REPORT OF INVESTIGATIONS NO. 60
1996

NETWORK DESCRIPTION AND INITIAL WATER-QUALITY DATA FROM A STATEWIDE GROUND-WATER-QUALITY NETWORK IN MARYLAND

by
David W. Bolton

Prepared in cooperation with the
United States Department of the Interior
Geological Survey,
United States Environmental Protection Agency
and
The Maryland Department of the Environment

Department of Natural Resources
Resource Assessment Service
Maryland Geological Survey
Emery T. Cleaves, Director

DEPARTMENT OF
NATURAL RESOURCES

MARYLAND GEOLOGICAL SURVEY

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Department of Natural Resources
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NETWORK DESCRIPTION AND INITIAL WATER-QUALITY DATA FROM A STATEWIDE GROUND-WATER-QUALITY NETWORK IN MARYLAND

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ABSTRACT

A statewide network of wells and springs was established to document ground-water-quality conditions in unconfined (water-table) aquifers in Maryland. Forty-two wells and ten springs were sampled between 1987 and 1992 to document water-quality conditions and potential problems in Maryland's unconfined aquifers. The network also includes four wells in confined aquifers in areas where salt-water intrusion may pose a problem or where the unconfined aquifer is not an important source of ground water. Network sites include U.S. Geological Survey (USGS) and Maryland Geological Survey (MGS) water-level observation wells and project wells, private water wells, and springs. No new wells were drilled specifically for the network. The network was not designed to provide a statistically valid assessment of water quality in the unconfined aquifers, but rather to identify potential water-quality problems in these aquifers, and to provide a basis for future water-quality monitoring. Sites were sampled in all of Maryland's physiographic provinces (Appalachian Plateau, Valley and Ridge, Blue Ridge, Piedmont, and Coastal Plain). All sites were tested for major ions, nutrients, trace elements, and field parameters. Most sites were also sampled for radon, pesticides (including chlorophenoxy herbicides, organochlorine and organophosphorus insecticides, and triazine herbicides), and volatile organic compounds. Additional samples were taken from several sites to investigate seasonal changes in major-ion chemistry.

Thirteen sites (nine wells and four springs) were sampled in the Appalachian Plateau and Valley and Ridge physiographic provinces. Most samples from the consolidated clastic aquifers in these provinces had a calcium-bicarbonate water type, with high total dissolved solids (TDS) and pH values near neutrality. Samples from the carbonate aquifers in the Hagerstown Valley were also calcium-bicarbonate waters, and tended to be closer to calcite saturation than the samples from the consolidated clastic aquifers. Fifteen sites (nine wells and six springs) were sampled in the Piedmont and Blue Ridge physiographic provinces. Samples from these sites were enriched in calcium relative to other cations or had a mixed-cation type; anion composition was variable. Samples from non-carbonate crystalline-rock aquifers were lower in TDS and pH than samples from the clastic or carbonate aquifers. Ten wells were sampled in the Western Shore Coastal Plain, including one well completed in a confined aquifer. Samples from these wells tended to be enriched in sodium and calcium relative to magnesium; iron was the dominant cation at one site. Bicarbonate was the major anion at four sites; chloride or sulfate was the major anion at the other sites. Fourteen wells were sampled in the Eastern Shore Coastal Plain, including three wells completed in confined aquifers; major-ion composition among these wells was variable. There was little variation in the major-ion chemistry of most of the sites that were sampled seasonally; however, the sampling frequency may have been insufficient to detect trends.

Water-quality data were evaluated with respect to upgradient land use, site characteristics, and other factors. Land use was defined as the dominant land use within one-quarter mile upgradient of each site (as inferred from topographic position). Nitrate concentrations tended to be higher at sites downgradient from cropland than from sites downgradient from forested land. Nitrate concentrations tended to be lower in wells with deeper completion intervals than in springs and wells with shallower completion intervals. There was no consistent relationship between nitrate concentration and well depth. Most wells with ammonia concentrations >0.1 milligrams per liter (mg/L) had no detectable nitrate; conversely, most wells with detectable nitrate (>0.1 mg/L) had little or no detectable ammonia. One well with significant amounts of both nitrate and ammonia was believed to be influenced by septic contamination in the area near the well. Nitrate concentrations varied greatly in samples with <100 micrograms per liter (µg/L) dissolved (0.45µ-filtered) iron, whereas nitrate concentrations were close to detection level for samples with iron concentrations >300 µg/L. Most samples with no detectable nitrate were anoxic (defined for this report as having <1.0 mg/L dissolved oxygen), while oxic samples had a wide range of nitrate. Most network sites with more than 20 mg/L chloride are within 100 feet of a paved road, although not all sites near roads had high chloride concentrations. Springs and shallow wells had a wide range of chloride concentrations; lower concentrations were seen in wells with open intervals greater than 60 feet deep. Dissolved-iron concentrations varied greatly among network sites; most sites had <20 µg/L dissolved iron. Wells and springs in crystalline and carbonate aquifers had low iron concentrations because of high dissolved-oxygen levels. Iron concentrations varied greatly in unconsolidated and consolidated clastic aquifers; most samples with high iron concentrations (>100 µg/L) were anoxic. Speciation calculations suggest that Fe^{2+} was the major dissolved iron species in anoxic aquifers, while $Fe(OH)_2^+$ or $Fe(OH)_3$ (aqueous) were the dominant species in oxic samples. Radon samples were obtained from 35 network sites. Samples from network sites in

crystalline-rock aquifers tended to have higher radon concentrations than samples from other lithologies. All network samples with radon concentrations >2,000 picocuries per liter (pCi/L) were from crystalline-rock aquifers. There was considerable overlap in radon values from network sites in carbonate, consolidated clastic, and unconsolidated sedimentary aquifers.

Forty sites were sampled for one or more USGS schedules of pesticides (Schedules 1304, 1331, and 1389). Fifteen different pesticides or pesticide metabolites were detected, although not all schedules were tested at each of the 40 sites. Pesticide data were not conclusive because of limited sampling, the length of time over which sampling occurred, and other factors. Many of the pesticide detections were at or near detection levels. Atrazine was the most frequently detected pesticide, although several widely used pesticides in Maryland (linuron, chlorpyrifos, glyphosate, and pendimethalin) were not analyzed. Pesticide detections appeared to be more closely linked to land use than to aquifer lithology. Limited data on the triazine metabolites de-ethyl atrazine and de-isopropyl atrazine suggest that pesticide metabolites may comprise a significant portion of synthetic organic chemicals in shallow ground water.

Network data were compared to several national, regional, and statewide studies of pesticide and nitrate occurrence. The pesticide and nitrate detection rates appear higher in the Maryland network than in the other studies; this is probably due partly to the higher percentage of unconfined aquifers and shallower wells tested in the Maryland network, as well as differences in well populations, and land use for the different studies. The comparisons between the studies are not definitive due to differences in study designs.

Water-quality data were compared to drinking-water regulations and health advisories established by the U.S. Environmental Protection Agency (U.S. EPA). Nitrate was the most common contaminant: ten of the 52 sites had at least one nitrate sample exceeding the Maximum Contaminant Level (MCL) of 10 mg/L as nitrogen. Nineteen of 35 sites exceeded the proposed MCL of 300 pCi/L for radon. pH was outside the Secondary Maximum Contaminant Level (SMCL) (6.5-8.5) at more than half the sites. Twenty-nine percent and 37% of sites exceeded the SMCL for iron (300 µg/L) and manganese (50 µg/L), respectively. Only one site had a pesticide detected above an MCL (atrazine); no other MCLs were exceeded for synthetic organic compounds. No Drinking Water Equivalent Levels (DWELs) were exceeded. The water-quality data collected from this project will provide a basis for monitoring for long-term changes in ground-water quality at network sites.

INTRODUCTION

Unconfined (water-table) aquifers are the primary sources of water for domestic, agricultural, commercial, and municipal supplies in many parts of Maryland. These aquifers are more prone to contamination than are confined aquifers because of the lack of overlying impermeable beds. Degradation of shallow ground-water quality can also lead to adverse impacts on the chemical quality of deeper aquifer systems. Furthermore, surface water quality can be affected by baseflow contribution of contaminated ground water.

Human activities that can affect the ground-water quality of unconfined aquifers include but are not limited to: (1) use of on-site waste-disposal systems; (2) application of fertilizers and pesticides to land surfaces; (3) application of de-icing salts to roads; (4) overpumping of ground water near a salt-water body, which may cause salt water to enter the aquifer; and (5) long-term changes in precipitation quality.

Many site-specific (point-source) ground-water contamination studies in Maryland have documented the adverse impacts on ground-water quality resulting from the disposal or accidental release of different chemical compounds. However, no attempt has been made to describe the chemical characteristics of unconfined aquifers on a statewide basis. In 1987, the Maryland Geological Survey, in cooperation with the U.S. Geological Survey began to establish and sample a state-wide network of wells and springs in order to document the water quality of selected unconfined aquifers in Maryland. Samples were also collected from several wells in confined aquifers in areas of the state that are threatened by salt-water and brackish-water intrusion, or where the unconfined aquifer is not a significant source of water.

PURPOSE AND SCOPE

The purpose of this report is to (1) describe the design of a statewide network of water-quality monitor wells and springs in Maryland and (2) describe ground-water-quality data collected during the initial 5-year phase of network operation.

The network consists of 42 wells and 10 springs that were sampled between 1987 and 1992 for major ions, nutrients, trace elements, radon, pesticides, volatile organic compounds, and field parameters (pH, specific conductance, and dissolved oxygen). Inorganic water-quality data are discussed by "segments" corresponding to physiographic provinces. Factors affecting the concentrations of nitrate, iron, radon, and pesticides are discussed for the network data as a whole. Nitrate and pesticide data are compared to several large-scale ground-water-quality studies. The data are also compared to U.S. EPA drinking-water regulations and health advisories.

The data presented in this report are not considered an end product; rather, they represent a baseline to which future data can be compared in order to detect ground-water quality changes with time. The utility of long-term ground-water data collection has been established for projects such as the USGS Maryland observation-well network, which provides data on seasonal and long-term changes in ground-water levels. The network water-quality data could be used to: (1) identify areas showing rapid changes in ground-water quality; (2) calibrate solute-transport and ground-water flow models; (3) determine ambient concentrations of naturally-occurring ions that may pose a health risk at higher concentrations; and (4) monitor the effectiveness of environmental regulations and policies enacted to maintain or improve ground-water quality. It is anticipated that the network will be expanded in the future to look at specific issues of concern to state and local government agencies.

ACKNOWLEDGMENTS

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This project has benefitted from the input of many individuals and organizations. The author wishes to express his gratitude to the homeowners, local and county officials, and State Park and National Park personnel who allowed water samples to be taken from their wells and springs on a regular basis. Harry Hansen and the entire staff of the MGS Hydrology and Hydrogeology Program have provided valuable input and assistance throughout the project. Many of the figures and tables were prepared by Donajean Appel and Cindy Lang-Bachur, whose assistance is gratefully acknowledged. Mark Danner and Rick Saffer of the USGS provided valuable assistance and support in the field sampling. Additional USGS personnel who have provided valuable assistance include Scott Phillips, Jim Gerhart, Michael Smigaj, Judy Tegeler, Lilian Maclin, and David Brower. Special thanks are extended to Bob Shedlock, Bill Banks, Joe Bachman, Pat Phillips, and other USGS personnel from the National Water-Quality Assessment Pilot study of the Delmarva Peninsula for their help with our work in Segment IV. Manuscript reviews by Randy McFarland and Scott Ator (USGS) and Norman Lazarus (MDE) were especially helpful. The water-quality analyses were performed by the USGS National Water Quality Laboratory (NWQL) in Arvada, Colorado.

HYDROGEOLOGY, GEOLOGY, AND GROUND-WATER QUALITY

AQUIFER CHARACTERISTICS

Aquifers can be classified as confined or unconfined, depending upon their hydrogeological setting. An unconfined (water-table) aquifer is one in which the water table forms the upper boundary (Freeze and Cherry, 1979) (fig. 1a). Confined (artesian) aquifers are bounded by relatively impermeable confining beds, and the pore spaces are completely water-saturated (fig.1b). Most ground water under unconfined conditions is derived from water percolating vertically downward through the overlying materials by gravity. Recharge to shallow confined aquifers is derived largely from water entering the aquifer in the recharge area, and to a lesser degree from leakage through confining beds. The water level in a well completed in a confined aquifer is typically higher than the upper boundary of the aquifer itself. If enough water-level data are available for a confined aquifer, contour maps can be made that show the elevation of the potentiometric surface, which represents the level to which water in a confined aquifer would rise in a well. If the pressure in the confined aquifer is sufficient to cause the water level in the well to rise above the land surface, the well is called a flowing artesian well.

In reality, confined and unconfined aquifers are end-members in a continuum. Confining beds often transmit some water into the aquifer; if the contribution of water is significant, the aquifer is termed semiconfined. Lateral and vertical changes in lithology may cause an aquifer to be locally confined, yet possess the overall attributes of an unconfined aquifer. An aquifer may be unconfined in one location and confined at another at the same time. For example, the Aquia aquifer is unconfined in central Anne Arundel and Prince Georges Counties, but is confined south and east of the outcrop area (Otton, 1955). It is more accurate to refer to the ground water, rather than the aquifer, as being confined or unconfined.

The open spaces through which ground water flows in an aquifer may be classified as either primary or secondary openings. Primary openings are those pore spaces that are found between the individual grains of aquifer material. Ground-water flow in both unconsolidated and moderately-consolidated deposits occurs largely through the primary openings. Secondary openings include joints, fractures, bedding-plane partings, and faults that are often present in crystalline and well-consolidated sedimentary rocks. These features may develop as a result of crustal compression and relaxation, thermal expansion and contraction, depositional and diagenetic processes, and physical and chemical weathering. In crystalline rocks and many well-consolidated sedimentary rocks, there are few primary openings, and ground-water flow is mostly through the secondary openings. Geologic materials are often characterized by porosity (the ratio of the volume of the voids to the total unit volume of the material) and hydraulic conductivity (which characterizes the capacity of materials to transmit water).

GEOLOGY AND PHYSIOGRAPHY OF MARYLAND

Maryland spans five physiographic provinces which have distinct hydrogeologic characteristics; from west to east, they are the Appalachian Plateau, the Valley and Ridge, the Blue

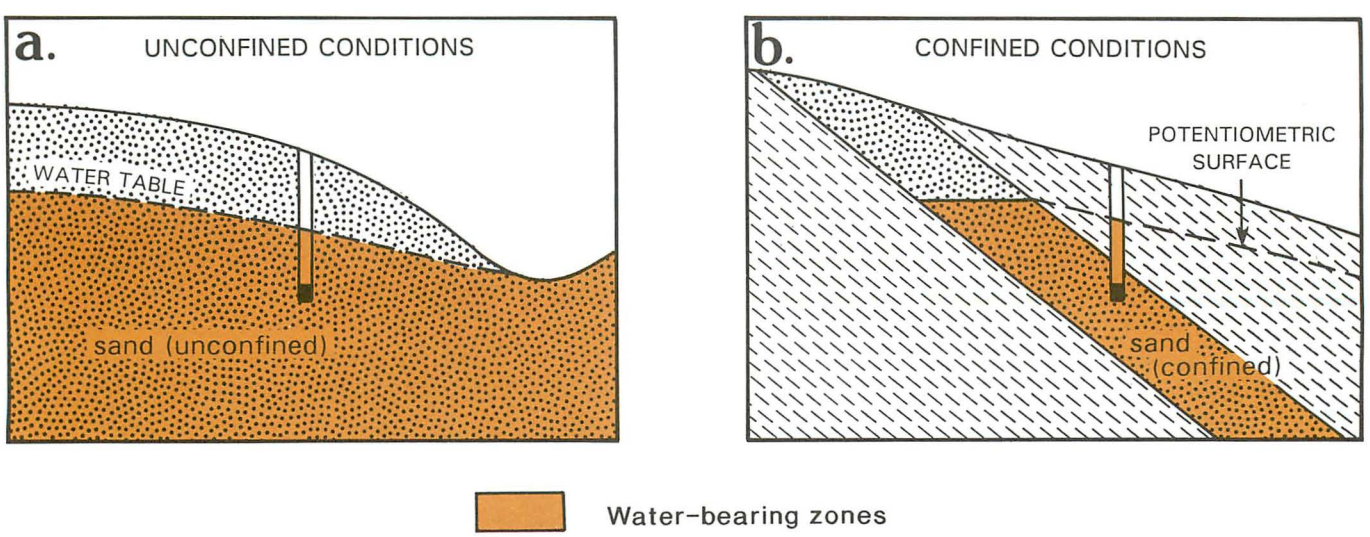


Figure 1.—Unconfined and confined conditions in an aquifer: (a) unconfined conditions, (b) confined conditions.

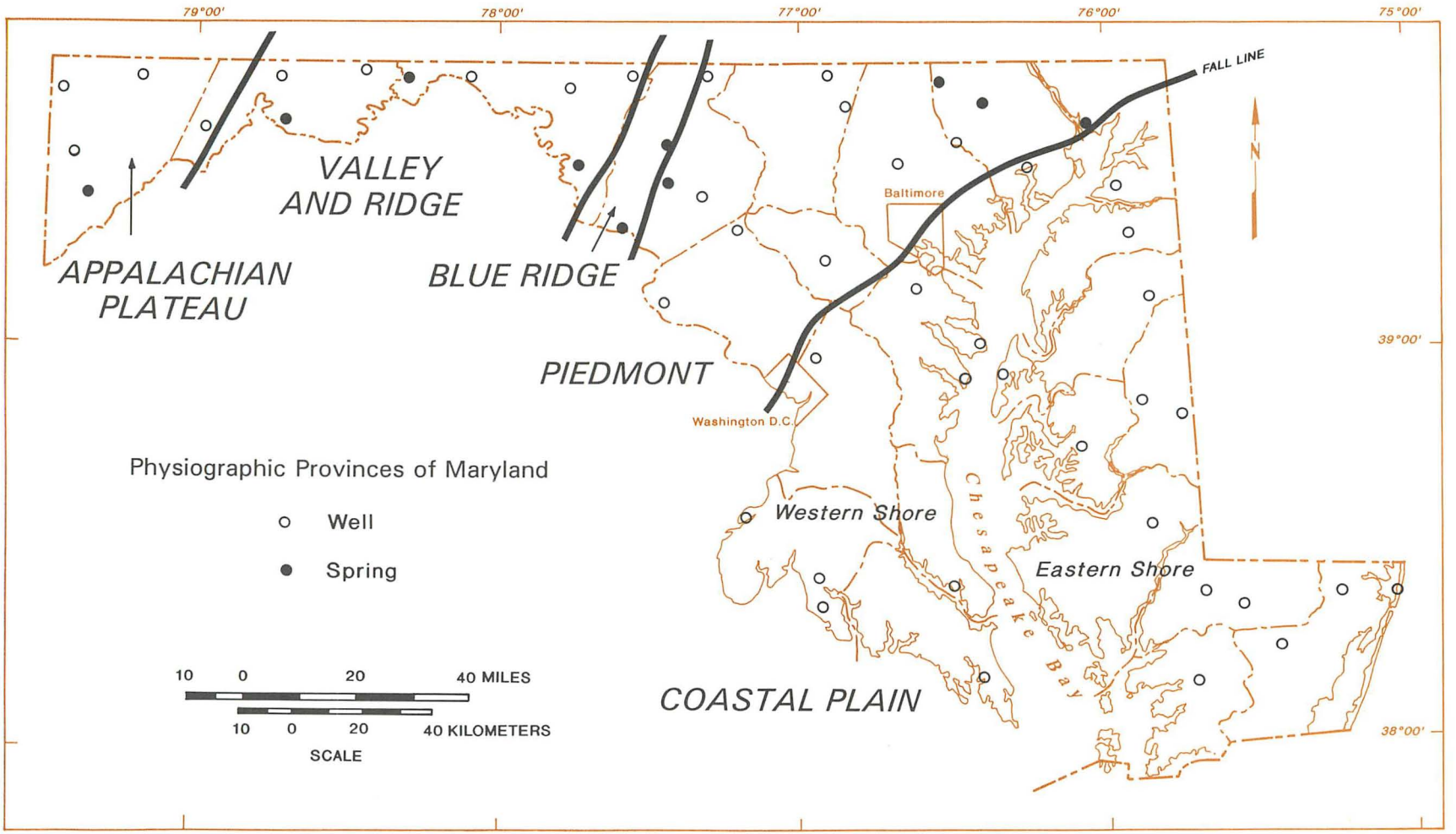


Figure 2.—Physiographic provinces of Maryland and locations of network sites.

