	-	-	-
17N/02W-17E01	4657421225759	175	115	0	<44	44	53	115	-	-
17N/02W-17F02	4657401225737	186	63	0	16	51	-	-	-	-
17N/02W-17H01	4657441225707	190	39	0	17	38	-	-	-	-
17N/02W-17J01	4657361225707	195	136	0	18	39	136	-	-	-
17N/02W-17L02	4657321225740	189	80	0	25	73	-	-	-	-
17N/02W-17N02	4657131225758	185	83	0	44	78	83	-	-	-
17N/02W-17R02	4657121225702	195	55	0	4	47	55	-	-	-
17N/02W-17R03	4657231225709	192	257	0	18	52	120	167	178	-
17N/02W-17R04	4657231225705	192	122	0	12	41	114	-	-	-
17N/02W-18H03	4657441225819	175	109	0	1	30	79	-	-	-
17N/02W-19A01	4657001225829	175	57	0	<55	-	-	-	-	-
17N/02W-19F01	4656431225857	164	100	0	11	36	47	97	-	-
17N/02W-19G04	4656451225847	174	60	0	14	46	-	-	-	-
17N/02W-19L03	4656331225903	164	67	0	5	48	62	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
17N/02W-20B05	4657051225729	188	80	0	27	42	71	-	-	-
17N/02W-20B06	4657051225717	191	91	0	18	40	-	-	-	-
17N/02W-20H02	4656561225657	191	74	0	28	43	70	-	-	-
17N/02W-20J02	4656401225658	190	123	0	55	NP	63	-	-	-
17N/02W-20J03	4656351225657	188	60	0	-	-	-	-	-	-
17N/02W-20K01	4656371225731	186	53	0	23	51	-	-	-	-
17N/02W-21A01	4657081225545	196	63	0	15	30	-	-	-	-
17N/02W-21F01	4656571225631	195	178	0	19	54	90	>121	178	-
17N/02W-21J01	4656361225550	193	26	0	-	-	-	-	-	-
17N/02W-22A01	4657031225428	200	83	0	54	79	-	-	-	-
17N/02W-22A02	4657091225428	197	60	0	20	53	-	-	-	-
17N/02W-22B04	4657001225455	205	53	0	18	40	-	-	-	-
17N/02W-22D02	4657061225535	200	86	0	2	73	-	-	-	-
17N/02W-22E02	4656531225532	200	117	0	60	77	87	NP	NP	112
17N/02W-22E03	4656551225533	200	106	0	76	NP	89	NP	NP	97
17N/02W-22F03	4656511225514	198	66	0	28	58	-	-	-	-
17N/02W-22H02	4656461225428	196	87	0	28	45	69	-	-	-
17N/02W-22H03	4656481225441	200	57	0	21	52	-	-	-	-
17N/02W-22Q03	4656361225448	200	45	0	1	34	-	-	-	-
17N/02W-23B01	4656541225328	215	57	0	4	41	-	-	-	-
17N/02W-23B02	4657091225333	200	40	0	24	38	-	-	-	-
17N/02W-23K01	4656361225342	196	59	0	3	20	-	-	-	-
17N/02W-24B01	4657091225209	224	100	0	12	72	76	92	-	-
17N/02W-24C02	4657081225246	210	243	0	NP	<42	42	56	NP	70
17N/02W-24D01	4656591225252	220	120	0	5	NP	NP	NP	47	52
17N/02W-24D02D1	4657091225305	200	-	0	NP	NP	NP	NP	NP	37
17N/02W-25N03	4655271225254	217	80	0	14	NP	NP	NP	NP	38
17N/02W-25Q01	4655291225222	243	155	0	6	NP	41	NP	56	122
17N/02W-25Q02	4655311225218	274	113	0	5	NP	49	NP	68	-
17N/02W-25Q03	4655341225215	276	280	0	8	55	63	NP	110	156

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
17N/02W-26D02	4656081225405	380	186	NP	0	NP	NP	58	88	183
17N/02W-26E01	4655571225418	200	68	0	NP	NP	NP	19	-	-
17N/02W-27J01	4655411225435	310	110	NP	0	NP	NP	NP	NP	19
17N/02W-27J02	4655431225425	200	212	NP	0	NP	NP	NP	NP	4
17N/02W-27P01	4655291225513	195	35	NP	0	NP	NP	25	-	-
17N/02W-28J01	4655481225542	200	62	NP	0	NP	NP	17	18	-
17N/02W-28J02	4655461225541	200	45	NP	0	NP	NP	19	23	-
17N/02W-28R01	4655381225557	198	28	0	20	NP	NP	27	-	-
17N/02W-29A01	4656101225709	188	44	0	18	42	-	-	-	-
17N/02W-29A02	4656081225703	190	50	0	34	46	-	-	-	-
17N/02W-29D01	4656101225804	180	56	0	NP	<55	-	-	-	-
17N/02W-29D02	4656121225759	180	60	0	32	55	-	-	-	-
17N/02W-29F01	4655571225738	186	57	0	16	37	-	-	-	-
17N/02W-29G01	4656041225728	195	50	0	3	47	-	-	-	-
17N/02W-29R01	4655261225658	195	100	0	20	22	35	88	-	-
17N/02W-30D02D1	4656101225915	163	-	0	15	38	?	?	?	?
17N/02W-30E02	4655591225909	180	146	0	10	NP	NP	NP	NP	21
17N/02W-30E03	4655541225915	186	146	0	19	NP	42	NP	NP	55
17N/02W-30E04	4656001225914	180	86	0	18	NP	20	84	-	-
17N/02W-30F01	4655591225857	185	148	0	25	30	34	NP	60	96
17N/02W-30P02	4655281225851	178	49	0	NP	NP	NP	17	NP	36
17N/02W-31E01	4655021225916	181	80	0	NP	NP	NP	NP	<32	-
17N/02W-31H01	4655091225824	220	112	0	<38	NP	NP	28	38	-
17N/02W-32E01	4655091225809	193	24	0	<19	NP	NP	19	-	-
17N/02W-32K01	4654461225732	188	38	0	NP	NP	8	-	-	-
17N/02W-33K02	4654591225608	205	41	NP	0	NP	NP	22	-	-
17N/02W-34J02	4654551225424	212	120	0	NP	NP	NP	<120	-	-
17N/02W-35C01	4655251225353	268	201	NP	0	NP	NP	NP	NP	20
17N/02W-36C02	4655171225243	290	170	0	10	NP	NP	NP	NP	25
17N/02W-36C03	4655191225232	310	95	0	4	NP	NP	NP	NP	29

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
17N/03W-01B01	4659471225956	240	117	NP	0	64	-	-	-	-
17N/03W-01G02	4659211230000	220	94	0	3	62	-	-	-	-
17N/03W-01J01	4659101225927	210	83	0	6	71	-	-	-	-
17N/03W-01L02	4659151230010	220	95	?	?	<60	-	-	-	-
17N/03W-01R03	4659031225939	205	113	NP	0	94	101	111	-	-
17N/03W-02G01	4659321230111	340	166	0	5	67	NP	NP	72	166
17N/03W-02H01	4659271230100	290	85	0	4	77	NP	NP	80	-
17N/03W-02J01	4659121230051	260	165	0	10	93	NP	NP	122	-
17N/03W-02J02	4659121230053	260	165	0	19	89	NP	NP	116	-
17N/03W-02J03D1	4659181230045	260	113	0	18	82	?	?	?	?
17N/03W-02K01	4659141230109	275	46	0	12	42	-	-	-	-
17N/03W-02K04	4659181230118	300	115	0	17	58	NP	NP	112	-
17N/03W-02Q01	4658571230115	270	203	0	2	72	NP	NP	78	142
17N/03W-10B01	4658461230227	510	74	0	6	NP	NP	NP	NP	21
17N/03W-10C01	4658481230255	600	110	0	16	NP	NP	NP	46	-
17N/03W-10D01	4658481230303	620	43	0	18	NP	NP	NP	26	-
17N/03W-11A03	4658481230054	240	94	0	6	88	-	-	-	-
17N/03W-11G01	4658361230117	240	99	0	37	67	-	-	-	-
17N/03W-11H01	4658371230051	240	100	NP	0	97	-	-	-	-
17N/03W-11K01	4658251230122	180	62	0	12	50	NP	NP	NP	60
17N/03W-11Q01	4658181230109	140	35	0	20	35	-	-	-	-
17N/03W-12A02	4658541225932	185	109	0	6	30	70	94	-	-
17N/03W-12A03	4658541225930	180	107	0	29	51	60	86	-	-
17N/03W-12A04	4658531225932	185	113	0	<25	64	70	72	-	-
17N/03W-12B02	4658501225950	240	103	0	17	80	103	-	-	-
17N/03W-12E01	4658371230029	200	56	0	9	54	-	-	-	-
17N/03W-12F01	4658351230016	220	119	0	22	87	-	-	-	-
17N/03W-14C02	4657551230128	140	70	0	NP	29	NP	NP	NP	70
17N/03W-14F03	4657531230143	170	402	0	NP	NP	NP	NP	5	21
17N/03W-14R02	4657201230048	200	101	NP	0	4	-	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
17N/03W-15A01	4658011230205	240	310	0	NP	NP	NP	NP	35	48
17N/03W-15B01	4657581230232	390	124	NP	NP	NP	NP	NP	0	52
17N/03W-15F01	4657421230258	580	64	NP	NP	NP	NP	NP	0	52
17N/03W-15N01	4657121230317	580	129	NP	NP	NP	NP	NP	0	-
17N/03W-15P01	4657181230249	400	282	0	NP	NP	NP	NP	NP	3
17N/03W-15P02	4657231230244	360	47	NP	NP	NP	NP	NP	0	41
17N/03W-17A01	4657551230444	515	40	NP	NP	NP	NP	NP	0	21
17N/03W-17B01	4657481230503	420	110	NP	NP	NP	NP	NP	0	25
17N/03W-17D01	4657561230537	485	75	NP	NP	NP	NP	NP	0	-
17N/03W-17G01	4657431230509	420	89	NP	NP	NP	NP	NP	0	-
17N/03W-17R01	4657231230454	380	79	NP	NP	NP	NP	NP	0	-
17N/03W-22J01	4656431230208	200	100	0	NP	<95	-	-	-	-
17N/03W-22L01	4656421230248	290	243	0	NP	NP	NP	NP	12	30
17N/03W-23L02	4656391230138	250	136	NP	0	110	-	-	-	-
17N/03W-23P01	4656241230132	245	98	NP	0	95	-	-	-	-
17N/03W-23Q02	4656341230118	230	113	NP	0	91	112	-	-	-
17N/03W-23R02	4656341230046	170	70	0	22	54	-	-	-	-
17N/03W-24D01	4657061230028	200	97	NP	0	30	-	-	-	-
17N/03W-24E02	4656581230032	200	89	NP	0	42	-	-	-	-
17N/03W-24E03	4656501230041	190	84	NP	0	41	-	-	-	-
17N/03W-25D01	4656191230039	160	113	0	<45	45	51	70	-	-
17N/03W-25D02	4656191230042	160	74	0	23	35	57	68	-	-
17N/03W-25G01	4655531225953	150	50	0	NP	NP	14	34	-	-
17N/03W-25H02	4655561225942	155	60	0	NP	NP	35	55	-	-
17N/03W-25J02	4655481225929	180	45	0	NP	NP	34	39	-	-
17N/03W-25K01	4655521225949	155	44	0	NP	NP	30	42	-	-
17N/03W-25R04	4655311225936	165	45	0	NP	NP	5	38	-	-
17N/03W-25R05	4655341225929	170	94	0	NP	NP	5	18	-	-
17N/03W-26A01	4656221230045	160	94	0	18	21	38	72	-	-
17N/03W-26F01	4656071230125	200	96	0	8	20	43	75	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
17N/03W-26G01	4656061230119	180	66	0	2	48	-	-	-	-
17N/03W-26H01	4656081230100	160	89	0	30	43	49	54	-	-
17N/03W-26H02	4656091230046	158	89	0	32	62	71	76	-	-
17N/03W-26J02	4655441230052	140	30	0	-	-	-	-	-	-
17N/03W-27N01	4655341230317	300	156	0	12	NP	NP	NP	46	-
17N/03W-34E03	4655091230258	250	95	0	<42	-	-	-	-	-
17N/03W-34E04	4655061230300	250	120	0	3	NP	NP	NP	73	93
17N/03W-34F01	4655061230256	250	288	0	1	NP	NP	NP	77	92
17N/03W-34J01	4654561230209	170	55	0	5	53	-	-	-	-
17N/03W-34M01	4654511230306	200	400	0	<17	NP	NP	NP	NP	17
17N/03W-35B02	4655221230120	140	54	0	34	46	-	-	-	-
17N/03W-35R01	4654421230049	140	47	0	3	26	32	43	-	-
17N/03W-36A01	4655151225936	171	55	0	NP	NP	24	45	-	-
17N/03W-36C01	4655201230009	160	248	0	<80	NP	NP	NP	80	115
17N/03W-36F01	4655111230014	160	34	0	NP	NP	12	20	-	-
17N/03W-36N05	4654441230028	160	40	0	NP	NP	5	30	-	-
17N/03W-36Q02	4654411225950	180	185	NP	NP	NP	NP	0	35	150
17N/03W-36R01	4654401225939	230	91	NP	0	NP	NP	NP	12	-
18N/01E-06N01	4704121224400	230	253	0	10	20	140	220	-	-
18N/01E-06R01	4704171224301	18	250	NP	NP	NP	0	135	234	-
18N/01E-07A01	4703591224306	15	130	NP	NP	NP	0	119	-	-
18N/01E-07D01	4703561224412	238	260	0	<65	65	130	225	-	-
18N/01E-07L01	4703311224338	15	100	NP	NP	NP	0	23	-	-
18N/01E-08B03	4703561224215	18	86	NP	NP	NP	0	80	-	-
18N/01E-08D03	4703581224253	10	112	NP	NP	NP	0	95	-	-
18N/01E-08H01	4703431224152	20	73	NP	NP	NP	0	68	-	-
18N/01E-09M02	4703301224131	25	108	NP	NP	NP	0	88	-	-
18N/01E-16E01	4702551224134	33	110	NP	NP	NP	0	104	-	-
18N/01E-17Q01	4702241224210	181	260	0	20	98	110	165	-	-
18N/01E-18A01	4703131224315	15	120	NP	NP	NP	0	111	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
18N/01E-18A02	4703091224313	10	123	NP	NP	NP	0	112	-	-
18N/01E-18B01	4703061224333	15	84	NP	NP	NP	0	48	-	-
18N/01E-18H01	4702511224259	10	130	NP	NP	NP	0	118	130	-
18N/01E-19J02	4701491224303	39	112	0	NP	33	NP	43	108	-
18N/01E-19Q01	4701401224324	70	137	0	NP	42	NP	64	-	-
18N/01E-19R01	4701371224306	95	332	0	NP	65	NP	105	-	-
18N/01E-20R02	4701401224154	221	207	0	88	120	NP	200	-	-
18N/01E-21N01	4701321224126	230	352	0	88	125	130	203	297	-
18N/01E-21N02	4701421224132	220	200	0	81	120	125	175	-	-
18N/01E-21P01	4701361224111	230	236	0	63	NP	<184	184	-	-
18N/01E-21P02	4701361224112	230	417	0	88	186	191	211	235	-
18N/01E-21P03	4701371224114	230	235	0	79	175	191	211	-	-
18N/01E-21Q02	4701311224101	238	227	0	116	NP	156	211	-	-
18N/01E-28M01	4700521224130	238	194	0	3	NP	84	179	-	-
18N/01E-28N01	4700431224129	244	197	0	10	140	155	185	-	-
18N/01E-29B01	4701241224207	94	303	0	NP	78	NP	104	-	-
18N/01E-29E01	4701121224243	112	330	0	NP	85	NP	127	-	-
18N/01E-29N04	4700431224252	130	222	0	NP	87	NP	120	-	-
18N/01E-30C01	4701191224348	160	32	0	26	-	-	-	-	-
18N/01E-30D02	4701181224355	160	153	0	35	71	76	130	-	-
18N/01E-30N01	4700401224402	212	194	0	37	NP	NP	161	192	-
18N/01E-30N02	4700401224403	212	191	0	51	NP	NP	163	191	-
18N/01E-30P01	4700471224347	212	287	0	41	NP	NP	185	223	-
18N/01E-31A01	4700371224307	83	92	0	NP	60	NP	80	-	-
18N/01E-31F01	4700181224349	222	220	0	NP	80	NP	184	-	-
18N/01E-31F02	4700191224354	216	215	0	NP	85	NP	179	-	-
18N/01E-31H01	4700141224302	108	101	0	NP	75	NP	98	-	-
18N/01E-31H02	4700161224311	111	119	0	NP	78	NP	109	-	-
18N/01E-31H03	4700231224307	160	193	0	NP	148	NP	165	-	-
18N/01E-31M01	4700001224412	215	194	0	10	NP	NP	164	191	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
18N/01E-31M02	4700001224413	215	192	0	15	NP	157	164	192	-
18N/01E-31N01	4659501224402	212	139	0	10	109	-	-	-	-
18N/01E-31Q01D1	4659571224318	156	373	0	NP	<111	NP	111	195	-
18N/01E-31R01	4659571224305	82	91	0	NP	<73	NP	73	-	-
18N/01E-31R02	4659571224301	78	85	0	NP	53	NP	84	-	-
18N/01E-32C02	4700331224237	140	128	0	NP	114	NP	123	-	-
18N/01E-32D04D1	4700281224244	80	76	0	NP	<62	NP	62	-	-
18N/01E-32D05	4700261224248	100	98	0	NP	76	NP	91	-	-
18N/01E-32D09	4700271224249	73	93	0	NP	57	NP	83	-	-
18N/01E-32E02	4700201224245	100	83	0	NP	55	NP	78	-	-
18N/01E-32E03	4700151224247	97	98	0	NP	49	NP	76	-	-
18N/01E-32E04	4700121224243	80	67	0	NP	26	NP	47	-	-
18N/01E-32H02	4700171224155	253	219	0	51	158	166	205	-	-
18N/01E-32M01	4700001224254	121	112	0	NP	80	NP	90	112	-
18N/01E-32N01	4659471224250	115	92	0	NP	60	NP	83	-	-
18N/01E-32N02	4659531224250	76	81	0	NP	<68	NP	68	-	-
18N/01E-32N03	4659501224240	162	158	0	NP	55	118	129	-	-
18N/01E-32P02	4659581224237	75	81	0	NP	<42	NP	42	-	-
18N/01E-34F03	4700101224004	260	260	0	NP	32	NP	40	-	-
18N/01E-34F04	4700111224004	260	280	0	NP	58	NP	65	-	-
18N/01E-34J01	4700031223926	264	231	0	NP	40	NP	57	-	-
18N/01E-34K01	4659581223931	273	239	0	NP	60	NP	88	-	-
18N/01E-34R01	4659501223924	280	212	0	NP	<86	NP	86	-	-
18N/01E-34R02	4659521223927	280	222	0	NP	<71	NP	71	-	-
18N/01W-01H01	4704421224418	225	120	0	11	94	-	-	-	-
18N/01W-01H02	4704361224432	225	255	0	42	119	121	248	-	-
18N/01W-01R01	4704101224419	245	237	0	22	142	150	224	-	-
18N/01W-02G01	4704421224550	235	155	0	8	109	130	-	-	-
18N/01W-02G02	4704411224552	237	241	0	13	119	135	222	-	-
18N/01W-02H01	4704361224536	245	139	0	11	124	-	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
18N/01W-02H02	4704381224548	235	319	0	3	117	138	248	284	-
18N/01W-02L01	4704211224624	235	212	0	60	NP	133	203	212	-
18N/01W-02M02	4704231224632	240	218	0	101	129	148	209	-	-
18N/01W-02R01	4704141224547	220	256	0	94	131	213	231	256	-
18N/01W-03B01	4704591224720	234	223	NP	0	141	187	203	223	-
18N/01W-03B02	4704581224713	238	280	NP	0	?	?	200	220	-
18N/01W-03E01	4704411224801	95	67	0	20	60	65	-	-	-
18N/01W-03G01	4704391224707	195	151	0	5	105	151	-	-	-
18N/01W-03H02	4704371224653	205	233	0	<166	<166	166	186	-	-
18N/01W-04M01	4704291224918	70	77	0	<61	63	-	-	-	-
18N/01W-04M02	4704281224905	65	158	0	30	78	89	140	-	-
18N/01W-04N01	4704121224911	80	326	0	47	65	74	109	222	-
18N/01W-04P01	4704181224854	50	76	0	NP	NP	28	-	-	-
18N/01W-05E02	4704341225027	165	50	NP	0	48	-	-	-	-
18N/01W-05E03	4704401225030	165	46	NP	0	38	-	-	-	-
18N/01W-05G01	4704391224939	90	75	0	12	28	-	-	-	-
18N/01W-05G02	4704431224953	110	56	0	10	46	-	-	-	-
18N/01W-05L02	4704331225006	160	40	NP	0	39	-	-	-	-
18N/01W-05L03	4704231225006	165	40	NP	0	36	-	-	-	-
18N/01W-05L05	4704311224956	136	153	NP	0	53	76	149	-	-
18N/01W-06A03	4704491225047	160	118	0	1	58	81	113	-	-
18N/01W-06D01	4704521225146	145	72	0	18	44	72	-	-	-
18N/01W-06E02	4704361225148	165	79	0	49	-	-	-	-	-
18N/01W-06G02	4704351225055	160	50	0	-	-	-	-	-	-
18N/01W-06H03D1	4704351225052	160	159	0	48	72	90	<126	131	-
18N/01W-06P03	4704111225125	170	91	0	73	81	86	-	-	-
18N/01W-06Q04	4704121225109	160	65	0	-	-	-	-	-	-
18N/01W-06R03	4704101225036	165	72	NP	0	46	-	-	-	-
18N/01W-07A06	4703591225048	175	67	NP	0	36	-	-	-	-
18N/01W-07C01	4704001225129	175	63	0	28	-	-	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
18N/01W-07E02	4703461225137	180	64	0	-	-	-	-	-	-
18N/01W-07E04	4703541225146	175	83	0	62	-	-	-	-	-
18N/01W-07H04	4703421225037	195	141	NP	0	94	99	130	-	-
18N/01W-07K03	4703341225112	185	91	0	90	-	-	-	-	-
18N/01W-07L04	4703301225125	180	91	0	16	72	-	-	-	-
18N/01W-07M02	4703401225140	185	79	0	37	72	-	-	-	-
18N/01W-07N03	4703191225134	195	98	0	21	92	-	-	-	-
18N/01W-07P02	4703241225127	181	53	0	17	45	-	-	-	-
18N/01W-08C02	4704061224956	150	140	NP	0	21	66	-	-	-
18N/01W-08E01	4703431225027	190	77	NP	0	71	-	-	-	-
18N/01W-08G02	4703481224948	150	67	NP	0	60	-	-	-	-
18N/01W-08H03D1	4703531224925	124	570	0	26	NP	54	189	221	-
18N/01W-08L01	4703321225004	202	101	NP	0	65	82	-	-	-
18N/01W-08L03	4703321225005	202	100	NP	0	95	99	-	-	-
18N/01W-09D01	4704061224903	85	71	0	NP	NP	46	-	-	-
18N/01W-09G01	4703531224829	82	345	0	NP	NP	60	140	200	-
18N/01W-09J01	4703321224816	105	197	0	NP	65	118	183	195	-
18N/01W-09K04	4703371224838	92	90	0	NP	49	-	-	-	-
18N/01W-10F01	4703511224739	150	195	0	55	100	125	-	-	-
18N/01W-10R02	4703161224651	208	171	0	5	82	90	150	-	-
18N/01W-10R03	4703241224657	210	178	0	7	68	90	163	-	-
18N/01W-11A01	4703571224529	217	481	0	4	104	172	230	242	-
18N/01W-11P05	4703211224621	205	73	0	15	70	-	-	-	-
18N/01W-12D01	4703551224521	220	200	0	<140	<140	140	180	-	-
18N/01W-12F01	4703411224508	215	390	0	10	97	114	203	237	-
18N/01W-12J02	4703321224414	240	232	0	2	<108	116	218	232	-
18N/01W-12M01D1	4703321224522	218	240	?	?	?	?	193	-	-
18N/01W-12R02	4703201224421	237	244	0	23	<92	92	216	-	-
18N/01W-12R03	4703191224427	235	145	0	23	39	108	-	-	-
18N/01W-13A01	4703121224425	225	228	0	14	58	105	217	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
18N/01W-13A02	4703141224430	235	242	0	2	33	94	190	-	-
18N/01W-13B01	4703081224433	230	259	0	17	70	95	229	258	-
18N/01W-13G02	4702491224449	210	259	0	10	71	105	241	-	-
18N/01W-13G03	4702541224441	223	275	0	7	39	92	247	-	-
18N/01W-13J01D1	4702471224427	240	321	0	2	82	101	222	258	-
18N/01W-13J02	4702471224420	245	336	0	20	80	122	197	245	-
18N/01W-13J03	4702461224434	240	293	0	10	90	98	240	246	-
18N/01W-13J04	4702481224418	240	325	0	9	68	97	170	200	-
18N/01W-13N01	4702331224524	265	286	0	32	133	135	268	285	-
18N/01W-14D04	4703061224642	203	226	0	15	21	81	187	226	-
18N/01W-14H04	4702491224538	232	260	0	45	64	74	190	260	-
18N/01W-14L02	4702401224611	218	53	0	25	53	-	-	-	-
18N/01W-14R01	4702241224541	225	254	0	42	88	100	206	-	-
18N/01W-15B04	4703041224718	180	149	0	16	56	69	130	-	-
18N/01W-15H01	4703001224701	175	186	0	3	40	49	156	177	-
18N/01W-16Q03	4702331224831	160	137	0	37	50	116	-	-	-
18N/01W-17C01	4703031225015	199	187	0	22	95	114	175	-	-
18N/01W-17C02	4703031225013	199	191	0	24	77	90	175	-	-
18N/01W-17G02	4702531224956	200	62	0	9	-	-	-	-	-
18N/01W-17H05	4702591224928	202	101	0	23	57	-	-	-	-
18N/01W-19A01	4702111225042	195	92	0	21	39	-	-	-	-
18N/01W-19C02	4702151225127	145	42	0	NP	12	-	-	-	-
18N/01W-19D05	4702161225139	162	83	0	NP	40	74	-	-	-
18N/01W-19F02	4702031225114	182	42	0	34	35	-	-	-	-
18N/01W-19G02	4701581225058	202	60	0	25	56	-	-	-	-
18N/01W-19H02	4702071225054	198	82	?	?	<64	-	-	-	-
18N/01W-19L03	4701511225119	185	78	0	40	72	-	-	-	-
18N/01W-19M05	4701521225131	210	70	0	28	63	-	-	-	-
18N/01W-21B04	4702201224822	175	130	0	60	66	120	-	-	-
18N/01W-21B05	4702141224826	182	107	0	58	75	-	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
18N/01W-21B06	4702151224827	178	488	0	<58	58	NP	136	204	-
18N/01W-21D03	4702101224912	194	153	0	33	44	129	139	-	-
18N/01W-21P01	4701341224858	228	119	0	22	48	-	-	-	-
18N/01W-21P02D1	4701351224858	235	403	0	<31	<145	145	173	270	-
18N/01W-22K01	4701451224715	199	56	0	-	-	-	-	-	-
18N/01W-23B02	4702091224550	167	32	0	-	-	-	-	-	-
18N/01W-23Q01	4701401224550	181	161	0	21	75	95	148	-	-
18N/01W-24A02	4702161224425	213	797	0	8	77	106	203	206	-
18N/01W-24A03	4702161224425	214	103	0	23	86	-	-	-	-
18N/01W-24B02	4702101224438	242	103	0	27	76	-	-	-	-
18N/01W-24D02	4702191224520	226	96	0	?	?	-	-	-	-
18N/01W-25B01	4701221224452	260	245	NP	0	111	161	216	-	-
18N/01W-25P02	4700501224501	181	59	0	30	43	-	-	-	-
18N/01W-26A02	4701211224539	230	118	0	38	50	-	-	-	-
18N/01W-26C02	4701221224616	189	65	0	NP	28	-	-	-	-
18N/01W-26G01	4701141224552	187	73	0	NP	59	-	-	-	-
18N/01W-26N01	4700391224628	182	85	0	42	73	-	-	-	-
18N/01W-26N02	4700391224629	185	500	0	?	?	94	100	?	-
18N/01W-27A03	4701201224701	166	78	0	25	71	-	-	-	-
18N/01W-27K01	4700551224706	205	84	0	40	57	-	-	-	-
18N/01W-27M02	4700581224749	190	388	0	21	41	98	141	174	-
18N/01W-28E01	4701051224915	232	217	NP	0	35	162	188	217	-
18N/01W-28J01	4700531224806	185	127	0	10	20	<120	120	-	-
18N/01W-28M01	4701041224914	232	238	NP	0	29	162	191	227	-
18N/01W-28P01	4700511224850	235	121	0	8	65	-	-	-	-
18N/01W-29E01	4701121225033	212	100	0	26	100	-	-	-	-
18N/01W-29Q02	4700421224932	238	137	0	13	84	134	-	-	-
18N/01W-30A01	4701191225045	278	378	NP	0	106	191	201	228	368
18N/01W-30E04	4701161225136	202	75	0	9	62	-	-	-	-
18N/01W-30L02	4701041225127	235	61	0	24	49	-	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
18N/01W-30M02	4700571225135	228	105	0	30	91	-	-	-	-
18N/01W-31A02	4700311225048	210	140	0	16	67	-	-	-	-
18N/01W-31A03	4700381225041	209	139	?	<62	72	-	-	-	-
18N/01W-31G01	4700141225056	205	84	0	17	71	-	-	-	-
18N/01W-31G02	4700151225057	204	102	0	11	76	102	-	-	-
18N/01W-31G03	4700131225058	205	80	0	8	64	-	-	-	-
18N/01W-31K03	4700001225103	185	64	0	9	56	-	-	-	-
18N/01W-31R02	4659561225043	200	154	0	19	43	65	126	-	-
18N/01W-32D02	4700341225028	203	91	0	20	77	-	-	-	-
18N/01W-32L01	4700021225014	215	79	0	39	75	-	-	-	-
18N/01W-32N02	4659581225031	212	98	0	22	<90	-	-	-	-
18N/01W-32P01	4659541225006	202	56	0	56	-	-	-	-	-
18N/01W-32P02	4659511225009	200	390	0	41	58	112	151	204	-
18N/01W-32P03	4659501225010	200	91	0	45	78	-	-	-	-
18N/01W-32P04	4659511225006	200	50	0	48	-	-	-	-	-
18N/01W-32P05	4659531225007	200	170	?	?	?	<119	128	-	-
18N/01W-33B01	4700381224823	212	118	0	60	99	-	-	-	-
18N/01W-33C01	4700361224851	208	73	0	23	48	-	-	-	-
18N/01W-33F01	4700251224854	208	62	0	34	45	-	-	-	-
18N/01W-33G02	4700231224833	212	102	0	75	85	-	-	-	-
18N/01W-33J02	4700041224811	201	61	0	60	-	-	-	-	-
18N/01W-33N01	4659531224905	197	440	0	50	65	122	168	203	-
18N/01W-33P01	4659511224852	198	216	0	53	72	124	169	211	-
18N/01W-34G01	4700221224706	175	59	0	-	-	-	-	-	-
18N/01W-34J01	4700041224651	172	55	0	12	49	-	-	-	-
18N/01W-34J02	4700101224650	200	510	0	50	73	74	NP	120	-
18N/01W-34M03	4700121224751	202	80	0	32	44	-	-	-	-
18N/01W-34Q01	4659541224719	194	110	0	68	79	-	-	-	-
18N/01W-35A04	4700351224533	161	32	0	8	15	-	-	-	-
18N/01W-35B02	4700301224606	176	84	0	26	44	-	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
18N/01W-35G02	4700141224549	181	139	0	2	63	64	119	-	-
18N/01W-35L02	4700111224619	193	56	0	5	37	-	-	-	-
18N/01W-35N01	4659521224630	185	76	0	4	20	-	-	-	-
18N/01W-36C01	4700261224503	195	230	0	3	56	<164	<164	164	-
18N/01W-36C02	4700271224503	195	336	0	20	76	115	147	175	-
18N/01W-36H02	4700201224418	221	188	0	28	94	96	168	-	-
18N/01W-36J01	4700061224420	228	263	0	36	NP	<172	172	228	-
18N/01W-36L01	4700031224503	222	164	0	46	126	134	155	-	-
18N/01W-36M02	4700031224523	225	160	0	75	86	148	154	-	-
18N/01W-36N01	4659531224513	218	217	0	NP	79	100	150	180	-
18N/02W-01E06	4704451225251	120	39	0	8	33	38	-	-	-
18N/02W-01F04	4704451225240	150	97	0	4	46	65	-	-	-
18N/02W-01G02	4704351225220	168	121	0	18	71	97	-	-	-
18N/02W-01G03	4704351225218	168	178	0	25	69	91	178	-	-
18N/02W-01Q03	4704131225219	178	74	0	22	69	-	-	-	-
18N/02W-01R05	4704101225152	165	164	0	58	92	116	157	-	-
18N/02W-02A03	4704471225324	110	48	0	7	-	-	-	-	-
18N/02W-02A04	4704481225320	115	115	0	31	72	105	109	-	-
18N/02W-02A05	4704531225324	119	133	0	50	68	99	125	-	-
18N/02W-02B05	4704551225339	130	74	0	11	69	-	-	-	-
18N/02W-02C07	4704481225401	55	43	NP	0	31	43	-	-	-
18N/02W-02C08	4704571225353	102	128	NP	0	NP	70	104	-	-
18N/02W-02C09	4704581225358	35	60	NP	0	NP	21	37	59	-
18N/02W-02F04	4704391225351	105	84	NP	0	73	-	-	-	-
18N/02W-02H04	4704451225321	110	81	NP	0	64	74	-	-	-
18N/02W-03N06	4704161225521	159	159	NP	0	59	60	156	-	-
18N/02W-04D01	4704481225633	145	69	NP	0	50	-	-	-	-
18N/02W-04F03	4704361225620	98	420	NP	0	NP	18	NP	<410	-
18N/02W-04G03	4704371225559	156	113	NP	0	69	80	-	-	-
18N/02W-04J08	4704341225553	170	125	0	12	NP	40	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
18N/02W-05B03	4704571225730	150	59	0	10	56	-	-	-	-
18N/02W-05C03	4704581225733	145	57	NP	0	35	-	-	-	-
18N/02W-05D02	4704501225805	160	110	NP	0	NP	73	-	-	-
18N/02W-05D03	4704471225755	180	106	NP	0	73	-	-	-	-
18N/02W-05D04	4704581225757	168	100	NP	0	78	-	-	-	-
18N/02W-05H01	4704361225700	140	60	0	17	38	-	-	-	-
18N/02W-06N01	4704131225916	150	169	0	12	78	114	159	-	-
18N/02W-07D01	4704051225916	160	99	0	22	95	-	-	-	-
18N/02W-07E01	4703471225918	163	101	0	34	73	-	-	-	-
18N/02W-07J03	4703391225826	195	149	NP	0	122	-	-	-	-
18N/02W-07L02	4703361225854	145	73	0	12	61	-	-	-	-
18N/02W-07N02	4703281225909	40	39	0	4	34	-	-	-	-
18N/02W-07N03	4703271225915	40	40	0	5	36	-	-	-	-
18N/02W-07R01	4703211225826	155	125	0	35	86	-	-	-	-
18N/02W-08E03	4703481225800	172	64	NP	0	61	-	-	-	-
18N/02W-08N03	4703271225808	160	128	0	19	77	120	-	-	-
18N/02W-09D01	4704071225638	178	67	0	20	57	-	-	-	-
18N/02W-09G01	4703541225609	248	191	NP	0	171	-	-	-	-
18N/02W-12A03	4704081225149	165	84	0	60	77	-	-	-	-
18N/02W-12E01	4703491225253	160	70	0	39	63	-	-	-	-
18N/02W-12G04	4703501225208	173	164	0	26	69	73	146	163	-
18N/02W-12H01	4703541225155	171	138	0	64	73	84	133	-	-
18N/02W-12J01	4703401225153	165	28	0	-	-	-	-	-	-
18N/02W-12K04	4703341225211	165	145	0	21	60	63	137	-	-
18N/02W-12Q03	4703191225226	165	44	0	16	34	-	-	-	-
18N/02W-12R01	4703191225200	158	139	0	36	48	55	133	-	-
18N/02W-16A01	4703151225539	193	140	0	5	123	-	-	-	-
18N/02W-17B02	4703041225729	165	118	0	16	83	118	-	-	-
18N/02W-17B03	4703041225731	166	123	0	25	83	-	-	-	-
18N/02W-17D05	4703141225800	175	125	0	4	-	-	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
18N/02W-17H02	4702531225710	185	120	NP	0	104	-	-	-	-
18N/02W-17H03	4702541225710	183	116	NP	0	98	109	-	-	-
18N/02W-17M02	4702451225808	150	131	NP	0	108	-	-	-	-
18N/02W-17M04	4702451225810	155	160	NP	0	105	-	-	-	-
18N/02W-17Q04	4702341225732	175	153	0	2	80	109	153	-	-
18N/02W-18A02	4703061225812	184	140	NP	0	132	-	-	-	-
18N/02W-18G04	4702591225841	160	100	0	5	82	90	-	-	-
18N/02W-18K02	4702401225848	120	160	NP	NP	0	NP	<160	-	-
18N/02W-18K03	4702411225841	145	200	NP	NP	0	NP	146	-	-
18N/02W-18L01	4702381225903	10	240	NP	NP	0	NP	26	76	-
18N/02W-18L02	4702411225847	130	200	NP	NP	0	NP	<200	-	-
18N/02W-20C01	4702171225735	170	85	NP	0	60	69	NP	NP	85
18N/02W-21Q01	4701431225615	135	77	0	NP	43	-	-	-	-
18N/02W-22D01	4702171225527	210	149	0	3	108	149	-	-	-
18N/02W-22E01	4702101225531	210	200	0	2	80	132	-	-	-
18N/02W-24B01	4702091225217	100	51	0	16	45	-	-	-	-
18N/02W-25A03	4701201225200	188	73	0	10	65	-	-	-	-
18N/02W-28J01	4700591225542	198	184	NP	0	NP	NP	NP	NP	27
18N/02W-28J02	4701021225552	135	84	0	NP	<77	NP	NP	NP	83
18N/02W-29N01	4700491225806	199	100	0	NP	NP	30	NP	NP	90
18N/02W-30Q02	4700421225836	175	163	0	NP	NP	NP	NP	45	115
18N/02W-31G01	4700241225837	150	80	0	12	NP	68	NP	NP	80
18N/02W-31J03	4700051225815	135	69	0	2	60	67	-	-	-
18N/02W-31L01	4700041225849	164	68	0	2	61	-	-	-	-
18N/02W-31P02	4659541225853	167	105	0	2	54	57	92	104	-
18N/02W-31P03	4659531225857	160	380	0	2	54	62	96	105	360
18N/02W-31R02	4659511225815	150	28	0	5	27	-	-	-	-
18N/02W-32A06	4700361225655	181	80	0	15	49	-	-	-	-
18N/02W-32B02	4700281225715	175	39	0	2	32	37	-	-	-
18N/02W-32D02	4700371225752	138	140	0	NP	NP	15	NP	40	77