Ridge, the Piedmont, and the Coastal Plain (fig. 2). The general geological and hydrogeologic features of each physiographic province are discussed below.

Appalachian Plateau

The eastern boundary of the Appalachian Plateau physiographic province in Maryland is the Allegheny Front, which is defined by the ridge that forms the summits of Dans, Piney, and Little Allegheny Mountains in western Allegany County. This province is characterized topographically by broad ridges and valleys. Structurally, the province is dominated by a series of broad, parallel northeast-trending synclines and anticlines that are deeply dissected in places. The surficial bedrock ranges in age from Devonian to Permian (fig. 3). The rocks are predominantly sandstones, siltstones, shales, and conglomerates, with smaller amounts of limestone and coal. Secondary openings along joints and fractures probably account for most of the porosity and hydraulic conductivity in this area (Figure 4a) (Seaber, Brahana, and Hollyday, 1988). The production of natural gas from depths exceeding 8,000 feet in Garrett County indicates the existence of porosity and hydraulic conductivity at great depths in the Appalachian Plateau in Maryland (Nutter and others, 1980). The bedrock is overlain by a relatively thin layer of weathered bedrock and soil collectively termed regolith. The water table in the Appalachian Plateau occurs in both the bedrock and the regolith; in general, it is found in the regolith in topographically low areas and in the bedrock beneath ridges. The thickness of the unconsolidated Quaternary and Recent deposits in the Appalachian Plateau varies greatly, but generally ranges between five and 30 feet. Many springs in the Appalachian Plateau issue from the soil or alluvium at the base of slopes. Because several communities and many households in the Appalachian Plateau and the Valley and Ridge provinces rely on springs for their water supplies, springs are an important source of water in this part of Maryland (Otton and Hilleary, 1985). The geology of the Appalachian Plateau in western Maryland is reviewed in Amsden (1954), Slaughter (1962), Vokes and Edwards (1974), and Brezinski (1989).

Valley and Ridge

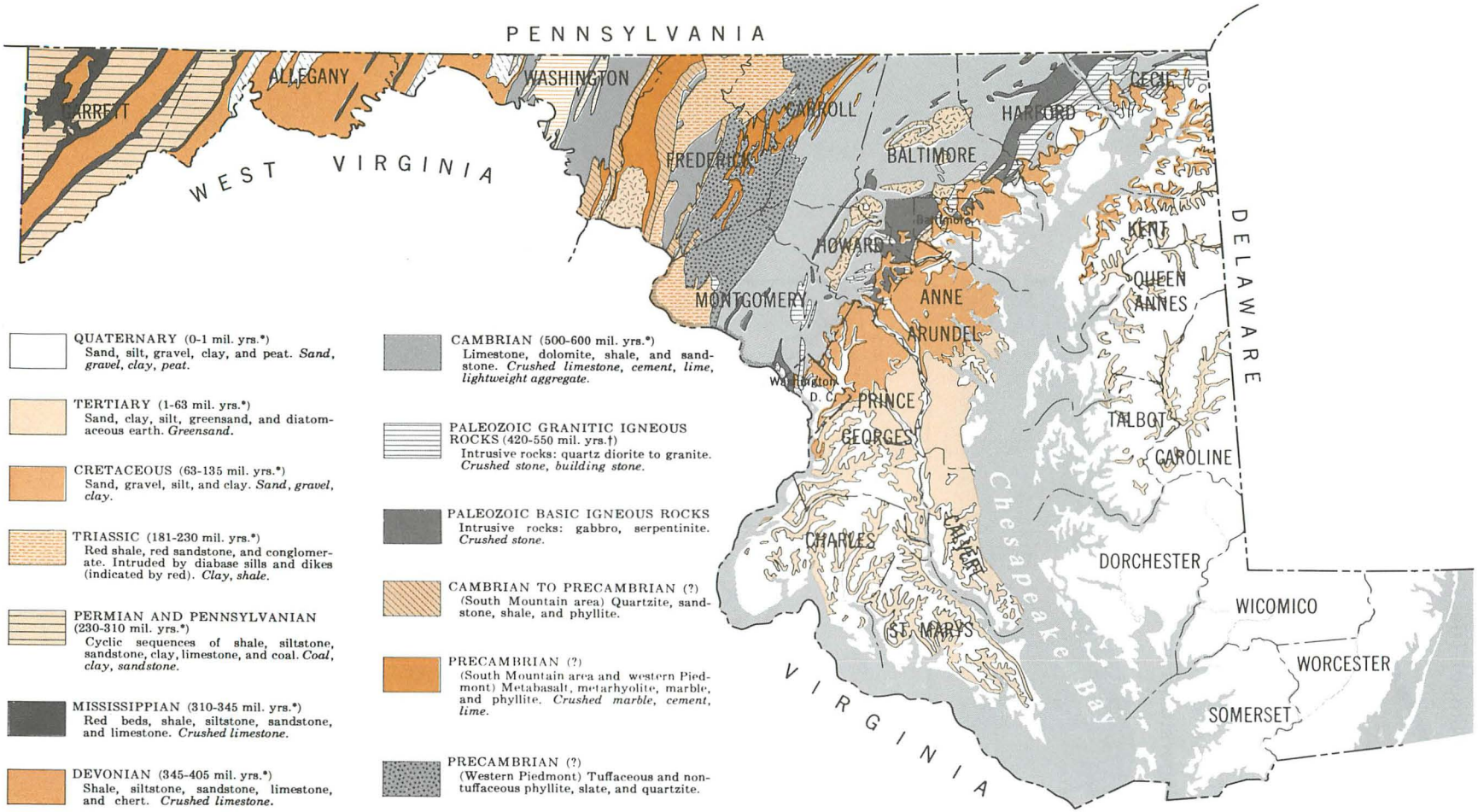
In Maryland, the Valley and Ridge physiographic province extends from the Allegheny Front in western Allegany County to South Mountain in eastern Washington County. The region is topographically lower than both the Appalachian Plateau to the west and the Blue Ridge to the east. The Valley and Ridge province is divided into two distinct subregions. The western subregion is characterized by a series of parallel, closely-spaced northeast-trending ridges that are developed on faulted and folded clastic and carbonate rocks ranging in age from Ordovician to Mississippian. The rocks are generally characterized by low primary porosity and hydraulic conductivity; secondary porosity and hydraulic conductivity play an important role in the ground-water flow regime (fig. 4a). Shallow ground-water flow tends to occur in isolated, adjacent flow systems (Seaber, Brahana and Hollyday, 1988). The eastern subregion of the Valley and Ridge in Maryland is the Hagerstown Valley, which is part of a regional geomorphic feature known as the Great Valley. The Hagerstown Valley extends northward into the Cumberland Valley of Pennsylvania, and southward into the Shenandoah Valley of Virginia. It is a broad lowland that is underlain by Cambrian and Ordovician limestones and dolomites, with smaller amounts of clastic rocks. The rocks of the Hagerstown Valley are characterized by low primary porosity and hydraulic conductivity. However, circulating ground water slowly dissolves soluble carbonate minerals along joints, bedding planes, and fault surfaces and greatly increases the hydraulic conductivity of the rocks (fig. 4b). As the network of fractures enlarges, more water circulates through the rock, and large conduits may develop. This process has rendered the carbonate rocks of the Hagerstown Valley into highly productive aquifers, and has resulted in distinct topographic and hydrologic features (sinkholes, sinking streams, and springs) that are collectively called karst. Karst development is extensive in the Hagerstown Valley and elsewhere in the Great Valley. The geology and water resources of the Valley and Ridge physiographic province are discussed in Slaughter (1962), Vokes and Edwards (1974), and Duigon and Dine (1991).

Blue Ridge

The Blue Ridge physiographic province occupies a narrow band extending from the western foot of South Mountain in eastern Washington County to the eastern foot of Catoctin and Blue Ridge Mountains in western Frederick County. The province is underlain by Precambrian and Cambrian igneous and metamorphic rocks, with ridges developed predominantly on quartzite, and the intervening Middletown Valley developed on metamorphosed basalt, rhyolite, granodiorite, and gneiss (Vokes and Edwards, 1974). The rocks are generally characterized by low primary porosity and hydraulic conductivity, and most ground-water flow is along fractures and other secondary openings (fig. 4c). The steep slopes of Catoctin, Blue Ridge, and South Mountains render much of the Blue Ridge unsuitable for development.

Piedmont

The Piedmont physiographic province extends from the foot of Catoctin Mountain eastward to the beginning of the Atlantic Coastal Plain sediments, which is approximately coinci-



QUATERNARY (0-1 mil. yrs.*)
Sand, silt, gravel, clay, and peat. *Sand, gravel, clay, peat.*

TERTIARY (1-63 mil. yrs.*)
Sand, clay, silt, greensand, and diatomaceous earth. *Greensand.*

CRETACEOUS (63-135 mil. yrs.*)
Sand, gravel, silt, and clay. *Sand, gravel, clay.*

TRIASSIC (181-230 mil. yrs.*)
Red shale, red sandstone, and conglomerate. Intruded by diabase sills and dikes (indicated by red). *Clay, shale.*

PERMIAN AND PENNSYLVANIAN (230-310 mil. yrs.*)
Cyclic sequences of shale, siltstone, sandstone, clay, limestone, and coal. *Coal, clay, sandstone.*

MISSISSIPPIAN (310-345 mil. yrs.*)
Red beds, shale, siltstone, sandstone, and limestone. *Crushed limestone.*

DEVONIAN (345-405 mil. yrs.*)
Shale, siltstone, sandstone, limestone, and chert. *Crushed limestone.*

SILURIAN (405-425 mil. yrs.*)
Shale, mudstone, sandstone, and limestone. *Glass sand, crushed limestone.*

ORDOVICIAN (425-500 mil. yrs.*)
Limestone, dolomite, shale, siltstone, and red beds. Slate and conglomerate in northern Harford County. *Crushed limestone, cement, clay, lime.*

CAMBRIAN (500-600 mil. yrs.*)
Limestone, dolomite, shale, and sandstone. *Crushed limestone, cement, lime, lightweight aggregate.*

PALEOZOIC GRANITIC IGNEOUS ROCKS (420-550 mil. yrs.†)
Intrusive rocks: quartz diorite to granite. *Crushed stone, building stone.*

PALEOZOIC BASIC IGNEOUS ROCKS
Intrusive rocks: gabbro, serpentinite. *Crushed stone.*

CAMBRIAN TO PRECAMBRIAN (?)
(South Mountain area) Quartzite, sandstone, shale, and phyllite.

PRECAMBRIAN (?)
(South Mountain area and western Piedmont) Metabasalt, metarhyolite, marble, and phyllite. *Crushed marble, cement, lime.*

PRECAMBRIAN (?)
(Western Piedmont) Tuffaceous and nontuffaceous phyllite, slate, and quartzite.

PRECAMBRIAN (?)
(Eastern Piedmont) Schist, metagraywacke, quartzite, marble, and metavolcanic rocks. *Crushed stone, crushed marble, building stone.*

PRECAMBRIAN BASEMENT COMPLEX (1100 mil yrs.†)
Gneiss, migmatite, and augen gneiss.

Most important mineral products in italics.
* Age ranges from Kulp, J. L., 1961, Geologic time scale: Science, v. 133, no. 3459, p. 1105-1114.
† Radiometric dates made on Maryland rocks.

MARYLAND GEOLOGICAL SURVEY

GENERALIZED GEOLOGIC MAP OF MARYLAND‡

1967

10 0 10 20 30 40
1 inch equals 25 miles

‡ A detailed Geologic Map of Maryland, 1968 at a scale of 1 inch equals 4 miles, is also available.

Figure 3.—Generalized geologic map of Maryland.

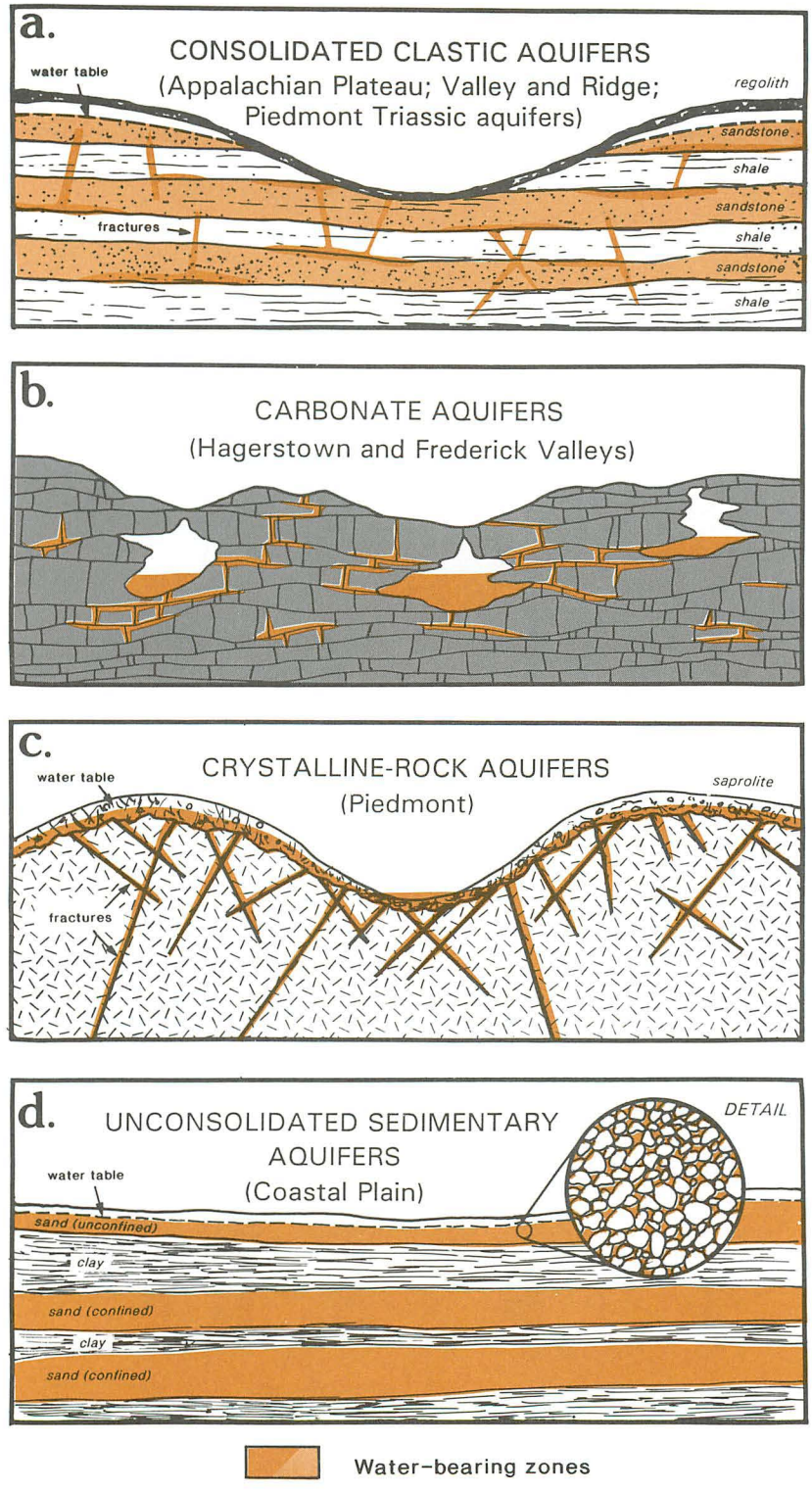


Figure 4.—Hydrogeologic settings in Maryland: (a) consolidated clastic aquifers, (b) carbonate aquifers, (c) crystalline rock aquifers, (d) unconsolidated sedimentary aquifers.

dent with Interstate 95. The eastern Piedmont is underlain by Precambrian to Ordovician sedimentary and igneous rocks that have been extensively metamorphosed; rock types include schist, phyllite, gneiss, slate, marble, serpentine, and granitic and gabbroic rocks (Vokes and Edwards, 1974). A series of elongated gneiss domes dominate the metamorphic structure of the eastern Piedmont. The geologic evolution of the eastern Piedmont is discussed by Crowley (1976).

Rocks in the western portion of the Piedmont are less heavily metamorphosed, and include marble, quartzite, schist, and metavolcanic and metasedimentary rocks. The Frederick Valley, on the western edge of the Piedmont, is underlain by moderately-deformed Cambrian to Ordovician limestones, dolomites, and siltstones in an asymmetrical synclinorium (Reinhardt, 1974). Red sandstones and shales of the (Triassic) Newark Group are found in portions of Frederick, Carroll, and Montgomery Counties. These rocks are part of a discontinuous series of filled Triassic-Jurassic grabens extending from Nova Scotia to North Carolina (Rast, 1989).

The igneous and metamorphic rocks of the Piedmont are overlain by a mantle of unconsolidated material called saprolite that is formed in situ by the chemical and physical weathering of the parent rock. In Maryland, saprolite thickness ranges from several feet to over 100 feet; it is usually thickest beneath hilltops and ridges and thinnest in valleys (Nutter and Otton, 1969).

Primary porosities and hydraulic conductivities of igneous and metamorphic rocks are extremely low, and ground-water flow in these rocks is largely along joints, faults, and fractures (fig. 4c). Wells drilled along surface traces of fractures generally have greater yields than those drilled away from fractures. Faults may increase or decrease well yields; fractures accompanying the faults can increase yields, but clay-rich gouge accompanying faults can decrease the hydraulic conductivity near a fault. Wells drilled in valleys and draws in the Maryland Piedmont tend to be more productive than those drilled on hilltops, because the valleys themselves may be developed along fracture traces, and the increased well yields may be due to drilling in fracture zones. Joints and fractures in crystalline rocks tend to decrease in size with depth; as a result, ground-water flow in crystalline-rock terrains such as the Piedmont is generally restricted to shallow depths. Factors affecting ground-water availability in the crystalline rocks of the Maryland Piedmont are reviewed by Nutter and Otton (1969).

Because porosity and hydraulic conductivity of crystalline rocks are so low, much of the available ground water in the Piedmont is stored in the saprolite. Porosities of 17 saprolite samples from the Maryland Piedmont reported by Dingman and Ferguson (1956) ranged from 34.3% to 60.3%. Measured permeabilities of saprolite samples vary widely (Stewart, 1964; Nutter and Otton, 1969), but are often low because of the high percentage of clay minerals. Water wells in the Maryland Piedmont are typically cased and grouted through the saprolite into the top of the bedrock; well water is derived principally from the shallow bedrock fractures that receive water from the overlying saprolite.

Ground-water flow in the Triassic rocks of the western Piedmont, as in the crystalline rocks, is largely along fractures; secondary porosity may also result from dissolution of sandstone cements. Unlike the crystalline rocks, however, deep water-bearing zones are common in the Triassic rocks, and deep wells often have larger yields than shallow wells (Nutter, 1975).

Ground-water occurrence and availability in the Frederick Valley are strongly controlled by the carbonate rocks. As in the Hagerstown Valley, extensive secondary porosity and hydraulic conductivity due to dissolution and fracturing have rendered the carbonates highly productive aquifers.