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
18N/02W-32D03	4700381225808	180	173	0	NP	NP	45	NP	120	-
18N/02W-32K01	4700091225720	177	68	0	26	60	-	-	-	-
18N/02W-32K02	4700101225725	177	61	0	10	51	-	-	-	-
18N/02W-33A03	4700391225543	155	50	0	NP	<50	NP	NP	NP	50
18N/02W-33C01	4700391225635	270	304	NP	0	NP	NP	NP	NP	32
18N/02W-33M01	4700021225642	181	120	0	30	NP	NP	NP	NP	34
18N/02W-33R02	4659581225553	163	60	0	-	-	-	-	-	-
18N/02W-34B01	4700351225456	170	37	0	-	-	-	-	-	-
18N/02W-34C02	4700301225508	170	61	0	-	-	-	-	-	-
18N/02W-35B02	4700331225344	185	264	0	NP	<110	110	225	256	260
18N/02W-35B04	4700361225345	170	251	0	NP	74	130	190	224	241
18N/02W-35B05	4700361225341	185	303	0	NP	<129	129	213	293	303
18N/02W-35F06	4700251225353	100	136	0	NP	<99	99	126	NP	134
18N/02W-35F08	4700191225402	95	155	0	NP	<147	147	-	-	-
18N/02W-35F11	4700181225359	100	157	0	NP	<150	150	-	-	-
18N/02W-35F12	4700151225400	95	143	0	NP	<132	132	-	-	-
18N/02W-35K01	4700021225342	105	323	0	NP	<92	92	93	153	-
18N/02W-35K02	4700041225343	105	347	0	NP	<93	93	106	151	-
18N/02W-35K03	4700061225335	110	393	0	NP	<104	104	136	198	-
18N/02W-35M02	4700071225409	110	92	0	NP	<92	-	-	-	-
18N/02W-35M03	4700051225411	110	96	0	NP	<96	-	-	-	-
18N/02W-35M04	4700061225409	110	90	0	NP	59	-	-	-	-
18N/02W-35M05	4700071225411	110	115	0	NP	<114	114	-	-	-
18N/02W-35M06	4700041225412	110	122	0	NP	<120	120	-	-	-
18N/02W-35M08	4700061225414	110	93	0	NP	<93	-	-	-	-
18N/02W-36D01	4700261225248	183	534	0	NP	<129	129	<283	283	-
18N/02W-36L01	4700071225245	185	124	0	NP	<124	-	-	-	-
18N/03W-01D02	4704541230027	10	65	NP	0	NP	<65	65	-	-
18N/03W-01D04	4704551230027	65	136	NP	0	NP	14	62	-	-
18N/03W-01J02	4704311225939	70	76	0	3	NP	28	61	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
18N/03W-01K04	4704261225954	20	72	NP	0	NP	39	70	-	-
18N/03W-01L01	4704251230008	50	53	0	3	NP	12	31	NP	53
18N/03W-02A02D1	4704501230046	130	181	NP	0	72	79	?	?	?
18N/03W-02B05	4704481230058	165	118	NP	0	105	117	-	-	-
18N/03W-02C02	4704571230130	180	180	NP	0	NP	NP	NP	NP	43
18N/03W-02H02	4704361230050	6	71	NP	0	NP	23	50	-	-
18N/03W-02H05	4704451230053	135	178	NP	0	79	82	172	-	-
18N/03W-03J02	4704321230210	180	24	NP	0	23	-	-	-	-
18N/03W-04R02	4704171230319	180	60	NP	0	23	24	40	46	51
18N/03W-04R03	4704181230320	180	65	NP	0	10	21	58	60	65
18N/03W-07L02	4703321230612	490	420	NP	NP	NP	NP	NP	0	15
18N/03W-08C01	4703591230513	525	460	NP	NP	NP	NP	NP	NP	0
18N/03W-11C01	4704021230121	150	138	NP	0	NP	NP	NP	NP	25
18N/03W-11D01	4704021230133	440	60	NP	NP	NP	NP	NP	NP	0
18N/03W-11P02	4703181230126	230	40	NP	0	NP	NP	NP	<40	-
18N/03W-11Q01	4703161230106	250	72	0	10	NP	NP	NP	21	-
18N/03W-12D01	4703591230023	50	106	NP	NP	NP	0	22	70	-
18N/03W-12G01	4703441225952	80	56	NP	0	49	-	-	-	-
18N/03W-12H01	4703451225930	160	207	0	3	100	120	154	176	-
18N/03W-12H02	4703541225942	170	121	NP	0	104	119	-	-	-
18N/03W-12H03	4703481225928	165	120	0	3	67	114	-	-	-
18N/03W-12K01	4703401225944	80	78	0	5	33	51	-	-	-
18N/03W-12L01	4703391230006	30	49	NP	0	NP	NP	20	-	-
18N/03W-13G06	4702521225948	20	69	NP	NP	NP	0	63	-	-
18N/03W-13H02	4702561225928	20	300	NP	NP	NP	0	NP	NP	32
18N/03W-13K03	4702441230001	75	79	0	8	NP	20	59	-	-
18N/03W-14J01	4702461230054	195	46	0	6	34	37	NP	NP	41
18N/03W-16E01	4702521230417	540	415	NP	NP	NP	NP	NP	NP	0
18N/03W-16N01	4702331230416	510	300	NP	NP	NP	NP	NP	0	61
18N/03W-16P02	4702241230355	460	80	NP	NP	NP	NP	NP	0	67

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
18N/03W-16Q01	4702241230348	425	47	NP	NP	NP	NP	NP	0	28
18N/03W-17R01	4702281230430	490	88	NP	NP	NP	NP	NP	0	-
18N/03W-18A01	4703031230544	670	400	NP	NP	NP	NP	NP	NP	0
18N/03W-18E01	4702541230650	490	215	NP	NP	NP	NP	NP	0	18
18N/03W-19C01	4702151230620	670	115	NP	NP	NP	NP	NP	0	105
18N/03W-19E01	4702031230650	490	30	NP	NP	NP	NP	NP	0	-
18N/03W-19F01	4702021230627	525	103	NP	NP	NP	NP	NP	0	-
18N/03W-22A01	4702101230211	410	290	0	17	NP	NP	NP	NP	85
18N/03W-22J01	4701521230206	320	47	0	28	40	-	-	-	-
18N/03W-23A01	4702101230052	210	54	0	<30	-	-	-	-	-
18N/03W-23A02	4702101230052	210	53	0	<10	NP	NP	NP	NP	53
18N/03W-23B02	4702151230114	230	40	NP	0	-	-	-	-	-
18N/03W-23F01	4702071230123	295	160	NP	0	NP	NP	NP	33	56
18N/03W-23G01	4702071230118	260	65	NP	0	NP	36	59	-	-
18N/03W-23H04	4701571230043	170	48	NP	0	41	-	-	-	-
18N/03W-23H05	4701571230043	170	48	NP	0	33	47	-	-	-
18N/03W-23J01	4701451230043	200	55	NP	0	-	-	-	-	-
18N/03W-23K02	4701471230105	225	59	0	4	54	-	-	-	-
18N/03W-23N01	4701401230146	330	41	0	5	39	-	-	-	-
18N/03W-23N02	4701351230153	355	63	NP	0	59	-	-	-	-
18N/03W-23P01	4701331230133	310	59	0	4	37	-	-	-	-
18N/03W-23Q01	4701401230121	245	88	0	6	60	70	82	-	-
18N/03W-24H01	4702061225931	20	207	NP	0	NP	18	46	52	-
18N/03W-24H02	4702021225943	35	44	NP	0	16	27	38	-	-
18N/03W-24J02	4701491225926	20	105	NP	0	NP	6	NP	<105	105
18N/03W-24J03	4701561225942	35	29	0	NP	NP	14	25	-	-
18N/03W-24M01D1	4701451230039	197	-	NP	0	56	>61	?	?	?
18N/03W-24P01	4701351230021	180	142	0	4	38	54	133	NP	136
18N/03W-24R06	4701431225936	30	143	NP	0	NP	19	NP	<118	-
18N/03W-25A02	4701301225932	30	65	NP	0	NP	4	50	NP	52

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
18N/03W-25J01	4700551225942	120	92	NP	0	NP	69	87	-	-
18N/03W-25P01	4700401230007	65	102	0	8	NP	30	88	-	-
18N/03W-25R04	4700401225936	125	130	NP	0	58	81	NP	NP	102
18N/03W-36B01	4700351230002	65	79	0	12	NP	<78	78	-	-
19N/01E-30M01	4706151224404	55	73	NP	0	NP	NP	34	51	-
19N/01E-30P06	4705571224344	155	186	0	13	45	55	150	-	-
19N/01E-30P07	4705551224343	150	60	0	9	48	-	-	-	-
19N/01E-30Q01	4705591224335	62	107	NP	NP	NP	0	29	50	-
19N/01E-30Q02	4706001224335	80	104	NP	NP	NP	0	56	84	-
19N/01E-31C04	4705491224346	190	38	0	-	-	-	-	-	-
19N/01W-03N01	4709311224753	30	98	NP	NP	NP	0	37	40	-
19N/01W-04D03	4710001224909	120	134	NP	0	50	57	66	-	-
19N/01W-04J02	4709401224804	55	66	NP	NP	0	8	47	-	-
19N/01W-04P01	4709221224856	165	215	NP	0	42	67	124	214	-
19N/01W-05H01	4709531224929	60	99	NP	0	NP	35	90	-	-
19N/01W-05R04	4709231224929	40	139	NP	0	NP	97	NP	110	-
19N/01W-05R05	4709311224930	10	204	NP	0	NP	62	NP	<176	-
19N/01W-05R06	4709291224930	20	196	NP	0	NP	72	NP	<185	-
19N/01W-06J06	4709401225048	22	37	NP	0	NP	<34	34	-	-
19N/01W-06J07	4709431225042	45	80	NP	0	NP	40	-	-	-
19N/01W-06K05	4709441225107	80	70	NP	0	NP	14	-	-	-
19N/01W-06L01	4709411225120	61	190	NP	0	NP	18	NP	<185	-
19N/01W-07A01	4709101225039	85	82	NP	0	NP	17	55	-	-
19N/01W-07N02	4708301225132	125	138	0	5	NP	35	136	-	-
19N/01W-08K01	4708451224932	80	89	NP	0	NP	25	80	-	-
19N/01W-08R01	4708351224934	50	79	NP	0	NP	NP	58	-	-
19N/01W-09L01	4708551224858	230	147	NP	0	140	147	-	-	-
19N/01W-09L02	4708461224852	190	90	NP	0	78	-	-	-	-
19N/01W-09R03	4708341224814	157	66	NP	0	58	-	-	-	-
19N/01W-09R04	4708301224804	162	56	NP	0	52	-	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
19N/01W-10F04	4709051224735	62	75	NP	0	NP	NP	34	-	-
19N/01W-10L04	4708421224735	70	83	NP	NP	NP	0	74	-	-
19N/01W-10N01	4708291224747	161	73	NP	0	60	-	-	-	-
19N/01W-10N02	4708401224752	148	56	NP	0	50	-	-	-	-
19N/01W-10P01	4708391224737	85	88	NP	0	NP	9	82	-	-
19N/01W-10Q02	4708291224717	70	121	NP	NP	NP	0	85	-	-
19N/01W-15C01	4708261224736	110	56	NP	0	54	56	-	-	-
19N/01W-15C02	4708211224739	145	100	NP	0	68	70	94	-	-
19N/01W-15C03	4708191224732	144	80	NP	0	77	-	-	-	-
19N/01W-15E01	4708031224746	165	69	NP	0	62	-	-	-	-
19N/01W-15K03	4707491224715	80	150	NP	NP	0	11	NP	110	-
19N/01W-15L01	4707501224730	137	192	NP	0	26	70	NP	<190	-
19N/01W-16K01	4707591224828	160	90	NP	0	67	-	-	-	-
19N/01W-16K02	4707581224832	155	71	NP	0	52	-	-	-	-
19N/01W-16L01	4707591224849	165	80	NP	0	57	-	-	-	-
19N/01W-16N02	4707421224913	121	78	NP	0	42	-	-	-	-
19N/01W-16R01	4707441224807	158	152	NP	0	60	85	93	150	-
19N/01W-17A05	4708241224935	40	176	NP	0	NP	NP	56	59	-
19N/01W-17J02	4707571224932	43	95	NP	0	NP	14	30	66	-
19N/01W-17M01	4708011225030	10	1,000	NP	NP	NP	NP	0	45	-
19N/01W-17N02	4707461225033	70	102	NP	0	NP	8	81	-	-
19N/01W-18E01	4708131225147	101	47	0	13	NP	25	-	-	-
19N/01W-18F01	4708111225128	90	64	NP	0	NP	23	-	-	-
19N/01W-18M02	4707581225148	85	49	0	9	NP	21	-	-	-
19N/01W-18P01	4707481225114	70	110	NP	0	NP	46	98	-	-
19N/01W-19L02	4707081225123	70	105	NP	0	NP	37	-	-	-
19N/01W-19P03	4706511225113	120	108	NP	0	NP	25	95	-	-
19N/01W-20G01	4707131224940	125	159	NP	0	21	57	121	-	-
19N/01W-20G04	4707181224940	110	124	NP	0	NP	29	106	124	-
19N/01W-20H01	4707131224924	150	178	NP	0	NP	68	151	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
19N/01W-20L01	4707101225006	15	377	NP	0	NP	?	NP	?	-
19N/01W-20Q01	4706451224958	95	116	NP	0	NP	40	105	-	-
19N/01W-21C03	4707251224857	162	67	NP	0	52	67	-	-	-
19N/01W-21K01	4707081224825	130	128	NP	0	55	81	-	-	-
19N/01W-21L02	4707081224855	115	80	NP	0	71	-	-	-	-
19N/01W-21M01	4707041224859	90	118	NP	0	77	83	108	-	-
19N/01W-21M02	4707051224917	90	124	NP	0	66	68	115	-	-
19N/01W-22A01	4707331224652	65	160	NP	NP	NP	0	NP	118	-
19N/01W-22G01	4707161224710	120	132	NP	0	NP	58	120	-	-
19N/01W-23D02	4707311224647	104	138	NP	0	NP	19	NP	136	-
19N/01W-23D03	4707251224641	60	119	NP	NP	NP	0	NP	115	-
19N/01W-23G02	4707111224554	84	109	NP	NP	NP	0	94	109	-
19N/01W-23LO1	4707091224623	100	347	NP	0	NP	12	NP	95	-
19N/01W-23N01	4706491224644	181	111	0	20	86	111	-	-	-
19N/01W-27A01	4706411224655	200	118	0	22	88	118	-	-	-
19N/01W-27N01	4706021224753	225	259	0	3	109	143	215	236	-
19N/01W-27N02	4706021224753	225	148	0	3	88	148	-	-	-
19N/01W-28A02	4706341224809	90	117	NP	0	38	78	110	-	-
19N/01W-28C02	4706351224848	170	146	NP	0	NP	92	135	-	-
19N/01W-28D04D1	4706431224900	150	250	NP	0	NP	33	NP	94	-
19N/01W-28F02	4706241224857	120	100	NP	0	NP	73	75	-	-
19N/01W-28F04	4706291224856	140	110	NP	0	NP	40	105	-	-
19N/01W-28L02	4706161224853	82	78	NP	0	NP	NP	22	-	-
19N/01W-28M01	4706071224900	60	84	NP	0	NP	NP	39	-	-
19N/01W-28M02	4706141224915	30	393	NP	0	NP	10	20	90	-
19N/01W-29C02	4706331224959	145	152	NP	0	69	73	143	-	-
19N/01W-29N01	4705531225033	135	120	0	12	67	74	112	-	-
19N/01W-30H03	4706291225038	120	89	0	54	74	-	-	-	-
19N/01W-30J02	4706071225036	115	74	0	38	70	-	-	-	-
19N/01W-30P04	4705561225128	115	122	NP	0	38	42	NP	<112	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
19N/01W-30R02	4706051225038	115	67	0	10	64	-	-	-	-
19N/01W-31B03	4705521225109	126	80	0	2	NP	73	-	-	-
19N/01W-31F01	4705371225114	140	130	0	32	NP	58	NP	115	-
19N/01W-31K04	4705201225109	155	78	0	9	-	-	-	-	-
19N/01W-31Q01	4705021225112	145	46	0	5	38	-	-	-	-
19N/01W-31R01	4705081225042	165	164	NP	0	58	70	NP	148	-
19N/01W-32B01	4705441224946	50	211	NP	0	NP	26	NP	<170	-
19N/01W-32C04	4705501225007	145	94	0	10	60	94	-	-	-
19N/01W-32D03	4705461225034	157	70	0	31	52	-	-	-	-
19N/01W-32K03	4705231224937	90	38	0	20	28	-	-	-	-
19N/01W-32K04	4705181224953	128	62	0	12	51	-	-	-	-
19N/01W-32N03	4705021225030	157	80	NP	0	52	-	-	-	-
19N/01W-32P03	4705071225015	142	75	0	7	58	-	-	-	-
19N/01W-32Q03	4705061224942	100	64	0	6	56	-	-	-	-
19N/01W-32R01	4705041224933	80	86	0	12	NP	86	-	-	-
19N/01W-33K04	4705221224823	160	164	0	4	55	110	148	164	-
19N/01W-33K05	4705141224829	150	129	NP	0	49	121	-	-	-
19N/01W-34B01	4705411224704	298	174	NP	0	152	-	-	-	-
19N/01W-34M02	4705131224753	151	111	0	2	63	-	-	-	-
19N/01W-34N03	4705031224747	151	112	0	15	97	112	-	-	-
19N/01W-34P01	4705021224744	170	148	NP	0	142	-	-	-	-
19N/01W-35G01	4705301224558	250	600	0	19	115	162	246	343	-
19N/01W-35M01	4705261224644	290	667	0	3	?	202	300	355	-
19N/02W-03E02	4709511225529	90	90	NP	0	26	55	78	83	-
19N/02W-04F03	4709581225631	115	156	NP	0	36	42	NP	94	-
19N/02W-04F05	4709581225632	125	156	NP	0	NP	49	NP	100	-
19N/02W-05J01	4709411225705	85	110	NP	0	NP	21	82	-	-
19N/02W-07P01	4708311225858	90	103	NP	0	44	55	98	-	-
19N/02W-07P02	4708341225854	80	99	NP	0	44	51	96	-	-
19N/02W-07R01	4708391225822	40	206	NP	NP	0	16	NP	<105	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
19N/02W-08A01	4709171225703	105	59	NP	0	54	-	-	-	-
19N/02W-08B01	4709091225731	50	130	NP	NP	NP	0	NP	8	-
19N/02W-08C02	4709171225733	60	160	NP	NP	NP	0	NP	28	-
19N/02W-08F02	4709031225742	40	172	NP	NP	NP	0	NP	35	-
19N/02W-08F03	4708591225743	60	156	NP	NP	NP	0	NP	34	-
19N/02W-08G01	4708571225723	100	144	NP	0	NP	39	NP	65	-
19N/02W-08G02	4709051225715	120	147	NP	0	18	47	NP	81	-
19N/02W-08H01	4708571225701	110	79	NP	0	NP	<65	65	-	-
19N/02W-08K01	4708551225721	100	130	NP	0	NP	<45	80	<130	-
19N/02W-08N03	4708401225801	40	221	NP	0	NP	<30	NP	30	-
19N/02W-08P01	4708311225744	125	87	NP	0	NP	<86	86	-	-
19N/02W-08Q01	4708421225726	90	140	NP	0	NP	<50	NP	54	-
19N/02W-09F02	4709021225628	100	139	NP	0	31	67	NP	94	-
19N/02W-09F03	4709071225618	70	79	NP	0	NP	12	NP	34	-
19N/02W-09G01	4709081225602	75	120	NP	0	17	51	NP	57	-
19N/02W-09H01	4709051225551	70	103	NP	0	NP	42	NP	64	-
19N/02W-09L06	4708461225626	30	43	NP	NP	NP	0	18	-	-
19N/02W-09N02	4708401225636	30	115	NP	NP	NP	0	37	54	-
19N/02W-09N03	4708381225647	80	105	NP	0	19	31	60	-	-
19N/02W-09R01	4708341225539	10	360	NP	0	NP	<30	30	65	-
19N/02W-11P02	4708361225349	60	351	NP	0	NP	21	NP	107	-
19N/02W-12L02	4708541225232	98	148	NP	0	NP	28	130	-	-
19N/02W-13N03	4707491225259	140	107	NP	0	75	-	-	-	-
19N/02W-14H03	4708101225317	130	40	NP	0	-	-	-	-	-
19N/02W-14H04	4708121225316	125	430	NP	0	48	98	NP	148	-
19N/02W-14J01	4707541225316	146	116	NP	0	78	96	-	-	-
19N/02W-14K01	4707531225344	110	68	NP	0	44	68	-	-	-
19N/02W-14P02	4707401225400	175	234	NP	0	<75	91	170	-	-
19N/02W-14Q03D1	4707381225326	140	130	NP	0	99	114	?	?	?
19N/02W-15N01	4707391225535	90	117	NP	0	NP	25	101	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
19N/02W-16J08	4707531225536	40	83	NP	NP	NP	0	59	83	-
19N/02W-16J09	4708011225539	85	114	NP	0	55	62	96	-	-
19N/02W-16K02D1	4708021225556	55	382	NP	0	NP	<88	88	93	-
19N/02W-16Q04D1	4707371225555	140	225	NP	0	NP	96	163	176	-
19N/02W-16Q05	4707381225558	140	151	NP	0	81	99	140	-	-
19N/02W-17C01	4708271225733	120	240	NP	0	38	55	NP	88	-
19N/02W-17D02	4708281225754	100	345	NP	0	35	85	NP	120	-
19N/02W-17F01	4708141225734	120	335	NP	0	21	45	NP	<335	-
19N/02W-17G01	4708111225725	105	210	NP	0	36	58	NP	115	-
19N/02W-18A02	4708191225818	120	220	NP	0	48	54	NP	89	-
19N/02W-18G01	4708081225832	120	207	NP	0	26	64	NP	86	-
19N/02W-18K02	4707541225843	130	166	NP	0	NP	52	NP	60	-
19N/02W-18K03	4708011225840	120	150	NP	0	NP	33	NP	63	-
19N/02W-18M01	4708011225920	80	71	NP	0	45	46	67	-	-
19N/02W-18N04	4707421225921	140	138	NP	0	25	40	118	-	-
19N/02W-19H01	4707201225823	100	113	NP	0	47	48	70	76	-
19N/02W-20D01	4707291225755	110	300	NP	0	48	60	85	90	-
19N/02W-20E02	4707111225756	120	233	NP	0	32	70	NP	84	-
19N/02W-21C02	4707331225627	60	89	NP	NP	NP	0	17	-	-
19N/02W-21F01	4707201225627	85	307	NP	NP	NP	0	82	130	-
19N/02W-21Q04	4706521225610	48	231	NP	NP	NP	NP	0	30	-
19N/02W-21R02	4706491225545	125	161	NP	0	NP	70	149	-	-
19N/02W-22D02	4707281225532	40	258	NP	NP	NP	0	68	117	-
19N/02W-22M06	4707101225524	10	439	NP	0	NP	38	67	98	-
19N/02W-23K01	4706581225334	20	385	NP	NP	NP	0	22	<175	-
19N/02W-24F01	4707181225238	105	80	0	17	52	60	-	-	-
19N/02W-24F02	4707171225230	120	86	0	30	79	-	-	-	-
19N/02W-24H01	4707161225154	120	115	NP	0	NP	47	-	-	-
19N/02W-24K01	4707081225225	120	93	NP	0	41	72	-	-	-
19N/02W-25A02	4706391225153	100	212	NP	0	40	72	NP	<212	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
19N/02W-25C07	4706381225235	118	140	0	18	NP	50	120	-	-
19N/02W-25D01	4706441225257	90	123	NP	0	NP	<110	110	-	-
19N/02W-25F01	4706201225245	145	93	NP	0	68	-	-	-	-
19N/02W-25N01	4705541225251	140	159	NP	0	68	70	148	-	-
19N/02W-25R01	4705561225206	165	74	NP	0	58	-	-	-	-
19N/02W-26B01	4706361225328	20	116	NP	NP	NP	0	30	-	-
19N/02W-26J01	4706131225322	125	154	NP	0	NP	56	118	148	-
19N/02W-27D03	4706411225527	78	114	NP	0	NP	15	109	-	-
19N/02W-27D04	4706321225527	50	115	NP	0	NP	20	110	-	-
19N/02W-28B02	4706371225604	60	390	NP	NP	NP	0	59	60	-
19N/02W-28J01	4706121225551	10	213	NP	0	NP	7	NP	<213	-
19N/02W-28L05	4706051225618	135	200	NP	0	54	58	NP	<200	-
19N/02W-28L06	4706181225614	108	460	NP	0	65	116	NP	<435	-
19N/02W-28N08	4706041225643	50	88	NP	0	NP	34	81	-	-
19N/02W-29B02	4706351225726	35	44	NP	0	NP	NP	37	-	-
19N/02W-29B03	4706321225722	30	74	NP	0	NP	42	50	-	-
19N/02W-29B04	4706321225728	58	91	NP	0	NP	64	85	-	-
19N/02W-29C01	4706421225738	40	76	NP	0	NP	NP	46	-	-
19N/02W-29F01	4706191225738	75	114	NP	0	14	34	72	-	-
19N/02W-29G02	4706201225729	20	43	NP	NP	NP	NP	0	-	-
19N/02W-30B01	4706421225842	100	79	NP	0	68	-	-	-	-
19N/02W-30E01	4706221225918	25	84	NP	0	28	30	78	-	-
19N/02W-30J02	4706121225820	25	79	NP	NP	NP	NP	0	60	-
19N/02W-30L03	4706141225846	20	109	NP	NP	NP	NP	0	92	-
19N/02W-30N01	4705541225912	65	45	NP	0	33	-	-	-	-
19N/02W-30N02	4706051225909	35	62	NP	0	3	12	55	-	-
19N/02W-31E03	4705321225909	60	109	NP	0	NP	25	94	109	-
19N/02W-31M03	4705241225911	20	104	NP	NP	0	12	104	-	-
19N/02W-32A06	4705471225656	30	228	NP	0	NP	27	43	110	-
19N/02W-32A07	4705431225705	130	70	NP	0	66	-	-	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
19N/02W-32G02	4705301225716	175	158	NP	0	>100	-	-	-	-
19N/02W-32G03	4705291225721	158	122	NP	0	105	-	-	-	-
19N/02W-32G04	4705321225711	195	211	NP	0	110	111	192	211	-
19N/02W-32H03	4705311225700	182	160	NP	0	NP	<150	150	160	-
19N/02W-32M05	4705241225754	60	52	NP	0	NP	20	48	-	-
19N/02W-32M06	4705251225750	65	65	NP	0	NP	30	58	-	-
19N/02W-33B02	4705441225555	192	134	NP	0	122	134	-	-	-
19N/02W-33D01	4705441225650	70	107	NP	0	NP	16	106	-	-
19N/02W-33F02	4705301225623	135	114	NP	0	NP	54	104	112	-
19N/02W-33G03	4705311225603	130	143	?	?	?	78	138	-	-
19N/02W-33H03	4705371225550	120	139	NP	0	?	?	?	?	?
19N/02W-33K08	4705241225556	19	120	NP	NP	NP	0	38	-	-
19N/02W-33M03	4705131225633	165	84	NP	0	71	-	-	-	-
19N/02W-33Q01	4705071225600	10	363	NP	NP	NP	0	<59	59	-
19N/02W-33Q03	4705071225600	30	227	NP	NP	NP	0	28	53	-
19N/02W-35B03	4705491225325	118	161	NP	0	34	40	143	159	-
19N/02W-35K05	4705151225356	70	107	NP	0	NP	69	93	-	-
19N/02W-35P03	4705011225347	123	276	NP	0	NP	48	97	175	-
19N/02W-36A03	4705461225206	160	68	0	5	67	-	-	-	-
19N/02W-36H02	4705291225152	160	77	0	4	47	-	-	-	-
19N/02W-36J01	4705231225158	160	73	0	<34	64	-	-	-	-
19N/02W-36M02	4705211225250	160	160	0	27	92	96	146	-	-
19N/02W-36N02	4705121225303	152	72	0	2	62	69	-	-	-
19N/02W-36N03	4705031225246	155	157	0	4	78	82	150	-	-
19N/03W-12Q01	4708421225945	100	199	NP	0	NP	<60	NP	<190	-
19N/03W-13K01	4707591225957	15	86	NP	NP	NP	0	18	-	-
19N/03W-24L01	4707111230001	130	71	NP	0	61	69	-	-	-
19N/03W-24M01	4707071230026	130	163	NP	0	47	91	154	163	-
19N/03W-25C01	4706381230010	135	118	NP	0	23	30	97	-	-
19N/03W-25E02	4706311230034	150	120	NP	0	82	99	108	-	-

Table A2. Depth to top of geohydrologic units in the study wells--Continued

Well identifer	Latitude and longitude	Land-surface altitude (feet)	Hole depth (feet)	Depth to top of indicated geohydrologic unit (feet)						
				Qvr	Qvt	Qva	Qf	Qc	TQu	Tb
19N/03W-25E03	4706281230018	130	118	0	23	45	NP	110	-	-
19N/03W-25J01	4706141225944	145	129	NP	0	47	68	127	-	-
19N/03W-25K01	4706171225952	175	42	0	42	-	-	-	-	-
19N/03W-25M03	4706151230034	150	123	0	41	90	-	-	-	-
19N/03W-25N02	4705531230032	150	106	0	45	90	95	102	-	-
19N/03W-26F01	4706221230122	130	104	NP	0	NP	73	86	-	-
19N/03W-26H02	4706311230039	150	182	NP	0	?	?	?	-	-
19N/03W-27L01	4706181230238	40	103	NP	NP	NP	0	35	55	-
19N/03W-27M02	4706211230309	165	103	0	16	68	NP	86	-	-
19N/03W-27N01	4706091230305	165	83	0	13	75	-	-	-	-
19N/03W-27R01	4706061230158	140	106	NP	0	67	69	98	-	-
19N/03W-27R02	4706051230204	125	115	NP	0	48	50	97	-	-
19N/03W-28H02	4706241230320	150	79	0	6	70	-	-	-	-
19N/03W-28J01	4706091230323	215	160	0	27	73	NP	86	-	-
19N/03W-34A01	4705481230203	130	48	NP	0	30	-	-	-	-
19N/03W-34H01	4705341230200	150	103	NP	0	34	48	99	-	-
19N/03W-34K01	4705281230222	140	127	NP	0	NP	49	116	-	-
19N/03W-34K02	4705281230222	140	134	NP	0	NP	34	117	NP	134
19N/03W-35J02	4705241230040	165	113	NP	0	81	99	107	-	-
19N/03W-36B04	4705491225958	160	111	0	4	52	85	104	-	-
19N/03W-36D03	4705401230016	150	92	0	49	NP	82	90	-	-
19N/03W-36E03	4705281230034	150	101	NP	0	?	?	?	?	?
19N/03W-36M02	4705231230036	150	105	NP	0	77	92	101	-	-
19N/03W-36P03	4705011230013	30	46	NP	NP	0	30	38	-	-
19N/03W-36R03	4705051225927	30	78	NP	0	NP	<74	74	-	-
20N/01W-33N01	4710191224911	91	120	NP	0	NP	34	110	-	-
20N/02W-28P01	4711071225623	10	425	NP	0	NP	NP	20	135	-
20N/02W-33F01	4710451225618	40	98	NP	NP	NP	0	47	61	-
20N/02W-33Q02	4710161225606	80	770	NP	0	NP	34	57	147	-

Table A3. Water-level measurements in wells used in this study, November 1988 through June 1990

EXPLANATION

<u>Water level</u>: A minus sign indicates water level above land surface.

<u>Water-level status</u>: F, flowing; R, recently pumped; S, nearby well recently pumped.

Table A3. Water-level measurements in study wells, November 1988 through June 1991--Continued

Well identifer	Date water level measured	Water level (feet below surface)	Water level status	Well identifer	Date water level measured	Water level (feet below surface)	Water level status
17N/01E-06C01	12-02-88	44.74	-	17N/01W-34L02	05-11-89	36.92	-
	01-05-89	44.43	-		06-08-89	38.85	-
	02-14-89	43.91	-		07-25-89	40.10	-
	03-14-89	42.78	-		08-18-89	42.25	-
	04-17-89	40.50	-		09-18-89	40.15	-
	05-09-89	40.95	-		10-17-89	40.79	-
	06-08-89	41.63	-		11-16-89	40.15	-
	07-26-89	42.80	-		12-20-89	34.65	-
	09-18-89	44.15	-		01-17-90	29.45	-
	10-17-89	44.80	-		02-13-90	25.17	-
	11-17-89	45.03	-		03-13-90	32.74	-
	12-20-89	43.92	-		04-17-90	36.40	-
	01-17-90	37.55	-		05-15-90	37.27	-
	02-13-90	35.05	-		06-20-90	37.30	-
	03-13-90	35.64	-				
	04-17-90	35.71	-	17N/02W-01E02	05-10-89	65.90	-
	05-15-90	36.15	-		06-08-89	65.29	-
	06-18-90	36.64	-		07-26-89	65.94	-
					08-18-89	66.28	-
17N/01E-06J04	12-02-88	53.14	-		09-18-89	66.56	-
	01-05-89	53.10	-		10-20-89	66.75	-
	02-14-89	52.83	-		11-16-89	65.95	-
	03-14-89	52.53	-		12-20-89	65.59	-
	04-04-89	51.90	-		01-19-90	64.31	-
	05-09-89	51.51	-		02-13-90	63.30	-
	06-08-89	51.87	-		03-13-90	63.06	-
	07-20-89	52.14	-		04-17-90	63.87	-
	09-18-89	52.66	-		05-15-90	64.32	-
	10-17-89	52.75	-		06-20-90	64.68	-
	11-17-89	52.77	-				
	12-20-89	52.73	-	17N/02W-05A02	05-10-89	2.37	-
	01-17-90	51.42	-		06-08-89	2.27	-
	02-13-90	50.83	-		07-25-89	2.35	-
	03-13-90	50.27	-		08-01-89	2.88	S
	04-17-90	50.14	-		09-20-89	3.01	-
	05-15-90	50.23	-		03-13-90	1.36	-
	06-18-90	50.48	-		04-18-90	1.75	-
					05-15-90	1.94	-
17N/01W-16L01	05-11-89	5.83	-		06-20-90	2.03	-
	06-08-89	6.96	-				
	07-26-89	9.54	-	17N/02W-14Q02	05-11-89	9.62	-
	09-20-89	8.84	-		06-08-89	11.15	-
	10-20-89	12.14	R		07-25-89	13.15	-
	11-16-89	13.03	-		08-18-89	14.15	-
	12-20-89	13.27	-		09-18-89	15.12	-
	01-18-90	10.17	-		10-20-89	16.10	-
	02-13-90	5.51	-		11-16-89	16.75	-
	03-13-90	7.45	-		12-20-89	14.69	-
	05-15-90	9.09	-		01-17-90	10.02	-

Table A3. Water-level measurements in study wells, November 1988 through June 1991--Continued

Well identifer	Date water level measured	Water level (feet below surface)	Water level status
17N/02W-14Q02	02-13-90	4.98	-
	03-13-90	5.52	-
	04-17-90	7.93	-
	05-15-90	9.33	-
	06-20-90	10.66	-
17N/02W-22H02	05-11-89	10.95	-
	06-08-89	12.31	-
	07-25-89	14.38	-
	08-18-89	15.54	-
	09-20-89	16.35	-
	10-17-89	17.11	-
	11-16-89	16.89	-
	12-20-89	13.37	-
	01-17-90	9.57	-
	02-13-90	6.80	-
	03-13-90	7.90	-
	04-18-90	10.18	-
	05-15-90	10.12	-
	06-20-90	12.00	-
17N/02W-30E03	05-11-89	20.15	-
	06-08-89	22.55	-
	07-25-89	21.64	-
	09-18-89	24.82	-
	10-20-89	21.44	-
	11-16-89	19.47	-
	12-20-89	19.54	-
	01-17-90	18.34	-
	02-13-90	17.00	-
	03-13-90	17.47	-
	04-18-90	21.28	-
	05-15-90	21.32	-
	06-20-90	20.88	-
17N/03W-22J01	05-11-89	27.01	-
	06-08-89	28.90	-
	07-25-89	32.20	-
	08-18-89	33.83	-
	09-18-89	35.63	-
	10-20-89	37.16	-
	11-16-89	37.93	-
	12-20-89	35.94	-
	01-17-90	32.08	-
	02-13-90	25.25	-
	03-13-90	23.08	-
	04-18-90	24.85	-
	05-15-90	26.85	-
	06-20-90	29.26	R
18N/01E-19J02	11-15-88	27.11	-
	12-01-88	27.00	-
	01-05-89	26.99	-
	02-14-89	26.73	-
	03-14-89	26.48	-
	04-04-89	26.05	-
	05-09-89	25.90	-
	06-08-89	26.20	-
	07-20-89	26.54	-
	08-22-89	26.84	-
	09-19-89	27.03	-
	10-17-89	27.13	-
	11-17-89	27.07	-
	12-20-89	26.80	-
	01-17-90	26.04	-
	02-13-90	25.37	-
	03-13-90	24.72	-
	04-17-90	25.01	-
	05-16-90	25.25	-
	06-18-90	25.46	-
18N/01E-31A01	12-02-88	63.65	-
	01-06-89	63.33	-
	02-14-89	62.66	-
	03-14-89	62.05	-
	04-04-89	60.79	-
	04-17-89	60.03	-
	05-09-89	59.97	-
	06-08-89	60.78	-
	07-20-89	61.90	-
	08-17-89	62.40	-
	09-19-89	63.01	-
	10-17-89	63.46	-
	11-17-89	64.60	-
	12-20-89	62.88	-
	01-17-90	61.86	-
	02-13-90	58.06	-
	03-13-90	55.36	-
	04-18-90	56.10	-
	05-15-90	56.97	-
	06-18-90	57.93	-
18N/01E-32H02	01-06-89	177.00	-
	02-14-89	176.91	-
	03-14-89	176.83	-
	04-14-89	176.02	-
	05-09-89	175.95	-
	06-08-89	176.06	-
	08-17-89	178.99	-