Coastal Plain

The Coastal Plain physiographic province in Maryland includes all land between the eastern edge of the Piedmont and the Atlantic Ocean. This area is underlain by a southeastward-dipping wedge of unconsolidated sands, silts, clays, and gravels ranging in thickness from zero at the western boundary to over 8,500 feet along the Atlantic Coast (Hansen, 1972a). The age of the Coastal Plain sediments ranges from Cretaceous to Quaternary. The western edge of the Coastal Plain province is irregular due to the variations in thickness and differential erosion of the unconsolidated sediments that pinch out against the crystalline rocks of the Piedmont. The Piedmont-Coastal Plain boundary is sometimes referred to as the "Fall Line" because of the many rapids and waterfalls that marked the upstream limit of navigation in colonial times. The Maryland Coastal Plain is part of the Atlantic and Eastern Gulf Coastal Plain that extends from Long Island to eastern Mississippi and whose sediments range in age from Jurassic to Quaternary (Meisler and others, 1988). The hydrogeologic framework of the Maryland portion of the Atlantic Coastal Plain is discussed in Vroblesky and Fleck (1991).

In Maryland, the Coastal Plain includes two physiographic subdivisions separated by the Chesapeake Bay. The Western Shore Coastal Plain is characterized by rolling topography similar to but lower in elevation than the Piedmont. Several important water-bearing formations, including the Patuxent, Patapsco, the Magothy, and the Aquia formations, are exposed at the surface in the northern and central areas of the Western Shore Coastal Plain, and become progressively deeper to the south and east (Otton, 1955). The Eastern Shore Coastal Plain is mostly flat and is almost completely covered with surficial deposits of sands, silts, clays, and gravels that overlie the updip edges of the older formations (Cushing, Kantrowitz, and Taylor, 1973).

Most Coastal Plain aquifers are highly productive. Ground-water flow in the Coastal Plain is through the primary openings (fig. 4d). Most wells in the Western Shore Coastal Plain are completed in confined aquifers, although unconfined aquifers are an important source of water in the northern and western areas where the Cretaceous aquifers are exposed at the

surface. Most of the Eastern Shore is covered with a veneer of highly productive sands collectively known as the Columbia Aquifer. Because of the importance of this unconfined aquifer and the potential for contamination due to extensive agricultural activity on the Delmarva Peninsula, the water resources have been studied extensively (e.g., Cushing, Kantrowitz, and Taylor, 1973; Bachman, 1984a; Denver, 1986). Ground-water quality of the Eastern Shore was investigated as part of the USGS National Water Quality Assessment (NAWQA) pilot study of the Delmarva Peninsula (Hamilton and others, 1993).

FACTORS AFFECTING GROUND-WATER QUALITY

Ground-water quality is a function of many factors, including precipitation-water quality, soil and aquifer characteristics, position in the flow system relative to recharge and discharge areas, and human activity. This section discusses some of the important factors that affect the concentrations of the major cations and anions found in Maryland's ground water.

The vast majority of ground water is derived from atmospheric precipitation. Cation and anion concentrations are low in precipitation samples in the Maryland area (tab. 1). As infiltrating precipitation moves toward the water table, solute concentrations are increased by evapotranspiration (the portion of precipitation that is returned to the atmosphere by evaporation or transpiration by plant material), although some solutes such as nitrogen compounds and phosphate are removed from the water by plants (Drever, 1982). Estimates of evapotranspiration rates range from 50% to over 70% of total precipitation in Maryland (Dingman and Ferguson, 1956; Slaughter, 1962; Cushing, Kantrowitz, and Taylor, 1973; Duigon and Dine, 1991).

Precipitation in Maryland and neighboring areas is acidic (pH<4.5) due to reactions with atmospheric carbon dioxide, sulphur dioxide, and nitrogen oxides. Carbon dioxide is produced naturally and by human activity. It reacts with atmospheric water to form carbonic acid (H_2CO_3), which dissociates into bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) ions. These reactions can be represented as:

$$CO_2\ (gas) + H_2O \rightleftharpoons H_2CO_3$$

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-} \qquad \text{(Drever, 1982)}$$

Sulphur dioxide and nitrogen oxides are produced largely by emissions resulting from human activity. These compounds

Table 1.—Major-ion chemistry of precipitation samples

[Concentrations are averages of the annual precipitation-weighted mean concentrations at each site from 1987 to 1992. MD03: Carroll County, Maryland (Piedmont physiographic province); MD13: Queen Anne's County, Maryland (Coastal Plain physiographic province); WV18: Tucker County, West Virginia (Appalachian Plateau physiographic province). Data from the National Atmospheric Deposition Network/National Trends Network. Concentrations are in mg/L, unless otherwise noted. μS/cm, microsiemens per centimeter]

Analyte	Concentrations in precipitation		
	MD03	MD13	VW18
Ca	0.11	0.09	0.15
Mg	0.027	0.036	0.019
K	0.02	0.02	0.02
Na	0.131	0.215	0.049
NH_4	0.26	0.25	0.23
NO3-N	0.37	0.33	0.37
Cl	0.29	0.42	0.13
SO_4	2.62	2.38	2.79
pH	4.26	4.32	4.25
Conductance (μS/cm)	29.1	26	29.2

can increase the concentrations of H^+ (i.e., decrease pH), sulfate (SO_4^{2-}), and nitrate in precipitation via the following generalized reactions:

$$S + O_2 \rightarrow SO_2 \text{ (gas)}$$

$$SO_2 + H_2O + \tfrac{1}{2}O_2 \rightarrow SO_4^{2-} + 2H^+$$

$$2NO_2 + H_2O + \tfrac{1}{2}O_2 \rightarrow 2NO_3^- + 2H^+$$

(Freeze and Cherry, 1979; Manahan, 1991)

The pH of infiltrating precipitation water is further decreased in the soil zone. When oxygen is available in the soil, decomposition of organic matter and plant respiration increases soil carbon dioxide concentrations above atmospheric concentrations. This in turn lowers the pH of the infiltrating water. Thus, by the time infiltrating precipitation reaches the water table, it has acquired a considerable degree of acidity which renders it capable of reacting with aquifer minerals.

The most abundant minerals in Maryland's aquifers fall into two categories: silicate minerals (including quartz, feldspars, and clay minerals) and carbonate minerals (including calcite and dolomite). These minerals are the primary "natural" sources of major ions in ground water, although in some areas, secondary minerals such as pyrite can have a large effect on water quality. The solubility and reaction kinetics of each mineral greatly influence the amounts of cations and anions that are dissolved.

Most of Maryland's aquifers are composed primarily of silicate and aluminosilicate minerals. Many of these minerals are thermodynamically unstable at near-surface temperatures and pressures, and they will react with ground water to produce more stable minerals (Freeze and Cherry, 1979). Aluminum is very insoluble at pH's found in most shallow ground water, and dissolution of aluminosilicate minerals is assumed to result in precipitation of new, more stable aluminosilicate minerals such as kaolinite, rather than simply dissolving entirely into ionic species (Freeze and Cherry, 1979). This process, known as incongruent solution, results in the release of calcium, sodium, potassium, silica, and other solutes (tab. 2), and is accompanied by consumption of hydrogen ions. Reaction rates tend to be slow, and ground water from aluminosilicate-rich aquifers with few secondary minerals (such as the schists and gneisses in the Piedmont province) tend to be lower in TDS than aquifers with greater amounts of more soluble secondary minerals.

Carbonate aquifers (including limestone and marble) are not extensive in Maryland, but they have a significant influence on ground-water quality because of the high solubility of the carbonate minerals. Calcite, the principal component of limestone and marble, dissolves rapidly in acidic water via the reaction

$$CaCO_3 + H_2O + CO_2 \rightleftharpoons Ca^{2+} + 2HCO_3^-$$ (Drever, 1982)

Ground water often has high calcium and bicarbonate concentrations and near-neutral pH's in areas underlain by limestone and marble in central and western Maryland, and by calcareous sediments in the Coastal Plain (McFarland, 1989; Duigon and Dine, 1991). Well water in these areas is often hard, and dissolution of carbonate minerals in limestone and marble aquifers can result in large solution channels and rapid flow rates which may increase the risk of ground-water contamination. This process also increases the risk of sinkhole development if ground-water levels are lowered.

Human activity as well as naturally-occurring processes can increase ionic concentrations in ground water. Fertilizer use and septic-system effluent can result in nitrate concentrations that comprise a significant percentage of total anion composition, especially in shallow unconfined aquifers. These impacts can also increase concentrations of calcium, magnesium, potassium, sodium, sulfate, and chloride (Denver, 1989; Hamilton and others, 1993). De-icing chemicals can increase sodium, calcium, and chloride concentrations, and have been implicated in high trace-element concentrations (Amrhein, Strong, and Mosher, 1992). Aquifer overpumping near the coast or in areas adjacent to brackish-water bays and rivers can lower ground-water heads enough to draw salt water into the aquifers, increasing chloride concentrations to unusable levels. In

Table 2.—Incongruent dissolution reactions for selected aluminosilicate minerals (from Freeze and Cherry, 1979, p. 270)

[Solid phases are indicated in bold type.]

Gibbsite→kaolinite	$\mathbf{Al_2O_3 \cdot 3H_2O} + 2Si(OH)_4 \rightleftarrows \mathbf{Al_2Si_2O_5(OH)_4} + 5H_2O$
Biotite→kaolinite	$\mathbf{KMg_3AlSi_3O_{10}(OH)_2} + 7H^+ + \tfrac{1}{2}H_2O \rightleftarrows \mathbf{\tfrac{1}{2}Al_2Si_2O_5(OH)_4} + K^+ + 3Mg^{2+} + 2Si(OH)_4$
Albite→kaolinite	$\mathbf{NaAlSi_3O_8} + H^+ + 9/2H_2O \rightleftarrows \mathbf{\tfrac{1}{2}Al_2Si_2O_5(OH)_4} + Na^+ + 2Si(OH)_4$
Anorthite→kaolinite	$\mathbf{CaAl_2Si_2O_8} + 2H^+ + H_2O \rightleftarrows \mathbf{Al_2Si_2O_5(OH)_4} + Ca^{2+}$
Microcline→kaolinite	$\mathbf{KAlSi_3O_8} + H^+ + 9/2H_2O \rightleftarrows \mathbf{\tfrac{1}{2}Al_2Si_2O_5(OH)_4} + K^+ + 2Si(OH)_4$

Maryland, brackish-water intrusion has been documented along the western shore of Kent Island and at Indian Head along the Potomac River (Drummond, 1988; Hiortdahl, 1990).

Other factors can also affect the concentrations of major ions. The position of shallow ground water in the flow system will have a profound effect on water quality. If a well is located in a recharge area, where ground-water flow direction is predominantly downward, water quality will be a function of the area near the well. However, if a shallow well is located near a discharge area, the flow lines intercepting the open interval may originate in a recharge area located far away from the well, and the water quality from the well will be affected by physical, chemical, and biological conditions over a longer flowpath. Ion exchange can significantly alter cation concentrations. Iron, manganese, and other trace-element concentrations can be greatly affected by microbiological activity, oxidation-reduction reactions, and sorption processes. Nitrogen is subject to transformation due to oxidation-reduction processes, plant uptake, and other factors. Many of these reactions will have an effect on ground-water pH and alkalinity. Thus, there are many chemical changes that ground water may undergo between precipitation infiltration and the point of sampling.

PREVIOUS INVESTIGATIONS

Many ground-water-quality investigations have been conducted in Maryland. Much of the data were collected or compiled during water-resources investigations of individual counties or small groups of counties in Maryland. Most of the data have been published by the MGS and the USGS.

Several publications have presented water-quality data collected on a statewide basis. Woll (1978) compiled previously published and unpublished water-quality data from approximately 1600 wells and springs in Maryland. These data comprise all water-quality analyses of Maryland ground water performed by the USGS laboratories through 1974. The chemical and physical characteristics of municipal water supplies in Maryland are presented in Thomas and Heidel (1969). Several studies have investigated ground-water quality on a regional basis. Cushing, Kantrowitz, and Taylor (1973), Hamilton, Shedlock, and Phillips (1989), Hamilton and others (1993), and Koterba, Banks, and Shedlock (1993) have discussed water quality of the Delmarva Peninsula. Foster (1950), Otton (1955), Back (1966), Otton and Mandle (1984), and Knobel (1985) discuss ground-water quality of the Atlantic Coastal Plain. Water quality of the carbonate rocks of the Frederick and Hagerstown Valleys and of the Triassic rocks in Maryland is discussed in Nutter (1973; 1975). Piedmont ground-water quality data are presented in Nutter and Otton (1969), Cleaves (1974), and Richardson (1980). Otton and Hilleary (1985) collected limited water-quality data for selected springs in the Appalachian Plateau, Valley and Ridge, and Piedmont physiographic provinces. Water-quality data have also been collected during studies of individual aquifers (Mack, 1974; Chapelle and Drummond, 1983; Bachman, 1984a, 1984b; Wilson, 1984).

NETWORK DESIGN

SITE SELECTION

The main goals of the Maryland ground-water-quality monitoring network were to document baseline water-quality data from selected unconfined aquifers and to initiate long-term monitoring of ground-water quality. To meet these goals, the following criteria were given high priority in the selection of network sites:

(1) The open or screened interval was in an unconfined aquifer;

(2) The aquifer was laterally extensive and/or was a significant source of water in the surrounding region;

(3) The land use near the site was representative of land use of the surrounding region;

(4) The site appeared to be accessible for long-term continued monitoring;

(5) No obvious point sources of contamination were observed in the area.

Candidate wells and springs were selected from data reports, well inventories, reports of investigations, computer databases, and other published and unpublished sources. Many of the sites are USGS water-level observation wells or USGS and MGS project wells. These wells offer several advantages: (1) well construction is documented; (2) most have water-quality data from earlier projects; (3) long-term access is reasonably likely; (4) the hydrogeologic framework is documented; and (5) most wells are removed from point sources of contamination. Wells and springs in local, state, and national parks also received high priority because of anticipated long-term accessibility. Several institutional wells and domestic wells were included, although in general these were avoided because of uncertainty about long-term access. Budget limitations precluded drilling wells for this project. Springs were included because they provide information on shallow ground-water quality in areas where the open intervals of most wells are below the top of the water table.

In addition to the wells in the unconfined aquifers, four wells completed in confined Coastal Plain aquifers were also included in the network. Two of the wells are located in areas where brackish-water intrusion has resulted from extensive pumping of aquifers adjacent to the Chesapeake Bay and the Potomac River. Two other wells completed in shallow confined aquifers were also sampled; these are located in areas where the unconfined aquifer is not a major source of water.

Several wells were sampled but were later dropped from the network, usually because the water quality appeared to have been affected by point sources of contamination. For example, one well with detectable levels of several pesticides was found to be downgradient from a previously undetected pesticide storage facility. Sites whose water-quality analyses showed evidence of non-point-source contamination were not dropped from the network.

Fifty-two wells and springs were sampled in the initial phase (1987-1992) of this project, with one to five sites in each of Maryland's 23 counties (fig. 3). Site characteristics are summarized in figure 5. This network of wells and springs was not designed to statistically evaluate water quality for all of Maryland's unconfined aquifers. The sites were not randomly selected, and consist largely of USGS observation wells. Water quality from wells and springs usually cannot be grouped together for quantitative analysis. When the network sites are assigned to different categories of land use, lithology, and other criteria, the sample size per category is very small, and quantitative evaluation has little meaning. The data were collected primarily to identify potential water-quality problems in the unconfined aquifers, and to provide a basis for future water quality monitoring.

ANALYTES

Water samples from network sites were analyzed for major cations and anions, trace elements, nutrients, radon, and selected indicators (pH, specific conductance, dissolved oxygen, total organic carbon, and others). Radon was analyzed at sites where a non-aerated sample could be obtained. Most network sites were also analyzed for three suites, or "schedules," of

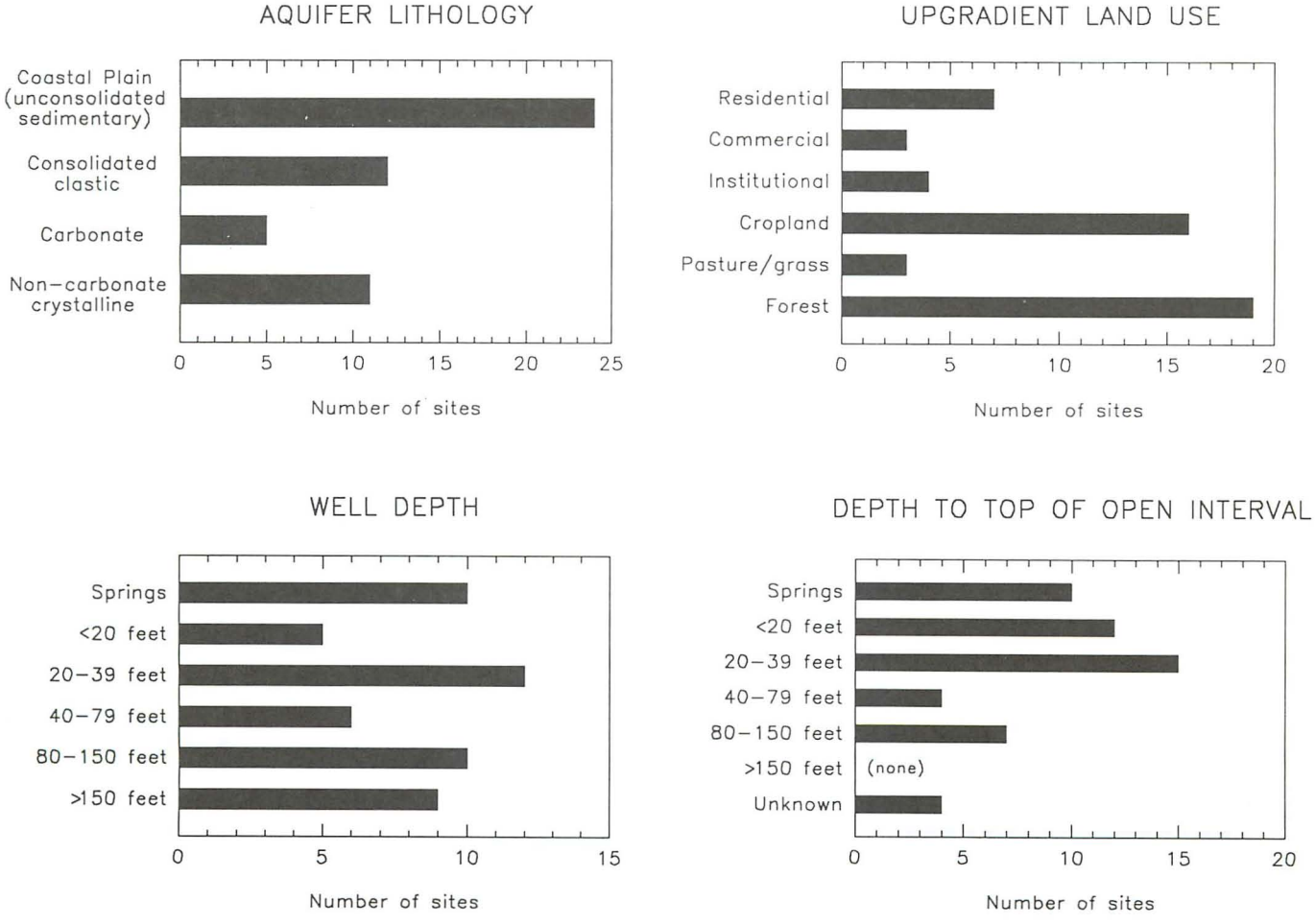


Figure 5.—Numbers of sites in categories of aquifer lithology, well depth, depth to top of open interval, and upgradient land use.

pesticides: USGS Schedules 1304 (chlorophenoxy herbicides), Schedule 1331 (organochlorine and organophosphorus insecticides), and Schedule 1389 (triazine herbicides and other pesticides). These schedules were selected after considering the broad-spectrum analytical capabilities of the NWQL, pesticide use in Maryland, and drinking-water standards and health advisories established for specific analytes by the U.S. EPA. Most network sites were also sampled for a suite of volatile organic compounds (USGS Schedule 1390). Budget constraints prevented sampling all network sites for all three pesticide and volatile organic compound schedules; most sites that were tested were downgradient (as determined by topographic position) from either cropland or forest. During the first five years of network sampling, many analytes were added to (and some were removed from) the schedules. Furthermore, several wells that were sampled by other projects were tested for additional analytes. Most of these additional analytes are listed in the data tables in Appendix A.