Table A3. Water-level measurements in study wells, November 1988 through June 1991--Continued

Well identifer	Date water level measured	Water level (feet below surface)	Water level status	Well identifer	Date water level measured	Water level (feet below surface)	Water level status
18N/01E-32H02	09-20-89	176.99	-	18N/01W-09J01	02-13-90	35.45	-
	10-18-89	177.13	-		03-14-90	34.76	-
	11-17-89	178.60	-		04-18-90	34.99	-
	12-20-89	177.09	-		05-15-90	35.02	-
	01-18-90	176.75	-		06-20-90	35.25	-
	02-14-90	175.32	-				
	03-13-90	174.23	-	18N/01W-24B02	05-11-89	50.08	-
	04-17-90	174.27	-		06-08-89	50.61	-
	05-16-90	174.17	-		07-20-89	51.94	-
	06-18-90	175.45	-		08-22-89	52.81	-
					09-19-89	53.58	-
18N/01W-05G02	05-10-89	21.97	-		10-17-89	54.25	-
	06-09-89	22.35	-		11-17-89	54.78	-
	07-20-89	22.84	-		12-20-89	53.99	-
	08-21-89	23.23	-		01-17-90	51.66	-
	09-19-89	23.55	-		02-13-90	48.87	-
	10-18-89	23.88	-		03-13-90	48.06	-
	11-17-89	23.93	-		04-17-90	48.59	R
	12-20-89	23.56	-		05-15-90	50.93	-
	01-17-90	22.60	-		06-18-90	50.85	-
	02-13-90	20.97	-				
	03-14-90	21.10	-	18N/01W-28J01	05-09-89	25.91	-
	04-18-90	21.77	-		06-08-89	26.03	-
	05-17-90	21.98	-		07-20-89	26.42	-
	06-20-90	22.03	-		08-17-89	26.73	-
					09-19-89	27.15	-
18N/01W-07C01	05-09-89	39.72	-		11-16-89	26.91	-
	06-13-89	39.77	-		12-20-89	26.58	-
	07-20-89	40.07	-		01-17-90	25.59	-
	08-21-89	40.62	-		02-13-90	24.94	-
	09-21-89	40.92	-		03-13-90	24.90	-
	10-18-89	41.25	-		04-17-90	24.96	-
	11-17-89	41.39	-		05-15-90	25.04	-
	12-20-89	42.14	-		06-18-90	25.08	-
	01-17-90	41.16	-				
	02-13-90	40.81	-	18N/01W-33C01	05-11-89	39.47	-
	03-14-90	38.85	-		06-09-89	38.79	-
	04-18-90	38.79	-		07-24-89	39.69	-
	05-16-90	39.19	-		08-22-89	40.44	-
	06-20-90	39.59	-		09-20-89	40.89	-
					10-17-89	41.35	-
18N/01W-09J01	05-09-89	35.78	-		11-16-89	41.87	-
	06-09-89	36.05	-		12-20-89	42.20	-
	07-24-89	36.48	-		01-17-90	41.85	-
	08-22-89	36.77	-		02-13-90	40.80	-
	09-19-89	38.18	-		03-13-90	39.53	-
	10-18-89	38.48	-		04-17-90	36.10	-
	11-17-89	39.20	-		05-15-90	36.42	-
	12-20-89	37.44	-		06-18-90	36.13	-
	01-17-90	36.60	-				

Table A3. Water-level measurements in study wells, November 1988 through June 1991--Continued

Well identifer	Date water level measured	Water level (feet below surface)	Water level status
18N/01W-35A04	03-21-89	8.85	-
	04-19-89	9.04	-
	05-09-89	8.34	-
	06-08-89	9.64	-
	07-27-89	10.03	-
	08-17-89	10.07	-
	09-21-89	10.48	-
	10-20-89	10.58	-
	11-17-89	10.23	-
	12-20-89	9.55	-
	01-17-90	8.58	-
	02-13-90	7.99	-
	03-13-90	8.48	-
	04-18-90	9.05	-
	05-15-90	9.35	-
	06-18-90	9.38	-
	07-24-90	9.84	-
18N/01W-36C02	03-21-89	126.28	-
	04-17-89	125.40	-
	05-09-89	124.87	-
	06-08-89	124.65	-
	07-20-89	126.98	-
	08-17-89	125.63	-
	09-19-89	126.08	-
	10-17-89	126.37	-
	11-17-89	125.45	-
	12-20-89	126.54	-
	01-17-90	126.18	-
	02-13-90	124.88	-
	03-13-90	122.93	-
	04-17-90	121.77	-
	05-15-90	121.74	-
	06-18-90	122.07	-
18N/01W-36N01	07-26-89	146.39	-
	08-17-89	146.85	-
	09-19-89	147.66	-
	10-17-89	148.28	-
	11-17-89	150.03	-
	12-20-89	149.28	-
	01-17-90	149.34	-
	02-13-90	147.75	-
	03-13-90	147.02	-
	04-17-90	147.05	-
	05-17-90	144.13	-
18N/02W-07R01	12-22-88	84.15	-
	01-06-89	84.48	-
	02-16-89	83.66	-
	03-15-89	82.78	-
	05-10-89	78.98	-
	06-09-89	80.15	-
	07-24-89	78.69	-
	08-21-89	80.73	-
	09-21-89	80.60	-
	10-18-89	81.47	-
	11-17-89	82.36	-
	12-20-89	83.09	-
	01-19-90	83.23	-
	02-14-90	82.30	-
	03-13-90	79.11	-
	04-18-90	76.26	-
	05-16-90	75.64	-
	06-20-90	75.64	-
18N/02W-08N03	05-11-89	82.15	-
	06-12-89	81.83	-
	07-24-89	82.73	-
	08-18-89	86.32	-
	09-21-89	84.39	-
	10-18-89	85.30	-
	11-17-89	85.99	-
	12-20-89	86.77	-
	01-17-90	86.43	-
	02-14-90	85.68	-
	03-13-90	81.50	-
	04-18-90	79.56	-
	05-15-90	79.48	-
	06-20-90	80.26	-
18N/02W-33C01	06-12-89	119.88	-
	07-27-89	104.60	-
	08-21-89	118.90	-
	09-20-89	80.08	-
	10-20-89	50.08	R
	11-16-89	35.00	-
	12-20-89	26.57	-
	01-17-90	25.65	-
	02-13-90	24.00	-
	03-13-90	30.94	-
	04-18-90	42.73	-
	05-15-90	36.91	-

Table A3. Water-level measurements in study wells, November 1988 through June 1991--Continued

Well identifer	Date water level measured	Water level (feet below surface)	Water level status	Well identifer	Date water level measured	Water level (feet below surface)	Water level status
18N/03W-01J02	06-09-89	34.90	-	19N/01W-16K01	07-24-89	48.56	-
	07-24-89	35.17	-		08-22-89	51.00	-
	08-18-89	34.54	-		09-19-89	51.67	-
	10-18-89	35.77	-		10-18-89	53.78	-
	11-17-89	37.43	-		11-16-89	54.89	-
					12-21-89	55.13	-
18N/03W-23N01	05-10-89	.85	-		01-17-90	54.69	-
	06-09-89	1.72	-		02-14-90	52.23	-
	07-27-89	1.73	-		03-14-90	46.36	-
	08-18-89	3.33	-		04-18-90	43.95	-
	09-21-89	2.72	-		05-17-90	44.09	-
	10-18-89	2.90	-		06-20-90	45.39	-
	11-17-89	1.86	-				
	12-20-89	1.35	-	19N/01W-22A01	09-20-89	57.52	-
	01-19-90	.76	-		10-18-89	57.59	-
	02-14-90	.10	-		11-16-89	59.09	-
	03-13-90	-.11	F		12-21-89	59.05	-
	04-18-90	.61	-		01-17-90	58.15	-
	05-15-90	.94	-		02-14-90	56.99	-
	06-20-90	1.12	-		03-14-90	59.40	-
					04-18-90	66.62	-
19N/01W-06L01	05-10-89	69.34	-		05-16-90	60.06	-
	06-09-89	69.75	-		06-20-90	59.94	-
	07-24-89	69.68	-				
	08-21-89	70.12	-	19N/01W-28F02	05-09-89	64.16	-
	09-21-89	69.78	-		06-09-89	63.95	-
	10-18-89	70.70	-		07-24-89	64.13	-
	11-16-89	70.00	-		08-21-89	64.46	-
	12-21-89	70.70	-		09-19-89	64.34	-
	01-17-90	68.96	-		10-18-89	65.80	-
	02-14-90	70.94	-		11-17-89	64.60	-
	03-14-90	70.55	-		12-21-89	65.30	-
	04-18-90	71.60	-		01-17-90	64.50	-
	05-17-90	69.72	-		02-14-90	64.17	-
	06-20-90	72.28	-		03-14-90	63.96	-
					04-18-90	63.78	-
19N/01W-09L02	07-24-89	52.15	-		05-17-90	61.60	-
	08-22-89	52.87	-		06-20-90	63.89	-
	09-19-89	54.63	-				
	10-18-89	54.11	-	19N/01W-33K05	07-24-89	51.69	-
	11-16-89	55.40	-		08-21-89	52.21	-
	12-21-89	55.13	-		09-20-89	52.21	-
	01-17-90	55.15	-		10-18-89	52.45	-
	02-14-90	54.40	-		11-17-89	52.51	-
	03-14-90	53.42	-		12-21-89	52.63	-
	04-18-90	51.26	-		01-17-90	51.69	-
	05-17-90	51.19	-		02-13-90	51.32	-
	06-20-90	51.51	-		03-14-90	50.23	-

Table A3. Water-level measurements in study wells, November 1988 through June 1991--Continued

Well identifer	Date water level measured	Water level (feet below surface)	Water level status
19N/01W-33K05	04-18-90	50.48	-
	05-15-90	50.63	-
	06-20-90	50.78	-
19N/02W-07P01	07-27-89	71.85	-
	08-17-89	72.81	-
	10-18-89	71.72	-
	12-21-89	72.82	-
	01-19-90	70.99	-
	03-14-90	69.55	-
	04-18-90	71.04	-
	05-17-90	71.39	-
	06-20-90	72.07	-
19N/02W-18K02	06-27-89	104.41	-
	08-17-89	102.66	-
	09-21-89	104.50	-
	10-18-89	104.69	-
	11-17-89	104.80	-
	12-20-89	104.55	-
	01-19-90	104.75	-
	02-14-90	105.26	-
	03-14-90	104.58	-
	04-18-90	108.15	-
	05-17-90	103.99	-
	06-20-90	104.52	-
19N/02W-18M01	07-27-89	37.18	-
	08-17-89	37.52	-
	09-21-89	37.13	-
	10-18-89	37.27	-
	11-17-89	37.33	-
	12-20-89	37.36	-
	01-19-90	37.09	-
	02-14-90	37.31	-
	03-14-90	36.78	-
	04-14-90	36.51	-
	05-17-90	37.30	-
	06-20-90	36.71	-
19N/02W-27D04	07-27-89	33.20	-
	08-21-89	33.85	-
	09-21-89	33.53	-
	10-18-89	34.25	-
	11-17-89	34.30	-
	12-20-89	34.56	-
	01-19-90	34.57	-
	02-14-90	34.68	-
	03-13-90	33.94	-
	04-18-90	34.29	-
	05-16-90	33.16	-
	06-20-90	32.99	-
20N/01W-33N01	07-24-89	84.04	-
	08-22-89	84.12	-
	09-19-89	84.06	-
	10-18-89	84.12	-
	11-17-89	83.89	-
	12-21-89	84.00	-
	01-17-90	83.76	-
	02-14-90	84.79	-
	03-14-90	83.76	-
	04-14-90	83.90	-
	05-17-90	83.97	-
	06-20-90	83.87	-

Appendix B. Quality-Assurance Assessment of Water-Quality Data

APPENDIX B

Quality-Assurance Assessment of Water-Quality Data

The quality-assurance plan for this study (G. L. Turney, U.S. Geological Survey, written commun., 1989) calls for quality-control procedures at all levels of data collection and analysis. Whereas many of the procedures address only methodology, some require the collection and analysis of quality-control samples. The resulting data are reviewed to determine the quality of the project data.

The water-quality data used in this study were good by most measures. Errors associated with most standard and duplicate samples were within project criteria for most constituents. Exceptions occurred where constituent concentrations were near detection limits and small absolute errors resulted in large percentage errors. Concentrations in blanks, various internal sample checks, and comparisons of field and laboratory determinations were within acceptable limits for most constituents and samples. The results of the quality-assurance analyses did not affect any interpretations of ground-water quality data.

In the following sections, data from standard reference samples, sample duplicates, blanks, internal sample checks, and checks on field values are discussed. The data are included in the tables of Appendix C.

Standard Reference Samples

Standard reference samples of various concentrations for selected inorganic constituents were inserted as blind samples into the laboratory sample runs at the National Water Quality Laboratory (NWQL). Each standard sample was submitted several times to obtain enough data to be statistically meaningful. The results were summarized and are available through computer programs maintained by the U.S. Geological Survey's Branch of Quality Assurance (BQA). The summary provides the mean concentration determined by the NWQL for each standard during a given period, along with the standard deviation of the laboratory concentrations, coefficient of variation, and number of times the standard was submitted and analyzed. These data for standards submitted from April 1 to July 15, 1989, were used to assess the error in the analytical accuracy of samples collected and analyzed from 461 Thurston County wells during that period. The standards used in the assessment were only those that enclosed the range of the sample concentrations or, in cases when that was not possible, those that best represented the sample concentrations.

First, the standard deviation of the concentration of a standard reference sample from the true concentration was determined for each standard reference sample using the following equation:

$$s_i = \sqrt{s_s^2 + \left(\bar{u}_s - MPV_s\right)^2} \ , \qquad (1)$$

where

s_i is the standard deviation of the concentration of the standard reference sample from the true concentration;

s_s is the standard deviation from the mean concentration determined by the NWQL;

$\bar{u}_s$ is the mean concentration of the standard reference sample as determined by the NWQL; and

MPV_s is the most probable value of the standard reference sample. This is an estimate of the true concentration of the standard reference sample based on analyses by as many as 150 independent laboratories.

Then equation 2 was used to determine the coefficient of variation $\left(CV_i\right)$ for the analysis of each standard:

$$CV_i = \frac{s_i}{MPV_s} \ . \qquad (2)$$

Then the overall coefficient of variation for a particular constituent was determined by averaging the squares of the coefficients of variation for all the standards that were in the range of concentrations found in Thurston County. This average was weighted by the number of times each standard was analyzed in the period as follows:

$$CV_o = \sqrt{\frac{\sum_{i=1}^{m}\left(n_i - 1\right)CV_i^2}{\sum_{i=1}^{m}\left(n_i - 1\right)}} \ , \qquad (3)$$

where

CV_o = overall coefficient of variation of all standards for a constituent;

n_i = number of times the standard was submitted and analyzed; and

m = number of standards.

The overall coefficient of variation usually overemphasizes standards at larger concentrations when the concentration ranges over several standards. This is because standards are submitted in approximately equal numbers over a large concentration range, but the concentrations in the ground-water samples are mostly near the smaller end of the range; only a small percentage of samples are near the larger end of the concentration range. In fact, in most cases the median ground-water concentration was smaller than the smallest standard, even though the sample concentration range covered several standards. In extreme cases, such as barium and chromium, the smallest standard concentration was larger than the largest ground-water concentration, so only the smallest standard was used. The consequences of these unequal concentration distributions between standards and samples is minimal, though, because the coefficients of variation for the standards do not vary much with concentration.

The overall coefficient of variation was used to estimate the overall error of analysis of the standard reference samples for the constituent, at the 95-percent confidence level. The following equation was used:

$$E = \left(1.96 \times CV_{o} \right) 100 \qquad (4)$$

where

E = overall error of analysis, in percent.

This error is also a representation of the average error in analytical accuracy of the samples from Thurston County and is shown in table B1 for each constituent. It is recognized that this error includes a degree of analytical precision. However, the accuracy and precision are difficult to separate in the given data and, in the interest of conservation, the error is considered to be entirely in the accuracy.

The average absolute standard deviation (S_o) for each constituent, in units based on concentration, is calculated using equation 5 and is shown in table B1.

$$S_{o} = \sqrt{\frac{\sum_{i=1}^{m} \left(n_i - 1 \right) s_i^{2}}{\sum_{i=1}^{m} \left(n_i - 1 \right)}} \qquad (5)$$

The estimated errors for the major cations and anions determined in this study are generally reasonable. Quality- assurance goals for this study called for a maximum error of 10 percent for cations, anions, and nutrients; all except potassium, fluoride, and nitrate are in that range. The errors for potassium and nitrate are 20 and 17 percent, respectively, and are probably representative. The larger error of 82 percent for fluoride is a result of the small concentrations that were close to the detection limit. At these low concentrations, acceptable small absolute errors (standard deviation) produce large percent errors. For example, an absolute error of 0.2 mg/L is a 20-percent error for a concentration of 1.0 mg/L, but is only a 2-percent error for a concentration of 10 mg/L.

Errors for metals range from 6.1 to 168 percent. In a few instances, the error is well within the goal of 20 percent. However, the generally large percent errors associated with metals usually occur because concentrations were at or near detection limits for all metals. Even though the percentages themselves are large at these low levels, the absolute errors are acceptable.

Internal surrogate standards were injected into each sample to be analyzed for concentrations of volatile organic compounds. The standards are used to determine percent recoveries, and those that are not detected within a certain percentage of the known concentrations (variable, dependent upon the compound) are identified by the NWQL. No samples were reported to have substandard volatile organic compound recoveries.

There might have been an analytical problem with one of the samples collected in May 1989 from well 17N/01W-02E03. This sample was reported as containing small concentrations of six volatile organic compounds (see table 9 on p. 48). Immediately after this sample was analyzed on the gas chromatograph/mass spectrometer, the instrument malfunctioned. During subsequent testing, the same sample was reanalyzed and no volatile organic compounds were detected. This second analysis was conducted, however, several days after the first, and after the suggested sample holding time of 14 days had expired. A second sample was collected in December 1989, and only two of the six compounds detected in May were present in December: 1,2-dibromoethane and 1,2-dichloropropane. Given this confirmation, it was concluded that these two compounds were likely present in the May sample. Therefore, the first analysis in May, which identified these two compounds and four others, is probably representative and the data were accepted. From the opposite point of view, the argument for rejecting this analysis and accepting the second May analysis of the original sample (which detected nothing) requires ignoring the violation of the holding time, which could be the real reason nothing was detected.

Table B1. Estimated error in analysis of inorganic constituents

[Concentrations in milligrams per liter unless otherwise noted. All are dissolved concentrates; µg/L, micrograms per liter]

Constituent	Number of standards	Number of times standards submitted	Median concentration in ground-water samples	Range of concentratins in ground-water samples	Range of concentration of standards	Average absolute standard deviation of standards	Average[1] percent error in analysis
Calcium	10	92	11	0.13 - 170	18.5 - 121	1.2	5.3
Magnesium	10	92	5.8	.01 - 55	3.1 - 65.7	0.92	6.5
Sodium	10	92	6.5	2.0 - 260	8.1 - 188	3.3	10
Potassium	13	104	1.6	.1 - 11	.17 - 6.18	.17	20
Alkalinity	13	104	56	7.0 - 464	40.6 - 177	1.8	4.8
Sulfate	3	27	4.0	<1.0 - 52	13.7 - 74.3	1.5	9.0
Chloride	13	104	3.4	1.3 - 600	10.7 - 62.8	1.3	7.9
Fluoride	5	48	.1	<. - .4	.06 - .66	.045	82
Silica	10	92	35	5.7 - 66	2.48 - 7.78	.16	7.3
Dissolved solids (analyzed)	12	100	112	28 - 1,140	102 - 1,353	18	9.4
Nitrate	4	137	.33	<.10 - 19	.60 - 3.7	.16	17
Phosphorus	7	149	.04	<.01 - 1.6	.23 - .78	.022	7.2
Iron (µg/L)	6	69	23	<3 -21,000	27.5 - 178	23	32
Manganese (µg/L)	6	71	5	<1 - 3,400	6.03 - 74.1	3.8	93
Arsenic (µg/L)	11	76	1	<1 - 21	1.60 - 8.48	1.2	49
Barium (µg/L)	1	10	4	<2 - 12	27.1 - .60	4.3	
Boron (µg/L)	2	12	10	<10 - 70	11.1 - 62.3	11	170
Cadmium (µg/L)	3	28	<1	<1 - 2	1.14 - 6.00	1.4	54
Chromium (µg/L)	1	4	<1	<1 - 5	5.38 - .90	33	
Copper (µg/L)	7	37	1	<1 - 80	9.21 - 50.0	2.8	25
Lead (µg/L)	4	18	<5	<1 - <5	1.55 - 4.47	1.7	170
Mercury (µg/L)	2	15	<.1	<.1 - 0.5	.07 - .60	.16	140
Selenium (µg/L)	1	10	<1	<1 - <1	1.94 - .060	6.1	
Silver (µg/L)	3	46	<1	<1 - 7	3.48 - 5.95	1.2	49
Zinc (µg/L)	6	69	36	<3 - 900	17.8 - 110	10	66

[1]At 95-percent confidence level. Computed using equations described in the text and data supplied by the U.S. Geological Survey's Branch of Quality Assurance. Error criterion is 10 percent for cations, anions, silica, dissolved solids, and nutrients. Error criterion is 20 percent for metals and trace elements.

Duplicate Samples

Duplicate pairs of samples were collected for all types of analyses performed. Precision criteria were a 10-percent maximum difference for cations, anions, silica, dissolved solids, and nutrients and a 20-percent maximum difference for trace elements and organic compounds. A difference for each pair was computed as a percentage of the average concentration for the pair. The average difference of all pairs and the number of pairs exceeding the difference criteria are listed for each constituent in table B2.

For most constituents, the average percent difference is well within the criteria presented above. Exceptions are iron and several trace elements. In almost all cases, the larger percent errors were a result of small absolute differences in small concentrations near the detection limit, and are therefore considered acceptable. For iron, a pair of samples from well 19N/01W-32B01 had concentrations of 660 and 840 µg/L and a pair from 19N/03W-25K01 had concentrations of 68 and 85 µg/L, well above the detection limit of 3 µg/L. This disparity may reflect a sampling or analytical problem, but the overall difference for iron is 16 percent (including these pairs) and the problem is probably isolated.

Table B2.--Average differences in constituent values and concentrations determined for duplicate samples

Constituents	Number of duplicate pairs	Average difference in percent	Number[1] of pairs exceeding difference criteria
Calcium	19	0.8	0
Magnesium	19	1.6	0
Sodium	19	1.9	0
Potassium	19	2.5	2
Alkalinity - Lab	19	.3	0
Sulfate	19	3.1	2
Chloride	19	1.6	0
Fluoride	19	2.1	1
Silica	19	.8	0
Dissolved solids (analyzed)	19	4.3	2
Dissolved solids (calculated)	19	.5	0
Nitrate	19	.6	0
Phosphorus	19	6.3	2
Iron	19	16	7
Manganese	19	2.4	1
Arsenic	3	.0	0
Barium	3	.0	0
Boron	2	34	2
Cadmium	3	22	1
Chromium	3	22	1
Copper	3	40	1
Lead	3	.0	0
Mercury	3	.0	0
Selenium	3	.0	0
Silver	3	33	1
Zinc	3	25	1
Radon-222	2	5.2	0
Dissolved organic carbon	2	5.3	0
Methylene blue active substance	2	12	1
All organic[2]	3	.0	0

[1]Difference criterion is 10 percent for cations, anions, silica, dissolved solids, and nutrients. Percent-difference criterion is 20 percent for all metals, trace elements, radiochemicals, and organic compounds. No percent-difference criterion was established for bacteria.

[2]Organic compounds were not detected in any of the duplicate samples, therefore, all differences for these compounds are zero.

Blanks

Blanks of deionized water were processed in the same manner as water samples and sent to the NWQL for analysis. Although no criteria were set for constituent concentrations in blanks, the significance of any constituent present in a blank is based on how close the constituent concentration is to the detection limit and how small it is compared with the median sample concentration. Also important is the number of times the constituent was detected in blank samples. These data are presented in table B3 and, when compared with these criteria, concentrations in blanks were considered insignificant for all constituents except iron, MBAS, dichloromethane, and toluene. Even though iron was detected in 13 blanks, and the maximum concentration was 31 µg/L, the average blank concentration was 6 µg/L. Excluding the one largest value, the average was 4 µg/L, which is acceptable considering that the median iron concentration was 23 µg/l in the samples (table B1). For ground-water MBAS, the largest blank concentration was equal to the median concentration of 0.03 mg/L. However, the concentrations of concern in the study were 0.04 mg/L or larger, so interpretations are not affected. Blank concentrations of the three volatile compounds were small, but their mere presence is of significance. Dichloromethane and trichlorofluoromethane were not detected in any water samples. Toluene was detected in one water sample but at a concentration of 0.4 mg/L, twice the largest blank concentration. Toluene may have originated from the laboratory or from the column used to prepare the deionized water.

Table B3. Summary of constituent values and concentrations determined for blank samples

[Concentrations in milligrams per liter unless otherwise note; µg/L, micrograms per liter; pCi/L, picocuries per ltier; col/100 mL, colonies per 100 milliliters]

Constituents	Number of blanks	Detection limit	Number of blanks equal to or exceeding detection limit	Maximum blank concentration	Median sample concentration
Calcium	18	0.02	5	.05	11
Magnesium	18	.01	8	.09	5.8
Sodium	18	.2	0	<.2	6.5
Potassium	18	.1	12	.1	1.6
Alkalinity	18	1	18	3	56
Sulfate	18	[1].2,1	0	[1]<1	4.0
Chloride	18	.1	3	.4	3.4
Fluoride	18	.1	11	.1	.1
Silica	18	.01	11	.38	35
Dissolved solids (analyzed)	18	1	6	11	106
Nitrate	18	.10	1	.23	.33
Phosphorus	18	.01	2	.02	.04
Iron (mg/L)	18	3	13	31	23
Manganese (mg/L)	18	1	4	2	5
Arsenic (mg/L)	3	1	0	<1	1
Barium (mg/L)	3	2	0	<2	4
Boron (mg/L)	2	10	0	<10	10
Cadmium (mg/L)	3	1	0	<1	<1
Chromium (mg/L)	3	1	1	2	<1
Copper (mg/L)	3	1	3	1	1
Lead (mg/L)	3	[2]1,5	1	[2]1,5	<5
Mercury (mg/L)	3	.1	3	.9	<.1
Selenium (mg/L)	3	1	0	<1	<1
Silver (mg/L)	3	1	1	1	<1
Zinc (mg/L)	3	3	1	17	36
Radon-222 (pCi/L)	2	80	1	110	410
Dissolved organic carbon	2	.1	2	.3	.4
Methylene blue active substance	2	.02	1	.03	.03
Dichloromethane (mg/L)	3	.2	3	.7	<.2
Trichlorofluoromethane (mg/L)	3	.2	1	.2	<.2
Tolune (mg/L)	3	.2	2	.2	<.2
All other organics[3]	3	.2	0	<.2	<.2
Fecal coliform (col/100 mL)	110	1	0	0	<1
Fecal streptococci (col/100 mL)	103	1	1	1	<1

[1]The analytical methodology for sulfate was changed on about April 15, 1989. At that time the detection limit increased from 0.2 to 1.0 mg/L.

[2]The analytical methodology for lead was changed on about May 16, 1989. At that time the detection limit decreased from 5 to 1 µg/L.

[3]Organic compounds other than those shown were not detected in the blanks.

Internal Sample Checks

Various sums, differences, and ratios based on the principles of aquatic chemistry were computed for each sample. These computations check the consistency between constituent concentrations in a sample, and provide a gross check in the accuracy and completeness of the analysis. Two of the most useful computations are the cation-anion balance and the calculated dissolved-solids concentration, which are discussed in the following paragraphs.

The cation-anion balance is calculated as a percent difference, using the following equation:

$$\frac{\sum \text{cations} - \sum \text{anions}}{\sum \text{cations} + \sum \text{anions}} + 100 \text{ percent} \qquad (6)$$

where

$\sum$ cation = the sum of the concentrations of cations, in milliequivalents; and

$\sum$ anion = the sum of the concentrations of anions, in milliequivalents.

Ideally, this value is zero, but nonzero values occur when a cation or anion concentration is in error or when an ion present in large concentrations (often a metal) is not analyzed for. The acceptable percent difference varies with the total sum of cations and anions, as shown on figure B1. For the samples collected in Thurston County, the cation-anion balance was good: only 19 of 359 analyses exceeded the allowable percent difference. Of these, 11 had iron concentrations in excess of 1,000 µg/L, and the cation sum exceeded the anion sum. For these 11 samples, the alkalinity determinations may be too low because the iron could have precipitated as iron carbonate in the untreated alkalinity sample. Of the remaining eight, seven were highly mineralized, with dissolved-solids concentrations greater than 300 mg/L, and six had chloride concentrations greater than 100 mg/L. It is possible that the large amount of dissolved minerals may contribute to precipitation reactions in untreated samples, which could have altered the sample chemistry enough to produce an unacceptable balance. In all 19 analyses, suspect concentrations were verified by reanalysis. All 19 analyses were kept and used because the indicated error was not likely to be large enough to affect any interpretations of the data. Even the largest difference was only 10.1 percent. Also, when the error could be attributed to a likely constituent, such as the alkalinity, there was no way to determine the correct concentration.

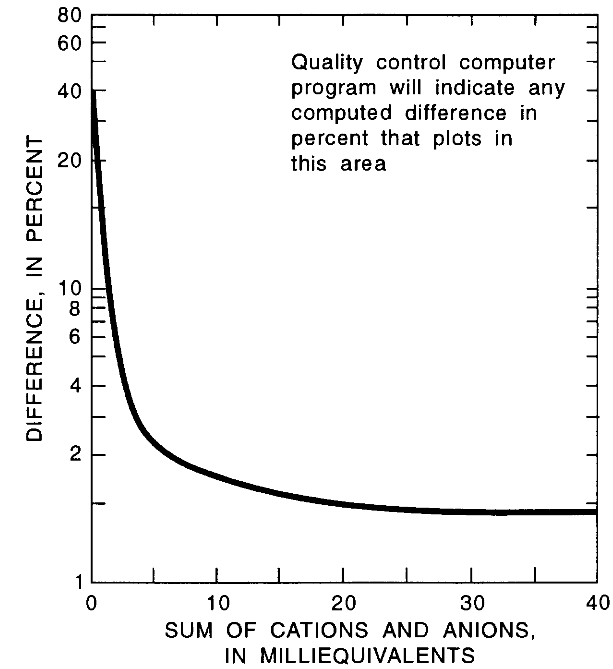

FIGURE B1.--Cation and anion percent difference curve.

Calculated solids is the dissolved-solids concentration determined by summing the concentrations of cations, anions, silica, and other major dissolved constituents. This value is theoretically equal to the dissolved-solids concentration determined analytically. Differences usually are due to errors in analyses of the various cations or anions (which may be verified by the cation-anion balance) or to errors in the analyzed dissolved-solids concentration.

For this study, the percent difference between the calculated and analyzed dissolved-solids concentrations was large for many samples. Samples from 106 of 359 wells had differences greater than 10 percent, up to a maximum of 31 percent. Only 139 samples had a difference of 5 percent or less. Furthermore, for 272 samples, the analyzed concentrations were less than the calculated concentrations, suggesting a strong bias for one of the determinations.

It was determined that the calculated concentrations of dissolved solids were the more accurate, on the basis of several considerations. First, no widespread problems could be found with the major ion analyses from which the calculated concentrations were determined; as noted previously, cation-anion balances were acceptable for most analyses. Secondly, errors in the calculated concentrations are normally errors of omission, usually by not analyzing for a contributing constituent. When that is the case, calculated concentrations are lower than analyzed concentrations, the opposite of that observed. Also, when questionable dissolved-solids concentrations were determined a second time, commonly the number was substantially different from the original. This discrepancy is also reflected by an average difference in duplicate pairs of 4.3 percent for analyzed concentrations, but only 0.5 percent for calculated concentrations (table B2). Finally, the error in analysis of the analyzed concentrations was 9.4 percent (table B1), which is somewhat large, given that all of the dissolved-solids concentrations were much larger than the detection limit.

It was decided, therefore, to use the calculated dissolved-solids concentration for interpretations in the study. This does not imply that the analyzed concentration is a poor number; it is just not as good as the calculated concentration. Subsequent investigations of the problem by personnel of the BQA and the NWQL have determined that a negative bias existed in some dissolved-solids analyses during the period the samples from this study were analyzed.

Checks on Field Values

The primary controls on the determinations of field values of pH, specific conductance, dissolved oxygen, and temperature are proper instrument calibration and field procedures. However, pH and specific conductance are also determined in the laboratory as standard procedure. Values of laboratory and field specific conductance differed by more than 5 percent for only 24 of 359 samples, and exceeded 10 percent for only 10 samples. Field and laboratory pH differed by more than 0.3 units for 86 of 359 samples, but only 31 of these differed by more than 0.5 units; the maximum difference was 1.6 units. Because pH and specific conductance values can change during the time between the field and laboratory determinations, these comparisons must be considered approximations at best, but the good agreement generally serves to confirm the field values.