SAMPLING FREQUENCY

For operational purposes, the state was divided into four segments according to physiographic province: the Appalachian Plateau and Valley and Ridge (Segment I); the Piedmont and Blue Ridge (Segment II); the Western Shore Coastal Plain (Segment III); and the Eastern Shore Coastal Plain (Segment IV). Sites in the Western Shore Coastal Plain were selected and sampled during the first year of the project; in each subsequent year, sites in additional segments were selected and sampled, and sites in previously-sampled segments were resampled. In addition, several sites in each segment were sampled more frequently in order to observe seasonal variability in water quality. The chronology of site selection and sampling is shown in table 3.

SAMPLING PROCEDURES

Consistent protocols were observed during sample collection and processing in order to ensure comparability between network sites. Collection protocols may have differed for samples that were collected for other projects, especially for older samples.

Prior to sampling, network wells were purged by evacuating the equivalent of three times the volume of standing water in the well, when possible. For wells where the water level could not be measured, the volume of standing water was assumed to be equal to the volume of the entire well. Due to their low yields, the two hand-dug wells in the network were pumped dry on the day prior to sampling; the water levels were allowed to recover overnight, and the wells were sampled the following day. Several devices were used for purging and sampling, including a two-cycle centrifugal pump, a trailer-mounted 3-inch submersible pump (Groundwater Pump Manufacturing Inc. Model 20X4P050-2), two portable Fultz submersible pumps (2- and 4-inch diameter models), and a Teflon bailer. The type of device used for purging was chosen based on the well dimensions, water level, type of sample analysis, and other factors.

Specific conductance, pH, and temperature were monitored at 5- or 10-minute intervals during purging at all sites. Specific conductance and temperature were measured with a YSI Model 34 conductivity/resistivity meter and a YSI 3000 T-L-C

Table 3.—Chronology of site selection, annual sampling, and seasonal sampling of sites in the Maryland ground-water-quality network.

[Shaded areas indicate when the specified activities occurred.]

		1987		1988				1989				1990				1991				1992			
Province	Task	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Western Shore Coastal Plain	SS/AS*																						
	Seasonal																						
Piedmont/Blue Ridge	SS/AS																						
	Seasonal																						
Eastern Shore Coastal Plain	SS/AS																						
	Seasonal																						
Valley and Ridge/ Appalachian Plateau	SS/AS																						
	Seasonal																						

* SS/AS: Site selection and annual sampling

conductivity meter. The meters were checked daily against specific conductance standards bracketing those of the samples being taken. pH was measured with a Beckman D12 pH/ISE meter, and a Beckman Model 39846 gel-filled combination pH electrode or a Beckman glass electrode. The pH meter was standardized daily using a 2-buffer standardization procedure. Dissolved oxygen was also monitored during purging at most sites with a YSI Model 87 dissolved-oxygen meter, which was calibrated at each site. Alkalinity was measured in the field by titration with sulfuric acid using a Hach digital titration kit. Other equipment was used occasionally when the regular equipment failed to function properly.

Once three well volumes had been purged and the field parameters were stable, the sample was taken. For some domestic wells, the sample was taken when the field parameters were stable, although three well volumes may not have been purged. Some of the deep and large-borehole wells were initially purged with a high-capacity pump and then were sampled with a lower-capacity pump or bailer, in order to minimize disturbance of the sample during sampling. Samples collected from domestic wells were obtained from the spigots closest to the wellhead that bypassed water treatment. Springs were monitored and sampled as close to the resurgence point as possible.

Unfiltered samples were collected first. Samples requiring filtration were immediately filtered through Micro Filtration Systems 0.45μ cellulose nitrate filters using a Cole-Parmer Portable Masterflex peristaltic pump. Chemical preservatives were added to samples as required to inhibit chemical and biological reactions in the sample containers. Containers and preservatives used in sample collection and preparation were in accordance with USGS specifications. Radon samples were collected by inserting a syringe through a Teflon septum attached directly to the pump outlet hose so that the sample was not exposed to the atmosphere. Radon samples from springs were collected by submerging the syringe in the spring resurgence and collecting the sample from the bottom of the resurgence. The sample was then injected into a sample bottle filled with mineral oil, which was then shaken to dissolve the radon in the oil.

After collection and treatment, the samples were stored in an ice-filled cooler prior to being shipped to the NWQL. Samples being analyzed for unstable analytes, such as radon, nutrients, and volatile organic compounds, were shipped immediately in accordance with USGS protocols for unstable constituents. All samples were analyzed at the USGS NWQL in Arvada, Colorado. Analytical methods are reported in Wershaw and others (1987) and Fishman and Friedman (1989).

QUALITY ASSURANCE

The validity of the water-quality data were evaluated using cation-anion charge balance errors and quality-assurance samples. Charge-balance errors were calculated from milliequivalent ion concentrations via the formula:

$$\%\ \text{charge balance error} = \frac{(\Sigma_{cations} - \Sigma_{anions})}{(\Sigma_{cations} + \Sigma_{anions})} \times 100$$

Water samples should be electrically neutral; that is, the milliequivalent sums of cations and anions should be equal. Most water samples have some charge-balance error for several reasons, including inaccurate laboratory analysis, non-analysis of one or more constituents, and post-collection precipitation of solid phases. Charge-balance errors for most of the Maryland network samples were <5%; samples with charge-balance errors >5% generally were low in TDS, where small differences in solute concentrations resulted in large differences in charge-balance error. Dissolved (filtered) concentrations were used in calculating charge-balance errors, except for nitrate-plus-nitrate. Most network samples were analyzed for total (unfiltered) rather than dissolved nitrate-plus-nitrite concentrations; for these samples, the total nitrate-plus-nitrite concentrations were used to calculate the charge-balance errors.

Twenty-nine quality-assurance (QA) samples from randomly-selected sites were collected in addition to the actual samples. The QA samples were analyzed for major ions, nutrients, trace elements, pesticides, and volatile organic compounds. Two types of QA samples were collected. Field blanks were collected to check for contamination that may have occurred during sample collection, treatment, storage, transport, or analysis. Field duplicate samples were collected to document the precision associated with the different inorganic analyses. The field blanks consisted of deionized water (for inorganic blanks) and high-purity ultra-pure water (for blanks analyzed for pesticides and volatile organic compounds). Both the blank and duplicate samples were collected and processed in the field in the same way as the actual samples, including filtration, preservation, and transport. The field blanks were not run through the well pumps. No field spikes or reference samples were submitted.

Most of the major-ion duplicate samples were within 5% of the actual samples. The concentrations of the duplicates with larger percentage errors are very low, so that a small difference in the absolute concentration of an analyte results in a large error. Concentrations of three duplicate analytes (one each of dissolved sulfate, total iron, and dissolved iron) in three different wells differ largely from the true samples. The differences do not affect the conclusions of the report. The concentrations of major ions measured in the sample blanks are very close to or below reporting limits of the individual species. Detections were reported from several total-ammonia blanks (0.02 mg/L as nitrogen) and one total-phosphorus blank (0.08 mg/L as P); all other nutrient species in the blanks were below reporting limits. These detections do not affect the conclusions of the report.

Field blanks were collected at 7 of the 40 sites that were tested for at least one of the pesticide schedules. Field blanks were also collected at six of the 36 sites tested for volatile

organic compounds. No detections of these compounds were reported in any of the blank samples. No duplicate samples for pesticides or volatile-organic compounds were collected.

NETWORK GROUND-WATER-QUALITY DATA

INORGANIC GROUND-WATER QUALITY

This section discusses general aspects of the inorganic water quality of samples from sites in the Maryland ground-water-quality network. Synthetic organic chemicals data are discussed in another section. Because the network sites were not all sampled the same number of times between 1987 and 1992, the analyte values discussed in this report usually refer to the median values at each site. Figures showing relationships between two or more analytes are plotted using data from a specific analysis (i.e., not the median site value). Median analyte values of groups of sites (for example, the median hardness of sites in carbonate aquifers, or median nitrate concentrations of sites in agricultural areas) refer to the overall median value of the individual median values. Except for nutrients (nitrate, nitrite, ammonia, phosphorus), analyte concentrations in this report refer to the "dissolved" (filtered) concentrations, unless otherwise noted. Samples were not analyzed specifically for nitrate, but rather for nitrate-plus-nitrite and also for nitrite; because nitrite concentrations were negligible, "nitrate" in this report refers to the analytical value of nitrate-plus-nitrite. All nitrate and ammonia concentrations are reported as nitrogen.

Segment I: Appalachian Plateau and Valley and Ridge Physiographic Provinces

Thirteen sites (9 wells and 4 springs) were sampled in the Appalachian Plateau and Valley and Ridge physiographic provinces. Ten sites are in consolidated clastic-rock aquifers; the other three are in carbonate-rock aquifers in the Hagerstown Valley. Aquifer data and major-ion types are given in table 4 and are illustrated in figures 6 and 7. Boxplots of major-ion concentrations and other water-quality data are shown by physiographic province and aquifer lithology in figures 8 through 14. Water-quality data are presented in tables A1-A6.

Samples from most of the network sites in the Appalachian Plateau and Valley and Ridge physiographic provinces were moderately hard to very hard calcium-bicarbonate waters; only three sites had soft water. Samples from these sites had the highest overall median hardness (150 mg/L as $CaCO_3$) and pH (7.2) of all four segments. Hardness categories are shown in Table 5.

Samples from most of the sites in consolidated clastic aquifers are characterized by high TDS and specific conductance, pH's near neutrality, and calcium-bicarbonate chemical character. (In this report, chemical character or water type was determined from milliequivalent percentages of cations and anions). These parameters reflect the extent of calcium carbonate in the aquifers of the Appalachian Plateau. TDS and specific conductance are highly correlated for all network sites (R=0.98) (fig. 15), which indicates the usefulness of specific conductance for estimating TDS in ground water. Median dissolved-oxygen values ranged from anoxic (defined for this report as <1 mg/L) to 9.6 mg/L. Saturation indices calculated using the geochemical speciation code WATEQ4F (Ball and Nordstrom, 1992) indicate that most samples are undersaturated with respect to calcite (fig. 16). The low TDS and pH of some of the springs issuing from clastic aquifers suggests short residence times and shallow depth of ground-water circulation. Sulfate is the dominant anion at two of the springs (GA Eb 72 and WA Ab 3), although the absolute concentrations (<10 mg/L at both sites) are less than those at most other sites. These springs were more undersaturated with respect to calcite than the segment's well-water samples. The spring samples typically have higher dissolved-oxygen concentrations than the well samples.

The three sites in the carbonate aquifers are all located in the Hagerstown Valley. Samples from these sites (two wells and a spring) are very hard calcium-bicarbonate waters, and are all at or near saturation with respect to calcite (fig. 16). These sites have higher nitrate and sulfate concentrations than most of the sites in the consolidated clastic aquifers. The samples have relatively high dissolved oxygen.

Silicate and aluminosilicate minerals such as quartz, feldspars, and micas are the dominant minerals in most of the clastic aquifers sampled in the Appalachian Plateau and Valley and Ridge physiographic provinces. Because dissolved aluminum tends to reprecipitate via incongruent dissolution, saturation indices for aluminosilicate minerals do not indicate which minerals may be expected to form. Stability diagrams can be constructed that show the stable mineral phases in relation to silica concentration and cation/hydrogen ion ratios (fig. 17). Data from network sites plotted on three stability diagrams indicate that kaolinite is the stable silicate mineral for sites in all carbonate and crystalline-rock aquifers and most unconsolidated and consolidated clastic aquifers, which suggests that

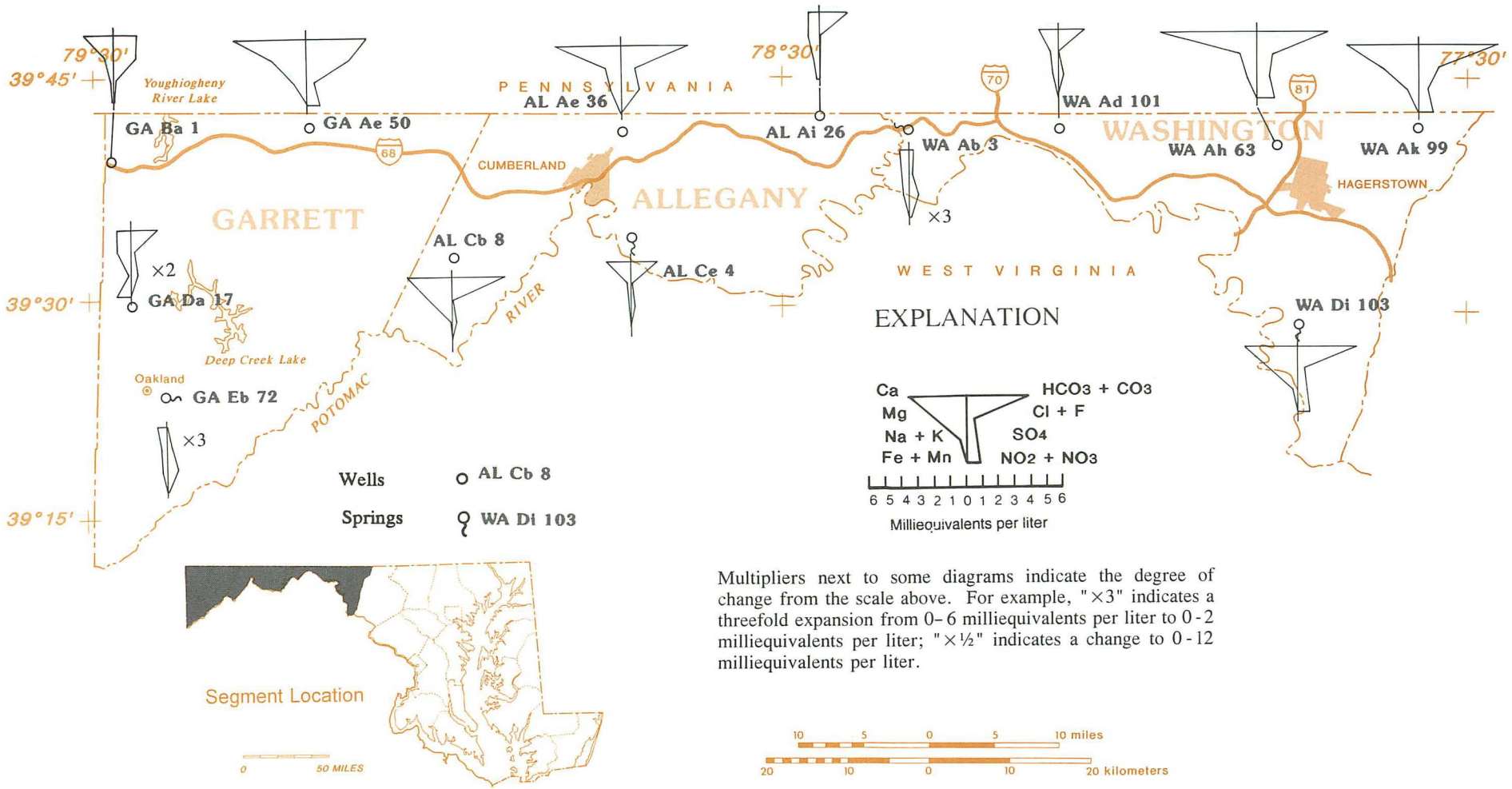
(Text continued on p. 23.)

Table 4.—Site characteristics, major-ion types, and upgradient land use for network wells and springs in the Appalachian Plateau and Valley and Ridge physiographic provinces.

[Land-use categories: 1, residential; 2, commercial; 3, institutional; 4, cropland; 5, pasture/grassland; 6, forest. See table 9 and text for additional comments.]

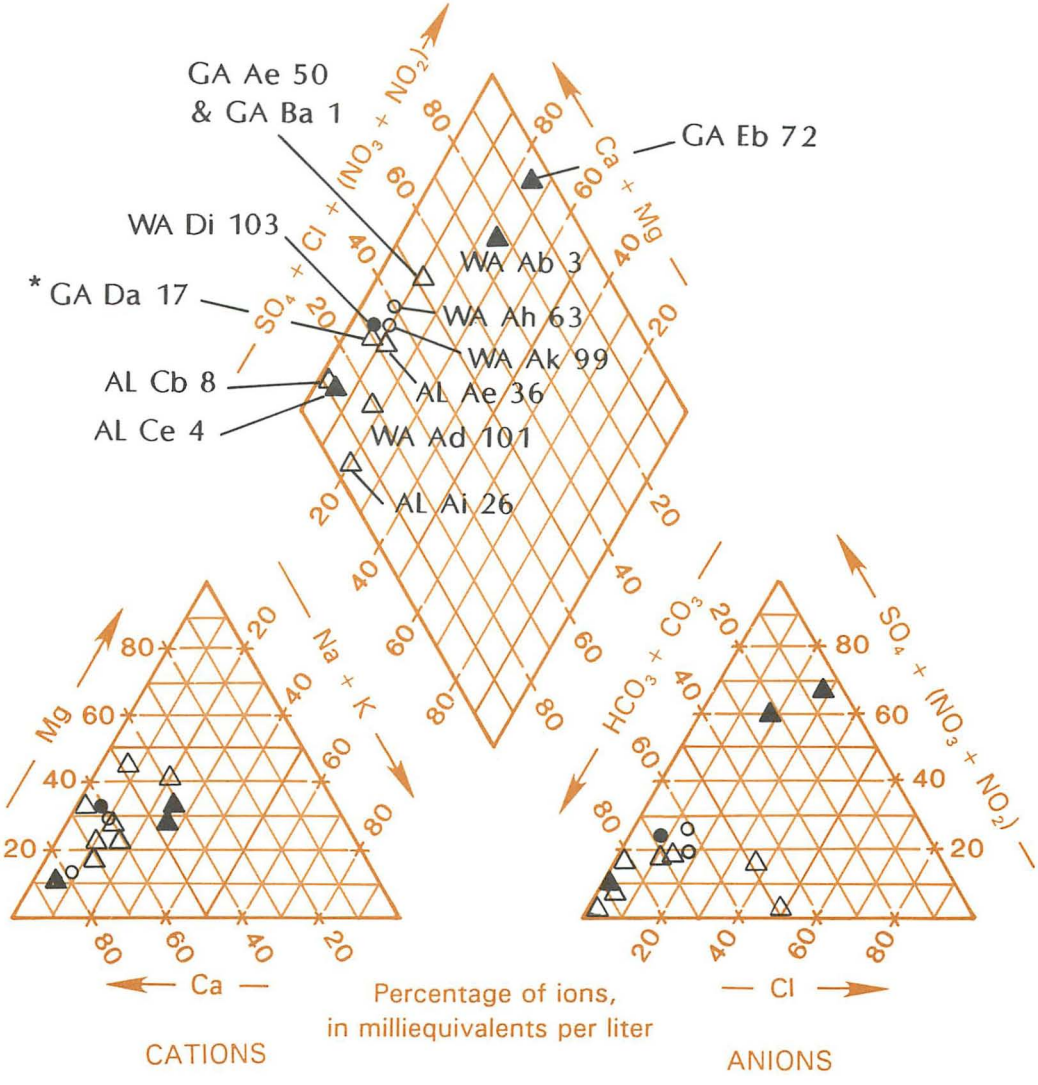
Site	Physiographic province	Geologic unit	Major lithology	Major ions*		Upgradient land use**
				Cations	Anions	
AL Ae 36	Valley & Ridge	Mahantango Fm.	Mudrock, siltstone, shale	Ca^{2+}	HCO_3^-	6
AL Ai 26	Valley & Ridge	Jennings Fm.	Shale, siltstone, conglomeratic sandstone	Mixed	HCO_3^-	6
AL Cb 8	Appalachian Plateau	Conemaugh Fm.	Interbedded argillaceous limestone, clay, claystone, shale, siltstone, sandstone; some conglomerate	Ca^{2+}	HCO_3^-	6
AL Ce 4	Valley & Ridge	Marcellus/Needmore Shale (near contact with Oriskany Group)	Shale, mudrock (Oriskany: Sandstone, some conglomerate)	Ca^{2+}	HCO_3^-	6
GA Ae 50	Appalachian Plateau	Conemaugh Fm.	Claystone, shale, siltstone, sandstone	Ca^{2+}	HCO_3^-, Cl^-	5
GA Ba 1	Appalachian Plateau	Conemaugh Fm.	Claystone, shale, siltstone, sandstone	Ca^{2+}	HCO_3^-, Cl^-	6
GA Da 17	Appalachian Plateau	Allegheny-Pottsville Fm.	Sandstone, siltstone, claystone, shale, coal	Ca^{2+}, Mg^{2+}, Fe^{2+}	HCO_3^-	6
GA Eb 72	Appalachian Plateau	Jennings Fm.	Shale, siltstone, sandstone	Mixed	SO_4^{2-}	6
WA Ab 3	Valley & Ridge	Hampshire Fm.	Sandstone, arkosic sandstone, red shale	Mixed	SO_4^{2-}	4
WA Ad 101	Valley & Ridge	Romney Fm.	Shale, sandstone, limestone	Ca^{2+}	HCO_3^-	6
WA Ah 63	Valley & Ridge	Rockdale Run Fm.	Limestone, dolomite	Ca^{2+}	HCO_3^-	4
WA Ak 99	Valley & Ridge	Tomstown Fm.	Limestone, dolomite, calcareous shale	Ca^{2+}	HCO_3^-	4
WA Di 103	Valley & Ridge	Conococheague Limestone	Limestone with shale interbeds	Ca^{2+}	HCO_3^-	4

* Determined from milliequivalent percentages of individual samples
** Dominant upgradient land use within 1/4 mile of site



Multipliers next to some diagrams indicate the degree of change from the scale above. For example, "×3" indicates a threefold expansion from 0-6 milliequivalents per liter to 0-2 milliequivalents per liter; "×½" indicates a change to 0-12 milliequivalents per liter.

Figure 6.—Stiff diagrams for network sites in the Appalachian Plateau and Valley and Ridge physiographic provinces.



EXPLANATION

GA Eb 72	Site number
△	Consolidated clastic aquifers
○	Carbonate aquifers

Hollow symbols indicate wells
Solid symbols indicate springs
* Fe+Mn > 10% of cation percentage

Figure 7.—Major-ion chemistry of network sites in the Appalachian Plateau and Valley and Ridge physiographic provinces.

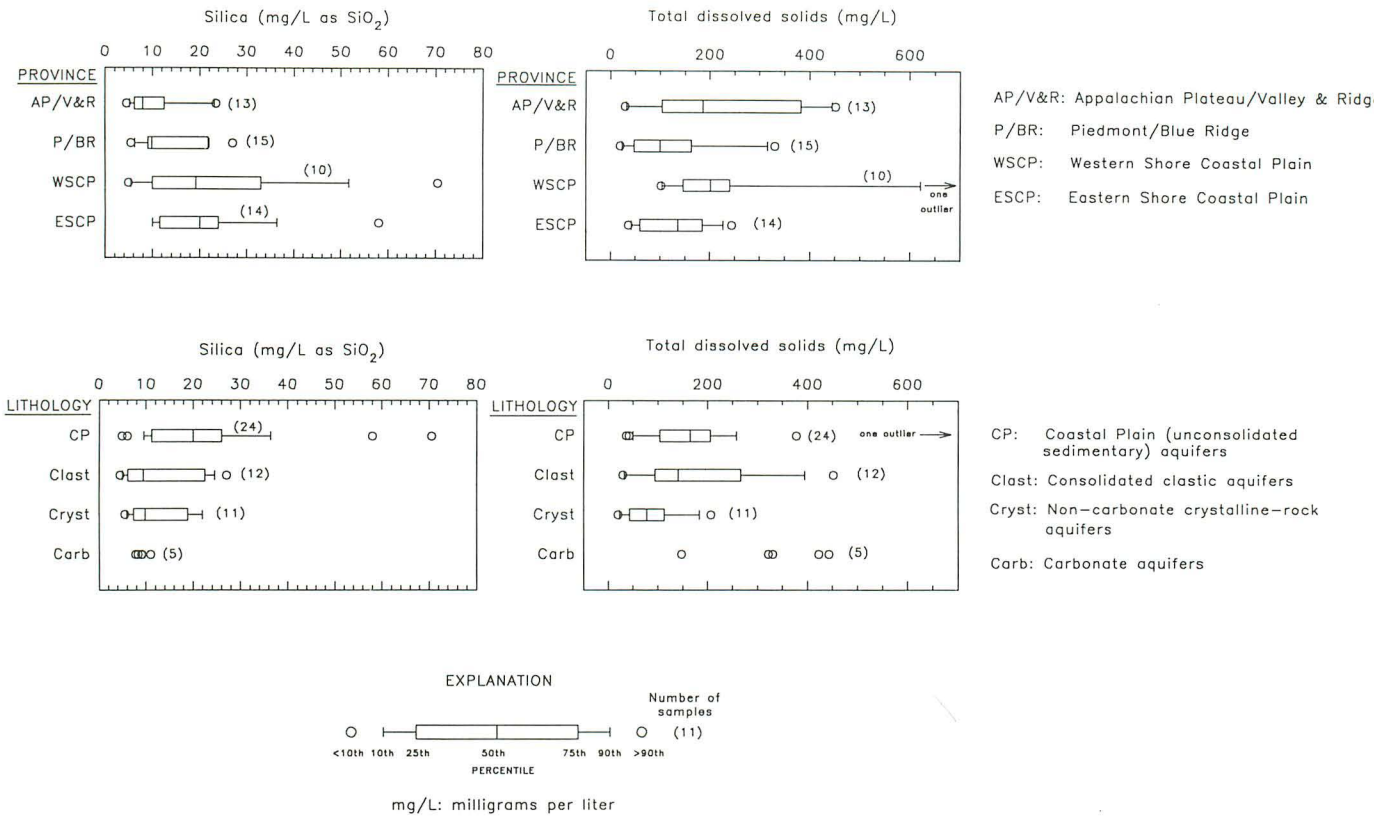


Figure 8.—Median silica and total-dissolved-solids values by physiographic province and aquifer lithology.

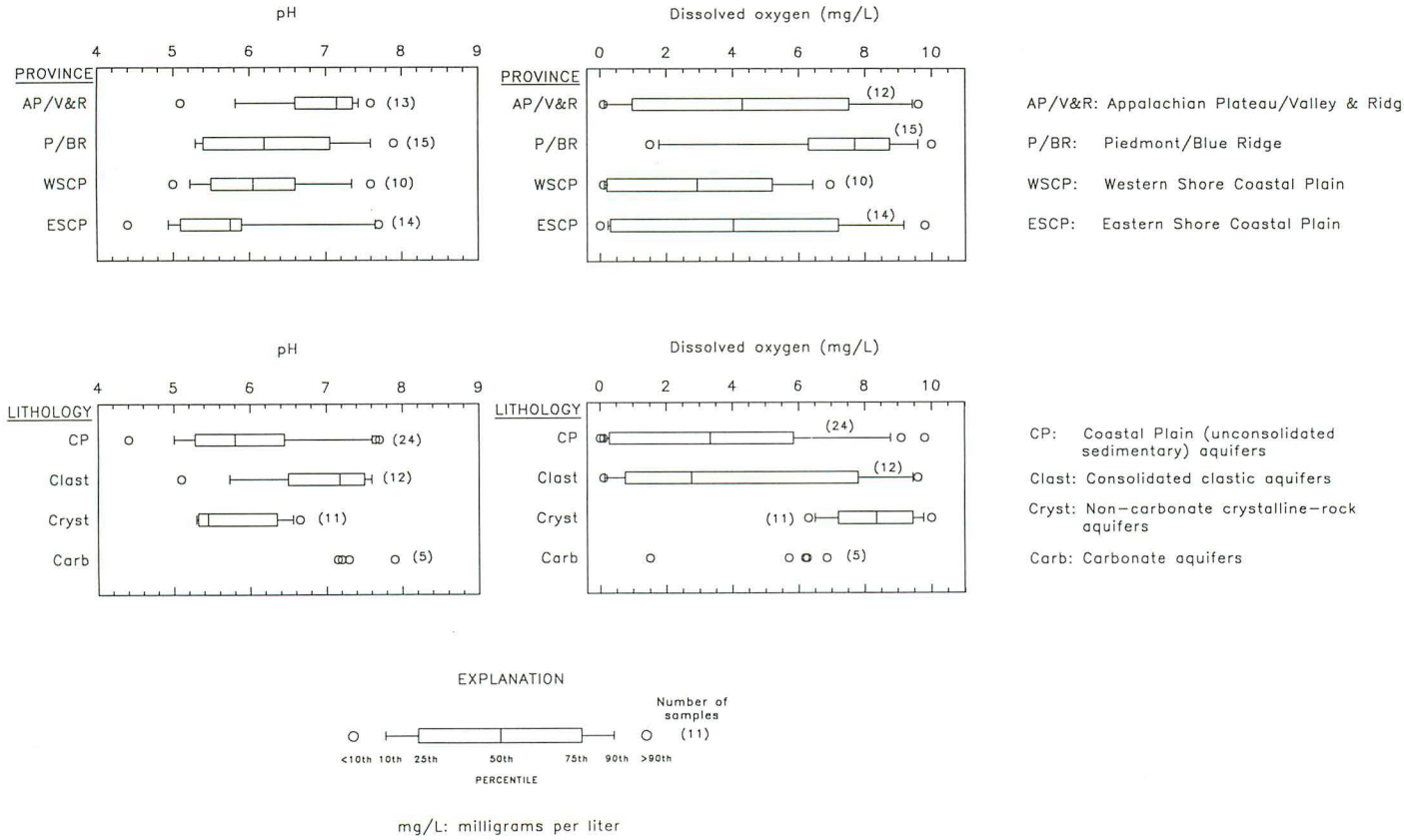


Figure 9.—Median pH and dissolved oxygen values by physiographic province and aquifer lithology.

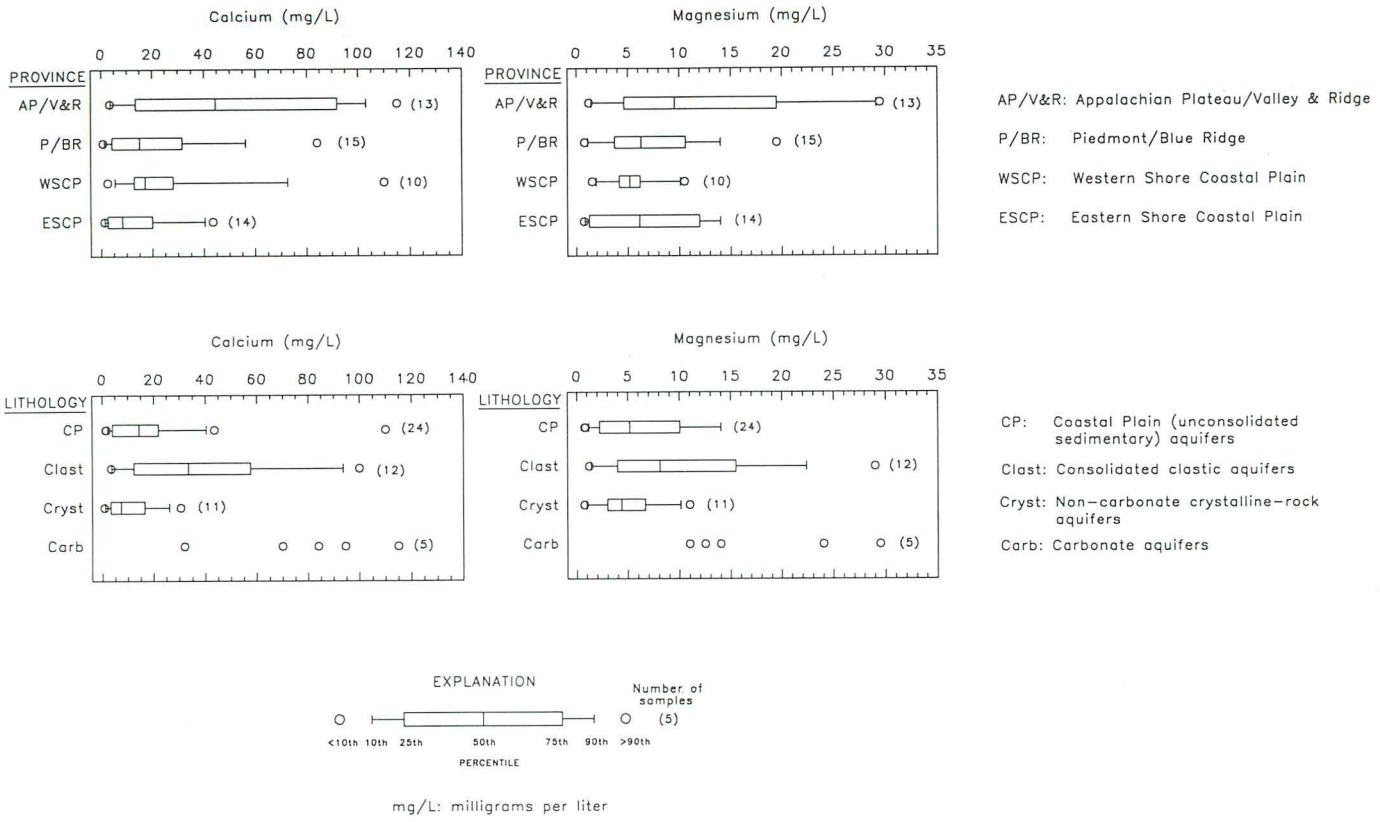


Figure 10.—Median calcium and magnesium concentrations by physiographic province and aquifer lithology.

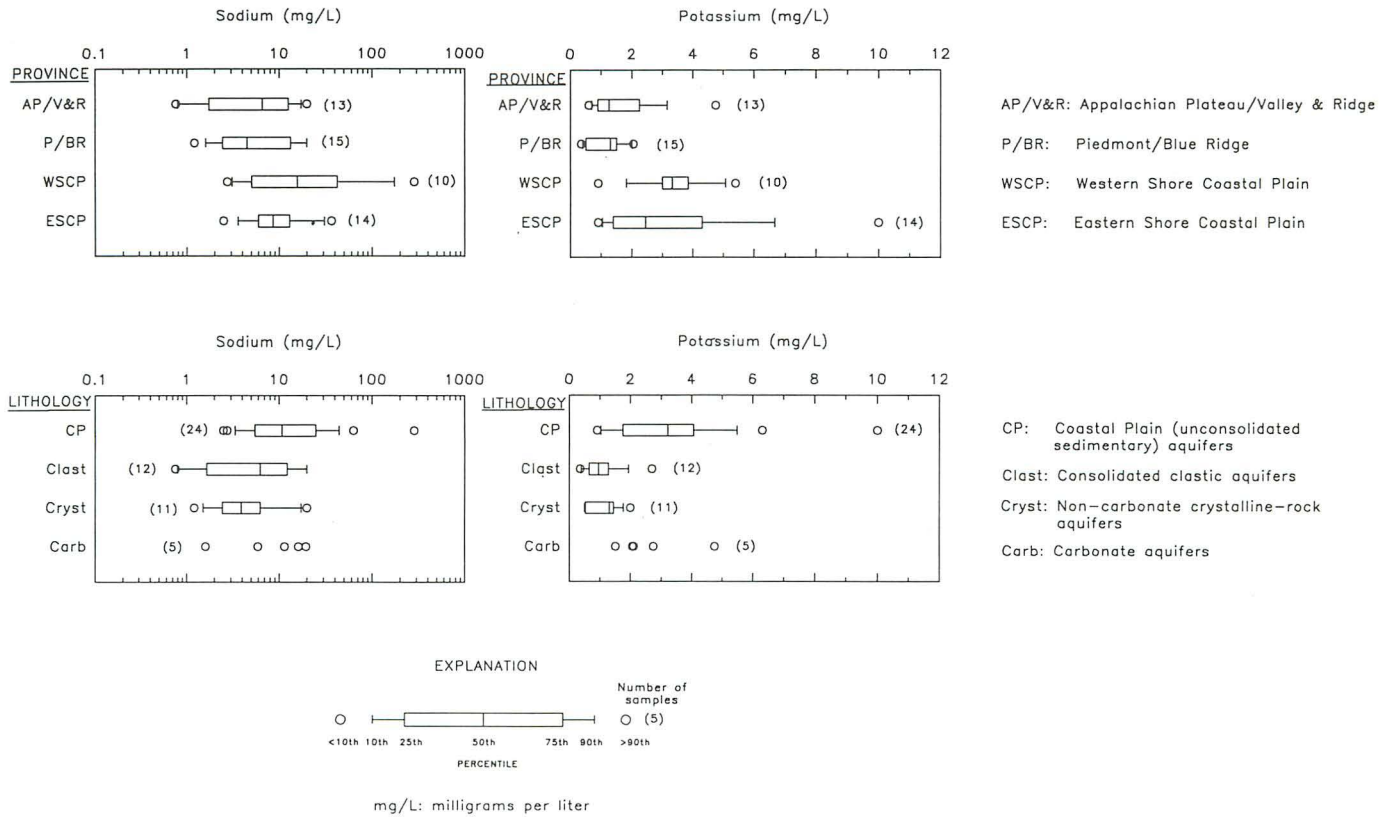


Figure 11.—Median sodium and potassium concentrations by physiographic province and aquifer lithology.

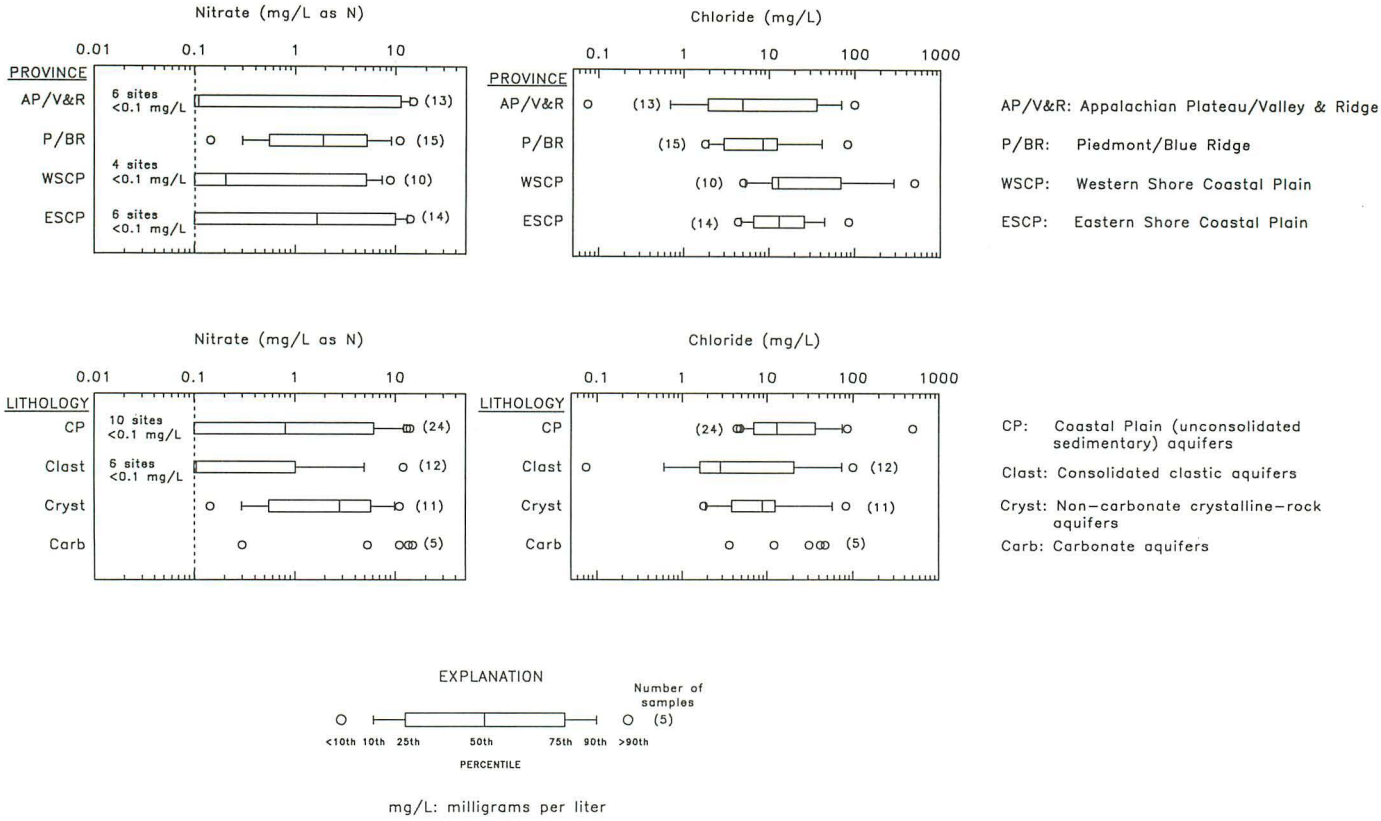


Figure 12.—Median nitrate and chloride concentrations by physiographic province and aquifer lithology.