Appendix C. Water-Quality Data Tables

Table C1. Values and concentrations of field measurements and common constituents

[°C; degrees Celsius; μS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; μg/L, micrograms per liter; <, not detected at the given concentration; >, concentration is greater than the given value; cols. per 100 mL, colonies per 100 milliliters; K in front of bacteria concentration denotes a non-ideal number of colonies on the counting plate; --, constituent concentration not determined; geohydrologic unit, see table A1 in Appendix A]

Table C1. Values and concentrations of field measurements and common constituents

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)
16N/01E-05F01	06-06-89	1340	Qc	518	274	11.5	133	134
16N/01E-07P02	06-06-89	1700	Tb	434	215	11.5	171	174
16N/01E-09F02	06-16-89	1500	Qva	428	120	10.0	121	122
16N/01E-09K01	06-16-89	1520	Qc	419	219	10.0	115	116
16N/01E-14G03	06-16-89	1355	Qc	450	120	10.5	144	146
16N/01E-16E01	06-19-89	1340	Tb	461	182	11.0	123	125
16N/01E-18N01	06-20-89	1215	Tb	340	100	13.5	98	99
16N/01E-18Q02	06-06-89	1530	Qvt	350	60	10.5	251	259
16N/01W-06L01	05-04-89	1215	Qva	243	58	11.5	145	112
16N/01W-21D04	05-04-89	1025	Qva	304	34	10.5	110	114
16N/02W-05N01	04-11-89	0950	TQu	270	149	10.5	122	123
16N/02W-05R01	04-04-89	1320	Tb	195	330	12.5	2,000	1,990
16N/02W-27H02	04-04-89	1520	Qva	260	47	10.0	68	68
16N/03W-02E01	06-09-89	1325	Qc	200	119	10.0	55	57
16N/03W-02H01	04-04-89	1055	Qva	155	88	10.0	121	121
	04-14-89	1555	Qva	155	88	10.5	125	122
16N/03W-12Q01	04-10-89	1325	TQu	217	80	10.5	89	89
17N/01E-05E01	06-07-89	1215	Qc	221	218	11.0	148	151
17N/01E-05N01	06-07-89	1305	Qc	225	305	11.0	136	141
17N/01E-06J03D1	06-20-89	1425	TQu	205	425	10.0	165	153
17N/01E-07F01	06-05-89	1420	Qva	208	104	11.5	124	125
17N/01E-07H01	06-12-89	1610	Qva	204	40	12.0	118	112
17N/01E-07L01	06-02-89	1545	Qva	215	72	11.5	114	115
17N/01E-07Q03	06-22-89	1020	Qva	211	35	10.0	208	206
17N/01E-08L03	06-02-89	1410	Qc	250	171	11.0	128	132
17N/01E-11R01	06-12-89	1150	TQu	315	193	12.0	240	242
17N/01E-13M02	06-05-89	1250	Qc	334	98	12.0	215	222
17N/01E-14D01	06-05-89	1100	Qc	375	158	12.0	158	162
17N/01E-14P01	06-16-89	1230	Qc	376	200	10.5	142	145
17N/01E-34M01	06-06-89	1915	Qva	470	196	11.0	148	153
17N/01E-35H01	06-06-89	1220	Qva	420	80	10.5	156	162
17N/01W-01B03	05-19-89	1240	Qc	222	182	11.5	155	158
17N/01W-01B04	05-19-89	1400	Qc	222	191	11.5	153	155
17N/01W-01F01	05-16-89	1315	Qc	230	160	10.5	144	144
17N/01W-01Q01	05-17-89	1335	Qva	205	97	10.5	132	134
17N/01W-01R01	05-17-89	1200	Qc	217	122	11.0	126	129
	05-17-89	1205	Qc	217	122	11.0	126	128
17N/01W-02E03	05-16-89	1515	Qva	178	49	11.0	154	155
17N/01W-02L02	05-16-89	1200	Qva	216	78	11.0	162	164

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	pH, (standard units)	pH, lab (standard units)	Oxygen, dissolved (mg/L)	Hardness total (mg/L as $CaCO_3$)	Hardness, noncarbonate total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
16N/01E-05F01	7.5	7.7	0.1	49	0	9.8	5.9	7.1
16N/01E-07P02	8.0	7.7	.2	64	0	21	2.9	11
16N/01E-09F02	6.9	7.1	9.8	46	0	9.6	5.4	6.0
16N/01E-09K01	6.9	7.1	9.5	43	0	9.0	5.0	5.9
16N/01E-14G03	6.6	6.6	7.5	54	1	11	6.5	6.7
16N/01E-16E01	7.2	7.4	6.3	41	0	12	2.8	9.1
16N/01E-18N01	6.4	7.0	6.1	30	0	8.9	2.0	6.7
16N/01E-18Q02	8.5	8.1	.0	53	0	18	1.9	40
16N/01W-06L01	7.0	6.7	.1	38	0	8.4	4.1	7.0
16N/01W-21D04	6.6	6.7	6.7	39	0	10	3.3	7.1
16N/02W-05N01	6.8	7.3	4.7	43	0	11	3.7	9.2
16N/02W-05R01	8.8	7.2	.5	430	420	170	.37	200
16N/02W-27H02	6.2	6.4	7.1	21	4	5.9	1.6	4.4
16N/03W-02E01	6.8	6.9	7.7	20	0	4.7	2.0	2.9
16N/03W-02H01	7.6	7.6	.0	50	0	11	5.5	5.9
	7.7	7.9	.0	48	0	10	5.5	5.6
16N/03W-12Q01	6.1	6.5	8.3	30	3	7.1	2.9	5.6
17N/01E-05E01	7.2	7.4	8.4	58	0	11	7.5	7.2
17N/01E-05N01	7.9	7.8	.1	54	0	10	7.0	7.3
17N/01E-06J03D1	7.3	7.7	.4	62	0	13	7.2	7.5
17N/01E-07F01	7.0	7.3	7.5	48	0	9.1	6.2	6.6
17N/01E-07H01	6.4	6.7	.4	38	0	8.3	4.3	6.4
17N/01E-07L01	6.2	6.6	8.1	41	6	9.4	4.2	6.6
17N/01E-07Q03	6.4	6.8	4.5	77	38	15	9.5	7.5
17N/01E-08L03	7.1	7.4	7.0	51	0	9.1	6.8	6.4
17N/01E-11R01	7.0	7.6	7.1	94	27	23	9.0	7.6
17N/01E-13M02	6.5	6.8	7.8	83	40	21	7.4	8.2
17N/01E-14D01	6.9	7.3	5.6	65	5	13	7.8	7.0
17N/01E-14P01	6.7	7.1	6.3	56	0	14	5.0	6.9
17N/01E-34M01	7.4	7.4	.8	64	0	12	8.2	7.1
17N/01E-35H01	6.6	7.0	8.5	64	2	15	6.5	7.7
17N/01W-01B03	7.1	7.5	9.3	62	18	13	7.2	6.4
17N/01W-01B04	7.1	7.3	6.5	58	12	12	6.8	6.3
17N/01W-01F01	6.9	7.1	4.6	55	3	11	6.8	5.8
17N/01W-01Q01	7.0	7.2	7.3	51	6	10	6.2	6.5
17N/01W-01R01	6.9	7.2	4.7	50	1	9.3	6.4	6.5
	6.9	7.3	4.7	48	0	9.1	6.2	6.2
17N/01W-02E03	6.8	7.0	8.7	61	20	15	5.8	6.2
17N/01W-02L02	6.9	7.0	7.8	64	15	14	7.1	6.9

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Sodium, percent	Sodium, adsorption ratio	Potassium, dissolved (mg/L as K)	Alkalinity, lab dissolved (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
16N/01E-05F01	23	0.5	2.1	49	7.0	7.1	0.2	51
16N/01E-07P02	27	.6	.3	74	11	2.6	.2	23
16N/01E-09F02	21	.4	1.5	46	3.0	3.4	.1	40
16N/01E-09K01	22	.4	1.4	46	2.0	3.7	.1	39
16N/01E-14G03	21	.4	1.4	53	3.0	4.8	<.1	38
16N/01E-16E01	32	.6	.9	56	2.0	2.0	.1	42
16N/01E-18N01	32	.5	.6	37	4.0	3.2	.1	23
16N/01E-18Q02	62	3	.1	122	9.0	3.3	.2	23
16N/01W-06L01	28	.5	1.5	42	9.0	7.6	.1	45
16N/01W-21D04	28	.5	.8	40	6.0	5.3	.1	31
16N/02W-05N01	31	.6	.9	60	1.3	2.2	.1	45
16N/02W-05R01	50	4	.7	11	26	600	.2	5.7
16N/02W-27H02	30	.4	.6	17	5.7	3.4	.1	16
16N/03W-02E01	24	.3	.2	20	1.0	2.6	<.1	17
16N/03W-02H01	20	.4	1.7	54	3.8	3.1	.1	38
	20	.4	1.7	54	3.3	3.1	.1	39
16N/03W-12Q01	29	.5	.5	27	4.1	2.5	.1	26
17N/01E-05E01	20	.4	2.1	66	5.0	3.5	.2	49
17N/01E-05N01	22	.4	2.1	67	2.0	2.6	.2	55
17N/01E-06J03D1	20	.4	2.3	73	<1.0	3.4	.1	56
17N/01E-07F01	22	.4	2.2	50	4.0	2.7	.1	45
17N/01E-07H01	26	.5	1.2	38	7.0	5.3	.1	34
17N/01E-07L01	25	.5	1.3	35	5.0	4.9	.1	38
17N/01E-07Q03	17	.4	1.9	39	12	12	.1	36
17N/01E-08L03	21	.4	2.5	56	4.0	2.9	.1	49
17N/01E-11R01	15	.4	2.1	68	6.0	8.0	.1	30
17N/01E-13M02	17	.4	1.5	43	8.0	9.1	.1	28
17N/01E-14D01	19	.4	1.8	60	4.0	4.8	.1	37
17N/01E-14P01	21	.4	1.5	57	3.0	4.0	.2	37
17N/01E-34M01	19	.4	2.3	67	3.0	3.6	.2	43
17N/01E-35H01	20	.4	1.6	62	5.0	5.2	.1	42
17N/01W-01B03	18	.4	2.0	44	10	3.4	<.1	34
17N/01W-01B04	18	.4	2.0	46	9.0	3.2	.1	34
17N/01W-01F01	18	3	2.0	53	6.0	3.4	.1	38
17N/01W-01Q01	21	.4	2.3	45	8.0	3.0	.1	43
17N/01W-01R01	21	.4	2.4	49	5.0	3.2	.1	43
	21	.4	2.4	50	5.0	3.2	.1	42
17N/01W-02E03	18	.4	1.2	41	8.0	4.9	.1	29
17N/01W-02L02	19	.4	1.4	49	8.0	4.8	.1	34

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Solids, residue at 180°C dis-solved (mg/L)	Solids, sum of consti-tuents, dis-solved (mg/L)	Nitro-gen NO_2+NO_3, dis-solved (mg/L as N)	Phos-phorous, dis-solved (mg/L as P)	Iron, dis-solved (µg/L as Fe)	Manga-nese, dis-solved (µg/L as Mn)	Coli-form, fecal (cols. per 100 mL)	Strep-tococci, fecal (cols. per 100 mL)
16N/01E-05F01	114	121	<0.10	0.05	940	140	<1	<1
16N/01E-07P02	103	116	<.10	.04	7	54	<1	<1
16N/01E-09F02	95	105	1.8	.05	7	<1	<1	<1
16N/01E-09K01	93	99	1.2	.04	5	1	<1	<1
16N/01E-14G03	108	113	2.3	.03	6	3	<1	<1
16N/01E-16E01	109	107	.51	.15	9	3	<1	<1
16N/01E-18N01	58	75	.98	.01	10	6	<1	1
16N/01E-18Q02	164	169	<.10	.01	7	18	<1	<1
16N/01W-06L01	128	119	<.10	<.01	11,000	340	<1	<1
16N/01W-21D04	94	90	.60	.04	6	<1	<1	<1
16N/02W-05N01	100	109	<.10	.11	9	3	<1	<1
16N/02W-05R01	1,130	1,010	<.10	<.01	250	39	<1	<1
16N/02W-27H02	38	52	1.0	.01	16	4	2	1
16N/03W-02E01	35	45	.58	<.01	29	2	<1	<1
16N/03W-02H01	89	102	<.10	.18	110	130	<1	<1
	97	101	<.10	.18	30	130	<1	<1
16N/03W-12Q01	70	74	2.0	.03	28	1	<1	<1
17N/01E-05E01	112	127	.37	.19	5	2	<1	<1
17N/01E-05N01	114	127	<.10	.20	19	300	<1	<1
17N/01E-06J03D1	130	138	<.10	.18	4,900	290	<1	<1
17N/01E-07F01	93	111	1.2	.06	8	<1	<1	<1
17N/01E-07H01	85	93	.17	.01	2,700	200	<1	8
17N/01E-07L01	92	98	1.8	.02	8	1	<1	<1
17N/01E-07Q03	162	152	7.9	.03	28	8	<1	<1
17N/01E-08L03	100	117	.58	.06	<3	<1	<1	<1
17N/01E-11R01	150	163	8.3	.02	14	<1	<1	<1
17N/01E-13M02	151	153	9.9	.01	6	<1	<1	<1
17N/01E-14D01	118	122	2.4	.03	7	1	<1	<1
17N/01E-14P01	113	112	1.5	.03	5	<1	<1	<1
17N/01E-34M01	116	122	.49	.09	6	53	<1	<1
17N/01E-35H01	110	126	1.4	.03	5	<1	<1	<1
17N/01W-01B03	112	123	4.6	.02	22	6	<1	<1
17N/01W-01B04	130	120	4.4	.03	6	1	<1	<1
17N/01W-01F01	118	112	1.6	.05	<3	<1	<1	<1
17N/01W-01Q01	109	115	2.0	.05	13	<1	<1	<1
17N/01W-01R01	105	111	1.4	.04	5	5	<1	<1
	100	110	1.3	.04	5	5	<1	<1
17N/01W-02E03	110	116	4.8	.02	10	<1	<1	<1
17N/01W-02L02	117	123	4.0	.02	17	2	<1	<1

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)
17N/01W-04E01	06-08-89	0845	Qvr	210	84	10.0	98	99
17N/01W-05H02	05-17-89	1530	Qvr	210	68	10.5	95	96
17N/01W-07R03	05-04-89	1545	Qc	210	120	12.0	119	118
17N/01W-08B02	05-19-89	1520	Qva	211	54	11.0	102	105
17N/01W-08L02	05-22-89	1120	Qva	200	85	11.5	133	136
17N/01W-09G02	05-22-89	1445	Qvt	216	55	11.5	134	136
17N/01W-09J02	05-22-89	1545	Qc	205	100	12.0	147	149
17N/01W-10N02	05-24-89	1045	Qva	236	78	11.5	145	148
17N/01W-11J01	05-26-89	1230	Qva	218	34	11.5	121	106
17N/01W-11M01	05-25-89	1305	TQu	270	334	10.5	118	117
17N/01W-13H01	05-25-89	1130	Qc	340	160	12.0	115	115
17N/01W-14H01	05-25-89	1430	Qva	218	50	13.0	101	102
17N/01W-14K01	05-26-89	0955	Qvr	218	29	11.0	118	120
	05-26-89	1000	Qvr	218	29	11.0	118	120
17N/01W-15A01	05-25-89	1000	Qva	264	91	10.5	94	96
17N/01W-15N02	05-31-89	1255	Qva	211	32	10.5	116	113
17N/01W-15P01	06-06-89	1025	Qva	210	40	11.5	104	108
	06-06-89	1030	Qva	210	40	11.5	104	108
17N/01W-16E02	05-19-89	1635	Qva	220	31	12.0	230	229
17N/01W-16L01	06-21-89	1445	Qva	210	51	10.5	127	129
17N/01W-17G02	05-22-89	1325	TQu	215	148	10.5	114	116
17N/01W-19C02	05-10-89	1130	TQu	220	119	9.5	121	119
17N/01W-19M02	05-03-89	1500	Tb	340	270	11.5	231	231
17N/01W-21K01	05-31-89	1125	Tb	360	507	11.5	410	395
17N/01W-32P02	06-01-89	1055	TQu	260	143	11.0	161	162
17N/01W-33E02	06-02-89	1100	Qc	245	81	11.5	104	106
17N/01W-33E03	05-31-89	1440	Qva	230	32	10.5	134	117
17N/01W-33E04	05-31-89	1610	Qva	230	54	10.5	203	169
17N/01W-34E01D1	06-30-89	1110	TQu	280	138	10.0	334	335
17N/01W-34L01	06-01-89	1815	Qc	290	70	11.0	750	756
17N/01W-34L02	06-01-89	1405	Tb	280	125	9.0	700	725
17N/01W-34M01	06-01-89	1545	Qvr	290	58	12.5	194	208
17N/02W-01E02	04-17-89	1400	Qva	175	92	12.0	167	168
17N/02W-02K01	04-17-89	1505	Qvr	170	60	11.0	114	113
17N/02W-03R02	05-24-89	1305	TQu	190	333	11.5	93	93
17N/02W-05A02	04-14-89	1200	Qvr	172	33	11.0	111	108
17N/02W-05J01D1	04-14-89	1315	Qc	190	106	10.5	124	120
	04-14-89	1320	Qc	190	106	10.5	124	119
17N/02W-06F03	04-14-89	1445	Qva	143	27	11.5	83	82
17N/02W-06P02	04-13-89	1330	Qc	137	59	12.0	125	113

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	pH, (standard units)	pH, lab (standard units)	Oxygen, dissolved (mg/L)	Hardness total (mg/L as $CaCO_3$)	Hardness, noncarbonate total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
17N/01W-04E01	6.6	6.9	9.2	36	8	10	2.6	4.6
17N/01W-05H02	6.6	6.9	8.4	34	5	9.6	2.5	4.7
17N/01W-07R03	7.4	7.5	7.4	45	0	9.7	5.1	6.1
17N/01W-08B02	6.6	6.6	8.8	37	4	9.9	3.0	6.1
17N/01W-08L02	7.8	7.8	.1	40	0	8.4	4.7	14
17N/01W-09G02	6.8	7.0	.8	53	2	11	6.1	6.9
17N/01W-09J02	7.5	7.5	.0	60	0	12	7.2	7.0
17N/01W-10N02	7.1	7.3	1.0	57	0	12	6.5	6.7
17N/01W-11J01	6.5	6.4	.0	38	5	9.3	3.5	5.9
17N/01W-11M01	7.7	7.4	.0	43	0	9.6	4.7	7.1
17N/01W-13H01	7.0	7.1	7.0	43	0	8.3	5.5	5.9
17N/01W-14H01	7.1	7.0	5.8	37	0	7.4	4.6	5.3
17N/01W-14K01	7.0	7.1	5.8	46	0	8.4	6.0	6.1
	7.0	7.0	5.8	46	0	8.5	6.0	6.1
17N/01W-15A01	6.6	6.9	7.9	35	1	8.9	3.0	5.1
17N/01W-15N02	7.5	7.6	6.8	43	0	7.9	5.7	6.5
17N/01W-15P01	7.2	7.4	2.2	40	0	7.7	5.0	5.8
	7.2	7.6	2.2	42	0	7.9	5.3	6.1
17N/01W-16E02	6.0	6.3	9.9	78	66	22	5.5	9.6
17N/01W-16L01	7.5	8.2	.1	45	0	9.5	5.2	8.8
17N/01W-17G02	7.8	7.9	.5	44	0	9.2	5.2	6.6
17N/01W-19C02	7.2	7.5	2.6	46	0	8.8	5.8	6.7
17N/01W-19M02	7.9	7.8	.1	76	0	24	3.9	23
17N/01W-21K01	7.8	8.0	.2	110	16	36	5.3	35
17N/01W-32P02	7.9	7.8	.2	45	0	16	1.2	20
17N/01W-33E02	6.4	6.9	4.0	38	0	10	3.2	6.0
17N/01W-33E03	6.6	6.9	3.4	45	0	10	4.8	5.9
17N/01W-33E04	6.6	6.7	.0	70	0	15	7.8	6.2
17N/01W-34E01D1	7.9	7.9	1.8	94	6	27	6.4	30
17N/01W-34L01	6.4	6.8	8.5	170	130	66	1.5	75
17N/01W-34L02	6.6	6.8	3.1	250	200	93	5.4	30
17N/01W-34M01	6.1	6.4	7.2	64	22	21	2.8	15
17N/02W-01E02	6.3	6.6	5.1	71	0	17	7.0	6.3
17N/02W-02K01	7.1	7.3	7.7	45	0	11	4.3	5.7
17N/02W-03R02	8.0	7.8	.0	32	0	8.0	2.8	6.7
17N/02W-05A02	7.4	7.7	2.6	40	2	7.3	5.3	5.2
17N/02W-05J01D1	7.9	7.7	5.5	44	11	9.8	4.7	5.2
	7.9	7.9	5.5	43	10	9.6	4.7	5.0
17N/02W-06F03	6.5	6.7	8.9	28	0	7.6	2.3	4.5
17N/02W-06P02	8.3	8.0	0.1	44	0	12	3.4	5.3

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Sodium, percent	Sodium, adsorption ratio	Potassium, dissolved (mg/L as K)	Alkalinity, lab dissolved (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
17N/01W-04E01	21	0.3	0.7	28	6.0	3.4	0.1	22
17N/01W-05H02	23	.4	.7	29	7.0	2.6	.1	21
17N/01W-07R03	22	.4	1.6	52	2.0	2.8	.1	47
17N/01W-08B02	26	.5	1.1	33	5.0	2.9	<.1	31
17N/01W-08L02	42	1	1.3	64	3.0	2.4	.2	28
17N/01W-09G02	22	.4	1.3	51	8.0	4.7	.1	39
17N/01W-09J02	20	.4	2.1	73	<1.0	2.4	.1	45
17N/01W-10N02	20	.4	1.9	62	4.0	4.9	.1	31
17N/01W-11J01	25	.4	1.1	33	8.0	7.7	.1	33
17N/01W-11M01	25	.5	1.6	53	4.0	2.7	.2	53
17N/01W-13H01	22	.4	2.1	48	4.0	3.0	.1	40
17N/01W-14H01	22	.4	1.9	39	4.0	3.3	.1	35
17N/01W-14K01	21	.4	2.3	50	4.0	3.4	.1	37
	21	.4	2.3	50	4.0	3.5	.1	38
17N/01W-15A01	24	.4	1.0	34	4.0	3.4	.1	28
17N/01W-15N02	23	.4	2.7	51	2.0	3.1	.1	44
17N/01W-15P01	23	.4	1.9	46	4.0	2.7	.1	46
	23	.4	1.9	46	4.0	2.7	.1	46
17N/01W-16E02	21	.5	1.2	12	1.0	11	.1	28
17N/01W-16L01	29	.6	1.8	57	2.0	3.6	.1	43
17N/01W-17G02	24	.4	1.6	56	2.0	1.9	.1	44
17N/01W-19C02	23	.4	2.4	46	8.0	2.7	.1	40
17N/01W-19M02	40	1	.4	106	11	3.4	.3	38
17N/01W-21K01	41	2	.1	96	19	52	.1	33
17N/01W-32P02	49	1	.4	78	3.0	3.0	.2	41
17N/01W-33E02	25	.4	.8	39	4.0	4.2	.1	27
17N/01W-33E03	22	.4	.8	54	2.0	4.6	.1	36
17N/01W-33E04	16	.3	.9	83	2.0	5.5	.1	57
17N/01W-34E01D1	41	1	.5	88	4.0	47	.1	38
17N/01W-34L01	49	3	1.0	39	8.0	210	<.1	27
17N/01W-34L02	20	.9	.3	55	11	170	.1	27
17N/01W-34M01	33	.9	.9	42	6.0	24	<.1	29
17N/02W-01E02	16	.3	1.5	75	3.6	3.7	<.1	34
17N/02W-02K01	21	.4	1.1	46	2.8	2.0	<.1	31
17N/02W-03R02	31	.5	1.1	44	<1.0	1.6	.1	41
17N/02W-05A02	21	.4	1.9	38	7.2	3.0	.1	33
17N/02W-05J01D1	20	.4	1.7	33	6.1	5.1	.1	31
	19	.3	1.7	33	6.2	5.1	.1	31
17N/02W-06F03	25	.4	.5	29	2.5	3.2	.1	18
17N/02W-06P02	20	.4	2.2	52	3.0	1.9	.1	26

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Solids, residue at 180°C dis-solved (mg/L)	Solids, sum of consti-tuents, dis-solved (mg/L)	Nitro-gen NO_2+NO_3, dis-solved (mg/L as N)	Phos-phorous, dis-solved (mg/L as P)	Iron, dis-solved (µg/L as Fe)	Manga-nese, dis-solved (µg/L as Mn)	Coli-form, fecal (cols. per 100 mL)	Strep-tococci, fecal (cols. per 100 mL)
17N/01W-04E01	68	75	2.1	0.01	4	<1	<1	<1
17N/01W-05H02	68	73	1.6	.01	4	16	<1	<1
17N/01W-07R03	108	108	.63	.05	6	1	<1	<1
17N/01W-08B02	87	89	2.4	.02	37	7	<1	<1
17N/01W-08L02	88	101	.14	.14	16	100	<1	<1
17N/01W-09G02	98	110	.42	<.01	46	15	<1	<1
17N/01W-09J02	109	120	<.10	.31	490	290	<1	<1
17N/01W-10N02	104	107	.69	.06	61	41	<1	<1
17N/01W-11J01	96	93	<.10	.01	5,000	100	<1	<1
17N/01W-11M01	109	115	<.10	.24	290	150	<1	<1
17N/01W-13H01	94	101	.72	.04	4	<1	<1	<1
17N/01W-14H01	77	90	.98	.03	32	10	<1	<1
17N/01W-14K01	94	100	.55	.03	6	1	<1	<1
	86	101	.55	.03	6	<1	<1	<1
17N/01W-15A01	77	79	1.1	.02	<3	<1	<1	<1
17N/01W-15N02	102	103	<.10	.09	82	4	<1	<1
17N/01W-15P01	86	102	.23	.09	<3	<1	<1	<1
	86	103	.23	.09	4	<1	--	--
17N/01W-16E02	202	169	19	.01	110	8	<1	<1
17N/01W-16L01	97	109	.11	.09	20	67	<1	<1
17N/01W-17G02	91	104	<.10	.06	20	2	<1	<1
17N/01W-19C02	94	104	.44	.05	18	21	<1	<1
17N/01W-19M02	165	168	<.10	.05	95	76	<1	<1
17N/01W-21K01	258	239	.13	.04	7	<1	<1	<1
17N/01W-32P02	123	132	<.10	.10	23	110	<1	<1
17N/01W-33E02	68	81	.63	<.01	24	6	<1	<1
17N/01W-33E03	96	101	<.10	.23	4,700	160	<1	<1
17N/01W-33E04	156	155	<.10	.75	10,000	490	<1	<1
17N/01W-34E01D1	203	206	.11	.05	10	42	<1	1
17N/01W-34L01	499	413	.33	.01	32	1	<1	<1
17N/01W-34L02	483	372	.48	.01	41	65	<1	<1
17N/01W-34M01	149	138	3.2	.01	30	<1	<1	<1
17N/02W-01E02	121	122	.67	<.01	680	110	<1	<1
17N/02W-02K01	94	93	1.6	.02	11	2	<1	<1
17N/02W-03R02	90	88	<.10	.22	210	130	<1	<1
17N/02W-05A02	86	91	1.1	.03	5	69	<1	<1
17N/02W-05J01D1	101	96	2.8	.04	<3	<1	<1	<1
	96	96	2.8	.04	5	<1	<1	<1
17N/02W-06F03	60	60	.91	.01	7	<1	<1	<1
17N/02W-06P02	90	85	<.10	.16	55	42	<1	<1

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)
17N/02W-06R01	04-14-89	1015	TQu	140	205	10.5	99	97
17N/02W-08L01	04-13-89	1025	Qvr	188	40	10.0	160	159
17N/02W-08R06	04-20-89	1010	Qva	195	65	10.5	80	80
17N/02W-09C02	05-02-89	1420	Qva	195	56	10.5	94	92
17N/02W-09G02	05-03-89	1100	Qva	190	56	11.5	122	128
17N/02W-10B02	05-24-89	1305	Qva	195	111	9.5	199	203
17N/02W-10N01	04-19-89	1310	Qva	190	56	12.5	107	106
17N/02W-11J01	04-13-89	1445	Qvr	198	79	11.0	126	125
17N/02W-12E02	04-19-89	1445	Qc	185	130	12.0	117	117
17N/02W-12L02	05-01-89	1120	Qc	195	157	12.5	137	137
17N/02W-14Q01	06-06-89	0900	Qva	198	65	10.0	112	114
17N/02W-14Q02	04-21-89	1405	Qva	200	40	10.5	95	96
17N/02W-17E01	05-02-89	0900	Qc	175	115	10.0	92	92
17N/02W-17H01	05-02-89	1530	Qva	190	39	11.0	93	91
17N/02W-17N02	04-20-89	1340	Qva	185	83	11.0	108	107
17N/02W-19F01	04-20-89	1450	Qc	164	100	11.0	127	126
17N/02W-20J03	04-21-89	1205	Qvr	188	60	11.0	181	176
17N/02W-22A02	04-13-89	1325	Qva	197	60	11.0	139	138
17N/02W-22H02	04-21-89	1530	Qva	196	67	11.5	153	150
17N/02W-23K01	04-24-89	1220	Qva	196	59	10.0	107	105
17N/02W-24D01	05-02-89	1030	Tb	220	120	11.0	215	210
17N/02W-25Q02	04-24-89	1415	TQu	274	113	10.5	238	227
17N/02W-25Q03	04-24-89	1520	MLT	276	280	10.5	172	163
17N/02W-26E01	04-26-89	1025	Qc	200	58	11.0	143	145
	04-26-89	1030	Qc	200	58	11.0	143	145
17N/02W-29A02	05-01-89	1405	Qva	190	50	10.5	107	105
17N/02W-29D02	05-01-89	1520	Qva	180	60	11.0	106	107
17N/02W-29G01	05-16-89	0935	Qva	195	50	10.5	126	127
17N/02W-29R01	04-13-89	1150	Qc	195	100	10.5	162	160
17N/02W-30E03	05-02-89	1215	Tb	186	146	10.0	168	166
17N/02W-31H01	04-07-89	1355	TQu	220	112	10.5	134	133
	04-07-89	1400	TQu	220	112	10.5	134	133
17N/02W-33K02	05-10-89	1015	Qc	205	41	11.0	141	140
17N/02W-35C01	04-10-89	1500	Tb	268	201	10.5	190	191
17N/03W-01G02	04-13-89	1000	Qva	220	93	10.5	108	108
17N/03W-02K01	04-13-89	1450	Qva	275	46	10.0	136	135
17N/03W-02K05	05-03-89	1305	Qva	300	105	10.5	153	153
17N/03W-10C01	04-12-89	1345	MLT	600	110	8.5	32	32
17N/03W-11K01	04-12-89	1530	Qva	180	58	10.5	117	116
17N/03W-12F01	04-17-89	1635	Qva	220	119	10.5	125	124

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	pH, (standard units)	pH, lab (standard units)	Oxygen, dissolved (mg/L)	Hardness total (mg/L as $CaCO_3$)	Hardness, noncarbonate total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
17N/02W-06R01	8.3	8.0	0.0	33	0	8.7	2.7	7.3
17N/02W-08L01	6.7	7.1	5.9	59	15	13	6.4	6.1
17N/02W-08R06	6.9	7.1	5.3	29	0	6.5	3.0	4.0
17N/02W-09C02	6.8	7.3	8.5	33	5	9.4	2.2	4.5
17N/02W-09G02	6.7	6.9	7.6	50	9	14	3.7	5.8
17N/02W-10B02	6.9	7.0	4.2	92	0	22	8.9	6.9
17N/02W-10N01	6.8	7.2	6.1	39	0	9.1	4.0	5.1
17N/02W-11J01	7.1	7.5	7.1	46	4	10	5.2	5.5
17N/02W-12E02	6.9	7.8	5.8	44	1	10	4.6	5.8
17N/02W-12L02	6.7	7.2	.3	53	0	13	4.9	7.4
17N/02W-14Q01	6.2	6.7	5.4	40	6	10	3.7	6.5
17N/02W-14Q02	6.2	6.3	4.7	32	3	7.9	2.9	5.8
17N/02W-17E01	7.6	7.8	5.0	34	0	7.2	3.8	5.0
17N/02W-17H01	6.6	6.8	6.8	32	5	7.9	3.0	4.7
17N/02W-17N02	6.8	7.1	4.2	41	0	10	4.0	5.3
17N/02W-19F01	7.2	7.4	1.1	51	0	11	5.8	5.7
17N/02W-20J03	6.9	6.9	.0	70	0	14	8.5	7.1
17N/02W-22A02	6.6	6.7	6.5	44	6	11	4.1	8.4
17N/02W-22H02	6.7	7.0	5.0	53	18	13	4.9	6.6
17N/02W-23K01	6.4	6.7	1.3	39	0	9.0	4.1	6.1
17N/02W-24D01	7.2	7.4	.2	80	2	22	6.0	13
17N/02W-25Q02	7.6	7.6	.1	94	0	23	8.8	14
17N/02W-25Q03	7.7	7.5	.0	65	0	14	7.2	9.5
17N/02W-26E01	7.3	7.4	.5	55	0	11	6.6	7.2
	7.3	7.4	.5	55	0	11	6.7	7.2
17N/02W-29A02	6.8	6.9	.6	42	0	9.7	4.3	4.7
17N/02W-29D02	7.4	7.7	.1	44	0	9.4	5.0	4.8
17N/02W-29G01	7.6	7.6	.1	51	0	12	5.0	5.2
17N/02W-29R01	7.9	7.8	.1	62	0	17	4.7	8.5
17N/02W-30E03	9.2	8.6	.1	18	0	5.6	.95	32
17N/02W-31H01	7.1	7.2	.3	49	0	9.0	6.4	7.7
	7.1	7.2	.3	49	0	9.1	6.4	7.7
17N/02W-33K02	6.5	7.0	5.1	53	8	12	5.7	7.1
17N/02W-35C01	8.4	8.2	3.5	47	0	16	1.6	24
17N/03W-01G02	7.4	7.5	10.1	46	0	12	3.9	3.6
17N/03W-02K01	6.9	7.3	7.2	58	0	13	6.2	4.7
17N/03W-02K05	7.9	7.8	.0	68	0	15	7.5	5.5
17N/03W-10C01	6.1	6.2	8.1	9	3	2.3	.91	2.0
17N/03W-11K01	6.9	7.0	9.2	51	0	13	4.5	3.9
17N/03W-12F01	8.2	7.8	8.7	52	0	13	4.8	4.1

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Sodium, percent	Sodium, adsorption ratio	Potassium, dissolved (mg/L as K)	Alkalinity, lab dissolved (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
17N/02W-06R01	32	0.6	0.9	48	<1.0	1.3	0.4	35
17N/02W-08L01	18	.4	1.6	44	11	7.3	.1	29
17N/02W-08R06	23	.3	1.0	31	1.7	2.2	.1	28
17N/02W-09C02	23	.4	.6	28	3.7	3.6	<.1	23
17N/02W-09G02	20	.4	1.0	41	4.0	3.5	.1	27
17N/02W-10B02	14	.3	1.9	98	3.0	2.5	<.1	30
17N/02W-10N01	21	.4	1.4	41	3.5	2.7	.1	28
17N/02W-11J01	20	.4	1.7	42	4.0	3.3	.1	32
17N/02W-12E02	22	.4	1.6	43	3.2	2.6	.1	36
17N/02W-12L02	23	.5	1.5	55	5.6	3.3	.1	31
17N/02W-14Q01	25	.5	1.0	34	5.0	4.6	.1	29
17N/02W-14Q02	28	.5	.9	29	5.2	4.0	<.1	28
17N/02W-17E01	23	.4	1.6	37	2.6	2.5	.1	32
17N/02W-17H01	24	.4	.8	27	6.0	3.8	.1	24
17N/02W-17N02	21	.4	1.3	43	2.6	3.1	.1	26
17N/02W-19F01	19	.4	1.9	55	3.5	2.9	.1	33
17N/02W-20J03	18	.4	2.2	80	4.3	4.8	.1	37
17N/02W-22A02	28	.6	1.4	38	4.9	7.2	.1	26
17N/02W-22H02	21	.4	1.5	35	3.0	7.7	.1	28
17N/02W-23K01	25	.4	1.2	41	6.7	2.7	<.1	36
17N/02W-24D01	26	.7	.2	78	22	4.4	.1	33
17N/02W-25Q02	24	.6	.9	119	3.8	2.5	<.1	28
17N/02W-25Q03	23	.5	2.9	78	6.1	2.4	<.1	45
17N/02W-26E01	21	.4	2.4	65	3.7	2.6	.1	38
	21	.4	2.5	65	3.7	2.6	.1	38
17N/02W-29A02	19	.3	1.3	42	5.7	3.6	.1	38
17N/02W-29D02	18	.3	1.8	48	3.1	2.8	.1	35
17N/02W-29G01	17	.3	2.4	56	4.0	3.5	.1	44
17N/02W-29R01	22	.5	2.9	78	2.0	3.5	.1	41
17N/02W-30E03	79	3	.4	82	1.4	3.0	.1	19
17N/02W-31H01	24	.5	3.6	63	2.4	2.5	.1	64
	24	.5	2.9	63	2.8	2.5	.1	63
17N/02W-33K02	22	.4	1.4	46	8.0	4.7	.1	31
17N/02W-35C01	53	2	.3	87	8.6	2.3	.1	23
17N/03W-01G02	14	.2	.6	46	1.9	2.7	.1	21
17N/03W-02K01	15	.3	.8	59	1.9	3.0	<.1	25
17N/03W-02K05	15	.3	1.1	74	2.3	2.3	.1	34
17N/03W-10C01	31	.3	.2	7.0	1.8	2.5	.1	11
17N/03W-11K01	14	.2	.5	51	2.5	2.3	.1	23
17N/03W-12F01	14	.3	.8	52	1.7	2.7	<.1	17

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Solids, residue at 180°C dis-solved (mg/L)	Solids, sum of consti-tuents, dis-solved (mg/L)	Nitro-gen NO_2+NO_3, dis-solved (mg/L as N)	Phos-phorous, dis-solved (mg/L as P)	Iron, dis-solved (µg/L as Fe)	Manga-nese, dis-solved (µg/L as Mn)	Coli-form, fecal (cols. per 100 mL)	Strep-tococci, fecal (cols. per 100 mL)
17N/02W-06R01	82	85	<0.10	0.32	61	92	<1	<1
17N/02W-08L01	118	113	2.7	.02	37	5	<1	<1
17N/02W-08R06	68	69	.91	.02	5	1	<1	<1
17N/02W-09C02	65	73	2.2	.01	<3	<1	<1	<1
17N/02W-09G02	98	98	3.3	.01	9	1	<1	<1
17N/02W-10B02	123	137	.73	<.01	<3	<1	<1	<1
17N/02W-10N01	85	83	1.0	.01	9	8	<1	<1
17N/02W-11J01	102	99	2.8	.03	6	<1	<1	<1
17N/02W-12E02	99	99	2.2	.04	7	2	<1	<1
17N/02W-12L02	87	105	1.2	<.01	64	100	<1	<1
17N/02W-14Q01	80	90	2.3	.02	6	<1	<1	<1
17N/02W-14Q02	79	78	1.4	.01	19	4	<1	<1
17N/02W-17E01	67	81	.82	.06	<3	<1	<1	<1
17N/02W-17H01	60	73	1.5	.02	5	<1	<1	<1
17N/02W-17N02	78	82	.86	.01	14	4	<1	<1
17N/02W-19F01	95	98	.25	.05	22	4	<1	<1
17N/02W-20J03	122	129	<.10	<.01	2,700	200	<1	<1
17N/02W-22A02	104	102	3.7	.02	6	<1	<1	<1
17N/02W-22H02	111	108	5.1	.03	6	1	<1	<1
17N/02W-23K01	91	92	.42	.02	74	2	<1	--
17N/02W-24D01	136	148	<.10	.02	81	57	<1	<1
17N/02W-25Q02	147	153	<.10	.05	250	3	<1	--
17N/02W-25Q03	124	134	<.10	.11	390	190	<1	--
17N/02W-26E01	103	112	.30	.13	24	7	<1	<1
	106	112	.30	.14	23	6	<1	<1
17N/02W-29A02	89	94	<.10	.01	1,100	180	<1	<1
17N/02W-29D02	89	91	<.10	.06	180	23	<1	<1
17N/02W-29G01	101	110	<.10	.18	60	140	<1	<1
17N/02W-29R01	127	127	<.10	.33	83	160	<1	<1
17N/02W-30E03	100	112	<.10	.08	5	15	<1	<1
17N/02W-31H01	127	134	<.10	.03	270	270	<1	<1
	129	133	<.10	.03	290	270	<1	1
17N/02W-33K02	95	107	2.0	.02	330	22	<1	<1
17N/02W-35C01	127	128	<.10	.03	7	<1	<1	<1
17N/03W-01G02	82	77	.93	.01	6	<1	<1	1
17N/03W-02K01	96	94	.90	.01	16	3	<1	<1
17N/03W-02K05	109	113	<.10	.21	340	360	<1	<1
17N/03W-10C01	30	28	.57	<.01	23	5	<1	<1
17N/03W-11K01	81	82	.43	<.01	5	<1	<1	<1
17N/03W-12F01	86	83	1.5	.01	3	8	<1	<1

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)
17N/03W-15A01	04-13-89	1125	Tb	240	310	10.5	147	148
17N/03W-17A01	04-12-89	1030	Tb	515	38	11.0	117	117
17N/03W-17D01	04-12-89	1205	TQu	485	75	9.5	77	74
17N/03W-22J01	04-11-89	1330	Qva	200	98	9.5	82	81
17N/03W-23Q02	04-11-89	1600	Qva	230	111	10.5	96	94
17N/03W-24D01	04-11-89	1145	Qva	200	97	11.0	92	93
17N/03W-25D01	04-06-89	1220	Qc	160	113	9.0	107	107
17N/03W-25J02	04-10-89	1130	Qc	180	45	10.5	98	93
17N/03W-25R04	04-06-89	1415	Qc	165	44	9.5	50	50
17N/03W-25R05	04-06-89	1100	Qc	170	94	11.5	127	120
17N/03W-26F01	04-07-89	1205	Qc	200	96	9.5	98	102
17N/03W-27N01	04-05-89	1510	TQu	300	156	9.5	94	96
17N/03W-34J01	04-05-89	0930	Qva	170	55	10.5	64	65
17N/03W-36N05	04-07-89	1025	Qc	160	40	10.0	95	96
18N/01E-06R01	06-07-89	1615	Qc	18	250	11.5	150	152
18N/01E-08D03	06-07-89	1725	Qc	10	110	12.0	182	181
18N/01E-17Q01	06-09-89	1110	Qc	181	260	10.5	132	134
18N/01E-18A01	06-16-89	1110	Qc	15	120	11.5	134	134
18N/01E-19J01S	06-19-89	1050	Qvr	7	--	11.5	186	187
18N/01E-19Q01S	06-19-89	1215	Qvr	5	--	10.5	148	148
18N/01E-21N02	06-14-89	1835	Qc	220	200	11.0	154	154
18N/01E-21P03	05-08-89	1355	Qc	230	235	12.5	135	135
18N/01E-28M01	06-30-89	0940	Qc	238	194	10.0	131	134
18N/01E-30C01	06-24-89	0940	Qvr	160	26	13.0	106	108
18N/01E-30N02	05-08-89	1215	Qc	212	190	10.5	152	153
18N/01E-31A01	05-10-89	1710	Qc	83	92	10.0	133	133
18N/01E-31F01	05-10-89	1540	Qc	222	214	10.5	131	129
18N/01E-31H03	06-21-89	1220	Qc	160	193	10.5	152	154
18N/01E-31N01	06-15-89	1235	Qva	212	139	11.0	121	121
18N/01E-31Q01D1	06-08-89	1600	TQu	156	373	10.5	172	161
18N/01E-32C02	06-14-89	1535	Qc	140	128	11.5	119	122
18N/01E-32H02	06-21-89	1320	Qc	253	216	10.5	129	130
18N/01E-32N01	06-14-89	1715	Qc	115	92	10.5	162	164
18N/01E-34F03	06-12-89	0950	Qc	260	255	10.0	144	148
18N/01E-34F04	06-23-89	1210	Qc	260	280	11.0	145	149
18N/01E-34J01	06-12-89	1315	Qc	264	229	10.5	140	142
18N/01W-01H02	05-08-89	1525	Qc	225	255	10.5	235	236
18N/01W-02G02	06-08-89	1140	Qc	237	241	11.5	498	500
18N/01W-02H01	06-08-89	1350	Qva	245	139	10.0	92	94
18N/01W-03E01	04-26-89	1455	Qva	95	63	10.0	75	74

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	pH, (standard units)	pH, lab (standard units)	Oxygen, dissolved (mg/L)	Hardness total (mg/L as $CaCO_3$)	Hardness, noncarbonate total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
17N/03W-15A01	9.9	9.2	0.4	4	0	1.6	0.12	32
17N/03W-17A01	7.0	7.0	8.8	51	0	11	5.8	5.1
17N/03W-17D01	6.6	6.8	6.5	34	0	7.0	4.0	3.1
17N/03W-22J01	6.6	7.1	7.0	31	0	8.2	2.6	4.2
17N/03W-23Q02	7.0	7.2	7.7	36	0	8.6	3.6	5.0
17N/03W-24D01	7.0	7.3	7.7	35	0	8.2	3.5	4.5
17N/03W-25D01	7.8	7.5	1.2	39	0	9.6	3.6	6.2
17N/03W-25J02	7.2	7.9	.0	35	0	7.7	3.9	4.9
17N/03W-25R04	6.4	7.8	6.1	15	1	3.7	1.3	3.5
17N/03W-25R05	7.3	7.2	2.0	45	0	10	4.9	5.2
17N/03W-26F01	7.2	7.4	7.4	39	0	7.9	4.6	5.1
17N/03W-27N01	6.9	7.1	3.3	37	0	8.9	3.7	4.2
17N/03W-34J01	6.7	7.1	5.7	25	0	5.9	2.5	3.4
17N/03W-36N05	7.2	7.2	1.7	37	0	8.1	4.1	5.0
18N/01E-06R01	7.7	7.5	.1	51	0	12	5.1	12
18N/01E-08D03	7.6	7.6	.0	64	0	15	6.4	12
18N/01E-17Q01	7.0	7.3	3.5	47	0	8.9	5.9	7.7
18N/01E-18A01	7.2	7.1	.4	52	0	11	5.9	6.2
18N/01E-19J01S	7.5	7.5	1.5	50	0	11	5.4	19
18N/01E-19Q01S	6.9	7.2	4.8	56	0	11	7.0	6.7
18N/01E-21N02	7.3	8.0	6.6	58	0	12	6.7	7.0
18N/01E-21P03	7.1	7.3	6.5	52	0	10	6.5	6.5
18N/01E-28M01	6.9	7.5	7.7	52	0	10	6.5	6.2
18N/01E-30C01	6.2	6.9	7.4	40	11	11	3.1	5.0
18N/01E-30N02	7.0	7.1	7.2	60	9	12	7.3	6.7
18N/01E-31A01	6.7	7.0	3.4	55	0	9.7	7.4	5.7
18N/01E-31F01	7.2	7.4	5.1	48	0	9.8	5.8	6.5
18N/01E-31H03	7.6	7.6	.1	65	0	11	9.2	5.9
18N/01E-31N01	7.1	7.3	.1	48	0	7.8	6.9	5.3
18N/01E-31Q01D1	7.1	7.1	.0	63	0	11	8.7	5.9
18N/01E-32C02	6.6	6.8	1.1	46	0	8.6	6.0	5.7
18N/01E-32H02	7.2	7.4	5.9	49	0	9.4	6.1	6.6
18N/01E-32N01	6.8	7.4	4.8	64	1	13	7.6	7.0
18N/01E-34F03	7.4	7.7	4.5	53	0	11	6.3	8.6
18N/01E-34F04	7.0	7.5	3.5	57	0	12	6.6	8.6
18N/01E-34J01	6.8	7.3	7.3	53	0	10	6.8	6.5
18N/01W-01H02	7.5	7.6	2.8	100	0	20	13	7.6
18N/01W-02G02	7.0	7.0	1.9	270	49	55	33	15
18N/01W-02H01	7.4	7.4	7.1	38	1	7.8	4.5	4.5
18N/01W-03E01	6.8	7.3	8.7	26	4	5.0	3.2	3.6

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Sodium, percent	Sodium, ad sorption ratio	Potassium, dissolved (mg/L as K)	Alkalinity, lab dissolved (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
17N/03W-15A01	94	7	0.1	54	3.8	9.5	0.3	33
17N/03W-17A01	18	0.3	.5	57	<1.0	3.3	.1	49
17N/03W-17D01	16	.2	.3	38	<1.0	1.8	.1	27
17N/03W-22J01	22	.3	.6	35	1.4	1.9	.1	26
17N/03W-23Q02	22	.4	1.1	40	1.9	2.1	.1	32
17N/03W-24D01	21	.3	1.0	42	1.2	2.4	.1	28
17N/03W-25D01	25	.4	1.7	50	2.6	2.1	.1	29
17N/03W-25J02	22	.4	1.3	38	12	3.3	.1	30
17N/03W-25R04	33	.4	.5	14	3.5	3.5	.1	22
17N/03W-25R05	19	.3	1.7	49	5.5	3.8	.1	46
17N/03W-26F01	21	.4	1.6	44	1.7	2.2	.1	36
17N/03W-27N01	19	.3	.8	45	1.6	2.5	.1	28
17N/03W-34J01	22	.3	.4	26	1.2	2.7	.1	20
17N/03W-36N05	22	.4	1.0	39	3.8	2.7	.1	31
18N/01E-06R01	33	.8	1.8	73	<1.0	3.1	.2	54
18N/01E-08D03	28	.7	2.5	90	<1.0	2.8	.2	51
18N/01E-17Q01	26	.5	1.8	58	5.0	2.8	.1	39
18N/01E-18A01	20	.4	1.9	53	7.0	3.3	.1	40
18N/01E-19J01S	44	1	2.3	83	2.0	6.7	.1	44
18N/01E-19Q01S	20	.4	2.0	56	5.0	4.1	.1	40
18N/01E-21N02	20	.4	2.0	58	6.0	3.9	.1	36
18N/01E-21P03	21	.4	2.0	53	5.0	3.2	.1	40
18N/01E-28M01	20	.4	2.0	56	4.0	3.1	.1	42
18N/01E-30C01	21	.4	.7	29	7.0	4.2	<.1	24
18N/01E-30N02	19	.4	2.1	51	7.0	3.9	.1	39
18N/01E-31A01	18	.3	1.9	58	4.0	3.2	.1	43
18N/01E-31F01	21	.4	2.7	50	5.0	3.1	.1	50
18N/01E-31H03	16	.3	2.2	72	2.0	2.8	.1	57
18N/01E-31N01	19	.3	2.2	55	2.0	3.3	.1	62
18N/01E-31Q01D1	16	.3	2.5	77	1.0	4.3	.1	50
18N/01E-32C02	20	.4	2.0	52	4.0	3.4	.1	32
18N/01E-32H02	22	.4	2.0	53	4.0	3.3	.1	44
18N/01E-32N01	19	.4	2.0	63	6.0	4.2	.1	42
18N/01E-34F03	25	.5	1.9	67	3.0	2.8	.2	52
18N/01E-34F04	24	.5	2.5	69	3.0	3.3	.1	51
18N/01E-34J01	20	.4	2.0	58	4.0	3.3	.1	40
18N/01W-01H02	13	.3	2.8	109	6.0	5.9	.1	31
18N/01W-02G02	11	.4	3.6	225	1.0	28	.1	45
18N/01W-02H01	20	.3	1.1	37	6.0	2.2	.1	28
18N/01W-03E01	23	.3	.9	22	6.5	2.4	.1	21

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Solids, residue at 180°C dis-solved (mg/L)	Solids, sum of consti-tuents, dis-solved (mg/L)	Nitro-gen NO_2+NO_3, dis-solved (mg/L as N)	Phos-phorous, dis-solved (mg/L as P)	Iron, dis-solved (µg/L as Fe)	Manga-nese, dis-solved (µg/L as Mn)	Coli-form, fecal (cols. per 100 mL)	Strep-tococci, fecal (cols. per 100 mL)
17N/03W-15A01	113	113	<0.10	<0.01	<3	<1	<1	<1
17N/03W-17A01	106	109	<.10	.06	6	<1	<1	<1
17N/03W-17D01	61	66	<.10	<.01	36	27	<1	<1
17N/03W-22J01	65	69	.61	.01	8	3	<1	<1
17N/03W-23Q02	78	82	.82	.02	<3	<1	<1	<1
17N/03W-24D01	69	76	.38	.02	9	3	<1	<1
17N/03W-25D01	74	85	<.10	.11	50	84	<1	<1
17N/03W-25J02	68	88	<.10	.02	1,900	160	<1	<1
17N/03W-25R04	40	48	.32	.01	8	<1	<1	<1
17N/03W-25R05	102	109	<.10	.15	2,100	230	<1	<1
17N/03W-26F01	86	88	.63	.03	17	8	<1	10
17N/03W-27N01	69	77	.11	.06	23	8	<1	<1
17N/03W-34J01	42	54	.49	.01	8	1	<1	<1
17N/03W-36N05	85	82	.50	.02	27	120	<1	<1
18N/01E-06R01	113	133	<.10	.70	170	630	<1	<1
18N/01E-08D03	130	145	<.10	.49	720	360	<1	<1
18N/01E-17Q01	98	107	.17	.14	43	<1	<1	<1
18N/01E-18A01	111	108	<.10	.04	890	35	<1	<1
18N/01E-19J01S	131	141	.15	.36	130	170	>60	>100
18N/01E-19Q01S	119	117	1.6	.10	4	<1	<1	<1
18N/01E-21N02	107	117	1.9	.04	7	<1	<1	<1
18N/01E-21P03	105	110	1.2	.06	<3	<1	<1	<1
18N/01E-28M01	104	112	.92	.04	28	<1	<1	<1
18N/01E-30C01	91	82	2.2	.01	7	1	<1	<1
18N/01E-30N02	114	122	3.0	.05	4	<1	<1	<1
18N/01E-31A01	113	112	.51	.08	<3	<1	<1	<1
18N/01E-31F01	99	119	1.4	.06	<3	<1	<1	<1
18N/01E-31H03	128	134	<.10	.15	150	600	<1	<1
18N/01E-31N01	105	123	<.10	.27	130	390	<1	<1
18N/01E-31Q01D1	120	138	<.10	.22	5,000	3,400	<1	<1
18N/01E-32C02	93	94	.25	.02	110	3	<1	<1
18N/01E-32H02	100	111	.88	.05	7	<1	<1	<1
18N/01E-32N01	110	128	1.8	.10	14	<1	<1	<1
18N/01E-34F03	118	127	.33	.14	<3	<1	<1	<1
18N/01E-34F04	122	130	.34	.11	6	<1	<1	<1
18N/01E-34J01	108	112	1.1	.04	<3	2	<1	<1
18N/01W-01H02	147	153	.21	.03	9	<1	<1	<1
18N/01W-02G02	311	316	<.10	<.01	490	260	<1	<1
18N/01W-02H01	70	76	<.10	.03	<3	<1	<1	<1
18N/01W-03E01	50	59	.64	.02	8	2	<1	<1

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)
18N/01W-03H02	06-14-89	0950	Qc	205	233	10.5	132	135
18N/01W-04M01	04-27-89	1440	Qva	70	77	9.5	161	162
18N/01W-04N01	04-27-89	1245	TQu	80	326	9.5	183	184
18N/01W-05E03	05-01-89	1325	Qva	165	46	11.5	442	381
18N/01W-05G02	04-27-89	1615	Qva	110	56	10.5	153	153
18N/01W-06A03	04-28-89	1410	Qc	160	118	11.5	161	145
18N/01W-06E02	05-01-89	1150	Qvt	165	79	10.0	136	135
18N/01W-07C01	04-28-89	1550	Qvt	175	63	11.0	132	130
18N/01W-07E04	04-28-89	1700	Qvt	175	80	9.5	81	79
	04-28-89	1705	Qvt	175	80	9.5	81	80
18N/01W-07H04	05-01-89	1455	Qc	195	141	11.5	119	117
18N/01W-07N03	05-04-89	1015	Qva	195	98	10.5	155	175
18N/01W-08G02	05-01-89	1640	Qva	150	67	10.5	97	94
18N/01W-09J01	05-03-89	1300	Qc	105	195	10.0	210	209
18N/01W-11P05	06-21-89	0950	Qva	205	73	12.5	163	165
	06-21-89	0955	Qva	205	73	12.5	163	166
18N/01W-12F01	06-08-89	1515	TQu	215	380	11.0	127	128
18N/01W-12M01D1	06-15-89	1045	Qc	218	239	11.0	127	128
18N/01W-12R03	06-13-89	1550	Qf	235	145	10.5	121	125
18N/01W-13A02	06-08-89	1415	Qc	235	240	11.5	132	133
18N/01W-13C01	06-14-89	1130	Qvr	200	16	11.0	145	147
18N/01W-13G02	06-14-89	1250	Qc	210	259	10.0	136	139
18N/01W-14L02	06-15-89	0945	Qva	218	53	11.5	312	311
18N/01W-14R01	05-08-89	1115	Qc	225	254	11.0	129	129
18N/01W-16Q03	06-06-89	1055	Qf	160	137	11.0	103	105
18N/01W-17H05	05-03-89	1110	Qva	202	101	11.5	182	178
18N/01W-19M05	05-03-89	1455	Qva	210	70	10.5	219	217
18N/01W-21B06	06-08-89	1250	TQu	178	481	9.0	134	136
18N/01W-22K01	05-04-89	1510	Qvr	199	56	13.5	235	227
18N/01W-23B02	06-15-89	1405	Qvr	167	32	11.5	129	132
18N/01W-24B02	06-13-89	1425	Qva	242	103	11.0	245	248
18N/01W-25B01	05-08-89	1015	Qc	260	239	10.5	142	143
18N/01W-25P02	06-14-89	1430	Qva	181	57	11.0	117	119
18N/01W-26A02	06-13-89	1245	Qva	230	118	11.0	180	182
18N/01W-27M02	05-05-89	1750	TQu	190	388	10.0	114	113
18N/01W-28E01	06-08-89	1115	Qc	232	217	10.5	165	168
18N/01W-28J01	05-05-89	1435	Qc	185	127	11.5	143	141
18N/01W-30E04	05-03-89	1630	Qva	202	75	10.5	128	125
18N/01W-31A02	05-08-89	1740	Qva	210	140	10.0	152	142
18N/01W-31A03	05-08-89	1310	Qva	209	139	10.5	136	129

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	pH, (standard units)	pH, lab (standard units)	Oxygen, dissolved (mg/L)	Hardness total (mg/L as $CaCO_3$)	Hardness, noncarbonate total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
18N/01W-03H02	7.4	8.1	9.2	52	3	9.0	7.1	5.6
18N/01W-04M01	6.8	7.4	3.6	64	11	12	8.3	6.5
18N/01W-04N01	8.3	7.9	.0	69	0	17	6.5	10
18N/01W-05E03	6.2	5.9	.1	98	82	21	11	26
18N/01W-05G02	6.8	7.2	8.2	63	1	12	8.0	6.6
18N/01W-06A03	7.1	7.1	.0	55	0	11	6.6	8.2
18N/01W-06E02	7.0	7.3	.5	54	2	10	7.1	5.7
18N/01W-07C01	6.5	6.7	7.8	49	11	11	5.3	6.0
18N/01W-07E04	6.5	6.9	6.6	27	0	6.3	2.7	5.0
	6.5	6.9	6.6	27	0	6.3	2.7	5.0
18N/01W-07H04	7.8	7.9	1.1	44	0	11	4.1	5.5
18N/01W-07N03	7.6	7.5	.5	71	0	13	9.3	7.1
18N/01W-08G02	7.6	7.6	.4	32	0	7.6	3.1	6.3
18N/01W-09J01	7.1	7.3	1.0	89	0	16	12	7.4
18N/01W-11P05	6.6	7.3	7.9	56	22	16	3.9	9.1
	6.6	7.3	7.9	56	22	16	4.0	9.1
18N/01W-12F01	7.6	7.7	5.7	50	0	10	6.0	7.0
18N/01W-12M01D1	7.5	7.7	7.7	48	0	9.7	5.8	6.2
18N/01W-12R03	7.7	7.8	4.5	47	0	10	5.3	5.6
18N/01W-13A02	7.4	7.4	4.8	54	3	12	5.9	5.8
18N/01W-13C01	7.3	7.8	4.6	56	2	12	6.4	6.3
18N/01W-13G02	7.1	7.2	4.1	54	0	12	5.8	6.1
18N/01W-14L02	6.6	7.0	5.2	130	36	34	11	9.3
18N/01W-14R01	7.1	7.2	4.4	50	1	11	5.5	5.9
18N/01W-16Q03	7.6	7.5	8.4	38	0	7.8	4.5	4.7
18N/01W-17H05	6.2	6.5	5.7	69	10	18	5.8	7.7
18N/01W-19M05	6.5	6.7	2.1	85	32	16	11	7.3
18N/01W-21B06	7.7	7.7	.2	53	0	7.5	8.4	6.2
18N/01W-22K01	6.1	6.3	5.1	74	36	20	5.8	12
18N/01W-23B02	7.1	7.4	8.6	51	11	13	4.5	5.4
18N/01W-24B02	7.6	7.8	5.4	110	5	24	11	8.1
18N/01W-25B01	7.0	7.2	7.5	58	8	13	6.1	5.9
18N/01W-25P02	7.0	7.3	7.4	45	5	11	4.3	5.4
18N/01W-26A02	6.9	7.2	7.8	69	10	15	7.7	7.7
18N/01W-27M02	8.1	8.0	2.1	46	0	11	4.4	5.4
18N/01W-28E01	6.8	6.9	7.5	66	5	14	7.5	7.9
18N/01W-28J01	7.0	7.4	8.1	57	9	13	6.0	6.1
18N/01W-30E04	6.5	6.9	7.7	46	0	10	5.1	6.6
18N/01W-31A02	7.1	7.2	.0	55	1	11	6.6	6.3
18N/01W-31A03	7.4	7.4	.0	48	0	7.5	7.1	8.6

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Sodium, percent	Sodium, adsorption ratio	Potassium, dissolved (mg/L as K)	Alkalinity, lab dissolved (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
18N/01W-03H02	18	0.3	1.9	49	6.0	4.0	0.1	27
18N/01W-04M01	18	.4	1.5	53	5.8	9.6	.1	33
18N/01W-04N01	23	.5	3.4	79	8.8	3.6	.1	36
18N/01W-05E03	36	1	1.7	16	4.0	100	.1	50
18N/01W-05G02	18	.4	1.5	62	4.8	4.8	.1	34
18N/01W-06A03	24	.5	1.8	70	<1.0	3.8	.2	60
18N/01W-06E02	18	.3	1.7	52	11	3.1	.1	38
18N/01W-07C01	20	.4	1.4	38	8.0	4.5	.1	33
18N/01W-07E04	28	.4	.9	28	5.7	2.6	.1	33
	28	.4	.9	28	5.7	2.5	.1	33
18N/01W-07H04	20	.4	2.3	51	4.0	3.0	.1	32
18N/01W-07N03	17	.4	1.9	77	8.0	4.0	.1	40
18N/01W-08G02	29	.5	1.8	45	<1.0	2.7	.1	47
18N/01W-09J01	15	.3	3.0	95	5.0	5.1	.1	40
18N/01W-11P05	26	.5	.9	34	9.0	7.7	<.1	21
	26	.5	.9	35	8.0	7.6	<.1	21
18N/01W-12F01	23	.4	1.8	51	4.0	3.5	.1	42
18N/01W-12M01D1	21	.4	2.1	49	5.0	3.9	.1	35
18N/01W-12R03	20	.4	2.2	49	7.0	2.6	.1	32
18N/01W-13A02	18	.4	1.7	51	5.0	3.5	.1	37
18N/01W-13C01	19	.4	1.8	54	6.0	4.4	.1	38
18N/01W-13G02	19	.4	1.7	54	5.0	3.4	.1	38
18N/01W-14L02	13	.4	1.5	94	14	9.2	<.1	26
18N/01W-14R01	20	.4	1.6	49	6.0	3.5	.1	38
18N/01W-16Q03	20	.3	2.3	38	7.0	2.3	.1	39
18N/01W-17H05	19	.4	1.1	59	9.0	6.6	.1	27
18N/01W-19M05	15	.4	1.8	53	30	9.9	.1	41
18N/01W-21B06	19	.4	3.2	57	7.0	3.0	.1	49
18N/01W-22K01	26	.6	1.2	38	14	12	.1	31
18N/01W-23B02	18	.3	.9	40	5.0	4.2	.1	22
18N/01W-24B02	14	.4	2.0	100	6.0	5.2	.1	22
18N/01W-25B01	18	.3	1.7	50	7.0	3.7	.1	35
18N/01W-25P02	20	.4	1.2	40	6.0	3.6	.1	25
18N/01W-26A02	19	.4	1.5	59	12	4.5	.1	37
18N/01W-27M02	20	.4	2.2	54	2.0	1.8	.1	49
18N/01W-28E01	20	.4	2.5	61	6.0	4.1	.1	45
18N/01W-28J01	18	.4	1.7	48	8.0	3.3	.1	31
18N/01W-30E04	23	.4	1.8	46	3.7	3.8	.1	42
18N/01W-31A02	19	.4	2.1	54	9.0	5.3	.1	54
18N/01W-31A03	27	.6	1.9	60	4.0	2.2	.1	54

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Solids, residue at 180°C dis-solved (mg/L)	Solids, sum of consti-tuents, dis-solved (mg/L)	Nitro-gen NO_2+NO_3, dis-solved (mg/L as N)	Phos-phorous, dis-solved (mg/L as P)	Iron, dis-solved (µg/L as Fe)	Manga-nese, dis-solved (µg/L as Mn)	Coli-form, fecal (cols. per 100 mL)	Strep-tococci, fecal (cols. per 100 mL)
18N/01W-03H02	84	96	1.4	0.05	9	2	<1	1
18N/01W-04M01	107	115	1.4	.06	20	1	<1	<1
18N/01W-04N01	136	133	<.10	.11	370	68	<1	<1
18N/01W-05E03	310	247	<.10	.09	21,000	2,100	<1	<1
18N/01W-05G02	114	115	1.4	.02	<3	<1	<1	<1
18N/01W-06A03	132	138	<.10	.39	4,400	260	<1	<1
18N/01W-06E02	99	109	.14	.03	100	32	<1	<1
18N/01W-07C01	101	106	3.1	.03	19	1	<1	<1
18N/01W-07E04	70	75	.34	.04	81	14	<1	<1
	71	75	.34	.04	82	14	<1	<1
18N/01W-07H04	81	93	<.10	.12	71	45	<1	<1
18N/01W-07N03	126	130	<.10	.14	66	280	<1	<1
18N/01W-08G02	84	96	<.10	.17	540	78	<1	<1
18N/01W-09J01	143	148	.44	.06	44	21	<1	1
18N/01W-11P05	118	113	5.6	<.01	5	<1	<1	<1
	116	111	5.4	<.01	10	<1	<1	<1
18N/01W-12F01	99	110	1.1	.14	32	15	<1	<1
18N/01W-12M01D1	94	103	1.2	.06	4	1	<1	<1
18N/01W-12R03	80	96	.44	.03	3	<1	<1	<1
18N/01W-13A02	99	107	1.3	.07	7	<1	<1	<1
18N/01W-13C01	102	115	1.7	.07	7	<1	<1	<1
18N/01W-13G02	97	109	1.1	.06	4	2	<1	<1
18N/01W-14L02	176	196	7.8	.01	14	<1	<1	<1
18N/01W-14R01	102	107	1.3	.06	4	<1	<1	<1
18N/01W-16Q03	77	94	.75	.03	4	<1	<1	<1
18N/01W-17H05	120	123	2.8	.01	44	2	<1	<1
18N/01W-19M05	156	155	1.3	.03	13	4	<1	1
18N/01W-21B06	102	119	<.10	.06	300	370	<1	<1
18N/01W-22K01	135	160	9.3	.01	6	<1	<1	<1
18N/01W-23B02	88	93	3.2	.02	5	<1	<1	<1
18N/01W-24B02	151	153	3.4	<.01	<3	<1	<1	<1
18N/01W-25B01	105	112	2.2	.06	<3	<1	<1	<1
18N/01W-25P02	80	89	1.8	.02	7	2	<1	<1
18N/01W-26A02	124	134	2.9	.01	9	3	<1	<1
18N/01W-27M02	100	108	<.10	.11	24	120	<1	<1
18N/01W-28E01	127	134	2.4	.03	<3	<1	<1	<1
18N/01W-28J01	104	109	2.5	.02	10	8	<1	<1
18N/01W-30E04	112	109	2.0	.03	4	2	<1	<1
18N/01W-31A02	132	130	<.10	.06	3,200	250	<1	<1
18N/01W-31A03	109	124	<.10	.11	2,200	170	<1	<1

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)
18N/01W-31K03	05-08-89	1615	Qva	185	64	11.0	134	132
18N/01W-31R02	06-07-89	1145	Qc	200	154	11.0	186	189
18N/01W-32P01	06-07-89	1330	Qvr	202	56	11.0	148	149
18N/01W-33C01	05-05-89	1215	Qva	208	73	10.5	126	123
18N/01W-33F01	05-04-89	1305	Qva	208	62	11.0	110	107
18N/01W-33P01	06-08-89	1000	Qc	198	208	10.5	110	112
18N/01W-34M03	05-08-89	1115	Qva	202	80	10.5	108	108
	05-08-89	1120	Qva	202	80	10.5	108	108
18N/01W-35G02	05-10-89	1240	Qc	181	139	10.5	156	134
18N/01W-35L02	05-08-89	1440	Qva	193	56	10.5	124	122
18N/01W-36H02	05-10-89	1415	Qc	221	188	10.5	159	157
18N/01W-36M02	05-10-89	1055	Qc	225	160	10.5	173	172
18N/02W-01F04	04-05-89	1605	Qf	150	92	11.0	132	129
18N/02W-02A03	04-06-89	1610	Qvt	110	47	11.0	158	162
18N/02W-02H04	04-24-89	1220	Qf	110	81	10.0	262	249
18N/02W-04D01	04-04-89	1145	Qva	145	69	9.5	120	122
18N/02W-04F03	04-26-89	1120	TQu	98	419	9.5	134	135
	04-26-89	1125	TQu	98	419	9.5	134	135
18N/02W-04J08	04-26-89	0950	Qf	170	125	9.5	369	371
18N/02W-05D03	05-09-89	1245	Qva	180	106	10.0	109	110
18N/02W-05H01	04-20-89	1050	Qva	140	60	10.0	140	138
18N/02W-07D01	05-09-89	1335	Qva	160	99	10.0	104	105
18N/02W-07N02	04-26-89	1715	Qva	40	39	10.0	146	145
18N/02W-08E03	04-05-89	1200	Qva	172	64	10.5	167	170
18N/02W-08N03	04-04-89	1445	Qva	160	120	9.5	114	118
18N/02W-09G01	04-05-89	0930	Qva	248	191	10.0	98	101
18N/02W-12H01	04-06-89	1030	Qc	171	138	10.0	155	147
18N/02W-12Q03	04-06-89	1440	Qva	165	44	10.5	255	257
18N/02W-17D05	04-27-89	1105	Qvt	175	125	10.5	128	131
18N/02W-17M02	04-14-89	1520	Qva	150	131	11.0	106	105
18N/02W-18L01	06-07-89	1530	TQu	10	229	9.0	111	112
18N/02W-18L01S	06-19-89	0930	Qva	10	--	9.5	98	101
18N/02W-20C01	04-13-89	1620	Qva	71	71	14.5	57	55
18N/02W-21Q01	04-12-89	1000	Qva	135	75	12.0	190	190
	04-12-89	1005	Qva	135	75	12.0	190	190
18N/02W-22E01	04-12-89	1245	Qf	210	200	10.0	94	95
18N/02W-24B01	04-25-89	1020	Qva	100	51	10.5	153	143
18N/02W-28J02	04-19-89	1610	Qva	135	83	10.0	116	115
18N/02W-31J03	04-14-89	1110	Qva	135	67	12.0	156	154
18N/02W-31R02	04-12-89	1440	Qva	150	28	9.5	103	103

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	pH, (standard units)	pH, lab (standard units)	Oxygen, dissolved (mg/L)	Hardness total (mg/L as $CaCO_3$)	Hardness, noncarbonate total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
18N/01W-31K03	6.5	6.9	2.9	49	7	9.6	6.0	6.1
18N/01W-31R02	7.6	7.6	0.2	43	0	10	4.4	23
18N/01W-32P01	6.2	6.3	6.7	53	11	14	4.4	7.9
18N/01W-33C01	6.5	6.8	7.9	48	7	10	5.6	5.9
18N/01W-33F01	7.0	7.2	7.8	41	2	10	3.8	4.8
18N/01W-33P01	7.7	7.8	1.0	42	0	9.6	4.4	5.9
18N/01W-34M03	6.7	6.9	8.2	41	9	11	3.3	5.0
	6.7	7.1	8.2	40	8	11	3.1	5.2
18N/01W-35G02	6.8	6.8	.0	53	0	12	5.5	5.1
18N/01W-35L02	6.5	6.7	5.0	45	9	10	4.9	5.3
18N/01W-36H02	7.0	7.3	7.5	60	10	12	7.2	6.6
18N/01W-36M02	6.6	6.9	9.4	65	21	17	5.4	6.9
18N/02W-01F04	7.3	7.4	.8	47	0	11	4.7	7.4
18N/02W-02A03	6.1	6.2	6.9	55	17	13	5.4	8.3
18N/02W-02H04	9.3	8.9	8.1	120	0	14	20	9.8
18N/02W-04D01	7.6	7.7	.1	48	0	9.9	5.6	6.0
18N/02W-04F03	8.0	8.0	.1	54	0	8.6	8.0	6.2
	8.0	7.8	.1	54	0	8.6	8.0	6.2
18N/02W-04J08	8.1	8.1	.1	87	0	28	4.2	51
18N/02W-05D03	6.6	6.8	6.9	42	0	9.2	4.6	5.5
18N/02W-05H01	7.2	7.4	.1	57	0	11	7.2	5.8
18N/02W-07D01	6.7	6.8	9.4	41	0	9.4	4.2	5.2
18N/02W-07N02	8.0	7.8	.1	56	0	13	5.6	7.9
18N/02W-08E03	7.6	7.8	.1	73	0	11	11	6.6
18N/02W-08N03	6.7	6.8	5.3	48	0	11	4.9	5.3
18N/02W-09G01	6.7	7.4	12.6	40	0	8.6	4.6	4.6
18N/02W-12H01	7.3	7.3	.0	55	0	12	6.0	7.8
18N/02W-12Q03	6.6	7.1	2.6	100	35	20	13	9.0
18N/02W-17D05	6.7	7.0	.8	53	1	10	6.8	5.4
18N/02W-17M02	6.6	7.4	9.8	41	0	9.8	4.1	5.0
18N/02W-18L01	8.4	8.2	.2	37	0	13	1.0	6.6
18N/02W-18L01S	6.6	6.9	9.3	39	0	9.7	3.6	4.5
18N/02W-20C01	6.5	7.3	7.3	19	2	5.4	1.4	2.7
18N/02W-21Q01	7.5	7.5	.2	81	0	19	8.2	5.6
	7.5	7.7	.2	81	0	19	8.2	5.6
18N/02W-22E01	7.1	7.1	5.6	35	0	7.1	4.3	4.8
18N/02W-24B01	7.1	7.4	.1	59	0	13	6.5	6.3
18N/02W-28J02	7.5	7.5	.2	46	0	10	5.1	4.7
18N/02W-31J03	6.9	7.4	3.8	50	0	14	3.7	11
18N/02W-31R02	7.0	7.3	6.8	40	0	8.3	4.7	4.6

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Sodium, percent	Sodium, adsorption ratio	Potassium, dissolved (mg/L as K)	Alkalinity, lab dissolved (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
18N/01W-31K03	21	0.4	1.7	42	6.0	6.1	0.1	40
18N/01W-31R02	52	2	2.8	84	8.0	3.9	.2	53
18N/01W-32P01	24	.5	1.1	42	8.0	6.2	.1	31
18N/01W-33C01	20	.4	1.7	41	8.0	3.6	.1	31
18N/01W-33F01	20	.3	1.0	39	6.0	2.8	.1	26
18N/01W-33P01	23	.4	1.5	43	8.0	2.8	.1	30
18N/01W-34M03	21	.4	.9	32	7.0	3.2	.1	26
	21	.4	.9	32	7.0	3.2	.1	26
18N/01W-35G02	17	.3	1.4	61	<1.0	4.6	.1	52
18N/01W-35L02	20	.4	1.8	36	10	4.2	.1	35
18N/01W-36H02	19	.4	2.2	50	9.0	3.9	.1	37
18N/01W-36M02	18	.4	1.2	44	11	5.5	<.1	28
18N/02W-01F04	25	.5	1.7	60	6.3	3.1	.2	46
18N/02W-02A03	24	.5	1.0	38	6.8	12	.1	31
18N/02W-02H04	15	.4	3.7	127	4.8	7.6	.2	48
18N/02W-04D01	21	.4	2.2	56	3.3	2.3	.1	35
18N/02W-04F03	19	.4	2.4	63	3.3	2.4	.1	37
	19	.4	2.5	63	3.3	2.4	.1	37
18N/02W-04J08	55	2	3.4	198	<1.0	2.6	.2	25
18N/02W-05D03	22	.4	.8	43	4.0	2.3	.1	29
18N/02W-05H01	18	.3	1.6	64	3.7	2.5	.1	30
18N/02W-07D01	21	.4	.8	43	2.0	2.7	.1	29
18N/02W-07N02	23	.5	1.8	72	<1.0	2.0	.1	42
18N/02W-08E03	16	.3	2.0	81	5.3	3.2	.1	28
18N/02W-08N03	19	.3	.9	54	2.3	2.5	.1	29
18N/02W-09G01	19	.3	1.0	41	3.9	3.3	.1	26
18N/02W-12H01	23	.5	1.6	72	<1.0	2.9	.2	56
18N/02W-12Q03	16	.4	1.8	69	19	11	.1	36
18N/02W-17D05	18	.3	1.4	52	6.7	3.6	.1	31
18N/02W-17M02	20	.3	.9	43	2.0	2.9	.1	27
18N/02W-18L01	27	.5	1.4	52	2.0	2.8	.3	31
18N/02W-18L01S	20	.3	.5	40	3.0	2.9	.1	25
18N/02W-20C01	23	.3	.4	17	4.4	2.3	.1	14
18N/02W-21Q01	12	.3	3.6	86	4.0	5.0	.1	41
	12	.3	3.5	86	4.0	5.3	.1	41
18N/02W-22E01	22	.4	1.7	37	3.0	2.7	.1	34
18N/02W-24B01	18	.4	2.5	68	3.2	3.6	.2	54
18N/02W-28J02	18	.3	1.7	52	4.3	2.2	.1	33
18N/02W-31J03	31	.7	1.6	54	5.5	6.2	.1	32
18N/02W-31R02	19	.3	1.2	44	2.2	2.7	.1	27

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Solids, residue at 180°C dis-solved (mg/L)	Solids, sum of consti-tuents, dis-solved (mg/L)	Nitro-gen NO_2+NO_3, dis-solved (mg/L as N)	Phos-phorous, dis-solved (mg/L as P)	Iron, dis-solved (µg/L as Fe)	Manga-nese, dis-solved (µg/L as Mn)	Coli-form, fecal (cols. per 100 mL)	Strep-tococci, fecal (cols. per 100 mL)
18N/01W-31K03	103	110	2.0	0.02	41	11	<1	<1
18N/01W-31R02	134	156	<.10	.65	59	48	<1	<1
18N/01W-32P01	100	113	3.5	.02	5	<1	<1	<1
18N/01W-33C01	91	99	2.0	.01	12	7	<1	<1
18N/01W-33F01	84	84	1.3	.02	16	<1	<1	2
18N/01W-33P01	65	88	<.10	.12	<3	13	<1	<1
18N/01W-34M03	85	85	2.2	.02	6	<1	<1	<1
	81	85	2.2	.01	5	<1	<1	<1
18N/01W-35G02	136	125	<.10	.29	6,800	710	<1	<1
18N/01W-35L02	95	100	1.7	.08	7	<1	<1	19
18N/01W-36H02	121	123	3.3	.04	3	<1	<1	<1
18N/01W-36M02	125	123	5.0	.02	7	<1	<1	<1
18N/02W-01F04	103	118	<.10	.47	1,700	170	<1	<1
18N/02W-02A03	115	116	3.5	.02	43	5	<1	<1
18N/02W-02H04	164	184	<.10	<.01	9	34	<1	<1
18N/02W-04D01	82	98	<.10	.28	36	100	<1	<1
18N/02W-04F03	91	106	<.10	.06	230	140	<1	<1
	95	106	<.10	.06	240	140	<1	<1
18N/02W-04J08	229	233	<.10	.53	52	44	<1	<1
18N/02W-05D03	82	88	1.6	.03	4	<1	<1	<1
18N/02W-05H01	87	101	<.10	.09	170	110	<1	<1
18N/02W-07D01	75	84	1.1	.02	<3	<1	<1	<1
18N/02W-07N02	108	116	<.10	.33	650	110	<1	<1
18N/02W-08E03	100	116	<.10	.06	44	190	<1	<1
18N/02W-08N03	74	90	.38	.01	27	1	<1	<1
18N/02W-09G01	68	79	.43	<.01	170	2	<1	<1
18N/02W-12H01	121	133	<.10	.66	3,300	230	<1	<1
18N/02W-12Q03	156	179	6.4	.02	4	<1	<1	<1
18N/02W-17D05	120	98	.33	<.01	67	6	<1	<1
18N/02W-17M02	79	81	.83	.02	6	2	<1	<1
18N/02W-18L01	79	89	<.10	.15	130	18	<1	<1
18N/02W-18L01S	73	77	.74	.02	6	<1	K99	46
18N/02W-20C01	41	42	.23	<.01	24	3	<1	<1
18N/02W-21Q01	132	138	<.10	.18	72	110	<1	<1
	135	139	<.10	.19	74	110	<1	<1
18N/02W-22E01	78	84	.96	.04	50	3	<1	<1
18N/02W-24B01	142	131	<.10	.33	880	130	<1	<1
18N/02W-28J02	90	93	<.10	.03	190	110	<1	<1
18N/02W-31J03	107	117	2.3	.13	<3	<1	<1	<1
18N/02W-31R02	76	79	.52	.03	4	<1	<1	<1