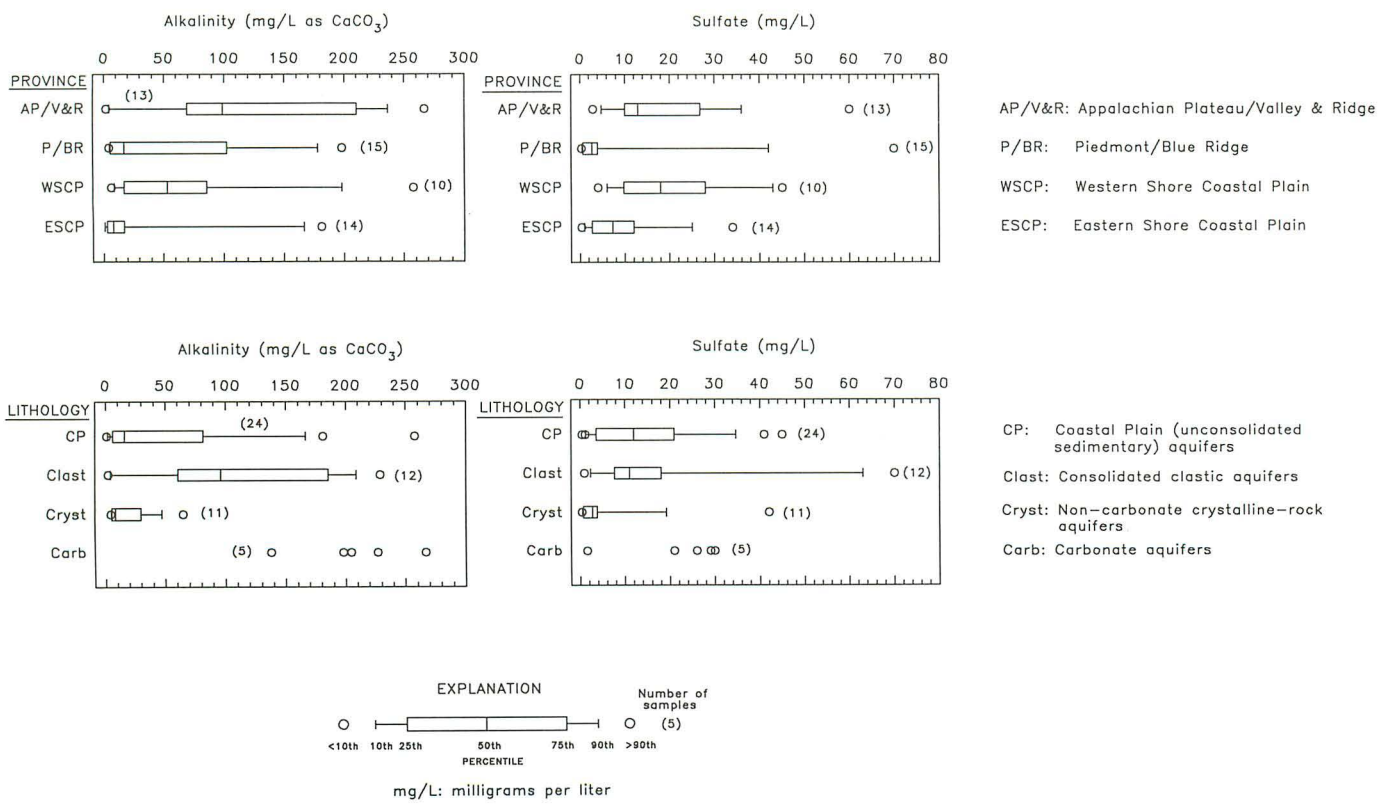


Figure 13.—Median alkalinity and sulfate concentrations by physiographic province and aquifer lithology.

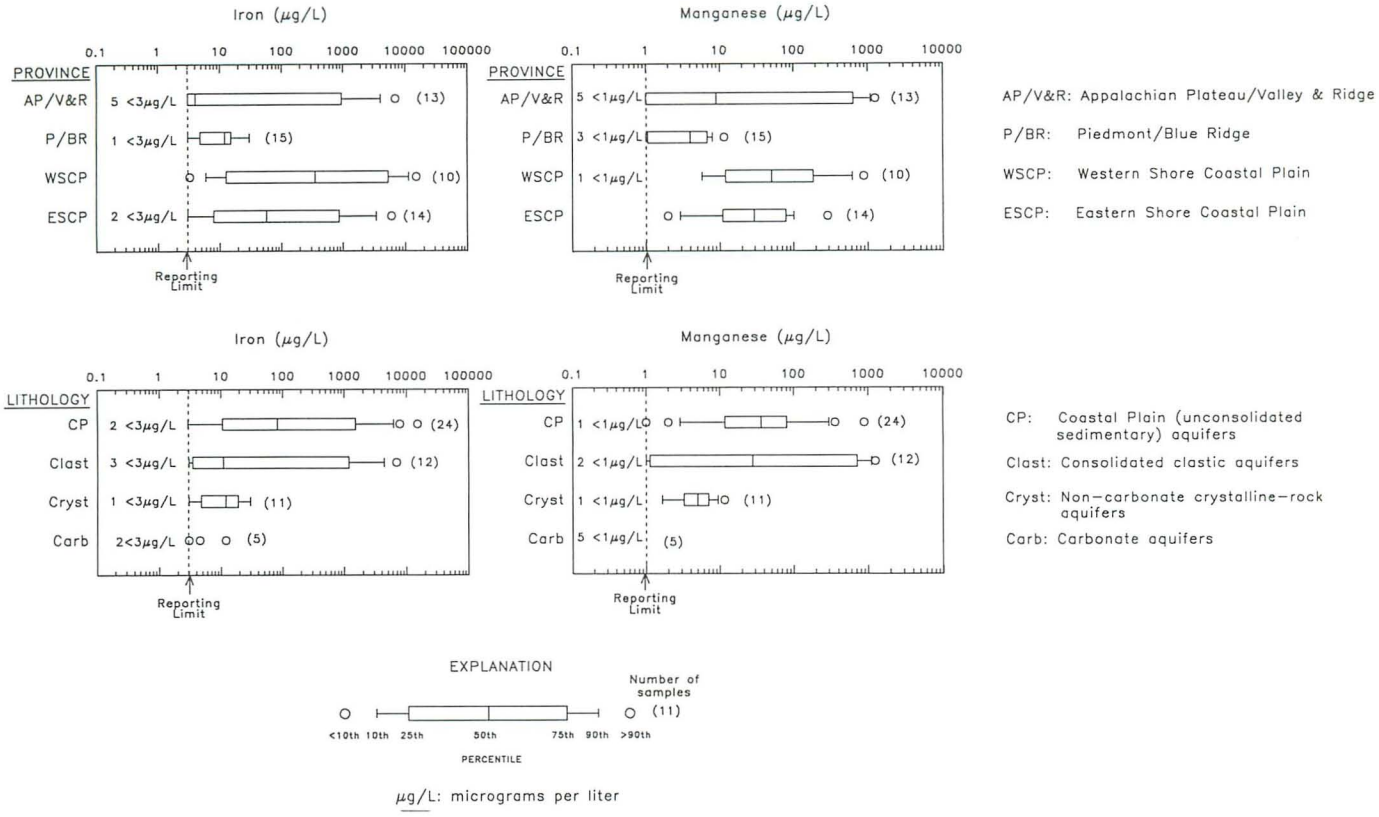


Figure 14.—Median iron and manganese concentrations by physiographic province and aquifer lithology.

the feldspars are weathering to produce kaolinite. Most samples are supersaturated with respect to quartz and undersaturated with respect to silica gel, which suggests that quartz doesn't control silica solubility.

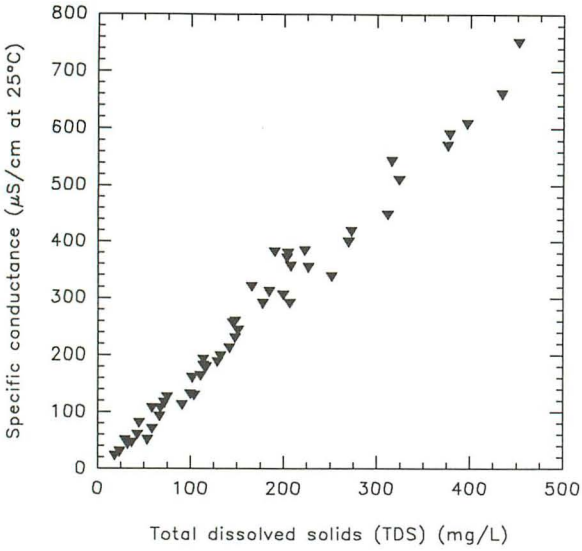
Median nitrate concentrations from network sites in the Appalachian Plateau and Valley and Ridge physiographic provinces ranged from <0.050 mg/L to 15 mg/L; the overall median nitrate concentration (0.11 mg/L) was the lowest of all four segments. Samples from three wells (GA Ae 50, WA Ah 63, WA Ak 99) and one spring (WA Di 103) exceeded the MCL of 10 mg/L nitrate. Three of the four sites are in carbonate aquifers in the Hagerstown Valley; the fourth site is in the Conemaugh Formation near Grantsville in Garrett County. The sites are all located in agricultural areas, although there are septic systems near all the sites. Ammonia concentrations exceeded nitrate concentrations in samples from well AL Ae 36. Median chloride concentrations in the samples ranged from <0.1 mg/L to 100 mg/L; the overall median chloride concentration was 5.0 mg/L, the lowest of all four segments. Chloride concentrations at two sites exceeded 50 mg/L, which probably reflects the influence of road salt. Chloride concentrations are discussed in more detail later in this report.

Median iron concentrations from network sites in consolidated clastic aquifers ranged from <3 μg/L to 6,900 μg/L; four sites exceeded 300 μg/L. Median manganese concentrations ranged from <1 μg/L to 1,300 μg/L, with five sites exceeding 50 μg/L. Iron and manganese concentrations from sites in carbonate aquifers were all close to the detection limit; the slightly alkaline, oxygenated waters in these aquifers do not support high iron or manganese concentrations. The median concentration of iron for all 13 sites was 4 μg/L, the lowest of the four segments. Barium concentrations exceeded 100 μg/L (the overall segment median) at wells in consolidated clastic aquifers; springs and carbonate aquifers all had concentrations <100 μg/L. Most other trace-element concentrations were <20 μg/L.

Dissolved-iron concentrations often varied between samples taken from the same site, especially in wells with high concentrations of iron. This is probably due in part to rapid oxidation of ferrous iron between sample collection and acidification,

Table 5.—Classification of hardness (from Hem, 1985, p. 159.)

Hardness range (milligrams per liter $CaCO_3$)	Description
0-60	Soft
61-120	Moderately hard
121-180	Hard
>180	Very hard



EXPLANATION

µS/cm: microsiemens per centimeter

mg/L: milligrams per liter

Data from PG Bc 37 (median TDS=864 mg/L; median specific conductance 1710 µS/cm) are not plotted

Figure 15.—Relationship between specific conductance and total-dissolved-solids.

and also to variations in colloidal iron passing the 0.45µ filter. The variations in some total-iron concentrations among samples taken from the same site appeared to be associated with the use of the trailer-mounted submersible pump or with wells with steel casing.

Four springs (AL Ce 4, GA Eb 72, WA Ab 3, and WA Di 103) were sampled quarterly between September 1990 and June 1991 for major ions and nutrients. In general, there was little change in the major-ion concentrations. Seasonal changes in chloride values at AL Ce 4, GA Eb 72, and WA Ab 3 were all <2 mg/L during the year; chloride values from WA Di 103 ranged from 12 mg/L to 17 mg/L. Nitrate concentrations showed no consistent seasonal trend among all four sites. WA Di 103 had both the highest levels and the largest changes in nitrate; the highest nitrate value (12 mg/L) was in December, while the lowest value (2.1 mg/L) was in early October. This spring is located in an area that is predominantly cropland. Nitrate concentrations from the other three sites were 1.0 mg/L; these sites are located in areas with smaller amounts of agricultural land use than WA Di 103.

Segment II: Piedmont and Blue Ridge Physiographic Provinces

Fifteen sites were sampled in the Piedmont and Blue Ridge physiographic provinces. Ten sites are in non-carbonate crystalline-rock aquifers; two sites are in Triassic (sedimentary) aquifers; two are in carbonate aquifers (including one in marble), and one well is in saprolite developed on schist. Aquifer data and major-ion types are given in table 6 and are illustrated in figures 18 and 19. Water-quality data are presented in tables A7-A12.

Samples from this segment were enriched in calcium relative to other cations, or had a mixed-cation composition; anion composition was mixed. The overall median TDS for these sites (100 mg/L) was the lowest median value of all four segments, which reflects the low solubility of the aluminosilicate minerals and general lack of soluble secondary minerals in non-carbonate crystalline-rock aquifers. Individual median pH's ranged from 5.3-7.9. Samples from most sites in this segment were soft or moderately hard.

Samples from non-carbonate crystalline aquifers were typically lower in TDS than samples from the consolidated clastic or carbonate aquifers. The higher TDS values in crystalline rocks are from sites with high chloride concentrations; lower TDS values in these aquifers tend to come from sites in recharge areas (as inferred from topographic position). The lowest TDS values are from two springs (FR Cd 38; HA Bc 31) that are downgradient from undeveloped land. Samples from non-carbonate crystalline aquifers were more acidic (median pH range: 5.3-6.7) than samples from the Triassic aquifers (7.6) or carbonate aquifers (7.2-7.9). Samples from all sites in the Piedmont and Blue Ridge physiographic provinces were supersaturated with respect to quartz and undersaturated with respect to amorphous silica. All samples plot in the kaolinite stability field (fig. 17).

The sites in carbonate aquifers (FR Dd 178 and BA Dc 444) and the consolidated clastic aquifers (FR Af 27 and MO Db 68) were calcium-bicarbonate or calcium-magnesium-bicarbonate waters, and were at or near saturation with respect to calcite. Samples from FR Dd 178 were chemically similar to those from network sites in the Hagerstown Valley. Well BA Dc 444, in the Cockeysville Marble, had lower TDS and hardness, and higher pH than samples from all other network sites in carbonate aquifers. This may reflect mineralogic and hydrogeologic differences between the sedimentary and metamorphic carbonate aquifers. Another factor could be that BA Dc 444 is cased to a depth of 86 feet below land surface (about 40 feet below the water table), and well water may be derived from deeper-flow ground water than the shallower wells in the Hagerstown Valley. If the deeper ground water is no longer in contact with the major source of carbon dioxide, this may result in depletion of carbon dioxide and increase in pH along the flowpath. The recharge water for shallow wells and springs probably receives continual input of carbon dioxide along the

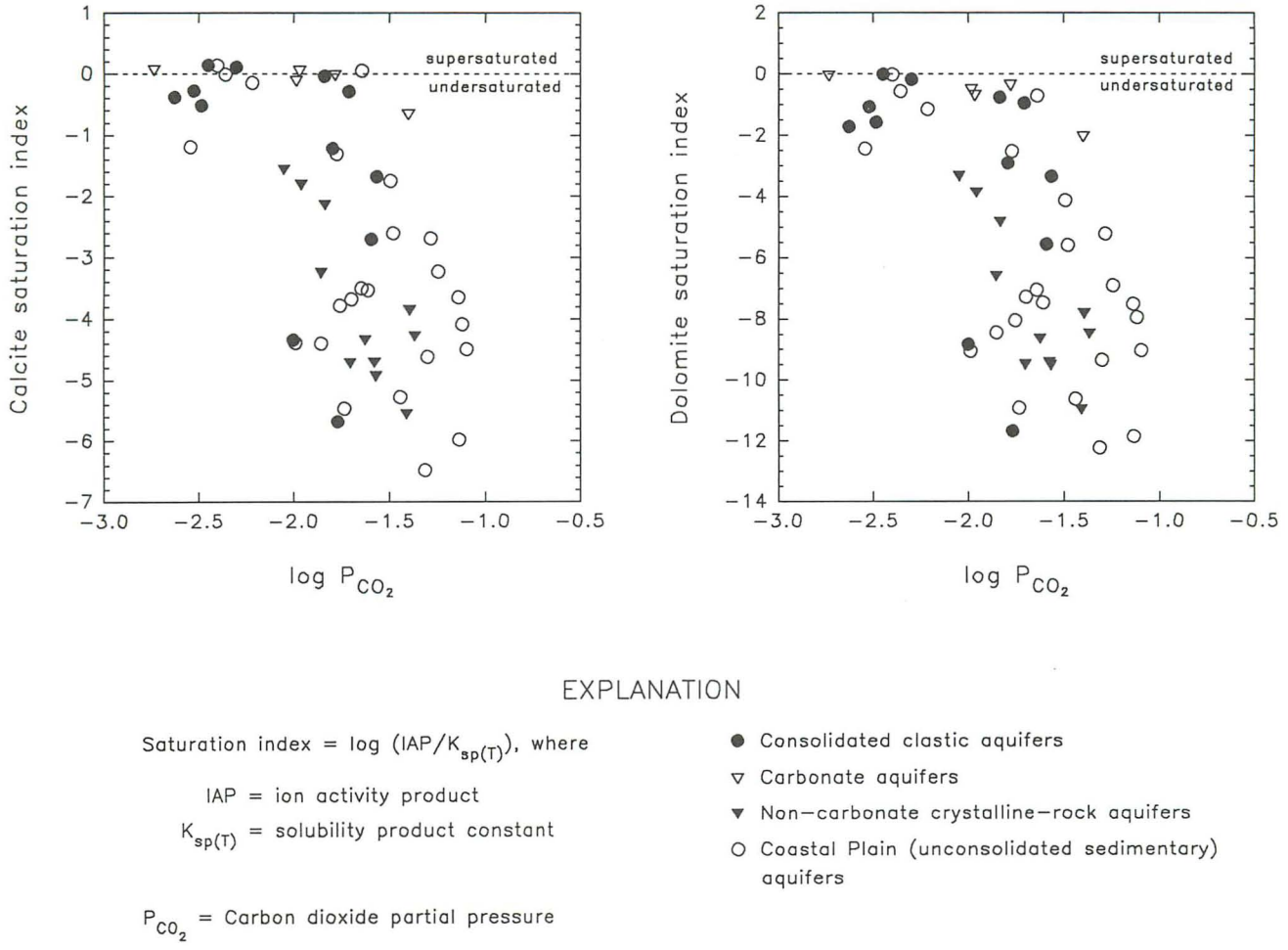


Figure 16.—Relationship between P_{CO2} and calcite and dolomite saturation indices.

flow path, resulting in lower pH compared to samples without carbon dioxide replenishment. The higher pH in ground water without carbon dioxide replenishment results in an increase in the proportion of carbonate ions, which brings the waters closer to saturation with respect to calcite and dolomite. Thus, deeper water wells in carbonate aquifers may have lower hardness values than shallow wells, yet both may be at or near saturation with respect to the carbonate minerals.