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)
18N/02W-32A06	04-14-89	1655	Qva	181	80	10.5	155	153
18N/02W-32B02	04-19-89	1505	Qva	175	37	9.5	56	58
18N/02W-33M01	04-20-89	1405	Tb	181	120	10.0	184	185
18N/02W-34B01	04-20-89	1535	Qvr	170	37	10.0	95	99
18N/02W-35B02	05-17-89	1115	Qc	185	258	10.5	199	200
18N/02W-35K03	05-17-89	1400	TQu	110	390	11.0	115	114
18N/02W-35M01	05-24-89	1400	Qva	110	80	9.0	111	113
18N/02W-36L01	04-11-89	1525	Qva	185	124	10.5	155	152
18N/03W-01K04	04-10-89	1125	Qc	20	72	10.0	123	122
	04-10-89	1130	Qc	20	72	10.0	123	121
18N/03W-01L01	06-09-89	1645	Qc	50	53	12.0	240	242
18N/03W-02B05	06-09-89	1515	Qva	165	117	11.0	178	181
18N/03W-02B06	04-27-89	1525	Qva	165	100	11.0	124	125
18N/03W-02H05	04-27-89	1410	Qc	135	178	10.0	136	136
18N/03W-04R03	04-27-89	1755	Qc	180	60	10.5	610	607
18N/03W-07L02	06-19-89	1515	Tb	490	420	11.0	138	139
18N/03W-11P02	04-20-89	1715	TQu	230	40	11.0	165	166
18N/03W-12H01	05-10-89	1600	TQu	160	207	10.0	119	119
18N/03W-12L01	04-20-89	1205	Qc	30	49	11.0	122	123
18N/03W-13K01	04-24-89	1535	Qc	50	85	10.5	108	105
18N/03W-16P02	04-24-89	1355	MLT	460	80	9.0	352	336
18N/03W-18A01	04-17-89	1440	Tb	670	400	10.0	134	135
18N/03W-19C01	04-17-89	1240	Tb	670	115	10.5	135	136
18N/03W-22A01	04-26-89	1605	Tb	410	290	11.5	223	220
18N/03W-23A01	06-06-89	1540	Qvt	210	53	10.0	158	160
18N/03W-23N01	04-25-89	1345	Qva	330	41	10.5	115	110
18N/03W-24H01	04-24-89	1645	TQu	20	207	10.5	720	696
18N/03W-24H02	04-26-89	1335	Qc	35	44	10.0	94	95
18N/03W-24J02	04-26-89	1500	Tb	20	105	11.5	730	732
18N/03W-24J03	04-25-89	1510	Qc	35	29	11.5	97	93
18N/03W-25A02	04-19-89	1340	Tb	30	65	11.5	930	923
18N/03W-25P01	04-25-89	1610	Qc	65	100	9.5	107	103
18N/03W-36B01	04-25-89	1710	Qc	65	79	10.0	78	76
19N/01E-30P06	06-05-89	1145	Qc	155	186	12.0	232	230
19N/01E-31C04	06-06-89	1255	Qvr	190	38	11.0	218	219
	06-06-89	1300	Qvr	190	38	11.0	218	220
19N/01W-04P01	04-19-89	1400	Qc	165	215	10.5	150	149
19N/01W-05H01	04-26-89	1130	Qc	60	99	11.0	318	308
19N/01W-05R05	04-28-89	1015	TQu	10	203	11.5	1,880	1,840
19N/01W-06L01	04-06-89	1020	TQu	61	190	11.5	2,100	2,130

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	pH, (standard units)	pH, lab (standard units)	Oxygen, dissolved (mg/L)	Hardness total (mg/L as $CaCO_3$)	Hardness, noncarbonate total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
18N/02W-32A06	7.5	7.6	0.1	60	0	10	8.6	6.3
18N/02W-32B02	6.5	6.6	--	17	2	5.0	1.2	3.6
18N/02W-33M01	8.2	8.2	3.3	71	0	22	3.9	12
18N/02W-34B01	6.3	6.7	7.8	37	0	10	2.9	4.6
18N/02W-35B02	7.7	7.7	.1	89	5	16	12	6.7
18N/02W-35K03	8.2	7.8	.1	34	0	10	2.2	8.9
18N/02W-35M01	6.8	6.9	5.7	42	4	9.4	4.6	5.2
18N/02W-36L01	6.8	7.1	5.9	62	3	12	7.7	6.6
18N/03W-01K04	8.1	8.0	.0	49	0	16	2.2	6.0
	8.1	8.1	.0	49	0	16	2.2	6.0
18N/03W-01L01	6.4	6.8	5.6	96	0	17	13	9.9
18N/03W-02B05	6.5	6.6	9.2	70	12	17	6.8	6.1
18N/03W-02B06	6.5	7.2	7.3	52	2	13	4.8	4.7
18N/03W-02H05	7.3	8.1	4.4	59	0	12	7.0	5.0
18N/03W-04R03	7.6	7.7	2.0	210	150	70	9.1	27
18N/03W-07L02	7.1	7.1	6.8	29	0	8.3	2.1	17
18N/03W-11P02	7.8	7.7	.1	70	0	17	6.6	6.1
18N/03W-12H01	8.2	8.1	.0	48	0	11	5.1	5.5
18N/03W-12L01	8.0	8.0	.1	51	0	13	4.4	4.6
18N/03W-13K01	7.3	7.9	9.8	44	0	10	4.7	4.2
18N/03W-16P02	7.8	7.8	4.3	110	34	36	4.3	20
18N/03W-18A01	9.5	9.0	.5	3	0	1.2	<.01	30
18N/03W-19C01	7.2	7.5	4.7	57	0	12	6.5	7.1
18N/03W-22A01	7.8	7.9	1.1	87	0	21	8.4	13
18N/03W-23A01	7.9	7.8	.2	67	0	17	6.0	6.7
18N/03W-23N01	7.5	7.6	.2	48	0	11	5.0	4.4
18N/03W-24H01	8.0	8.1	.2	220	170	85	2.2	42
18N/03W-24H02	6.5	6.8	7.5	39	0	9.0	4.0	3.9
18N/03W-24J02	8.1	8.0	.1	240	170	88	4.5	39
18N/03W-24J03	6.2	6.8	7.8	36	10	8.9	3.4	3.9
18N/03W-25A02	8.1	8.0	.3	320	210	120	4.3	41
18N/03W-25P01	7.1	7.7	2.9	44	0	11	4.0	4.6
18N/03W-36B01	6.5	7.1	3.9	30	0	7.2	2.9	3.5
19N/01E-30P06	7.0	7.1	.0	96	0	17	13	12
19N/01E-31C04	6.2	6.4	6.5	80	35	21	6.6	11
	6.2	6.6	6.5	77	32	20	6.5	11
19N/01W-04P01	7.6	7.7	.6	62	0	11	8.5	6.1
19N/01W-05H01	6.9	7.1	.2	140	0	18	22	12
19N/01W-05R05	7.6	7.5	.1	600	470	160	49	100
19N/01W-06L01	7.5	7.3	--	580	420	140	55	190

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Sodium, percent	Sodium, adsorption ratio	Potassium, dissolved (mg/L as K)	Alkalinity, lab dissolved (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
18N/02W-32A06	18	0.4	2.4	70	5.0	3.4	0.1	34
18N/02W-32B02	30	.4	.5	15	1.7	3.6	.1	19
18N/02W-33M01	27	.6	.1	82	9.0	2.7	.1	19
18N/02W-34B01	21	.3	.3	38	5.0	3.3	.1	26
18N/02W-35B02	14	.3	2.6	84	15	4.2	.1	42
18N/02W-35K03	35	.7	1.1	38	<1.0	11	.1	38
18N/02W-35M01	20	.4	1.4	38	6.0	3.1	.1	28
18N/02W-36L01	18	.4	1.7	59	3.9	3.0	.1	36
18N/03W-01K04	21	.4	.6	59	2.1	2.1	.1	36
	21	.4	.6	59	2.2	2.1	.1	36
18N/03W-01L01	18	.4	1.5	102	15	4.7	.1	47
18N/03W-02B05	16	.3	.3	59	5.0	5.7	<.1	26
18N/03W-02B06	16	.3	.4	50	2.8	3.1	.1	22
18N/03W-02H05	15	.3	.5	60	2.8	3.4	.1	26
18N/03W-04R03	22	.8	.7	65	4.0	140	.1	24
18N/03W-07L02	56	1	.1	44	4.0	11	<.1	22
18N/03W-11P02	16	.3	1.4	81	<1.0	3.3	.2	35
18N/03W-12H01	19	.4	1.3	55	3.0	2.1	.1	36
18N/03W-12L01	16	.3	.8	57	3.4	2.3	.1	23
18N/03W-13K01	17	.3	.6	47	3.3	2.2	.1	22
18N/03W-16P02	29	.9	.5	74	2.0	56	<.1	29
18N/03W-18A01	96	8	.1	56	5.5	4.7	.2	26
18N/03W-19C01	21	.4	.4	63	<1.0	3.9	.1	23
18N/03W-22A01	24	.6	.7	113	1.0	2.4	.1	30
18N/03W-23A01	17	.4	1.4	80	<1.0	1.8	.2	30
18N/03W-23N01	16	.3	1.7	55	1.8	2.0	<.1	30
18N/03W-24H01	29	1	1.1	50	4.0	180	.1	26
18N/03W-24H02	18	.3	.6	41	3.0	2.0	.1	24
18N/03W-24J02	26	1	2.6	64	4.0	180	.1	30
18N/03W-24J03	19	.3	.4	26	1.8	5.0	<.1	18
18N/03W-25A02	22	1	2.6	110	9.0	210	.1	32
18N/03W-25P01	18	.3	.9	46	2.3	4.0	<.1	27
18N/03W-36B01	20	.3	.5	32	1.9	2.2	<.1	22
19N/01E-30P06	21	.5	3.5	116	<1.0	3.2	.2	66
19N/01E-31C04	23	.6	1.0	45	21	7.4	.1	37
	23	.6	1.0	45	22	7.5	.1	37
19N/01W-04P01	17	.3	2.1	71	2.5	2.6	.1	27
19N/01W-05H01	16	.5	2.1	137	14	8.5	.1	53
19N/01W-05R05	26	2	9.2	130	52	490	.1	29
19N/01W-06L01	41	4	9.7	158	37	580	.1	36

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Solids, residue at 180°C dis-solved (mg/L)	Solids, sum of consti-tuents, dis-solved (mg/L)	Nitro-gen NO_2+NO_3, dis-solved (mg/L as N)	Phos-phorous, dis-solved (mg/L as P)	Iron, dis-solved (µg/L as Fe)	Manga-nese, dis-solved (µg/L as Mn)	Coli-form, fecal (cols. per 100 mL)	Strep-tococci, fecal (cols. per 100 mL)
18N/02W-32A06	112	112	<0.10	0.07	60	260	<1	<1
18N/02W-32B02	50	49	1.1	.02	6	1	<1	<1
18N/02W-33M01	106	118	<.10	<.01	<3	<1	<1	<1
18N/02W-34B01	68	76	.26	.02	130	3	<1	<1
18N/02W-35B02	144	150	<.10	.07	40	700	<1	<1
18N/02W-35K03	90	94	<.10	.19	95	46	<1	<1
18N/02W-35M01	86	89	1.9	<.01	14	1	<1	<1
18N/02W-36L01	114	118	2.6	.02	7	<1	<1	<1
18N/03W-01K04	94	101	<.10	.22	65	16	<1	<1
	98	101	<.10	.22	63	16	<1	<1
18N/03W-01L01	161	171	.29	.09	18	<1	<1	<1
18N/03W-02B05	113	122	4.4	.01	5	<1	<1	<1
18N/03W-02B06	89	87	1.5	.01	9	1	<1	<1
18N/03W-02H05	96	95	.49	.05	19	<1	<1	<1
18N/03W-04R03	399	314	.13	.04	28	2	<1	<1
18N/03W-07L02	94	94	.60	.01	4	6	1	<1
18N/03W-11P02	111	119	<.10	.58	470	240	<1	<1
18N/03W-12H01	90	97	<.10	.10	63	48	<1	<1
18N/03W-12L01	80	86	<.10	.11	33	11	<1	<1
18N/03W-13K01	74	78	.55	.02	7	<1	<1	<1
18N/03W-16P02	215	192	<.10	.03	11	3	<1	<1
18N/03W-18A01	105	102	<.10	<.01	530	3	<1	<1
18N/03W-19C01	93	92	.26	.03	53	2	<1	<1
18N/03W-22A01	133	144	<.10	.03	52	19	<1	<1
18N/03W-23A01	112	111	<.10	.77	39	110	<1	<1
18N/03W-23N01	85	89	<.10	.14	24	58	<1	<1
18N/03W-24H01	412	370	<.10	.17	78	29	<1	<1
18N/03W-24H02	67	73	.39	.01	7	24	<1	<1
18N/03W-24J02	444	387	<.10	.18	49	38	<1	<1
18N/03W-24J03	68	70	2.9	.01	15	10	<1	<1
18N/03W-25A02	600	485	<.10	.06	56	26	<1	<1
18N/03W-25P01	76	82	.12	.06	<3	<1	<1	<1
18N/03W-36B01	68	62	.67	<.01	12	2	<1	<1
19N/01E-30P06	180	186	<.10	.74	1,300	370	<1	<1
19N/01E-31C04	166	158	6.0	.03	8	1	<1	<1
	159	158	6.0	.03	10	1	<1	<1
19N/01W-04P01	97	103	<.10	.07	17	48	<1	<1
19N/01W-05H01	196	215	<.10	.03	3,200	190	<1	<1
19N/01W-05R05	1,140	968	<.10	.39	120	500	<1	<1
19N/01W-06L01	1,230	1,140	<.10	.12	1,400	560	<1	<1

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)
19N/01W-07A01	05-10-89	1300	Qc	85	82	10.5	300	298
19N/01W-07N02	04-04-89	1300	Qc	125	138	11.0	380	388
19N/01W-07R01	04-04-89	1110	TQu	40	1,000	12.0	231	232
19N/01W-09L02	04-18-89	1550	Qva	190	90	10.0	99	100
19N/01W-10F04	04-20-89	1230	Qc	62	74	11.0	891	883
19N/01W-10L02	04-20-89	1030	Qc	30	85	11.0	1,270	1,250
19N/01W-10N02	04-19-89	1640	Qva	148	56	11.0	96	95
	04-19-89	1645	Qva	148	56	11.0	96	95
19N/01W-10Q02	04-26-89	1300	Qc	70	119	10.5	1,350	1,340
19N/01W-15K03	04-20-89	1420	Qf	80	82	9.5	192	192
19N/01W-16K01	04-18-89	1400	Qva	160	90	10.5	147	146
19N/01W-17A05	05-01-89	1025	TQu	40	174	10.5	144	142
19N/01W-17J02	04-18-89	1710	TQu	43	95	12.0	310	308
19N/01W-17N02	04-07-89	1200	Qc	70	102	10.5	103	118
19N/01W-18F01	04-06-89	1755	Qf	90	64	11.0	193	190
19N/01W-18M02	04-04-89	1500	Qf	85	49	12.0	271	277
19N/01W-18P01	04-04-89	1615	Qc	70	108	10.5	239	244
19N/01W-19P03	04-10-89	1630	Qc	120	105	10.5	251	232
19N/01W-20H01	04-13-89	1515	Qc	150	178	11.5	228	222
19N/01W-21C03	04-18-89	1235	Qva	162	67	11.0	114	113
19N/01W-21K01	04-28-89	1145	Qf	130	126	10.0	161	160
19N/01W-21L02	04-18-89	1115	Qva	115	78	10.5	219	219
19N/01W-22A01	04-27-89	1020	TQu	65	143	10.0	200	209
19N/01W-23G02	06-15-89	1545	Qc	84	108	14.0	158	158
19N/01W-25P01	06-08-89	1645	Qva	225	140	10.0	178	180
19N/01W-27A01	04-20-89	1630	Qva	200	118	9.5	97	95
19N/01W-28F02	04-13-89	1300	Qc	120	99	11.0	142	139
19N/01W-29C02	04-06-89	1305	Qc	145	152	11.5	194	190
19N/01W-29N01	04-06-89	1615	Qc	135	120	10.5	152	156
19N/01W-30P04	04-07-89	1610	TQu	115	122	10.0	222	221
19N/01W-30R02	04-07-89	1405	Qva	115	67	11.0	132	129
19N/01W-31B03	04-10-89	1055	Qf	126	78	10.0	130	131
19N/01W-31K04	05-09-89	1020	Qvt	155	77	10.5	145	147
19N/01W-32B01	04-10-89	1415	TQu	50	211	10.0	825	818
	04-10-89	1420	TQu	50	211	10.0	825	818
19N/01W-32C04	04-10-89	1240	Qva	145	94	10.0	155	153
19N/01W-32N03	04-13-89	1140	Qva	157	70	10.0	166	167
19N/01W-32R01	04-13-89	1020	Qvt	80	86	11.0	137	136
19N/01W-33K03	05-10-89	1405	Qva	160	110	10.0	158	157
19N/01W-33K04	05-10-89	1450	Qc	160	163	9.5	113	113

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	pH, (standard units)	pH, lab (standard units)	Oxygen, dissolved (mg/L)	Hardness total (mg/L as $CaCO_3$)	Hardness, noncarbonate total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
19N/01W-07A01	6.9	7.1	0.7	140	0	17	24	9.5
19N/01W-07N02	7.7	7.8	.2	110	0	23	13	46
19N/01W-07R01	8.2	8.0	.1	58	0	16	4.3	28
19N/01W-09L02	7.3	7.6	5.0	38	0	6.5	5.4	5.1
19N/01W-10F04	7.1	7.3	2.2	130	0	19	20	130
19N/01W-10L02	7.2	7.3	.9	340	260	63	44	98
19N/01W-10N02	6.3	6.8	6.4	35	0	7.8	3.8	5.0
	6.3	6.8	6.4	35	0	7.8	3.8	5.1
19N/01W-10Q02	7.2	7.5	.3	1	0	.13	.16	260
19N/01W-15K03	7.1	7.3	6.7	81	0	11	13	7.6
19N/01W-16K01	6.8	7.2	3.5	58	0	10	8.1	7.0
19N/01W-17A05	8.1	7.8	.1	58	0	12	6.7	7.0
19N/01W-17J02	7.2	7.4	6.7	140	0	17	23	13
19N/01W-17N02	6.8	6.9	11.0	47	0	7.6	6.9	5.9
19N/01W-18F01	7.0	7.2	2.6	79	0	12	12	7.6
19N/01W-18M02	6.8	7.0	5.3	130	0	14	23	10
19N/01W-18P01	7.4	7.5	.3	110	0	16	16	12
19N/01W-19P03	7.0	7.0	.0	100	12	15	16	8.2
19N/01W-20H01	6.9	7.0	4.5	95	0	15	14	9.0
19N/01W-21C03	7.2	7.7	3.2	45	0	8.2	6.0	4.9
19N/01W-21K01	8.3	7.9	.5	71	0	12	9.9	5.9
19N/01W-21L02	6.7	7.0	4.2	93	0	16	13	9.6
19N/01W-22A01	8.2	8.0	.2	80	0	19	7.9	13
19N/01W-23G02	7.3	7.5	.5	57	0	9.0	8.5	9.9
19N/01W-25P01	7.0	6.9	5.3	79	2	16	9.4	6.7
19N/01W-27A01	6.9	7.3	6.6	36	0	7.2	4.3	4.3
19N/01W-28F02	8.1	7.8	.4	57	0	9.2	8.3	5.5
19N/01W-29C02	7.0	7.2	.6	65	0	12	8.6	13
19N/01W-29N01	7.1	7.3	1.2	64	1	9.6	9.6	6.2
19N/01W-30P04	7.3	7.3	.1	100	0	19	13	7.5
19N/01W-30R02	7.2	7.3	.2	52	0	8.7	7.3	5.4
19N/01W-31B03	7.0	7.4	2.7	49	0	9.1	6.4	7.6
19N/01W-31K04	6.5	6.7	7.6	56	5	13	5.6	6.7
19N/01W-32B01	8.1	8.0	.1	210	0	56	18	110
	8.1	8.0	.1	210	0	56	18	110
19N/01W-32C04	7.7	7.7	.8	64	1	9.5	9.8	5.9
19N/01W-32N03	6.7	7.6	7.5	67	11	13	8.3	6.8
19N/01W-32R01	8.2	8.1	.2	57	0	8.5	8.7	5.3
19N/01W-33K03	7.2	7.5	8.6	67	6	12	8.9	5.7
19N/01W-33K04	7.6	7.7	3.0	44	0	7.5	6.2	5.5

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Sodium, percent	Sodium, adsorption ratio	Potassium, dissolved (mg/L as K)	Alkalinity, lab dissolved (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
19N/01W-07A01	13	0.4	0.9	152	4.0	3.3	0.1	38
19N/01W-07N02	46	2	4.4	209	1.3	4.1	0.2	27
19N/01W-07R01	48	2	5.8	119	2.1	2.5	.2	49
19N/01W-09L02	22	.4	1.4	44	4.0	1.9	<.1	30
19N/01W-10F04	68	5	4.1	132	28	180	.2	31
19N/01W-10L02	38	2	5.8	77	22	330	.1	36
19N/01W-10N02	23	.4	.9	37	3.0	2.8	.1	29
	23	.4	.9	37	3.1	2.9	.1	29
19N/01W-10Q02	99	110	2.6	83	32	340	.1	40
19N/01W-15K03	16	.4	2.5	86	5.9	4.5	.1	41
19N/01W-16K01	20	.4	1.7	63	3.4	3.2	.1	37
19N/01W-17A05	20	.4	2.8	66	1.8	3.5	.1	28
19N/01W-17J02	17	.5	3.4	153	5.0	4.9	.1	44
19N/01W-17N02	21	.4	1.3	57	1.9	1.3	.1	43
19N/01W-18F01	17	.4	1.5	88	7.5	2.8	.1	38
19N/01W-18M02	14	.4	2.2	138	4.6	3.0	.1	42
19N/01W-18P01	19	.5	3.3	119	6.1	2.6	.1	40
19N/01W-19P03	14	.4	2.0	91	21	9.4	.1	51
19N/01W-20H01	17	.4	2.3	109	2.9	3.7	.1	37
19N/01W-21C03	19	.3	1.4	50	1.8	3.4	.1	26
19N/01W-21K01	15	.3	2.4	76	4.0	2.5	.1	43
19N/01W-21L02	18	.4	1.8	104	3.8	4.2	.1	44
19N/01W-22A01	25	.7	3.4	107	<1.0	2.4	.1	41
19N/01W-23G02	26	.6	3.3	79	<1.0	2.4	.2	47
19N/01W-25P01	15	.3	1.6	77	6.0	3.2	.1	30
19N/01W-27A01	20	.3	1.1	38	5.5	2.4	.1	28
19N/01W-28F02	17	.3	2.4	64	6.2	2.0	.1	40
19N/01W-29C02	29	.7	2.4	88	4.3	4.1	.1	38
19N/01W-29N01	17	.3	1.8	63	6.6	4.4	.1	39
19N/01W-30P04	14	.3	2.2	110	2.7	4.0	.1	56
19N/01W-30R02	18	.3	1.5	52	8.5	3.2	.1	41
19N/01W-31B03	25	.5	1.2	58	6.9	1.6	.1	36
19N/01W-31K04	20	.4	1.3	51	5.0	7.5	.1	37
19N/01W-32B01	51	3	11	464	3.4	7.6	.2	37
	51	3	11	464	3.2	7.6	.3	36
19N/01W-32C04	16	.3	2.0	63	9.2	4.4	.1	46
19N/01W-32N03	18	.4	1.3	56	5.7	8.7	.1	31
19N/01W-32R01	16	.3	2.0	61	5.5	2.8	.1	35
19N/01W-33K03	15	.3	2.6	61	5.0	4.3	.1	34
19N/01W-33K04	20	.4	2.2	48	5.0	2.5	.1	36

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Solids, residue at 180°C dis-solved (mg/L)	Solids, sum of consti-tuents, dis-solved (mg/L)	Nitro-gen NO_2+NO_3, dis-solved (mg/L as N)	Phos-phorous, dis-solved (mg/L as P)	Iron, dis-solved (µg/L as Fe)	Manga-nese, dis-solved (µg/L as Mn)	Coli-form, fecal (cols. per 100 mL)	Strep-tococci, fecal (cols. per 100 mL)
19N/01W-07A01	174	190	0.39	0.04	56	51	<1	<1
19N/01W-07N02	217	245	<.10	.09	66	160	<1	<1
19N/01W-07R01	162	180	<.10	.99	520	83	<1	<1
19N/01W-09L02	82	81	<.10	.04	60	7	<1	<1
19N/01W-10F04	477	493	.28	.01	43	1	<1	<1
19N/01W-10L02	687	646	<.10	.04	110	1,100	<1	<1
19N/01W-10N02	84	78	.69	.03	<3	<1	<1	<1
	88	78	.69	.02	4	<1	<1	<1
19N/01W-10Q02	724	725	<.10	.06	12	3	<1	<1
19N/01W-15K03	131	138	.29	.06	5	<1	<1	<1
19N/01W-16K01	114	113	1.1	.03	9	2	<1	<1
19N/01W-17A05	88	102	<.10	.16	66	44	<1	<1
19N/01W-17J02	193	204	.38	.07	5	<1	<1	<1
19N/01W-17N02	101	103	.21	.05	45	7	<1	<1
19N/01W-18F01	121	134	<.10	.04	48	5	<1	47
19N/01W-18M02	169	186	.94	.04	60	6	<1	<1
19N/01W-18P01	148	170	.50	.20	250	66	<1	<1
19N/01W-19P03	170	184	<.10	.04	6,300	450	<1	<1
19N/01W-20H01	143	151	.39	.01	10	2	<1	1
19N/01W-21C03	84	82	.14	.04	35	3	<1	<1
19N/01W-21K01	119	126	<.10	.08	44	290	<1	<1
19N/01W-21L02	152	156	.32	.04	21	2	<1	<1
19N/01W-22A01	131	151	<.10	.13	92	160	<1	<1
19N/01W-23G02	107	128	<.10	.38	350	180	<1	<1
19N/01W-25P01	113	124	1.0	.03	7	3	<1	<1
19N/01W-27A01	78	76	<.10	.05	370	18	<1	<1
19N/01W-28F02	113	112	<.10	.06	25	200	<1	<1
19N/01W-29C02	118	137	.43	.14	260	13	<1	11
19N/01W-29N01	110	119	.98	.04	68	5	<1	<1
19N/01W-30P04	168	172	<.10	.13	1,600	320	<1	<1
19N/01W-30R02	108	108	<.10	.05	740	230	<1	<1
19N/01W-31B03	101	106	.43	.02	360	17	<1	<1
19N/01W-31K04	105	113	1.3	.04	5	<1	<1	<1
19N/01W-32B01	507	522	<.10	1.0	660	210	<1	<1
	516	521	<.10	1.0	840	210	<1	<1
19N/01W-32C04	119	125	<.10	.08	110	320	<1	<1
19N/01W-32N03	115	116	1.6	.03	12	<1	<1	<1
19N/01W-32R01	117	105	<.10	.04	68	150	<1	<1
19N/01W-33K03	105	116	1.6	.03	<3	<1	<1	<1
19N/01W-33K04	85	94	<.10	.08	9	8	<1	<1

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)
19N/01W-33K05	04-18-89	0930	Qva	150	122	9.5	112	113
19N/02W-03E02	06-06-89	1720	Qc	90	90	10.5	380	372
19N/02W-04F05	05-03-89	1420	TQu	125	156	11.5	229	229
19N/02W-07P01	05-01-89	1325	Qc	90	102	10.5	165	166
19N/02W-08F03	05-03-89	1530	TQu	60	156	11.0	244	243
19N/02W-08H01	05-04-89	1425	Qc	110	79	11.5	138	139
19N/02W-08K01	05-01-89	1640	TQu	100	130	12.5	176	177
19N/02W-08P01	05-01-89	1540	Qc	125	87	10.0	149	152
19N/02W-08Q01	05-02-89	1320	TQu	90	140	10.5	189	191
19N/02W-14H03	05-18-89	1600	Qvt	130	36	10.5	168	169
19N/02W-14H04	04-11-89	1230	TQu	125	430	11.5	311	326
19N/02W-14J01	04-11-89	1110	Qf	146	116	10.5	330	301
19N/02W-14P02	04-11-89	1350	Qc	175	232	10.5	205	202
19N/02W-16K02D1	04-18-89	1135	TQu	55	382	11.5	174	173
19N/02W-16Q05	04-28-89	1310	Qc	140	151	10.5	198	200
19N/02W-18A02	04-28-89	1730	MLT	120	67	11.0	180	179
19N/02W-18K02	05-01-89	1435	TQu	130	166	11.0	142	143
19N/02W-18M01	05-02-89	1615	Qc	80	70	10.5	164	165
19N/02W-19H01	05-16-89	1115	TQu	100	112	11.0	125	124
	05-16-89	1120	TQu	100	112	11.0	125	124
19N/02W-21C02	04-28-89	1210	Qc	60	89	11.0	620	619
19N/02W-21Q04	04-19-89	1040	TQu	48	231	11.5	164	163
19N/02W-22D02	05-18-89	1320	TQu	40	258	12.5	168	162
19N/02W-24F02	04-06-89	1215	Qva	120	86	10.5	136	141
19N/02W-25A02	04-10-89	1410	TQu	100	212	9.5	260	252
19N/02W-25F01	04-07-89	1440	Qva	145	91	10.5	170	174
19N/02W-26J01	04-07-89	1245	Qc	125	147	10.5	220	221
19N/02W-27D03	06-22-89	1330	Qc	78	114	12.5	738	741
19N/02W-28L05	04-18-89	1545	Qva	135	54	11.0	187	189
19N/02W-29C01	05-02-89	1500	Qc	40	76	10.5	158	161
19N/02W-30B01	05-15-89	1440	Qva	100	79	10.5	170	169
19N/02W-30J02	05-15-89	1335	TQu	25	79	10.5	144	143
19N/02W-31E03	05-03-89	1730	Qc	60	109	10.5	117	119
19N/02W-32A06	04-17-89	1655	TQu	30	224	10.5	150	150
19N/02W-32G04	04-14-89	1355	Qc	195	210	10.0	175	171
19N/02W-32H03	05-09-89	1145	Qc	182	158	10.0	169	171
19N/02W-33B02	04-25-89	1220	Qva	192	134	10.5	218	211
19N/02W-33K08	04-18-89	1330	Qc	19	120	13.0	168	169
	04-18-89	1335	Qc	19	120	13.0	168	169
19N/02W-33M03	05-04-89	1030	Qva	165	84	11.0	158	159

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	pH, (standard units)	pH, lab (standard units)	Oxygen, dissolved (mg/L)	Hardness total (mg/L as $CaCO_3$)	Hardness, noncarbonate total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
19N/01W-33K05	7.4	7.6	2.4	45	0	6.8	6.9	5.1
19N/02W-03E02	7.3	7.3	.0	140	0	25	20	23
19N/02W-04F05	7.4	7.4	.1	97	0	19	12	8.1
19N/02W-07P01	7.9	7.8	.1	75	0	12	11	4.9
19N/02W-08F03	7.9	7.7	.1	85	0	22	7.3	19
19N/02W-08H01	6.5	7.0	4.6	56	0	10	7.6	6.2
19N/02W-08K01	7.7	7.7	.0	74	0	13	10	6.4
19N/02W-08P01	6.8	7.0	7.1	63	2	14	6.9	5.4
19N/02W-08Q01	7.0	7.2	4.0	79	0	15	10	7.9
19N/02W-14H03	6.9	7.0	5.3	69	3	12	9.4	7.9
19N/02W-14H04	7.8	7.1	.1	150	0	24	21	12
19N/02W-14J01	6.7	7.8	5.7	73	0	20	5.6	38
19N/02W-14P02	7.8	7.9	.2	78	0	16	9.3	12
19N/02W-16K02D1	7.8	7.8	.4	36	0	11	2.0	23
19N/02W-16Q05	6.8	7.0	4.5	82	0	13	12	8.3
19N/02W-18A02	7.3	7.4	8.9	75	14	17	7.8	5.5
19N/02W-18K02	8.0	7.8	.1	57	0	16	4.2	5.9
19N/02W-18M01	7.1	7.7	6.7	73	0	11	11	5.5
19N/02W-19H01	7.0	7.7	2.1	54	0	11	6.4	4.5
	7.0	7.5	2.1	54	0	11	6.5	4.7
19N/02W-21C02	6.7	6.9	6.2	30	0	4.4	4.7	120
19N/02W-21Q04	7.9	8.2	.8	42	0	13	2.3	18
19N/02W-22D02	7.4	7.6	.0	45	0	13	3.1	17
19N/02W-24F02	6.9	7.3	4.8	56	0	10	7.6	6.5
19N/02W-25A02	8.0	8.0	.1	86	0	23	6.9	19
19N/02W-25F01	6.6	7.0	4.4	68	7	13	8.6	7.1
19N/02W-26J01	7.3	7.4	1.3	95	0	15	14	8.7
19N/02W-27D03	7.8	7.8	.0	140	0	41	9.6	97
19N/02W-28L05	6.9	7.1	6.3	87	0	15	12	7.6
19N/02W-29C01	7.5	7.8	.7	66	0	9.9	10	6.6
19N/02W-30B01	6.7	7.2	8.0	67	10	11	9.5	8.3
19N/02W-30J02	7.3	7.7	3.2	62	0	9.8	9.0	5.8
19N/02W-31E03	7.2	7.3	6.4	51	1	11	5.7	4.7
19N/02W-32A06	8.1	8.2	.1	47	0	13	3.6	12
19N/02W-32G04	7.8	7.9	.1	74	0	17	7.6	6.9
19N/02W-32H03	7.9	7.7	.1	71	0	19	5.6	6.1
19N/02W-33B02	6.4	6.8	4.0	90	0	18	11	8.1
19N/02W-33K08	7.9	7.8	.4	63	0	17	4.9	11
	7.9	7.9	.4	63	0	17	5.1	11
19N/02W-33M03	7.5	7.5	8.0	65	0	12	8.4	6.7

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Sodium, percent	Sodium, adsorption ratio	Potassium, dissolved (mg/L as K)	Alkalinity, lab dissolved (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
19N/01W-33K05	19	0.3	2.0	49	4.8	4.3	0.1	36
19N/02W-03E02	25	.9	3.0	187	<1.0	8.2	.2	54
19N/02W-04F05	15	.4	3.1	115	<1.0	3.3	.2	46
19N/02W-07P01	12	.3	1.1	78	3.0	3.1	.1	21
19N/02W-08F03	32	.9	2.8	123	<1.0	2.8	.2	49
19N/02W-08H01	19	.4	1.2	58	4.4	3.2	.1	38
19N/02W-08K01	15	.3	2.4	82	6.0	3.0	.1	38
19N/02W-08P01	15	.3	.7	61	4.8	4.9	.1	29
19N/02W-08Q01	18	.4	1.6	91	4.0	2.7	.1	28
19N/02W-14H03	20	.4	1.5	66	6.0	3.8	.1	36
19N/02W-14H04	15	.4	2.3	147	5.7	8.3	.1	38
19N/02W-14J01	51	2	4.5	157	2.2	4.2	.1	41
19N/02W-14P02	24	.6	3.3	101	1.1	4.4	.1	25
19N/02W-16K02D1	57	2	2.1	78	<1.0	7.6	.1	43
19N/02W-16Q05	18	.4	1.6	83	5.0	6.2	.1	35
19N/02W-18A02	14	.3	.7	61	2.0	7.8	.1	27
19N/02W-18K02	17	.4	2.8	66	1.8	3.0	.1	31
19N/02W-18M01	14	.3	.9	74	3.3	3.5	.1	31
19N/02W-19H01	15	.3	.7	58	3.0	2.6	.1	24
	16	.3	.7	58	3.0	2.4	.1	24
19N/02W-21C02	89	10	1.3	75	38	120	.1	26
19N/02W-21Q04	46	1	2.5	77	<1.0	3.9	.1	45
19N/02W-22D02	43	1	2.4	80	<1.0	2.6	.1	51
19N/02W-24F02	20	.4	1.4	67	3.4	1.7	.1	38
19N/02W-25A02	31	.9	5.6	132	1.3	2.9	.2	39
19N/02W-25F01	18	.4	1.3	61	6.0	7.1	.1	31
19N/02W-26J01	16	.4	2.0	115	<1.0	2.5	.1	33
19N/02W-27D03	59	4	5.3	150	14	130	.2	44
19N/02W-28L05	16	.4	1.9	90	4.0	3.4	.1	46
19N/02W-29C01	17	.4	1.7	79	<1.0	3.4	.1	34
19N/02W-30B01	21	.5	1.3	57	3.0	4.3	.1	44
19N/02W-30J02	17	.3	1.3	68	3.0	2.8	.1	31
19N/02W-31E03	16	.3	.7	50	2.8	3.2	.1	25
19N/02W-32A06	34	.8	2.0	74	<1.0	2.1	.1	43
19N/02W-32G04	16	.4	2.7	86	<1.0	2.4	.1	39
19N/02W-32H03	15	.3	3.9	81	2.0	2.7	.1	37
19N/02W-33B02	16	.4	1.6	96	3.9	4.6	<.1	36
19N/02W-33K08	27	.6	1.9	85	<1.0	2.2	.1	47
	27	.6	1.9	85	<1.0	2.2	.1	47
19N/02W-33M03	18	.4	1.9	74	3.0	3.9	.1	38