Median nitrate concentrations from the Piedmont and Blue Ridge sites ranged from 0.15 mg/L to 11 mg/L (overall median: 3.3 mg/L). Samples from two sites (both located in agricultural areas) exceeded 10 mg/L. Nitrate concentrations in two network wells (CL Ae 1 and HA Ca 23) showed slight increases between 1974-75 to 1990-92, while one spring (FR Fb 12) showed a slight decrease from 1983 to 1989. Ammonia was not a significant constituent in samples from these sites, probably because the aquifers were well-oxygenated. Median chloride concentrations ranged from 1.8 mg/L to 82 mg/L (overall median: 8.5 mg/L). Median chloride concentrations at 4 springs and 2 wells exceeded 10 mg/L. Samples from several sites (CE Cc 40; CL Ae 1; FR Dd 178) showed increases in chloride concentrations relative to pre-1987 samples.

Trace-element concentrations from the Piedmont and Blue Ridge sites were generally low. Median iron concentrations ranged from <3 µg/L to 30 µg/L (overall median: 12 µg/L); median manganese concentrations ranged from <1 µg/L to 12 µg/L (overall median: 4 µg/L). Iron and manganese concentrations are low probably because these elements are relatively insoluble under the oxidizing conditions found in aquifers in the Piedmont and Blue Ridge. Median barium concentrations ranged from <2 µg/L to 120 µg/L (overall median: 29 µg/L). The concentrations of most other detected trace elements were <10 µg/L.

Four sites (three wells and one spring) were sampled several times between September, 1988 and October, 1989 for major ions, nutrients and other constituents. Samples were collected from well HO Cd 78 during a separate study of the effect of agricultural practices on ground-water quality. There was little change in the concentrations of the major ions and field parameters in these seasonal samples. Well HO Cd 78, a

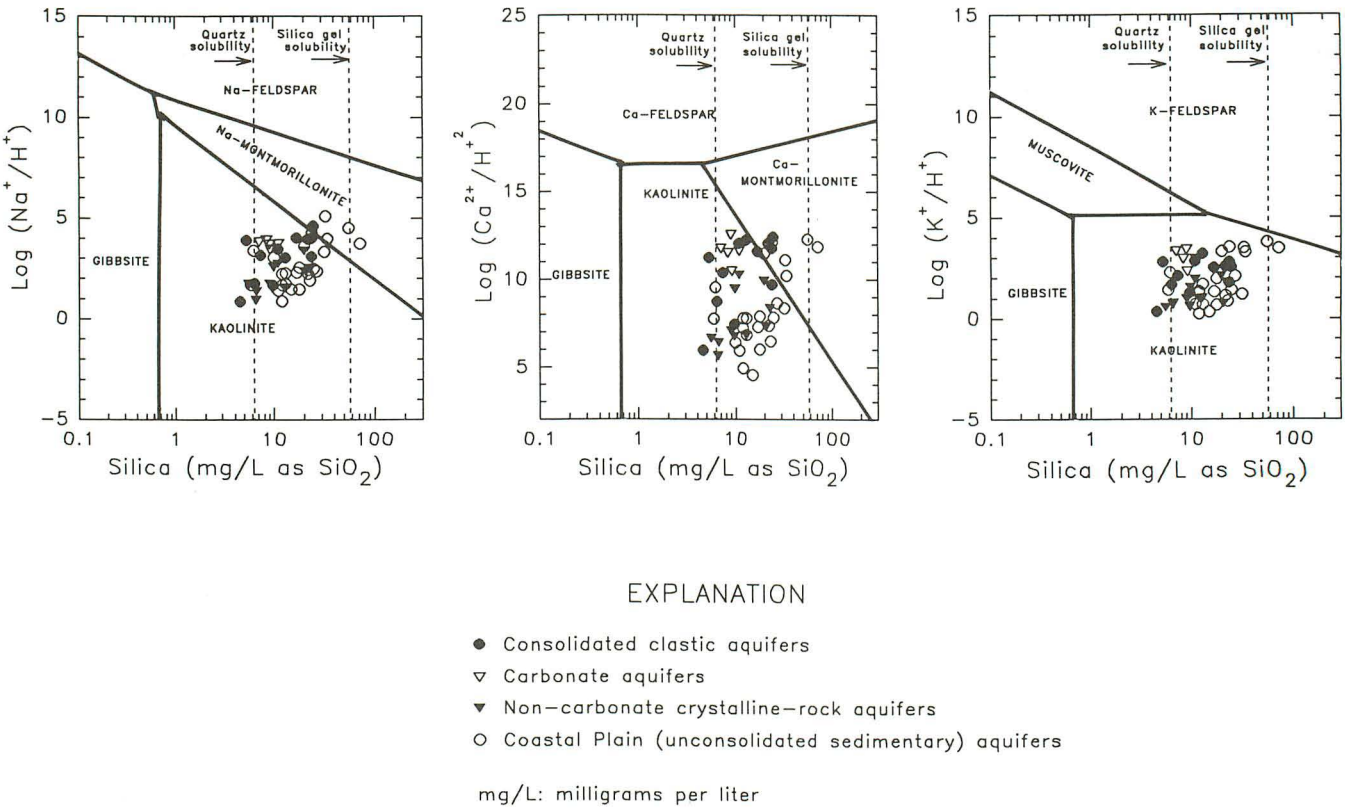


Figure 17.—Relationship between network water-quality data and stable phases of silicate minerals (modified from Freeze and Cherry, 1979).

shallow well completed in saprolite, had the lowest specific conductance and pH of any of these sites, and showed the largest relative change during the year. These low values are probably attributable to the well's shallow depth, which suggests short residence time of the ground water. Variation in chloride concentration in these sites was no more than 1 mg/L at any site during the sample period; no consistent temporal trend in chloride concentration between the sites was observed. Variation in nitrate concentrations were all <3 mg/L; the highest nitrate concentrations at CL Bf 184 and HA Ca 23, which are both located in agricultural areas, were recorded in late winter and spring. Well BA Dc 444, located in Oregon Ridge State Park, had the lowest and least variable nitrate values of all the seasonally sampled wells in the segment.

Segment III: Western Shore Coastal Plain

Ten wells were sampled in the Western Shore Coastal Plain. Nine wells are completed in unconfined or semiconfined aquifers; one (CH Cb 7) is completed in a confined aquifer. Aquifer data and major-ion types are given in table 7 and are illustrated in figures 20 and 21. Water-quality data are presented in Tables A13-A18.

Major-ion chemistry was variable among sites in the Western Shore Coastal Plain. Samples tended to be enriched in sodium and calcium relative to magnesium; iron was the major cation at one site. Anion composition was also variable: bicarbonate was the major anion at four of the sites, and chloride or sulfate was the major anion at the other sites. Sodium and chloride were the dominant cation and anion in two wells (PG Bc 37 and HA Dd 92). Overall median TDS (201 mg/L) was the highest of the four segments. Median pH values ranged from 5.0 to 7.6 (overall median: 6.1). All but one site had soft or moderately hard water (median hardness: 77 mg/L as $CaCO_3$). Samples from CA Fc 13, which is completed in an aquifer containing calcareous bivalve shells, were very hard and were saturated with respect to calcite; all other wells were undersaturated with respect to calcite. Most sites plot in the kaolinite stability field.

Well CH Cb 7, which is completed in a confined aquifer of the Potomac Group, had a sodium-bicarbonate water-quality type. The well is located on the Indian Head Peninsula in Charles County, where long-term high-volume ground-water withdrawals from Potomac Group aquifers have created a cone of depression in the regional potentiometric surface. This has caused brackish water from the nearby Potomac River to enter the aquifer, resulting in increased sodium, chloride, dissolved solids, and total-organic carbon concentrations in several wells relative to background concentrations of these constituents in

Table 6.—Site characteristics, major-ion types, and upgradient land use for network wells and springs in the Piedmont and Blue Ridge physiographic provinces.

[Land-use categories: 1, residential; 2, commercial; 3, institutional; 4, cropland; 5, pasture/grassland; 6, forest. See table 9 and text for additional comments.]

Site	Physiographic province	Geologic unit	Major lithology	Major ions*		Upgradient land use**
				Cations	Anions	
BA Dc 444	Piedmont	Cockeysville Marble	Metadolostone	Ca^{2+}, Mg^{2+}	HCO_3^-	6
CE Cc 40	Piedmont	James Run Fm.	Amphibolite, granofels	Mixed	Cl^-	6
CL Ae 1	Piedmont	Marburg Schist	Muscovite-chlorite-albite-quartz schist	Mixed	Cl^-	6
CL Bf 184	Piedmont	Prettyboy Schist	Albite-chlorite-muscovite-quartz schist	Ca^{2+}	HCO_3^-, NO_3^-	4
FR Af 27	Piedmont	Gettysburg Shale	Red shale, sandstone, siltstone	Ca^{2+}	HCO_3^-	1
FR Cd 38	Blue Ridge	Weverton Fm.	Quartzite, phyllite, conglomerate	Mixed	Mixed	6
FR Dd 178	Piedmont	Frederick Fm.	Limestone, dolomite	Ca^{2+}	HCO_3^-	3
FR Df 35	Piedmont	Urbana Fm.	Phyllite, metasiltstone, quartzite	Ca^{2+}	HCO_3^-	6
FR Fb 12	Blue Ridge	Granodiorite and Biotite Granite Gneiss	Granodiorite, biotite granite gneiss	Ca^{2+}	Mixed	1
HA Aa 9	Piedmont	Prettyboy Schist	Albite-muscovite-quartz schist	Mixed	NO_3^-, Cl^-	4
HA Bc 31	Piedmont	Wissahickon Boulder Gneiss	Biotite-muscovite-plagioclase quartz metagraywacke	Mixed	HCO_3^-	6
HA Ca 23	Piedmont	Loch Raven Schist	Biotite-muscovite-plagioclase-quartz schist	Mixed	NO_3^-	4
HO Cd 78	Piedmont	Saprolite developed on Loch Raven Schist	Loch Raven Schist: biotite-plagioclase-garnet-muscovite-quartz schist	Mixed	Mixed	4
MO Be 62	Piedmont	Ijamsville Fm.	Phyllite, slate	Mixed	Mixed	5
MO Db 68	Piedmont	New Oxford Conglomerate	Sandstone, siltstone, shale, conglomerate	Ca^{2+}	HCO_3^-	5

* Determined from milliequivalent percentages of individual samples
** Dominant upgradient land use within 1/4 mile of site

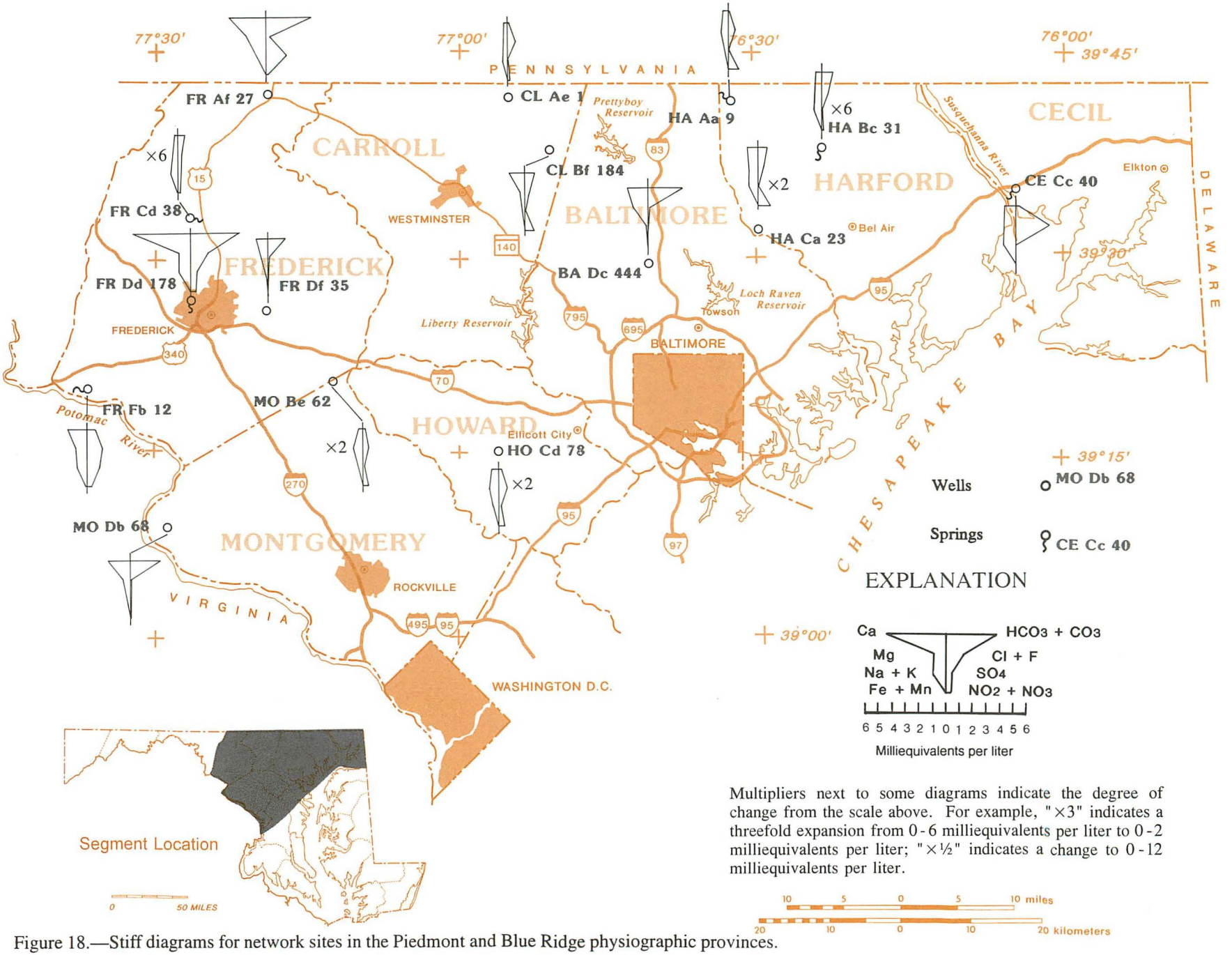
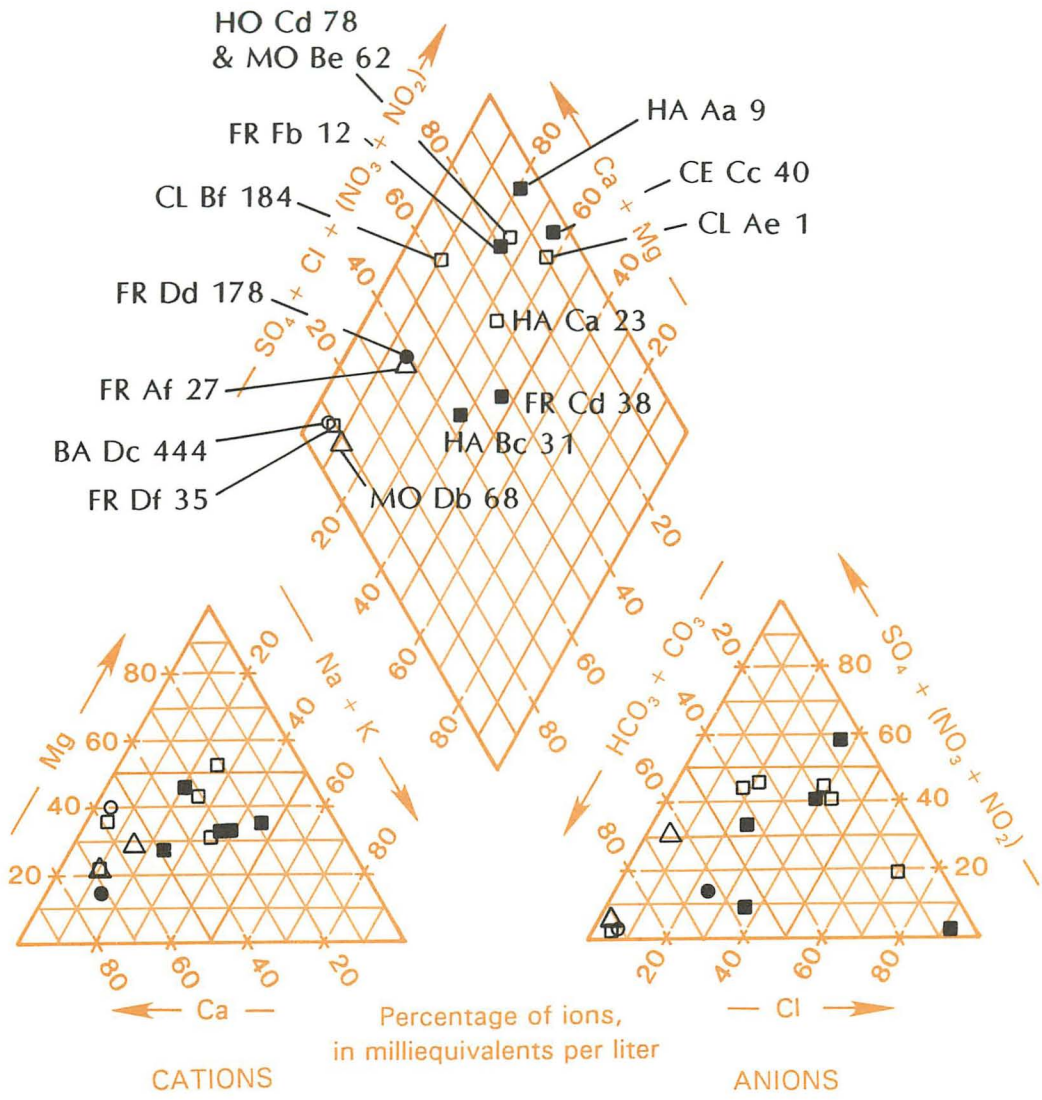


Figure 18.—Stiff diagrams for network sites in the Piedmont and Blue Ridge physiographic provinces.



EXPLANATION

CL Bf 184	Site number
△	Consolidated clastic aquifers
□	Non-carbonate crystalline-rock aquifers
○	Carbonate aquifers

Hollow symbols indicate wells
Solid symbols indicate springs

Figure 19.—Major-ion chemistry of network sites in the Piedmont and Blue Ridge physiographic provinces.

Table 7.—Site characteristics, major-ion types, and upgradient land use for network wells in the Western Shore Coastal Plain

[Land-use categories: 1, residential; 2, commercial; 3, institutional; 4, cropland; 5, pasture/grassland; 6, forest. See table 9 and text for additional comments.]

Site	Geologic unit	Major lithology	Major ions*		Upgradient land use**
			Cations	Anions	
AA Ad 104	Patapsco Fm.	Sand, silt, clay	Ca^{2+}, Na^{+}	Cl^{-}, HCO_3^{-}	2
AA Cg 25	Aquia Fm.	Glauconitic sand, calcareous sandstone	Fe^{2+}	HCO_3^{-}	6
AA Df 103	Aquia Fm.	Glauconitic sand, calcareous sandstone	Mixed	Cl^{-}	1
CA Fc 13	Chesapeake Group	Sand, silt, clay	Ca^{2+}	HCO_3^{-}	4
CH Cb 7	Potomac Group	Sand, silt, clay, gravel	Na^{+}	HCO_3^{-}	6
CH Ee 16	Maryland Point Fm.	Sand, clay	Ca^{2+}	HCO_3^{-}	6
CH Ee 90	Nanjemoy Fm.	Glauconitic sand, silty clay	Mixed	SO_4^{2-}	1
HA Dd 92	Talbot Fm.	Sand, gravelly sand, silt, clay	Na^{+}	Cl^{-}	1
PG Bc 37	Patuxent Fm.	Sand, gravel, silt, clay	Na^{+}	Cl^{-}	3
SM Ef 80	Omar Fm.	Clay, clayey sand	Ca^{2+}	SO_4^{2-}	4

* Determined from milliequivalent percentages of individual samples
** Dominant upgradient land use within 1/4 mile of site

the aquifer (Hiortdahl, 1990). CH Cb 7 does not yet show these effects; however, the well is very close to the mixing zone between river water and native ground water, and continued sampling will provide data on movement of the mixing zone.