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Solids, residue at 180°C dis-solved (mg/L)	Solids, sum of consti-tuents, dis-solved (mg/L)	Nitro-gen NO_2+NO_3, dis-solved (mg/L as N)	Phos-phorous, dis-solved (mg/L as P)	Iron, dis-solved (µg/L as Fe)	Manga-nese, dis-solved (µg/L as Mn)	Coli-form, fecal (cols. per 100 mL)	Strep-tococci, fecal (cols. per 100 mL)
19N/01W-33K05	102	96	0.13	0.04	85	17	<1	<1
19N/02W-03E02	238	250	<.10	.33	3,900	560	<1	<1
19N/02W-04F05	155	162	<.10	.26	340	680	<1	<1
19N/02W-07P01	80	103	<.10	.04	61	60	<1	<1
19N/02W-08F03	173	178	<.10	1.5	330	310	<1	<1
19N/02W-08H01	106	110	.94	.02	28	2	<1	<1
19N/02W-08K01	115	128	<.10	.12	160	120	<1	<1
19N/02W-08P01	103	107	1.1	.02	9	<1	<1	<1
19N/02W-08Q01	120	126	.32	.01	12	<1	<1	<1
19N/02W-14H03	109	125	2.0	.05	3	<1	<1	<1
19N/02W-14H04	193	210	2.4	.03	18	12	<1	<1
19N/02W-14J01	196	210	<.10	.61	210	96	<1	<1
19N/02W-14P02	124	132	<.10	.07	17	84	<1	<1
19N/02W-16K02D1	129	136	<.10	.36	140	55	<1	<1
19N/02W-16Q05	111	138	1.6	.01	7	1	<1	<1
19N/02W-18A02	122	122	4.0	.02	28	5	<1	<1
19N/02W-18K02	96	104	<.10	.50	38	28	<1	<1
19N/02W-18M01	110	115	.99	.01	6	2	<1	<1
19N/02W-19H01	78	87	<.10	.02	14	<1	<1	--
	93	87	<.10	.02	16	<1	<1	--
19N/02W-21C02	350	361	.15	.02	410	9	<1	<1
19N/02W-21Q04	126	131	<.10	.66	430	50	<1	<1
19N/02W-22D02	123	138	<.10	.65	480	110	<1	<1
19N/02W-24F02	92	110	.21	.04	35	3	<1	<1
19N/02W-25A02	168	178	<.10	.73	410	110	<1	<1
19N/02W-25F01	116	120	2.2	.05	19	8	<1	<1
19N/02W-26J01	136	144	<.10	.01	79	33	<1	<1
19N/02W-27D03	431	432	<.10	1.6	240	240	<1	<1
19N/02W-28L05	164	147	.13	.04	1,700	37	<1	<1
19N/02W-29C01	97	113	<.10	.07	9	45	<1	<1
19N/02W-30B01	126	131	3.5	.02	5	<1	<1	--
19N/02W-30J02	93	104	.11	.02	5	1	<1	--
19N/02W-31E03	92	87	.80	.01	54	3	<1	<1
19N/02W-32A06	110	120	<.10	.35	53	39	<1	<1
19N/02W-32G04	125	128	<.10	.50	320	160	<1	<1
19N/02W-32H03	119	125	<.10	.41	7	54	<1	<1
19N/02W-33B02	140	148	1.7	.02	12	4	<1	<1
19N/02W-33K08	130	135	<.10	.41	170	74	<1	<1
	129	135	<.10	.41	160	73	--	--
19N/02W-33M03	115	119	<.10	.23	21	120	<1	<1

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)
19N/02W-35P03	04-07-89	0915	TQu	123	208	10.5	137	137
19N/02W-36J01	04-07-89	1045	Qva	160	73	10.0	100	102
19N/02W-36N03	04-07-89	1600	Qc	155	157	10.0	139	136
19N/03W-12Q01	05-04-89	1300	TQu	100	199	10.0	140	140
	05-04-89	1305	TQu	100	199	10.0	140	140
19N/03W-24D03	05-02-89	1120	Qc	100	120	11.5	174	177
19N/03W-24M01	05-03-89	1630	Qc	130	163	10.5	136	138
19N/03W-25E03	04-28-89	1605	Qc	130	118	10.5	158	155
19N/03W-25K01	05-01-89	1150	Qvr	175	41	10.5	102	103
	05-01-89	1155	Qvr	175	41	10.5	102	103
19N/03W-25N02	04-27-89	1630	Qc	150	106	10.5	139	143
19N/03W-26F01	05-15-89	1115	Qc	130	101	9.5	125	124
19N/03W-27L01	05-15-89	0950	TQu	40	103	11.5	154	154
19N/03W-27N01	05-18-89	1010	Qva	165	83	10.0	116	119
19N/03W-34A01	05-16-89	1135	Qva	130	47	10.5	153	153
19N/03W-34H01	05-15-89	1215	Qc	150	103	10.0	150	148
19N/03W-36M02	05-02-89	1740	Qc	150	105	9.5	140	141
20N/01W-33L02	04-19-89	1000	TQu	5	500	12.0	228	223
20N/01W-33N01	04-19-89	1255	Qc	91	119	11.0	562	566
20N/02W-33Q02	05-03-89	1045	TQu	80	757	13.0	193	194
BLANK -								
Deionized water	04-07-89	1500	--	--	--	--	--	1
	04-10-89	1230	--	--	--	--	--	1
	04-10-89	1520	--	--	--	--	--	2
	04-12-89	1100	--	--	--	--	--	2
	04-14-89	1420	--	--	--	--	--	1
	04-18-89	1400	--	--	--	--	--	1
	04-19-89	1700	--	--	--	--	--	1
	04-26-89	1130	--	--	--	--	--	1
	04-26-89	1200	--	--	--	--	--	1
	04-28-89	1800	--	--	--	--	--	1
	05-01-89	1250	--	--	--	--	--	2
	05-04-89	1400	--	--	--	--	--	1
	05-08-89	1215	--	--	--	--	--	8
	05-17-89	1300	--	--	--	--	--	1
	05-26-89	1030	--	--	--	--	--	1
	06-06-89	1130	--	--	--	--	--	2
	06-06-89	1400	--	--	--	--	--	1
	06-21-89	1100	--	--	--	--	--	1

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	pH, (standard units)	pH, lab (standard units)	Oxygen, dissolved (mg/L)	Hardness total (mg/L as $CaCO_3$)	Hardness, noncarbonate total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
19N/02W-35P03	7.4	7.3	0.2	49	0	11	5.3	8.6
19N/02W-36J01	7.4	7.3	8.1	40	0	7.3	5.3	5.3
19N/02W-36N03	7.1	7.2	6.4	53	0	11	6.2	6.6
19N/03W-12Q01	7.6	7.8	.5	59	0	13	6.4	5.3
	7.6	7.7	.5	58	0	13	6.2	5.0
19N/03W-24D03	7.2	7.5	3.2	78	0	13	11	6.1
19N/03W-24M01	7.6	7.5	.2	62	0	11	8.5	5.5
19N/03W-25E03	7.6	7.5	0	67	0	12	8.9	5.7
19N/03W-25K01	6.4	6.7	6.7	41	0	9.8	3.9	4.4
	6.4	6.7	6.7	41	0	10	3.9	4.7
19N/03W-25N02	6.6	6.9	4.9	61	1	13	6.9	5.2
19N/03W-26F01	7.5	8.0	4.1	55	0	10	7.2	4.8
19N/03W-27L01	7.1	7.3	2.8	64	0	18	4.7	7.8
19N/03W-27N01	7.2	7.4	8.6	55	1	11	6.6	4.3
19N/03W-34A01	6.8	7.8	7.9	69	0	16	7.0	5.1
19N/03W-34H01	8.0	8.0	.0	67	0	18	5.3	4.7
19N/03W-36M02	6.8	7.0	1.8	57	0	12	6.6	5.5
20N/01W-33L02	7.9	7.7	3.6	66	0	20	3.9	20
20N/01W-33N01	7.1	7.6	2.2	240	130	35	37	13
20N/02W-33Q02	8.2	8.0	.0	55	0	19	1.9	21
BLANK -								
Deionized water	--	7.5	--	--	--	< .02	< .01	< .2
	--	7.9	--	--	--	.03	<.01	<.2
	--	8.3	--	0	0	.03	.09	<.2
	--	7.5	--	--	--	.05	<.01	<.2
	--	7.5	--	--	--	<.02	<.01	<.2
	--	7.9	--	--	--	<.02	.03	<.2
	--	7.5	--	--	--	<.02	<.01	<.2
	--	7.5	--	--	--	<.02	.02	<.2
	--	7.9	--	--	--	<.02	.06	<.2
	--	7.0	--	--	--	<.02	<.01	<.2
	--	6.7	--	--	--	<.02	<.01	<.2
	--	7.3	--	--	--	<.02	<.01	<.2
	--	7.1	--	--	--	.03	<.01	<.2
	--	8.4	--	--	--	<.02	.06	<.2
	--	7.0	--	--	--	<.02	.08	<.2
	--	7.4	--	--	--	<.02	.06	<.2
	--	7.3	--	--	--	<.02	.06	<.2
	--	8.3	--	--	--	.02	<.01	<.2

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Sodium, percent	Sodium, adsorption ratio	Potassium, dissolved (mg/L as K)	Alkalinity, lab dissolved (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
19N/02W-35P03	27	0.5	1.8	67	<1.0	2.3	0.2	52
19N/02W-36J01	22	.4	1.0	44	4.8	2.5	.1	26
19N/02W-36N03	21	.4	2.0	65	<1.0	3.3	.2	53
19N/03W-12Q01	16	.3	1.5	67	1.5	2.6	.1	43
	15	.3	1.3	68	1.4	2.6	.1	42
19N/03W-24D03	14	.3	1.1	82	3.5	3.8	.1	28
19N/03W-24M01	16	.3	.9	64	3.6	3.4	.1	25
19N/03W-25E03	15	.3	1.4	76	<1.0	3.1	.1	39
19N/03W-25K01	19	.3	.4	43	2.8	3.4	.1	27
	20	.3	.4	43	2.9	3.5	.1	28
19N/03W-25N02	15	.3	.8	60	1.5	3.3	.1	31
19N/03W-26F01	16	.3	.5	57	2.0	2.7	.1	21
19N/03W-27L01	21	.4	.6	80	<1.0	4.2	.1	40
19N/03W-27N01	14	.3	.5	54	3.0	2.6	.1	25
19N/03W-34A01	14	.3	.5	72	2.0	2.9	.1	27
19N/03W-34H01	13	.3	.4	72	<1.0	2.4	.1	36
19N/03W-36M02	17	.3	.8	57	8.0	3.5	.1	23
20N/01W-33L02	39	1	2.6	103	<1.0	8.9	.1	44
20N/01W-33N01	10	.4	3.8	108	7.8	110	.1	32
20N/02W-33Q02	44	1	2.0	86	<1.0	9.4	.1	42
BLANK -								
Deionized water	--	--	<.1	1.0	<.2	<.1	.1	.05
	--	--	.1	1.0	<.2	<.1	.1	.02
	--	--	.1	2.0	<.2	<.1	.1	.01
	--	--	.1	1.0	<.2	<.1	.1	.05
	--	--	.1	1.0	<1.0	<.1	.1	<.01
	--	--	.1	1.0	<1.0	<.1	.1	.03
	--	--	.1	1.0	<1.0	<.1	.1	<.01
	--	--	.1	1.0	<1.0	<.1	<.1	.02
	--	--	<.1	1.0	<1.0	<.1	<.1	.04
	--	--	.1	2.0	<1.0	<.1	.1	<.01
	--	--	.1	1.0	<1.0	.2	<.1	<.01
	--	--	<.1	1.0	<1.0	.4	.1	<.01
	--	--	.1	3.0	<1.0	<.1	<.1	<.01
	--	--	.1	1.0	<1.0	<.1	<.1	.04
	--	--	.1	1.0	<1.0	<.1	<.1	.38
	--	--	<.1	1.0	<1.0	<.1	.1	.03
	--	--	<.1	1.0	<1.0	<.1	.1	.03
	--	--	<.1	1.0	<1.0	.1	<.1	<.01

Table C1. Values and concentrations of field measurements and common constituents--Continued

Local well number	Solids, residue at 180°C dis-solved (mg/L)	Solids, sum of consti-tuents, dis-solved (mg/L)	Nitro-gen NO_2+NO_3, dis-solved (mg/L as N)	Phos-phorous, dis-solved (mg/L as P)	Iron, dis-solved (µg/L as Fe)	Manga-nese, dis-solved (µg/L as Mn)	Coli-form, fecal (cols. per 100 mL)	Strep-tococci, fecal (cols. per 100 mL)
19N/02W-35P03	121	122	<0.10	0.48	790	180	<1	<1
19N/02W-36J01	76	79	<.10	.03	7	2	<1	<1
19N/02W-36N03	117	123	<.10	.55	1,300	240	<1	<1
19N/03W-12Q01	114	114	<.10	.23	310	130	1	<1
	114	113	<.10	.23	310	130	<1	<1
19N/03W-24D03	101	118	.51	.03	5	<1	<1	<1
19N/03W-24M01	96	96	<.10	.01	63	1	<1	<1
19N/03W-25E03	112	118	<.10	.22	1,600	170	<1	<1
19N/03W-25K01	71	79	.39	.02	68	3	<1	<1
	79	81	.39	.02	85	4	<1	<1
19N/03W-25N02	107	105	1.6	.01	10	2	<1	<1
19N/03W-26F01	75	84	.26	.02	4	<1	<1	--
19N/03W-27L01	111	125	.34	.70	84	23	<1	--
19N/03W-27N01	77	86	.16	.02	4	<1	<1	<1
19N/03W-34A01	99	105	.34	.01	9	2	<1	--
19N/03W-34H01	106	110	<.10	.69	240	58	<1	--
19N/03W-36M02	91	96	.47	<.01	9	<1	<1	<1
20N/01W-33L02	162	162	<.10	.34	220	67	<1	>100
20N/01W-33N01	318	305	.26	.02	32	1	<1	<1
20N/02W-33Q02	143	147	<.10	.30	56	14	<1	<1
BLANK -								
Deionized water	3	--	<.10	<.01	3	<1	--	--
	<1	--	<.10	<.01	<3	<1	--	--
	<1	--	<.10	<.01	4	1	--	--
	<1	--	<.10	.01	7	1	--	--
	<1	--	<.10	<.01	3	<1	--	--
	2	--	<.10	<.01	4	2	--	--
	11	--	<.10	<.01	<3	<1	--	--
	<1	--	<.10	<.01	<3	<1	--	--
	<1	--	<.10	<.01	4	<1	--	--
	<1	--	<.10	<.01	3	<1	--	--
	<1	--	<.10	<.01	31	2	--	--
	<1	--	<.10	<.01	5	<1	--	--
	<1	--	<.10	<.01	<3	<1	--	--
	2	--	<.10	.02	<3	<1	--	--
	10	--	<.10	<.01	3	<1	--	--
	6	--	<.10	<.01	4	<1	--	--
	<1	--	<.10	<.01	5	<1	--	--
	<1	--	.23	<.01	<11	<1	--	--

Table C2. Concentrations of selected trace elements

[µg/L, micrograms per liter; pCi/L, picocuries per liter; <, not detected at the given concentration; --, constituent not determined; geohydrologic unit, see table 1 in text]

Local well number	Date	Time	Geo-hydro-logic unit	Arsenic, dis-solved (µg/L as As)	Barium, dis-solved (µg/L as Ba)	Cadmium, dis-solved (µg/L as Cd)	Chro-mium, dis-solved (µg/L as Cr)	Copper, dis-solved (µg/L as Cu)	Lead, dis-solved (µg/L as Pb)	Mercury, dis-solved (µg/L as Hg)	Sele-nium, dis-solved (µg/L as Se)	Silver, dis-solved (µg/L as Ag)	Zinc, dis-solved (µg/L as Zn)	Radon 222, total (pCi/L)
16N/03W-02H01	04-14-89	1555	Qva	3	4	<1	<1	<1	<5	<0.1	<1	3	37	230
17N/01W-02E03	05-16-89	1515	Qva	<1	3	<1	<1	3	<1	<.1	<1	1	58	450
17N/01W-02L02	05-16-89	1200	Qva	1	3	1	<1	3	<1	<.1	<1	<1	26	490
17N/01W-14H01	05-25-89	1430	Qva	1	<2	<1	1	1	<1	<.1	<1	2	190	410
17N/01W-16L01	06-21-89	1445	Qva	2	2	<1	1	<1	1	<.1	<1	<1	44	660
17N/01W-19C02	05-10-89	1130	TQu	1	4	<1	<1	<1	<1	<.1	<1	7	130	420
17N/02W-09G02	05-03-89	1100	Qva	<1	3	<1	<1	1	<5	<.1	<1	<1	59	440
17N/02W-17H01	05-02-89	1530	Qva	<1	2	<1	<1	2	<5	<.1	<1	2	37	440
17N/02W-31H01	04-07-89	1355	TQu	1	5	<1	<1	<1	<5	.1	<1	<1	<3	480
	04-07-89	1400	TQu	1	5	<1	<1	4	<5	.1	<1	<1	5	470
17N/02W-33K02	05-10-89	1015	Qc	<1	5	<1	<1	<1	<1	<.1	<1	2	<3	370
17N/03W-12F01	04-17-89	1635	Qva	<1	2	<1	<1	2	<5	.4	<1	<1	900	190
17N/03W-15A01	04-13-89	1125	Tb	<1	<2	<1	<1	1	<5	<.1	<1	<1	130	640
18N/01E-19J01S	06-19-89	1050	Qvr	6	4	<1	1	1	1	<.1	<1	<1	4	110
18N/01E-19Q01S	06-19-89	1215	Qvr	2	2	<1	1	1	2	.5	<1	<1	9	180
18N/01E-32H02	06-21-89	1320	Qc	1	2	<1	1	<1	<1	<.1	<1	<1	<3	460
18N/01E-32N01	06-14-89	1715	Qc	2	3	1	<1	2	<1	<.1	<1	2	100	--
18N/01W-02G02	06-08-89	1140	Qc	1	5	<1	<1	5	<1	<.1	<1	<1	65	280
18N/01W-02H01	06-08-89	1350	Qva	<1	2	<1	1	<1	<1	<.1	<1	<1	20	480
18N/01W-06A03	04-28-89	1410	Qc	<1	4	<1	1	1	<5	<.1	<1	<1	120	<80
18N/01W-06E02	05-01-89	1150	Qvt	<1	4	<1	<1	1	<5	<.1	<1	<1	5	510
18N/01W-07N03	05-04-89	1015	Qva	5	6	<1	<1	2	<5	<.1	<1	<1	<3	92
18N/01W-11P05	06-21-89	0950	Qva	<1	3	<1	2	3	<1	.1	<1	<1	39	490
	06-21-89	0955	Qva	<1	3	2	<1	3	<1	<.1	<1	3	32	--
18N/01W-12F01	06-08-89	1515	TQu	2	3	<1	<1	<1	<1	<.1	<1	<1	4	640
18N/01W-12M01D1	06-15-89	1045	Qc	1	<2	2	1	<1	<1	<.1	<1	2	31	550
18N/01W-16Q03	06-06-89	1055	Qf	<1	2	<1	2	1	<1	<.1	<1	<1	19	440
18N/01W-17H05	05-03-89	1110	Qva	<1	5	<1	<1	2	<5	<.1	<1	1	17	520
18N/01W-19M05	05-03-89	1455	Qva	1	5	<1	5	1	<5	<.1	<1	1	160	280
18N/01W-21B06	06-08-89	1250	TQu	2	7	<1	<1	<1	<1	<.1	<1	<1	4	250

Table C2. Concentrations of selected trace elements--Continued

Local well number	Date	Time	Geo-hydro-logic unit	Arsenic, dis-solved (µg/L as As)	Barium, dis-solved (µg/L as Ba)	Cadmium, dis-solved (µg/L as Cd)	Chro-mium, dis-(µg/L as Cr)	Copper, dis-solved µg/L as Cu)	Lead, dis-solved (µg/L as Pb)	Mercury, dis-solved (µg/L as Hg)	Sele-nium, dis-(µg/L as Se)	Silver, dis-solved (µg/L as Ag)	Zinc, dis-solved (µg/L as Zn)	Radon 222, total (pCi/L)
18N/01W-22K01	05-04-89	1510	Qvr	<1	6	<1	<1	80	<5	<.1	<1	1	<3	420
18N/01W-23B02	06-15-89	1405	Qvr	<1	2	<1	1	1	<1	<.1	<1	<1	17	290
18N/01W-31R02	06-07-89	1145	Qc	21	6	<1	<1	2	<1	<.1	<1	<1	6	480
18N/02W-17D05	04-27-89	1105	Qvt	<1	5	<1	1	1	<5	<.1	<1	<1	240	310
18N/02W-20C01	04-13-89	1620	Qva	<1	<2	<1	<1	7	<5	<.1	<1	4	530	540
18N/02W-21Q01	04-12-89	1000	Qva	4	8	<1	<1	<1	<5	0.1	<1	<1	47	230
	04-12-89	1005	Qva	4	8	<1	<1	<1	<5	.1	<1	<1	50	250
18N/02W-22E01	04-12-89	1245	Qvf	1	3	<1	<1	<1	<5	<.1	<1	<1	190	300
18N/02W-24B01	04-25-89	1020	Qva	<1	4	<1	1	<1	<5	<.1	<1	<1	6	410
18N/02W-32A06	04-14-89	1655	Qva	2	5	<1	3	<1	<5	.2	<1	1	50	160
18N/02W-33M01	04-20-89	1405	Tb	<1	<2	<1	<1	<1	<5	<.1	<1	1	34	<80
18N/02W-34B01	04-20-89	1535	Qvr	<1	<2	<1	1	6	<5	<.1	<1	<1	170	320
18N/02W-35B02	05-17-89	1115	Qc	3	8	<1	2	<1	<1	<.1	<1	<1	<3	320
19N/01W-09L02	04-18-89	1550	Qva	1	3	<1	5	<1	<5	.2	<1	1	48	150
19N/01W-21K01	04-28-89	1145	Qf	<1	7	<1	<1	1	<5	<.1	<1	1	3	<80
19N/02W-08Q01	05-02-89	1320	TQu	<1	6	<1	<1	3	<5	<.1	<1	<1	850	480
19N/02W-22D02	05-18-89	1320	TQu	2	12	<1	<1	<1	<1	<.1	<1	1	<3	300
19N/02W-26J01	04-07-89	1245	Qc	<1	7	<1	<1	<1	<5	<.1	<1	<1	330	450
19N/02W-28L05	04-18-89	1545	Qva	1	6	<1	2	1	<5	<.1	<1	2	350	160
19N/02W-30B01	05-15-89	1440	Qva	<1	6	<1	<1	3	<1	<.1	<1	<1	4	560
BLANK - Deionized water	04-07-89	1500	--	<1	<2	<1	<1	1	<5	.1	<1	<1	<3	<80
	04-12-89	1100	--	<1	<2	<1	<1	1	<5	.4	<1	<1	17	110
	06-21-89	1100	--	<1	<2	<1	12	1	1	.9	<1	1	<3	--

Table C3. Concentrations of volatile organic compounds

[μg/L, micrograms per liter; <, not detected at the given concentration; --, constituent not determined; geohydrologic unit, see table 1 in text]

Local well number	Date	Time	Geo-hydro-logic unit	Chloro-methane, total (μg/L)	Di-chloro-methane, total (μg/L)	Tri-chloro-methane, total (μg/L)	Tetra-chloro-methane, total (μg/L)	Bromo-methane, total (μg/L)	Di-bromo-methane. total (μg/L)	Tri-bromo-methane, total (μg/L)
16N/03W-02H01	04-14-89	1555	Qva	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
17N/01W-02E03	05-16-89	1515	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	12-13-89	1105	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-02L02	05-16-89	1200	Qva	.2	<.2	<.2	<.2	<.2	<.2	<.2
	12-13-89	1200	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-14H01	05-25-89	1430	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-16L01	06-21-89	1445	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-19C02	05-10-89	1130	TQu	.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-09G02	05-03-89	1100	Qva	.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-17H01	05-02-89	1530	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-31H01	04-07-89	1355	TQu	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	04-07-89	1400	TQu	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-33K02	05-10-89	1015	Qc	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/03W-12F01	04-17-89	1635	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/03W-15A01	04-13-89	1125	Tb	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-19J01S	06-19-89	1050	Qvr	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-19Q01S	06-19-89	1215	Qvr	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-32H02	06-21-89	1320	Qc	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-32N01	06-14-89	1715	Qc	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-02G02	06-08-89	1140	Qc	<.2	<.2	.3	<.2	<.2	<.2	<.2
18N/01W-02H01	06-08-89	1350	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-06A03	04-28-89	1410	Qc	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-06E02	05-01-89	1150	Qvt	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-07N03	05-04-89	1015	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-11P05	06-21-89	0950	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	06-21-89	0955	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-12F01	06-08-89	1515	TQu	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-12M01D1	06-15-89	1045	Qc	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-16Q03	06-06-89	1055	Qf	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-17H05	05-03-89	1110	Qva	<.2	<.2	.2	<.2	<.2	<.2	<.2
18N/01W-19M05	05-03-89	1455	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-21B06	06-08-89	1250	TQu	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-22K01	05-04-89	1510	Qvr	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-23B02	06-15-89	1405	Qvr	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-31R02	06-07-89	1145	Qc	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-17D05	04-27-89	1105	Qvt	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-20C01	04-13-89	1620	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-21Q01	04-12-89	1000	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	04-12-89	1005	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-22E01	04-12-89	1245	Qf	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-24B01	04-25-89	1020	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-32A06	04-14-89	1655	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-33M01	04-20-89	1405	Tb	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-34B01	04-20-89	1535	Qvr	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-35B02	05-17-89	1115	Qc	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table C3. Concentrations of volatile organic compounds--Continued

Local well number	Bromo-di-chloro-methane, total (µg/L)	Di-bromo-chloro-methane, total (µg/L)	Tri-chloro-fluoro-methane, total (µg/L)	Dichloro-di-fluoro-methane, total (µg/L)	Chloro-ethane, total (µg/L)	1,1-Di-chloro-ethane, total (µg/L)	1,2-Di-chloro-ethane, total (µg/L)	1,1,1-Tri-chloro-ethane, total (µg/L)	1,1,2-Tri-chloro-ethane. total (µg/L)	1,1,1,2-Tetra-chloro-ethane, total (µg/L)
16N/03W-02H01	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
17N/01W-02E03	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-02L02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-14H01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-16L01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-19C02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-09G02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-17H01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-31H01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-33K02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/03W-12F01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/03W-15A01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-19J01S	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-19Q01S	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-32H02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-32N01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-02G02	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-02H01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-06A03	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-06E02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-07N03	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-11P05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	.2	<.2	<.2
18N/01W-12F01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-12M01D1	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-16Q03	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-17H05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-19M05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-21B06	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-22K01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-23B02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	< 2
18N/01W-31R02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-17D05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-20C01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-21Q01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-22E01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-24B01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-32A06	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-33M01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-34B01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-35B02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table C3. Concentrations of volatile organic compounds--Continued

Local well number	1,1,2,2-Tetra-chloro-ethane, total (µg/L)	1,2-Dibromo-ethane, total (µg/L)	Chloro-ethene, total (µg/L)	1,1-Di-chloro-ethene, total (µg/L)	1,2-Di-chloro-ethene, total (µg/L)	Tri-chloro-ethene, total (µg/L)	Tetra-chloro-ethene, total (µg/L)	1,2-Di-chloro-propane. total (µg/L)	1,3-Di-chloro-propane, total (µg/L)
16N/03W-02H01	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
17N/01W-02E03	<.2	.9	<.2	.5	<.2	.4	<.2	.8	<.2
	<.2	.68	<.2	<.2	<.2	<.2	<.2	.9	<.2
17N/01W-02L02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	1.5	<.2
	<.2	.12	<.2	<.2	<.2	<.2	<.2	.9	<.2
17N/01W-14H01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-16L01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-19C02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-09G02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-17H01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-31H01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-33K02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/03W-12F01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/03W-15A01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-19J01S	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-19Q01S	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-32H02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-32N01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-02G02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-02H01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-06A03	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-06E02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-07N03	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-11P05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-12F01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-12M01D1	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-16Q03	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-17H05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-19M05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-21B06	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-22K01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-23B02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-31R02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-17D05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-20C01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-21Q01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-22E01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-24B01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-32A06	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-33M01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-34B01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-35B02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table C3. Concentrations of volatile organic compounds--Continued

Local well number	2,2-Di-chloro-propane, total (µg/L)	1,2,3-Tri-chloro-propane, total (µg/L)	1,2-Di-bromo-3-chloro-propane, total (µg/L)	1,1-Di-chloro-propene, total (µg/L)	cis 1,3-Di-chloro-propene, total (µg/L)	trans 1,3-Di-chloro-propene, total (µg/L)	Benzene, total (µg/L)	Chloro-benzene. total (µg/L)	1,2-Di-chloro-benzene, total (µg/L)
16N/03W-02H01	<0.2	<0.2	--	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
17N/01W-02E03	<.2	<.2	--	<.2	<.2	<.2	<.2	.5	<.2
	<.2	<.2	<0.03	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-02L02	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	.16	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-14H01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-16L01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-19C02	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-09G02	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-17H01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-31H01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-33K02	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
17N/03W-12F01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
17N/03W-15A01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-19J01S	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-19Q01S	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-32H02	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-32N01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-02G02	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-02H01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-06A03	<.2	<.2	--	<.2	<.2	<.2	.3	<.2	<.2
18N/01W-06E02	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-07N03	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-11P05	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-12F01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-12M01D1	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-16Q03	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-17H05	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-19M05	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-21B06	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-22K01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-23B02	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-31R02	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-17D05	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-20C01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-21Q01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-22E01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-24B01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-32A06	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-33M01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-34B01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-35B02	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2

Table C3. Concentrations of volatile organic compounds--Continued

Local well number	1,3-Di-chloro-benzene, total (µg/L)	1,4-Di-chloro-benzene, total (µg/L)	Bromo-benzene, total (µg/L)	Toluene, total (µg/L)	2-Chloro-toluene, total (µg/L)	4-Chloro-toluene, total (µg/L)	Di-methyl-benzene, total (µg/L)	Ethyl-benzene. total (µg/L)	Ethenyl-benzene, total (µg/L)
16N/03W-02H01	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
17N/01W-02E03	<.2	<.2	<.2	.4	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-02L02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-14H01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-16L01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/01W-19C02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-09G02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-17H01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-31H01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/02W-33K02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/03W-12F01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
17N/03W-15A01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-19J01S	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-19Q01S	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-32H02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01E-32N01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-02G02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-02H01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-06A03	<.2	<.2	<.2	<.2	<.2	<.2	.2	.3	<.2
18N/01W-06E02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-07N03	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-11P05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-12F01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-12M01D1	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-16Q03	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-17H05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-19M05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-21B06	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-22K01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-23B02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/01W-31R02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-17D05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-20C01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-21Q01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-22E01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-24B01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-32A06	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-34B01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-33M01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
18N/02W-35B02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table C3. Concentrations of volatile organic compounds--Continued

[µg/L, micrograms per liter; <, not detected at the given concentration; --, constituent not determined; geohydrologic unit, see table 1 in text]

Local well number	Date	Time	Geo-hydro-logic unit	Chloro-methane, total (µg/L)	Di-chloro-methane, total (µg/L)	Tri-chloro-methane, total (µg/L)	Tetra-chloro-methane, total (µg/L)	Bromo-methane, total (µg/L)	Di-bromo-methane. total (µg/L)	Tri-bromo-methane, total (µg/L)
19N/01W-09L02	04-18-89	1550	Qva	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
19N/02W-08Q01	05-02-89	1320	TQu	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-22D02	05-18-89	1320	TQu	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-26J01	04-07-89	1245	Qc	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-28L05	04-18-89	1545	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-30B01	05-15-89	1440	Qva	<.2	<.2	<.2	<.2	<.2	<.2	<.2
BLANK -										
Deionized water	04-07-89	1500	--	<.2	.4	<.2	<.2	<.2	<.2	<.2
	04-12-89	1100	--	<.2	.5	<.2	<.2	<.2	<.2	<.2
	06-21-89	1100	--	<.2	.7	<.2	<.2	<.2	<.2	<.2

Table C3. Concentrations of volatile organic compounds--Continued

Local well number	Bromo-di-chloro-methane, total (µg/L)	Di-bromo-chloro-methane, total (µg/L)	Tri-chloro-fluoro-methane, total (µg/L)	Dichloro-di-fluoro-methane, total (µg/L)	Chloro-ethane, total (µg/L)	1,1-Di-chloro-ethane, total (µg/L)	1,2-Di-chloro-ethane, total (µg/L)	1,1,1-Tri-chloro-ethane, total (µg/L)	1,1,2-Tri-chloro-ethane. total (µg/L)	1,1,1,2-Tetra-chloro-ethane, total (µg/L)
19N/01W-09L02	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
219N/02W-08Q01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-22D02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-26J01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-28L05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-30B01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
BLANK - Deionized water	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table C3. Concentrations of volatile organic compounds--Continued

Local well number	1,1,2,2-Tetra-chloro-ethane, total (µg/L)	1,2-Dibromo-ethane, total (µg/L)	Chloro-ethene, total (µg/L)	1,1-Di-chloro-ethene, total (µg/L)	1,2-Di-chloro-ethene, total (µg/L)	Tri-chloro-ethene, total (µg/L)	Tetra-chloro-ethene, total (µg/L)	1,2-Di-chloro-propane. total (µg/L)	1,3-Di-chloro-propane, total (µg/L)
19N/01W-09L02	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
19N/02W-08Q01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-22D02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-26J01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-28L05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-30B01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
BLANK -									
Deionized water	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table C3. Concentrations of volatile organic compounds--Continued

Local well number	2,2-Di-chloro-propane, total (µg/L)	1,2,3-Tri-chloro-propane, total (µg/L)	1,2-Di-bromo-3-chloro-propane, total (µg/L)	1,1-Di-chloro-propene, total (µg/L)	cis 1,3-Di-chloro-propene, total (µg/L)	trans 1,3-Di-chloro-propene, total (µg/L)	Benzene, total (µg/L)	Chloro-benzene. total (µg/L)	1,2-Di-chloro-benzene, total (µg/L)
19N/01W-09L02	<0.2	<0.2	--	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
19N/02W-08Q01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-22D02	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-26J01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-28L05	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-30B01	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
BLANK -									
Deionized water	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	--	<.2	<.2	<.2	<.2	<.2	<.2

Table C3. Concentrations of volatile organic compounds--Continued

Local well number	1,3-Di-chloro-benzene, total (μg/L)	1,4-Di-chloro-benzene, total (μg/L)	Bromo-benzene, total (μg/L)	Toluene, total (μg/L)	2-Chloro-toluene, total (μg/L)	4-Chloro-toluene, total (μg/L)	Di-methyl-benzene, total (μg/L)	Ethyl-benzene. total (μg/L)	Ethenyl-benzene, total (μg/L)
19N/01W-09L02	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
19N/02W-08Q01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-22D02	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-26J01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-28L05	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
19N/02W-30B01	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
BLANK -									
Deionized water	<.2	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	.2	<.2	<.2	<.2	<.2	<.2
	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2

Table C4. Concentrations of septage-related compounds

[mg/L, milligrams per liter; µg/L, micrograms per liter; <, not detected at the given concentration; --, constituent not determined; geohydrologic unit, see table 1 in text]

Local well number	Date	Time	Geo-hydro-logic unit	Nitrogen, NO_2+NO_3 dis-solved (mg/L as N)	Boron, dis-solved (µg/L as B)	Carbon, organic, dis-solved (mg/L as C)	Methy-lene blue active sub-stances (mg/L)
17N/01E-07H01	06-12-89	1610	Qva	0.17	<10	1.7	<0.02
17N/01E-14P01	06-16-89	1230	Qc	1.5	<10	.4	.06
17N/01W-04E01	06-08-89	0845	Qvr	2.1	10	.3	.05
17N/01W-16L01	06-21-89	1445	Qva	.11	<10	--	.04
17N/02W-08L01	04-13-89	1025	Qvr	2.7	<10	.5	.05
17N/02W-11J01	04-13-89	1445	Qvr	2.8	<10	.2	.06
17N/02W-22A02	04-13-89	1325	Qva	3.7	<10	.3	.07
17N/02W-29R01	04-13-89	1150	Qc	<.10	20	1.2	<.02
18N/01E-06R01	06-07-89	1615	Qc	<.10	20	.8	<.02
18N/01E-19J01S	06-19-89	1050	Qvr	.15	10	.7	.03
18N/01E-19Q01S	06-19-89	1215	Qvr	1.6	20	.4	.03
18N/01W-05E03	05-01-89	1325	Qva	<.10	20	.9	.02
18N/01W-07C01	04-28-89	1550	Qvt	3.1	20	.3	.05
18N/01W-07H04	05-01-89	1455	Qc	<.10	20	.2	<.02
18N/01W-07N03	05-04-89	1015	Qva	<.10	10	.3	<.02
18N/01W-09J01	05-03-89	1300	Qc	.44	10	.3	<.02
18N/01W-11P05	06-21-89	0950	Qva	5.6	30	.5	.09
	06-21-89	0955	Qva	5.4	40	.5	.07
18N/01W-12F01	06-08-89	1515	TQu	1.1	30	.3	.04
18N/01W-12M01D1	06-15-89	1045	Qc	1.2	20	.3	<.02
18N/01W-13C01	06-14-89	1130	Qvr	1.7	<10	.2	.03
18N/01W-14L02	06-15-89	0945	Qva	7.8	30	.5	.21
18N/01W-19M05	05-03-89	1455	Qva	1.3	10	.6	.03
18N/01W-23B02	06-15-89	1405	Qvr	3.2	10	.3	.05
18N/01W-26A02	06-13-89	1245	Qva	2.9	20	.4	.03
18N/01W-31A03	05-08-89	1310	Qva	<.10	<10	.4	<.02
18N/01W-32P01	06-07-89	1330	Qvr	3.5	30	.4	.04
18N/01W-33C01	05-05-89	1215	Qva	2.0	10	.3	.03
18N/01W-33F01	05-04-89	1305	Qva	1.3	10	.2	.03
18N/01W-33P01	06-08-89	1000	Qc	<.10	<10	.3	<.02
18N/01W-35G02	05-10-89	1240	Qc	<.10	<10	3.1	<.02
18N/01W-36M02	05-10-89	1055	Qc	5.0	20	.3	.07
18N/02W-02H04	04-24-89	1220	Qf	<.10	<10	.8	<.02
18N/02W-04J08	04-26-89	0950	Qf	<.10	70	1.6	.03
18N/02W-05H01	04-20-89	1050	Qva	<.10	<10	.2	<.02
18N/02W-20C01	04-13-89	1620	Qva	.23	<10	.6	.03
18N/02W-22E01	04-12-89	1245	Qf	.96	<10	.4	<.02
18N/02W-24B01	04-25-89	1020	Qva	<.10	<10	.8	<.02
18N/02W-31J03	04-14-89	1110	Qva	2.3	40	.3	.03
18N/02W-34B01	04-20-89	1535	Qvr	.26	<10	.3	<.02
18N/02W-35B02	05-17-89	1115	Qc	<.10	20	.4	<.02
19N/01W-21K01	04-28-89	1145	Qf	<.10	<10	.4	<.02
19N/02W-33K08	04-18-89	1330	Qc	<.10	30	1.0	<.02
	04-18-89	1335	Qc	<.10	20	.9	<.02
19N/02W-33M03	05-04-89	1030	Qva	<.10	<10	.3	<.02
20N/01W-33N01	04-19-89	1255	Qc	.26	10	.3	.03
BLANK - Deionized water	04-18-89	1400	--	<.10	<10	.3	<.02
	06-21-89	1100	--	.23	<10	.3	.03

Table C5. Values and concentrations of field measurements and common constituents for samples collected in 1988 and 1989 from wells near McAllister Springs

[°C, degrees Celsius; µS/cm, microsiemans per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, not detected at given concenration; >, concentration is greater than the given value; cols. per 100 mL, colonies per 100 milliliters; --, constituent not determined; geohydrologic unit, see table 1 in text]

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)
17N/01E-05E01	11-14-88	0925	Qc	221	218	11.0	144	150
	06-07-89	1215	Qc	221	218	11.0	148	151
17N/01E-05N01	11-15-88	1445	Qc	225	305	11.0	128	135
	06-07-89	1305	Qc	225	305	11.0	136	141
17N/01E-06J03D1	11-17-88	0945	TQu	205	425	10.0	158	164
	06-20-89	1425	TQu	205	425	10.0	165	153
17N/01E-08L02	11-15-88	1100	TQu	218	258	11.0	225	235
17N/01E-08L03	11-15-88	0930	Qc	250	171	10.5	124	130
	06-02-89	1410	Qc	250	171	11.0	128	132
17N/01W-01B04	11-18-88	1100	Qc	222	191	10.5	150	158
	05-19-89	1400	Qc	222	191	11.5	153	155
17N/01W-01F01	11-14-88	1115	Qc	230	160	10.5	142	148
	05-16-89	1315	Qc	230	160	10.5	144	144
18N/01E-17Q01	11-16-88	1115	Qc	181	260	10.5	127	133
	11-16-88	1120	Qc	181	260	10.5	127	133
	06-09-89	1110	Qc	181	260	10.5	132	134
18N/01E-19J01	11-14-88	1155	Qc	70	68	11.5	269	272
18N/01E-19J01S	11-16-88	0950	Qvr	7	--	11.0	175	185
	06-19-89	1050	Qvr	7	--	11.5	186	187
18N/01E-19Q01S	11-16-88	0850	Qvr	5	--	10.0	136	146
	06-19-89	1215	Qvr	5	--	10.5	148	148
18N/01E-20M01	11-15-88	1250	Qc	120	130	11.0	165	168
18N/01E-21N02	11-17-88	0920	Qc	220	200	10.5	148	153
	06-14-89	1835	Qc	220	200	11.0	154	154
18N/01E-28M01	11-18-88	1245	Qc	238	194	10.0	126	130
	06-30-89	0940	Qc	238	194	10.0	131	134
18N/01E-30C01	11-19-88	0900	Qvr	160	26	10.5	100	104
	06-24-89	0940	Qvr	160	26	13.0	106	108
18N/01E-30N02	11-14-88	0945	Qc	212	190	10.5	150	154
	05-08-89	1215	Qc	212	190	10.5	152	153
18N/01E-31A01	11-16-88	1410	Qc	83	92	10.5	130	135
	05-10-89	1710	Qc	83	92	10.0	133	133
18N/01E-31F01	11-16-88	1535	Qc	222	214	10.5	124	127
	05-10-89	1540	Qc	222	214	10.5	131	129

Table C5. Values and concentrations of field measurements and common constituents for samples collected in 1988 and 1989 from wells near McAllister Springs--Continued

Local well number	pH, (standard units)	pH, lab (standard units)	Oxygen, dissolved (mg/L)	Hardness total (mg/L as $CaCO_3$)	Hardness, noncarbonate total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
17N/01E-05E01	7.1	7.2	6.5	60	0	11	8.0	7.0
	7.2	7.4	8.4	58	0	11	7.5	7.2
17N/01E-05N01	7.8	7.7	.1	54	0	9.8	7.2	7.1
	7.9	7.8	.1	54	0	10	7.0	7.3
17N/01E-06J03D1	7.2	7.6	.0	70	0	15	7.9	7.3
	7.3	7.7	.4	62	0	13	7.2	7.5
17N/01E-08L02	7.1	7.2	5.1	100	11	17	14	9.1
17N/01E-08L03	7.1	7.3	5.5	51	0	8.9	7.1	6.5
	7.1	7.4	7.0	51	0	9.1	6.8	6.4
17N/01W-01B04	7.0	7.1	7.1	60	17	12	7.3	6.4
	7.1	7.3	6.5	58	12	12	6.8	6.3
17N/01W-01F01	7.0	7.0	4.7	60	7	12	7.3	6.2
	6.9	7.1	4.6	55	3	11	6.8	5.8
18N/01E-17Q01	7.1	7.3	3.5	50	0	9.3	6.5	8.1
	7.1	7.2	3.5	50	0	9.3	6.5	8.1
	7.0	7.3	3.5	47	0	8.9	5.9	7.7
18N/01E-19J01	7.2	7.3	2.9	85	21	16	11	19
18N/01E-19J01S	7.4	7.4	1.3	52	0	11	5.9	20
	7.5	7.5	1.5	50	0	11	5.4	19
18N/01E-19Q01S	6.9	7.0	4.9	58	2	11	7.5	6.9
	6.9	7.2	4.8	56	0	11	7.0	6.7
18N/01E-20M01	6.9	7.1	2.2	61	0	12	7.5	12
18N/01E-21N02	7.3	7.4	7.9	63	5	13	7.3	6.7
	7.3	8.0	6.6	58	0	12	6.7	7.0
18N/01E-28M01	7.2	7.3	10.6	52	0	9.7	6.8	6.2
	6.9	7.5	7.7	52	0	10	6.5	6.2
18N/01E-30C01	6.4	6.7	10.0	37	5	9.6	3.1	4.6
	6.2	6.9	7.4	40	11	11	3.1	5.0
18N/01E-30N02	7.1	7.2	7.5	61	11	12	7.6	6.3
	7.0	7.1	7.2	60	9	12	7.3	6.7
18N/01E-31A01	6.7	6.8	3.8	56	0	9.4	7.9	5.4
	6.7	7.0	3.4	55	0	9.7	7.4	5.7
18N/01E-31F01	7.3	7.3	5.1	49	0	9.4	6.1	6.2
	7.2	7.4	5.1	48	0	9.8	5.8	6.5

Table C5. Values and concentrations of field measurements and common constituents for samples collected in 1988 and 1989 from wells near McAllister Springs--Continued

Local well number	Sodium, percent	Sodium, adsorption ratio	Potassium, dissolved (mg/L as K)	Alkalinity, lab (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
17N/01E-05E01	19	0.4	2.1	66	4.2	3.3	0.1	49
	20	.4	2.1	66	5.0	3.5	.2	49
17N/01E-05N01	21	.4	2.1	65	2.6	2.2	.2	55
	22	.4	2.1	67	2.0	2.6	.2	55
17N/01E-06J03D1	18	.4	2.5	81	3.2	3.1	.1	55
	20	.4	2.3	73	<1.0	3.4	.1	56
17N/01E-08L02	16	.4	3.7	89	15	11	.1	50
17N/01E-08L03	21	.4	2.5	55	4.7	2.9	.1	48
	21	.4	2.5	56	4.0	2.9	.1	49
17N/01W-01B04	18	.4	1.9	43	9.6	3.8	<.1	34
	18	.4	2.0	46	9.0	3.2	.1	34
17N/01W-01F01	18	.4	1.9	53	6.5	3.5	.1	38
	18	.3	2.0	53	6.0	3.4	.1	38
18N/01E-17Q01	25	.5	1.8	57	5.4	2.5	.1	40
	25	.5	1.8	57	5.5	2.5	.1	41
	26	.5	1.8	58	5.0	2.8	.1	39
18N/01E-19J01	32	.9	2.5	64	13	14	.1	35
18N/01E-19J01S	44	1	2.3	83	2.5	6.9	.1	43
	44	1	2.3	83	2.0	6.7	.1	44
18N/01E-19Q01S	20	.4	2.0	56	5.4	4.1	.1	39
	20	.4	2.0	56	5.0	4.1	.1	40
18N/01E-20M01	29	.7	2.2	71	5.9	4.2	.1	40
18N/01E-21N02	18	.4	2.0	58	5.6	3.9	<.1	37
	20	.4	2.0	58	6.0	3.9	.1	36
18N/01E-28M01	20	.4	2.1	54	4.1	3.3	<.1	42
	20	.4	2.0	56	4.0	3.1	.1	42
18N/01E-30C01	21	.3	.8	32	7.9	3.4	<.1	24
	21	.4	.7	29	7.0	4.2	<.1	24
18N/01E-30N02	18	.4	2.1	50	7.6	4.0	.1	38
	19	.4	2.1	51	7.0	3.9	.1	39
18N/01E-31A01	17	.3	1.9	57	3.9	3.6	.1	41
	18	.3	1.9	58	4.0	3.2	.1	43
18N/01E-31F01	20	.4	3.1	49	5.2	3.1	.1	49
	21	.4	2.7	50	5.0	3.1	.1	50

Table C5. Values and concentrations of field measurements and common constituents for samples collected in 1988 and 1989 from wells near McAllister Springs--Continued

Local well number	Solids, residue at 180°C dis- solved (mg/L)	Solids, sum of consti- tuents, dis- solved (mg/L)	Nitro- gen NO_2+NO_3, dis- solved (mg/L as N)	Phos- phorous, dis- solved (mg/L as P)	Iron, dis- solved (µg/L as Fe)	Manga- nese, dis- solved (µg/L as Mn)	Coli- form, fecal (cols. per 100 mL)	Strep- tococci, fecal (cols. per 100 mL)
17N/01E-05E01	114	126	0.37	0.19	4	4	<1	<1
	112	127	.37	.19	5	2	<1	<1
17N/01E-05N01	120	125	<.10	.06	23	290	<1	<1
	114	127	<.10	.20	19	300	<1	<1
17N/01E-06J03D1	132	144	<.10	.19	1,400	270	<1	<1
	130	138	<.10	.18	4,900	290	<1	<1
17N/01E-08L02	165	174	<.10	.09	420	360	<1	15
17N/01E-08L03	116	116	.56	.01	<3	2	<1	<1
	100	117	.58	.06	<3	<1	<1	<1
17N/01W-01B04	114	123	5.0	.03	9	<1	<1	1
	130	120	4.4	.03	6	1	<1	<1
17N/01W-01F01	113	117	2.3	.04	<3	3	<1	<1
	118	112	1.6	.05	<3	<1	<1	<1
18N/01E-17Q01	96	109	.23	.12	8	<1	<1	<1
	109	110	.24	.12	4	<1	<1	<1
	98	107	.17	.14	43	<1	<1	<1
18N/01E-19J01	184	184	7.9	.20	9	2	<1	<1
18N/01E-19J01S	142	142	.11	.33	130	200	450	3,100
	131	141	.15	.36	130	170	> 60	>100
18N/01E-19Q01S	99	117	1.6	.10	7	2	<1	<1
	119	117	1.6	.10	4	<1	<1	<1
18N/01E-20M01	123	130	.86	.14	5	<1	<1	<1
18N/01E-21N02	115	119	1.9	.04	<3	<1	<1	<1
	107	117	1.9	.04	7	<1	<1	<1
18N/01E-28M01	108	110	.78	.06	<3	<1	<1	<1
	104	112	.92	.04	28	<1	<1	<1
18N/01E-30C01	77	78	1.3	.01	57	8	<1	<1
	91	82	2.2	.01	7	1	<1	<1
18N/01E-30N02	126	121	3.1	.04	4	<1	<1	<1
	114	122	3.0	.05	4	<1	<1	<1
18N/01E-31A01	100	110	.57	.07	<3	<1	<1	<1
	113	112	.51	.08	<3	<1	<1	<1
18N/01E-31F01	104	118	1.4	.07	7	<1	<1	<1
	99	119	1.4	.06	<3	<1	<1	<1

Table C5. Values and concentrations of field measurements and common constituents for samples collected in 1988 and 1989 from wells near McAllister Springs--Continued

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)
18N/01E-31H03	11-18-88	1115	Qc	160	193	10.5	146	150
	06-21-89	1220	Qc	160	193	10.5	152	154
18N/01E-31N01	11-17-88	1215	Qva	212	139	11.0	114	121
	06-15-89	1235	Qva	212	139	11.0	121	121
18N/01E-31Q01D1	11-14-88	1335	TQu	156	373	10.0	170	161
	11-14-88	1340	TQu	156	373	10.0	170	161
	06-08-89	1600	TQu	156	373	10.5	172	161
18N/01E-32C02	11-16-88	0940	Qc	140	128	11.5	116	119
	06-14-89	1535	Qc	140	128	11.5	119	122
18N/01E-32H02	11-18-88	0940	Qc	253	216	10.5	121	128
	06-21-89	1320	Qc	253	216	10.5	129	130
18N/01E-32N01	11-15-88	1320	Qc	115	92	10.5	155	163
	06-14-89	1715	Qc	115	92	10.5	162	164
18N/01W-24B02	11-15-88	0910	Qva	242	103	11.0	226	232
	06-13-89	1425	Qva	242	103	11.0	245	248
18N/01W-26A02	11-15-88	1035	Qva	230	118	10.0	179	184
	06-13-89	1245	Qva	230	118	11.0	180	182
18N/01W-36H02	11-17-88	1235	Qc	221	188	10.5	150	155
	05-10-89	1415	Qc	221	188	10.5	159	157
18N/01W-36M02	11-14-88	1445	Qc	225	160	10.5	150	154
	05-10-89	1055	Qc	225	160	10.5	173	172

Table C5. Values and concentrations of field measurements and common constituents for samples collected in 1988 and 1989 from wells near McAllister Springs--Continued

Local well number	pH, (standard units)	pH, lab (standard units)	Oxygen, dissolved (mg/L)	Hardness total (mg/L as $CaCO_3$)	Hardness, noncarbonate total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)
18N/01E-31H03	7.6	7.5	0.1	64	0	10	9.6	5.8
	7.6	7.6	.1	65	0	11	9.2	5.9
18N/01E-31N01	7.1	7.4	.0	51	0	7.9	7.6	5.1
	7.1	7.3	.1	48	0	7.8	6.9	5.3
18N/01E-31Q01D1	7.1	7.0	.0	65	0	11	9.0	5.8
	7.1	7.0	.0	65	0	11	9.0	5.8
	7.1	7.1	.0	63	0	11	8.7	5.9
18N/01E-32C02	6.6	6.7	.2	49	0	8.5	6.7	5.5
	6.6	6.8	1.1	46	0	8.6	6.0	5.7
18N/01E-32H02	7.1	7.2	7.0	48	0	8.8	6.4	5.9
	7.2	7.4	5.9	49	0	9.4	6.1	6.6
18N/01E-32N01	6.8	7.0	7.1	67	4	13	8.3	7.0
	6.8	7.4	4.8	64	1	13	7.6	7.0
18N/01W-24B02	7.6	7.5	6.4	100	7	23	11	7.5
	7.6	7.8	5.4	110	5	24	11	8.1
18N/01W-26A02	7.0	7.2	7.4	75	12	16	8.6	7.9
	6.9	7.2	7.8	69	10	15	7.7	7.7
18N/01W-36H02	7.1	7.2	6.5	61	13	12	7.5	6.4
	7.0	7.3	7.5	60	10	12	7.2	6.6
18N/01W-36M02	6.8	6.9	9.2	58	17	15	5.1	6.2
	6.6	6.9	9.4	65	21	17	5.4	6.9

Table C5. Values and concentrations of field measurements and common constituents for samples collected in 1988 and 1989 from wells near McAllister Springs--Continued

Local well number	Sodium, percent	Sodium, adsorption ratio	Potassium, dissolved (mg/L as K)	Alkalinity, lab (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)
18N/01E-31H03	16	0.3	2.2	72	3.0	2.9	0.1	56
	16	.3	2.2	72	2.0	2.8	.1	57
18N/01E-31N01	17	.3	2.1	56	3.8	3.3	.1	63
	19	.3	2.2	55	2.0	3.3	.1	62
18N/01E-31Q01D1	16	.3	2.4	80	15	4.3	.1	49
	16	.3	2.4	80	15	4.3	.1	49
	16	.3	2.5	77	1.0	4.3	.1	50
18N/01E-32C02	19	.4	1.9	51	3.6	4.1	.1	32
	20	.4	2.0	52	4.0	3.4	.1	32
18N/01E-32H02	20	.4	2.1	53	4.0	3.3	.1	41
	22	.4	2.0	53	4.0	3.3	.1	44
18N/01E-32N01	18	.4	2.1	63	7.1	4.1	.1	43
	19	.4	2.0	63	6.0	4.2	.1	42
18N/01W-24B02	13	.3	2.0	96	5.7	5.5	.1	22
	14	.4	2.0	100	6.0	5.2	.1	22
18N/01W-26A02	18	.4	1.7	63	13	4.3	.1	37
	19	.4	1.5	59	12	4.5	.1	37
18N/01W-36H02	18	.4	2.1	48	8.4	4.0	.1	37
	19	.4	2.2	50	9.0	3.9	.1	37
18N/01W-36M02	18	.4	1.2	42	9.1	5.6	.1	28
	18	.4	1.2	44	11	5.5	<.1	28

Table C5. Values and concentrations of field measurements and common constituents for samples collected in 1988 and 1989 from wells near McAllister Springs--Continued

Local well number	Solids, residue at 180°C dis-solved (mg/L)	Solids, sum of consti-tuents, dis-solved (mg/L)	Nitro-gen NO_2+NO_3, dis-solved (mg/L as N)	Phos-phorous, dis-solved (mg/L as P)	Iron, dis-solved (µg/L as Fe)	Manga-nese, dis-solved (µg/L as Mn)	Coli-form, fecal (cols. per 100 mL)	Strep-tococci, fecal (cols. per 100 mL)
18N/01E-31H03	123	133	<0.10	0.17	70	590	<1	<1
	128	134	<0.10	0.15	150	600	<1	<1
18N/01E-31N01	116	127	<0.10	0.29	150	390	<1	<1
	105	123	<0.10	0.27	130	390	<1	<1
18N/01E-31Q01D1	134	153	<0.10	0.23	5,100	3,500	<1	<1
	132	153	<0.10	0.17	5,100	3,500	<1	<1
	120	138	<0.10	0.22	5,000	3,400	<1	<1
18N/01E-32C02	82	95	0.43	0.03	140	5	<1	<1
	93	94	0.25	0.02	110	3	<1	<1
18N/01E-32H02	94	107	0.80	0.06	<3	<1	<1	<1
	100	111	0.88	0.05	7	<1	<1	<1
18N/01E-32N01	117	130	1.8	0.10	15	5	<1	<1
	110	128	1.8	0.10	14	<1	<1	<1
18N/01W-24B02	142	147	2.9	0.02	6	3	<1	<1
	151	153	3.4	<0.01	<3	<1	<1	<1
18N/01W-26A02	134	138	2.7	0.03	220	8	<1	<1
	124	134	2.9	0.01	9	3	<1	<1
18N/01W-36H02	104	121	3.4	0.04	6	1	<1	<1
	121	123	3.3	0.04	3	<1	<1	<1
18N/01W-36M02	116	112	3.7	0.01	17	3	<1	<1
	125	123	5.0	0.02	7	<1	<1	<1

Table C6. Concentrations of chloride for samples collected in 1978 and 1989 from 112 coastal wells

[°C, degrees Celsius; µS/cm, microsiemans per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; --, constituent not determined; geohydrologic unit, see table 1 in text]

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)	Chlo-ride, dis-solved (mg/L as Cl)
18N/01E-05M01	05-08-78	--	TQu	10	900	11.0	155	--	3.6
	05-03-89	1645	TQu	10	900	11.5	170	166	3.8
18N/01E-08D03	05-08-78	--	Qc	10	110	11.0	165	--	2.6
	06-07-89	1725	Qc	10	110	12.0	182	181	2.8
18N/01E-08F02	05-08-78	--	Qc	18	100	10.5	195	--	2.3
	04-17-89	1525	Qc	18	100	11.5	210	216	5.1
18N/01E-18A01	05-08-78	--	Qc	15	120	11.5	122	--	3.6
	04-10-89	1255	Qc	15	120	12.0	126	131	3.3
	06-16-89	1110	Qc	15	120	11.5	134	134	3.3
18N/02W-02C04	05-15-78	--	Qc	100	143	10.5	141	--	2.8
	05-01-89	1825	Qc	100	143	11.5	152	150	3.0
18N/02W-02E02	05-15-78	--	TQu	5	200	10.5	124	--	1.6
	05-01-89	1850	TQu	5	200	11.0	140	140	2.1
18N/02W-04F02	05-15-78	--	TQu	20	400	--	134	--	2.1
	04-18-89	1240	TQu	20	400	9.0	132	142	2.2
18N/02W-06E02	05-17-78	--	Qc	35	45	11.0	104	--	2.1
	06-16-89	1255	Qc	35	45	14.5	115	114	2.1
18N/03W-01D02	05-18-78	--	Qc	10	64	10.0	116	--	2.8
	04-20-89	1605	Qc	10	64	9.5	122	124	2.9
18N/03W-02J01	05-18-78	--	Qc	35	55	11.5	179	--	16
	04-19-89	1355	Qc	35	55	12.0	--	183	13
18N/03W-12R01	05-17-78	--	Qc	12	27	--	117	--	2.6
	04-20-89	1100	Qc	12	27	10.5	128	127	2.0
18N/03W-13B01	05-18-78	--	--	15	50	11.5	455	--	89
	04-19-89	1445	--	15	50	12.0	448	463	94
18N/03W-13G02	05-17-78	--	Qc	20	90	10.5	85	--	2.3
	04-19-89	1515	Qc	20	90	11.5	--	99	2.1
18N/03W-13K01	05-17-78	--	Qc	50	85	10.5	97	--	2.3
	04-24-89	1535	Qc	50	85	10.5	108	105	2.2
18N/03W-13Q01	05-17-78	--	--	60	83	10.5	96	--	2.6
	06-16-89	1435	--	60	83	13.0	99	108	2.1
18N/03W-24H01	05-17-78	--	TQu	20	207	--	685	--	170
	04-24-89	1645	TQu	20	207	10.5	720	696	180

Table C6. Concentrations of chloride for samples collected in 1978 and 1989 from 112 coastal wells---Cont.

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)	Chlo-ride, dis-solved (mg/L as Cl)
18N/03W-24J01	05-17-78	--	TQu	20	116	10.0	310	--	71
	04-19-89	1550	TQu	20	116	12.0	355	380	79
18N/03W-24R04	05-17-78	--	TQu	20	115	10.0	610	--	140
	04-19-89	1625	TQu	20	115	11.0	490	515	120
19N/01E-30E01	05-08-78	--	Qc	10	34	9.5	98	--	2.6
	04-17-89	1645	Qc	10	34	9.5	109	116	3.5
19N/01E-31C03	05-08-78	--	Qc	200	238	11.0	164	--	2.1
	04-17-89	1735	Qc	200	238	10.5	161	173	2.5
19N/01W-03N01	05-09-78	--	TQu	30	98	11.5	650	--	140
	04-10-89	1525	TQu	30	98	12.0	655	653	150
19N/01W-04F02	05-09-78	--	Qc	100	116	--	183	--	2.6
	05-02-89	1240	Qc	100	116	11.0	191	195	2.7
19N/01W-04G01	05-09-78	--	Qc	55	90	11.0	2,420	--	650
	04-12-89	1520	Qc	55	90	11.5	2,200	2,190	570
19N/01W-04J02	05-09-78	--	Qc	55	66	11.0	2,260	--	610
	04-10-89	1630	Qc	55	66	11.5	1,510	1,550	390
19N/01W-05H01	05-09-78	--	Qc	60	99	11.0	280	--	6.5
	04-26-89	1130	Qc	60	99	11.0	318	308	8.5
19N/01W-05J01	05-09-78	--	TQu	5	337	12.0	139	--	2.1
	05-02-89	1320	TQu	5	337	11.5	152	149	1.8
19N/01W-05R04	05-09-78	--	TQu	40	139	11.5	192	--	2.6
	04-28-89	1545	TQu	40	139	11.5	200	194	2.7
19N/01W-06H01	05-11-78	--	Qc	30	144	11.0	720	--	.52
	05-01-89	1450	Qc	30	144	12.5	750	749	8.8
19N/01W-06K04	05-11-78	--	Qc	40	65	10.5	140	--	4.1
	05-02-89	1555	Qc	40	65	10.5	153	150	4.3
19N/01W-06M03	05-11-78	--	TQu	65	300	11.0	632	--	140
	04-28-89	1300	TQu	65	300	11.5	800	780	180
19N/01W-07N01	05-11-78	--	Qc	120	133	10.5	232	--	4.7
	05-02-89	1720	Qc	120	133	11.0	270	266	4.6
19N/01W-07R01	05-11-78	--	TQu	40	1,000	11.0	227	--	2.3
	04-04-89	1110	TQu	40	1,000	12.0	231	232	2.5
	04-28-89	1405	TQu	40	1,000	12.0	227	231	2.5

Table C6. Concentrations of chloride for samples collected in 1978 and 1989 from 112 coastal wells---Cont.

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (μS/cm)	Spe-cific con-duc-tance, lab (μS/cm)	Chlo-ride, dis-solved (mg/L as Cl)
19N/01W-08A03	05-10-78	--	TQu	60	137	10.5	113	--	2.6
	04-12-89	1615	TQu	60	137	10.5	121	125	2.5
19N/01W-08J01	05-10-78	--	Qc	40	87	--	132	--	2.3
	04-12-89	1305	Qc	40	87	11.0	138	145	2.8
19N/01W-10C02	05-09-78	--	Qc	65	90	11.0	875	--	190
	04-10-89	1425	Qc	65	90	12.0	689	688	140
19N/01W-10L02	05-09-78	--	Qc	30	85	11.0	1,100	--	270
	04-20-89	1030	Qc	30	85	11.0	1,270	1,250	330
19N/01W-15G01	05-09-78	--	TQu	40	80	10.0	116	--	2.8
	05-03-89	1305	TQu	40	80	10.0	136	130	3.0
19N/01W-17A03	05-10-78	--	TQu	30	128	10.0	134	--	4.4
	04-12-89	1155	TQu	30	128	11.0	138	145	4.1
19N/01W-17K01	05-10-78	--	Qc	5	38	12.0	2,340	--	650
	05-02-89	1415	Qc	5	38	12.0	2,010	2,070	550
19N/01W-17M01	05-11-78	--	TQu	10	995	12.5	116	--	2.3
	06-30-89	1415	TQu	10	995	14.0	177	182	2.1
19N/01W-19B01	05-11-78	--	Qc	50	85	--	167	--	7.2
	04-11-89	1310	Qc	50	85	11.5	168	174	8.4
19N/01W-20G01	05-10-78	--	Qc	125	159	--	582	--	110
	04-28-89	1505	Qc	125	159	11.0	530	521	92
19N/01W-20R03	05-10-78	--	Qc	15	68	10.5	122	--	1.6
	04-11-89	1515	Qc	15	68	11.0	121	129	1.2
19N/01W-21N01	05-10-78	--	TQu	125	218	--	281	--	2.6
	04-12-89	1620	TQu	125	218	10.5	350	355	3.0
19N/01W-23F02	05-09-78	--	TQu	40	388	9.5	194	--	2.3
	05-03-89	1140	TQu	40	388	10.5	209	202	3.3
19N/01W-28N02	05-10-78	--	Qc	60	112	10.5	133	--	1.8
	04-11-89	1100	Qc	60	112	10.5	132	143	2.0
19N/01W-29A01	05-10-78	--	TQu	12	225	10.5	133	--	1.8
	04-11-89	1155	TQu	12	225	11.0	138	144	1.9
19N/01W-33D03	05-10-78	--	Qc	25	70	10.5	133	--	2.6
	04-11-89	1640	Qc	25	70	11.0	138	142	1.9

Table C6. Concentrations of chloride for samples collected in 1978 and 1989 from 112 coastal wells---Cont.

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)	Chlo-ride, dis-solved (mg/L as Cl)
19N/01W-33E01	05-10-78	--	TQu	5	150	9.5	357	--	3.6
	04-11-89	1535	TQu	5	150	10.0	359	367	3.5
19N/02W-01Q01	05-11-78	--	Qc	80	118	11.0	200	--	4.4
	06-23-89	1520	Qc	80	118	13.0	210	218	5.0
19N/02W-01R03	05-11-78	--	Qc	85	90	11.0	352	--	40
	05-01-89	1545	Qc	85	90	11.0	400	402	50
19N/02W-03M02	05-19-78	--	Qc	60	104	11.0	1,100	--	220
	04-24-89	1330	Qc	60	104	11.0	1,260	1,240	290
19N/02W-04F03	05-22-78	--	TQu	115	156	11.0	211	--	2.8
	04-27-89	1315	TQu	115	156	11.5	224	216	3.1
19N/02W-07L02	05-23-78	--	TQu	15	120	11.0	217	--	3.1
	04-05-89	1355	TQu	15	120	11.0	--	222	2.9
19N/02W-08C01	05-22-78	--	TQu	60	85	--	186	--	5.7
	04-05-89	1505	TQu	60	85	11.0	--	199	3.0
19N/02W-08M01	05-23-78	--	TQu	10	80	11.5	205	--	2.3
	04-27-89	1235	TQu	10	80	12.0	230	222	2.5
19N/02W-09L05	05-19-78	--	Qc	15	37	11.0	116	--	5.2
	04-24-89	1145	Qc	15	37	11.0	124	124	5.8
19N/02W-09R01	05-15-78	--	TQu	10	360	--	178	--	4.7
	05-23-89	1140	TQu	10	360	12.0	142	150	8.1
19N/02W-12C02	05-11-78	--	Qc	50	120	11.5	2,180	--	570
	05-01-89	1645	Qc	50	120	11.5	1,750	1,740	430
19N/02W-12F03	10-10-78	--	Qc	60	65	13.0	490	--	83
	04-28-89	1145	Qc	60	65	10.5	350	353	24
19N/02W-12M02	05-12-78	--	TQu	80	621	11.0	141	--	1.6
	05-01-89	1715	TQu	80	621	12.0	140	145	1.8
19N/02W-15N01	05-15-78	--	Qc	90	117	10.5	261	--	28
	04-24-89	1805	Qc	90	117	10.5	235	234	19
19N/02W-16A01	05-15-78	--	TQu	10	552	13.0	217	--	14
	04-18-89	1755	TQu	10	552	13.0	210	222	13
19N/02W-16J06	05-15-78	--	Qc	80	105	--	150	--	5.2
	04-18-89	1725	Qc	80	105	11.0	150	160	5.2

Table C6. Concentrations of chloride for samples collected in 1978 and 1989 from 112 coastal wells---Cont.

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)	Chlo-ride, dis-solved (mg/L as Cl)
19N/02W-16P01	05-15-78	--	Qc	40	70	11.0	570	--	110
	04-24-89	1830	Qc	40	70	10.5	520	519	110
19N/02W-17A01	05-19-78	--	Qc	60	64	10.0	115	--	7.0
	05-23-89	1450	Qc	60	64	10.0	127	127	5.9
19N/02W-17G01	05-19-78	--	TQu	105	210	10.5	283	--	7.8
	05-23-89	1405	TQu	105	210	10.5	293	294	7.5
19N/02W-18B01	05-23-78	--	TQu	25	100	10.5	264	--	2.6
	05-23-89	1515	TQu	25	100	11.0	270	269	2.4
19N/02W-18C01	05-23-78	--	TQu	35	120	10.5	130	--	2.3
	04-28-89	1150	TQu	35	120	10.5	140	135	2.7
19N/02W-18F01	05-23-78	--	TQu	40	73	10.0	175	--	3.9
	04-27-89	1115	TQu	40	73	11.0	174	169	3.3
19N/02W-18K02	05-23-78	--	TQu	130	166	10.5	135	--	2.6
	05-01-89	1435	TQu	130	166	11.0	142	143	3.0
19N/02W-20E01	05-19-78	--	TQu	85	138	--	135	--	2.8
	05-23-89	1325	TQu	85	138	10.5	148	147	2.8
19N/02W-21F01	05-15-78	--	TQu	85	306	11.0	160	--	7.8
	04-18-89	1425	TQu	85	306	11.0	165	170	8.1
19N/02W-21L01	05-16-78	--	Qc	50	84	--	314	--	44
	04-14-89	1435	Qc	50	84	12.0	184	197	8.1
19N/02W-21Q03	05-17-78	--	TQu	60	275	12.0	142	--	3.4
	04-18-89	1335	TQu	60	275	12.5	142	154	3.9
19N/02W-22D01	05-15-78	--	Qc	80	90	10.5	191	--	4.9
	04-14-89	1505	Qc	80	90	11.5	200	214	4.2
19N/02W-22M06	05-15-78	--	TQu	10	439	--	224	--	14
	04-14-89	1550	TQu	10	439	--	220	232	13
19N/02W-22N01	05-15-78	--	Qc	50	65	11.0	161	--	3.6
	04-24-89	1905	Qc	50	65	11.0	169	166	3.7
19N/02W-23K01	05-12-78	--	TQu	20	385	11.0	148	--	2.1
	04-13-89	1550	TQu	20	385	11.0	150	157	4.1
19N/02W-25D01	05-12-78	--	Qc	90	123	11.0	127	--	2.3
	05-03-89	1505	Qc	90	123	11.0	130	131	2.9

Table C6. Concentrations of chloride for samples collected in 1978 and 1989 from 112 coastal wells---Cont.

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)	Chlo-ride, dis-solved (mg/L as Cl)
19N/02W-26K02	05-12-78	--	TQu	80	173	10.0	205	--	2.3
	05-03-89	1435	TQu	80	173	11.0	220	215	2.4
19N/02W-26Q01	05-12-78	--	--	15	--	10.5	122	--	2.1
	04-13-89	1450	--	15	--	11.0	122	136	1.9
19N/02W-27D05	05-15-78	--	TQu	10	240	11.5	158	--	3.6
	04-24-89	1925	TQu	10	240	12.0	168	164	3.4
19N/02W-28J01	05-15-78	--	TQu	10	213	12.0	154	--	2.1
	04-14-89	1215	TQu	10	213	12.0	152	161	2.2
19N/02W-28L02	05-17-78	--	Qc	80	146	11.0	182	--	2.8
	05-23-89	1050	Qc	80	146	11.0	195	194	2.4
19N/02W-28N02	05-16-78	--	Qc	30	75	11.0	194	--	2.6
	04-14-89	1330	Qc	30	75	12.0	209	219	6.4
19N/02W-29B02	05-18-78	--	Qc	35	44	--	185	--	6.7
	05-23-89	1230	Qc	35	44	10.0	227	226	5.8
19N/02W-29M01	05-18-78	--	Qc	90	150	--	143	--	3.1
	04-21-89	1415	Qc	90	150	10.0	136	136	2.8
19N/02W-30F01	05-18-78	--	Qva	70	70	10.5	116	--	3.1
	04-20-89	1810	Qva	70	70	10.5	120	128	3.0
19N/02W-30K03	05-18-78	--	Qc	60	110	--	125	--	2.8
	04-21-89	1335	Qc	60	110	10.5	144	134	3.8
19N/02W-31M01	05-18-78	--	Qva	40	86	10.5	126	--	2.1
	04-20-89	1700	Qva	40	86	11.0	134	135	2.3
19N/02W-31N01	05-18-78	--	Qc	40	50	11.0	133	--	4.1
	04-20-89	1530	Qc	40	50	11.0	122	127	2.6
19N/02W-31R03	05-17-78	--	Qc	25	58	10.5	104	--	2.6
	04-20-89	1220	Qc	25	58	11.0	120	125	2.5
19N/02W-32A04	05-16-78	--	Qc	80	120	11.0	113	--	2.8
	05-23-89	1010	Qc	80	120	11.0	232	232	2.7
19N/02W-32B05	05-16-78	--	TQu	5	228	10.5	133	--	1.8
	04-20-89	1435	TQu	5	228	10.5	188	170	2.3
19N/02W-32F02	05-17-78	--	Qc	30	60	11.0	132	--	2.1
	04-20-89	1340	Qc	30	60	11.5	136	144	2.8

Table C6. Concentrations of chloride for samples collected in 1978 and 1989 from 112 coastal wells---Cont.

Local well number	Date	Time	Geo-hydro-logic unit	Land surface eleva-tion (feet above sea level)	Depth of well, total (feet)	Tempe-rature, water (°C)	Spe-cific con-duc-tance (µS/cm)	Spe-cific con-duc-tance, lab (µS/cm)	Chlo-ride, dis-solved (mg/L as Cl)
19N/02W-32M03	05-17-78	--	Qc	35	90	9.5	122	--	2.6
	06-16-89	1345	Qc	35	90	14.0	122	135	2.4
19N/02W-33H02	05-15-78	--	Qc	150	165	10.0	162	--	2.3
	04-14-89	1120	Qc	150	165	10.5	160	171	2.2
19N/02W-33K05	05-15-78	--	Qc	140	150	10.5	144	--	2.3
	04-14-89	1055	Qc	140	150	11.0	151	161	2.7
19N/02W-33Q01	05-16-78	--	TQu	10	355	11.0	131	--	2.1
	04-14-89	1015	TQu	10	355	10.0	129	140	1.7
19N/02W-35B01	05-12-78	--	Qc	110	173	11.0	178	--	2.6
	04-13-89	1420	Qc	110	173	12.0	178	187	2.4
19N/02W-35G02	05-12-78	--	Qc	120	160	10.0	172	--	2.6
	05-03-89	1410	Qc	120	160	10.5	190	184	2.5
19N/02W-35P02	05-15-78	--	Qc	120	132	11.0	171	--	3.4
	04-13-89	1325	Qc	120	132	12.0	179	178	3.6
19N/03W-13K01	05-23-78	--	Qc	15	86	--	170	--	3.6
	04-05-89	1310	Qc	15	86	9.5	--	175	3.9
19N/03W-24D03	05-23-78	--	Qc	100	120	10.5	160	--	3.1
	05-02-89	1120	Qc	100	120	11.5	174	177	3.8
19N/03W-27K01	05-23-78	--	Qc	35	70	10.5	223	--	2.6
	04-05-89	1225	Qc	35	70	10.0	--	228	2.9
19N/03W-36P01	05-18-78	--	Qc	135	142	10.0	128	--	2.6
	06-23-89	1045	Qc	135	142	10.5	133	135	2.8
20N/01W-33L02	05-09-78	--	TQu	5	500	12.0	220	--	9.1
	04-19-89	1000	TQu	5	500	12.0	228	223	8.9
20N/02W-28P01	05-22-78	--	TQu	10	425	12.0	253	--	1.6
	06-30-89	1310	TQu	10	425	12.5	265	261	1.5
20N/02W-33L01	05-22-78	--	Qc	65	107	11.5	1,500	--	360
	04-24-89	1500	Qc	65	107	11.5	1,480	1,440	360
20N/02W-33L02	05-22-78	--	TQu	55	455	11.5	254	--	6.7
	10-10-78	--	TQu	55	455	12.0	263	--	6.8
	04-24-89	1545	TQu	55	455	12.0	271	264	6.9
20N/02W-33L03	10-10-78	--	TQu	25	500	13.0	253	--	2.5
	04-24-89	1430	TQu	25	500	11.5	262	256	2.5

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