Median nitrate concentrations ranged from <0.1 mg/L to 8.9 mg/L (overall median: 0.21 mg/L). Median nitrate concentrations exceeded 3 mg/L in three wells, all of which are located in agricultural areas. Ammonia was the dominant nitrogen species from sites with anoxic ground water (AA Ad 104; AA Cg 25; CH Cb 7; HA Dd 92). Median chloride concentrations ranged from 5.1 mg/L to 500 mg/L (overall median: 13 mg/L). Samples from sites in the Western Shore and Eastern Shore Coastal Plain had the same overall median chloride concentration (13 mg/L); both exceed the overall median chloride concentrations from sites in the Appalachian Plateau/Valley and Ridge and Piedmont/Blue Ridge physiographic provinces. Median chloride concentrations exceeded 50 mg/L at four of the ten wells. Well PG Bc 37, located less than 100 feet from State Route 193 in College Park, had the highest individual TDS of any network site (864 mg/L), most of which was due to sodium and chloride. Chloride concentrations increased at several sites during the study period.

Iron and manganese are common constituents of ground water in the Western Shore Coastal Plain. Sources of iron include pyrite, siderite, goethite, glauconite, and iron hydroxides (Glaser, 1971; Hansen, 1972b; Drummond and Blomquist, 1993). Median iron concentrations at network sites in this segment ranged from 3 µg/L to 15,000 µg/L; the overall median iron concentration (350 µg/L) was the highest of all four segments. Median manganese concentrations ranged from <1 µg/L to 890 µg/L (median concentration: 51 µg/L). Most of the high iron and manganese values were in anoxic samples from wells completed in unconfined aquifers; several of these wells have completion intervals close to the top of the water table in recharge areas, which suggests that oxygen depletion takes place relatively close to the surface.

Well AA Cg 25 had an iron-bicarbonate chemical character; the median iron concentration at this well (15,000 µg/L) was the highest of any network site. The well is completed in the Aquia Formation. Regionally, the Aquia is composed largely of calcareous sediments; however, in the area near the well, the Aquia contains abundant limonite (iron hydroxide) and is leached of carbonate to depths of seventy feet (Glaser, 1971), which may explain the low calcium concentrations in samples from the well. Well PG Bc 37 had high iron concentrations (median: 7,900 µg/L), and concentrations of aluminum, barium, cobalt, nickel, vanadium, and zinc were higher at this well than at other network sites. These occurrences are discussed in relation to the high sodium and chloride concen-

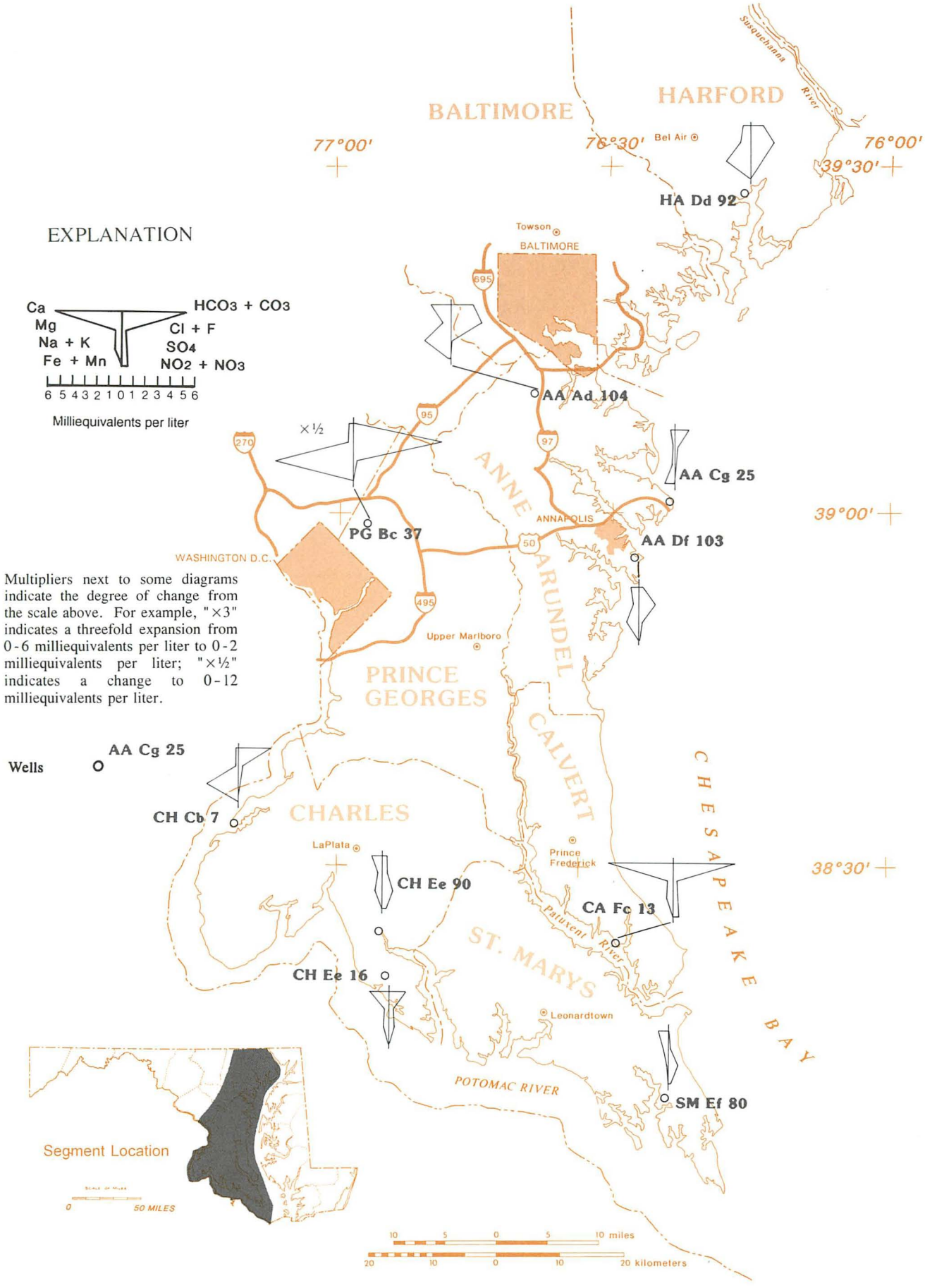
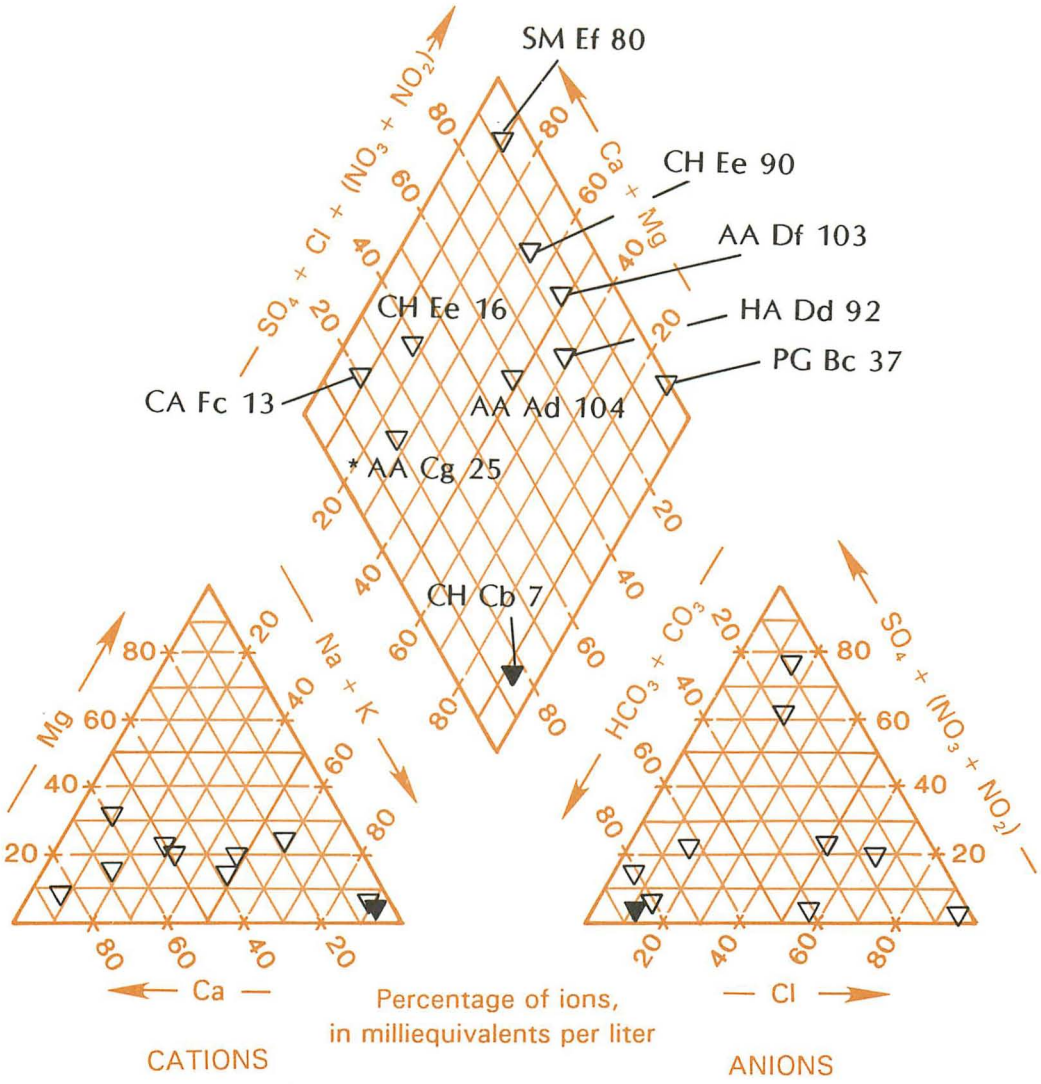


Figure 20.—Stiff diagrams for network sites in the Western Shore Coastal Plain.



EXPLANATION

AA Cg 25	Site number
▽	Unconfined aquifers
▼	Confined aquifers
*	Fe+Mn > 10% of cation percentage

Figure 21.—Major-ion chemistry of network sites in the Western Shore Coastal Plain.

trations in the well in another section of this report.

Samples from well CH Ee 16 consistently had the highest fluoride concentrations (1.0-1.6 mg/L) of all network sites, and also had higher total phosphorus levels than most other wells in the Western Shore Coastal Plain. One possible source of the high fluoride and phosphorus values is fluoroapatite ($Ca_5[PO_4]_3F$) in fossil shark teeth in the aquifer materials. The (upper Pleistocene) Maryland Point Formation, in which the well is completed, consists mainly of reworked sediments from the adjacent highlands, which in the vicinity of the well includes sediments of the fossil-rich (Miocene) Calvert Formation (McCartan, 1989). The well is interpreted as being close to the contact of the Maryland Point Formation and the underlying Calvert Formation, and it is possible that some of the ground water supplied to the well comes from the Calvert Formation. Samples from the well are supersaturated with respect to fluoroapatite, whereas samples from other sites in the Western Shore Coastal Plain are either undersaturated or less supersaturated with respect to fluoroapatite than CH Ee 16. Because the geochemistry of fluoride does not follow strict chemical equilibria (Hem, 1985), the significance of the saturation-index data is difficult to evaluate. Fluoride concentrations of 2 mg/L to 3 mg/L in Coastal Plain sediments of South Carolina have been attributed to fossil shark teeth, although calcium and bicarbonate concentrations were higher than in well CH Ee 16 (Zack, 1980). The Calvert Formation contains layers of phosphatic sand grains, pebbles, and thin phosphatic shells (McCartan, 1989) which may be the source of the phosphorus.

Six sites in the Western Shore Coastal Plain (AA Ad 104, AA Cg 25, AA Df 103, CA Fc 13, CH Ee 16, and HA Dd 92) were sampled several times between September, 1987 and January, 1989 for major ions, nutrients, and field parameters. Samples from well CA Fc 13 were collected more frequently during a separate study of the effects of agricultural practices on ground-water quality. Changes in seasonal major-ion concentrations were generally smaller than changes observed over the entire sample period (1987-1992). Two wells (AA Ad 104 and AA Df 103) showed relatively large variations in chloride concentration. The data show no consistent correlation between chloride concentration and time of year.

Very little seasonal variation in nitrate concentrations was observed. Nitrate measured at wells AA Ad 104, CH Ee 16, HA Dd 92, and AA Cg 25 were 0.3 mg/L or less; most of the nitrogen in three of these wells is in the form of ammonia (seasonal ammonia concentrations were not measured). The seasonal nitrate data from CA Fc 13 show no consistent relationship with water level, although additional nutrient data from this and other nearby wells indicate that nitrate levels tend to increase as ground-water levels rise and decrease when they fall (McFarland, 1989).

Segment IV: Eastern Shore Coastal Plain

Fourteen wells were sampled in the Eastern Shore Coastal Plain. Eleven wells are completed in unconfined or semiconfined aquifers; three are completed in confined aquifers. Aquifer data and major-ion types are given in table 8 and are illustrated in figures 22 and 23. Water-quality data are presented in Tables A19-A24.

Major-ion chemistry from Eastern Shore wells was variable. The shallow wells in unconfined aquifers tended to be enriched in nitrate and/or sulfate relative to bicarbonate, or had a mixed-anion composition; cation composition was variable. Most of these wells are completed in the Beaverdam or Pensauken Formations, which are composed predominantly of quartz and feldspars. The overall median TDS (136 mg/L) was slightly lower than that from Western Shore Coastal Plain wells. Overall median pH (5.8) and hardness (5.8 and 49 mg/L as $CaCO_3$) of Eastern Shore Coastal Plain wells were the lowest of all four network segments. The low pH's found in the surficial aquifer probably reflect the slow reaction rates of the aquifer minerals. The highest pH values were from two confined-aquifer wells and a well completed in a semiconfined aquifer in Ocean City. Median dissolved-oxygen concentrations ranged from zero to 9.8 mg/L (overall median: 4.0 mg/L). Most samples were oxygenated; wells completed in confined aquifers, located in poorly-drained areas, or with high iron concentrations typically had low dissolved-oxygen levels.

Three wells (CE Dd 102, QA Ea 78, and TA Ce 7) are completed in confined aquifers. Well CE Dd 102 is located in Cecil County, where the surficial aquifer is relatively thin. The well is relatively shallow (122 feet deep), and is completed in the Magothy Formation. TDS values are the lowest of any Eastern Shore network well. Although the aquifer is confined, dissolved-oxygen and nitrate concentrations as well as major-ion proportions are similar to samples from unconfined aquifers. These characteristics suggest that the confining units may be leaky, and that flow paths and travel times may not have been long enough to deplete dissolved-oxygen levels or allow extensive reactions with aquifer minerals.

Well TA Ce 7, located in the city of Easton, is completed in a confined sand in the (Miocene) Calvert Formation. The well is located near several municipal-supply wells that produce from the Calvert and several deeper aquifers (Mack, Webb, and Gardner, 1971). Seasonal pumpage causes the water levels to fluctuate about 20 feet in the well. The well was sampled to observe effects of pumpage on water quality in an urban area. Samples from the well indicate a calcium-bicarbonate water quality. Water-quality data suggest that the recharge area is not near the well; samples are characterized by low dissolved oxygen and chloride, high pH and TDS, and ammonia as the dominant nitrogen species. Furthermore, there was

Table 8.—Site characteristics, major-ion types, and upgradient land use for network wells in the Eastern Shore Coastal Plain

[Land-use categories: 1, residential; 2, commercial; 3, institutional; 4, cropland; 5, pasture/grassland; 6, forest. See table 9 and text for additional comments.]

Site	Geologic unit	Major lithology	Major ions*		Upgradient land use**
			Cations	Anions	
CO Dc 146	Pensauken Fm.†	Feldspathic sand	Mg^{2+}	Cl^-, NO_3^-	4
CO De 16	Beaverdam Fm.†	Feldspathic sand	Na^+	Cl^-	4
CE Dd 102	Magothy Fm.	Lignitic sand and clay	Na^+	Cl^-, NO_3^-	4
DO Cg 46	Beaverdam Fm.†	Sand, silty sand	Mixed	Cl^-, SO_4^{2-}	6
KE Be 47	Pensauken Fm.†	Feldspathic sand	Mixed	NO_3^-	4
QA Cg 1	Pensauken Fm.†	Feldspathic sand	Mixed	Mixed	1
QA Ea 78	Aquia Fm.	Glauconitic sand	Ca^{2+}	HCO_3^-	3
SO Ce 98	Beaverdam Fm.†	Sand, silty sand	Na^+	SO_4^{2-}	3
TA Ce 7	Calvert Fm.	Silt, clayey silt, quartz sand	Ca^{2+}	HCO_3^-	2
WI Cd 71	Beaverdam Fm.†	Feldspathic sand	Mixed	Cl^-, SO_4^{2-}	4
WI Ce 13	Pensauken Fm.†	Feldspathic sand	Ca^{2+}, Na^+	Mixed	1
WO Bf 87	Beaverdam Fm.†	Feldspathic quartz sand	Ca^{2+}, Mg^{2+}	Mixed	4
WO Bh 84	Beaverdam Fm.†	Feldspathic quartz sand	Mixed	HCO_3^-	2
WO Cc 3	Beaverdam Fm.†	Feldspathic quartz sand	Na^+	Mixed	6

* Determined from milliequivalent percentages of individual samples
** Dominant upgradient land use within 1/4 mile of site
† Part of the Columbia Aquifer

very little variation in water quality during the study period.

Well QA Ea 78, located on the western shore of Kent Island in Queen Annes County, is completed in the upper portion of the Aquia aquifer. The aquifer is confined, and subcrops beneath the Chesapeake Bay to the west (Drummond, 1988). The Aquia has been used as a water source for much of the residential and commercial development over the past several decades on Kent Island. This has lowered the potentiometric surface in the aquifer, causing brackish water from the Chesapeake Bay to enter some portions of the Aquia aquifer. Chloride concentrations in some Aquia wells on the western shore of Kent Island exceed 250 mg/L (Drummond, 1988). Brackish water has not yet affected QA Ea 78: samples plot in the calcium-bicarbonate field, and chloride concentrations are low (median concentration: 5.6 mg/L). The water level in the well is usually below sea level, however, and the well is being monitored to document any advances of the brackish-water/freshwater interface inland from the shoreline.

Well WO Bh 84, located adjacent to Isle of Wight Bay in Ocean City, is completed in the surficial (Pleistocene) aquifer. The surficial aquifer overlies two deeper confined aquifers (the Ocean City and Manokin aquifers) which are used for municipal water supplies in Ocean City. The well is being sampled to monitor for potential salt-water intrusion into the aquifer. Salty water has been reported in the surficial aquifer from two nearby areas; the salinity was attributed to sea water entering the Pleistocene deposits through discontinuous permeable material in the fine sediment above the aquifer (Weigle, 1974). Chloride concentrations from WO Bh 84 were not extremely high for a coastal setting (range: 36-45 mg/L), and have changed little since the well was drilled in 1973 (Phelan, 1987). However, the potentiometric surface of the Pleistocene aquifer is very close to sea level, and a cone of depression exists in the Ocean City/Manokin aquifer system due to pumping from the confined aquifers (Weigle, 1974).

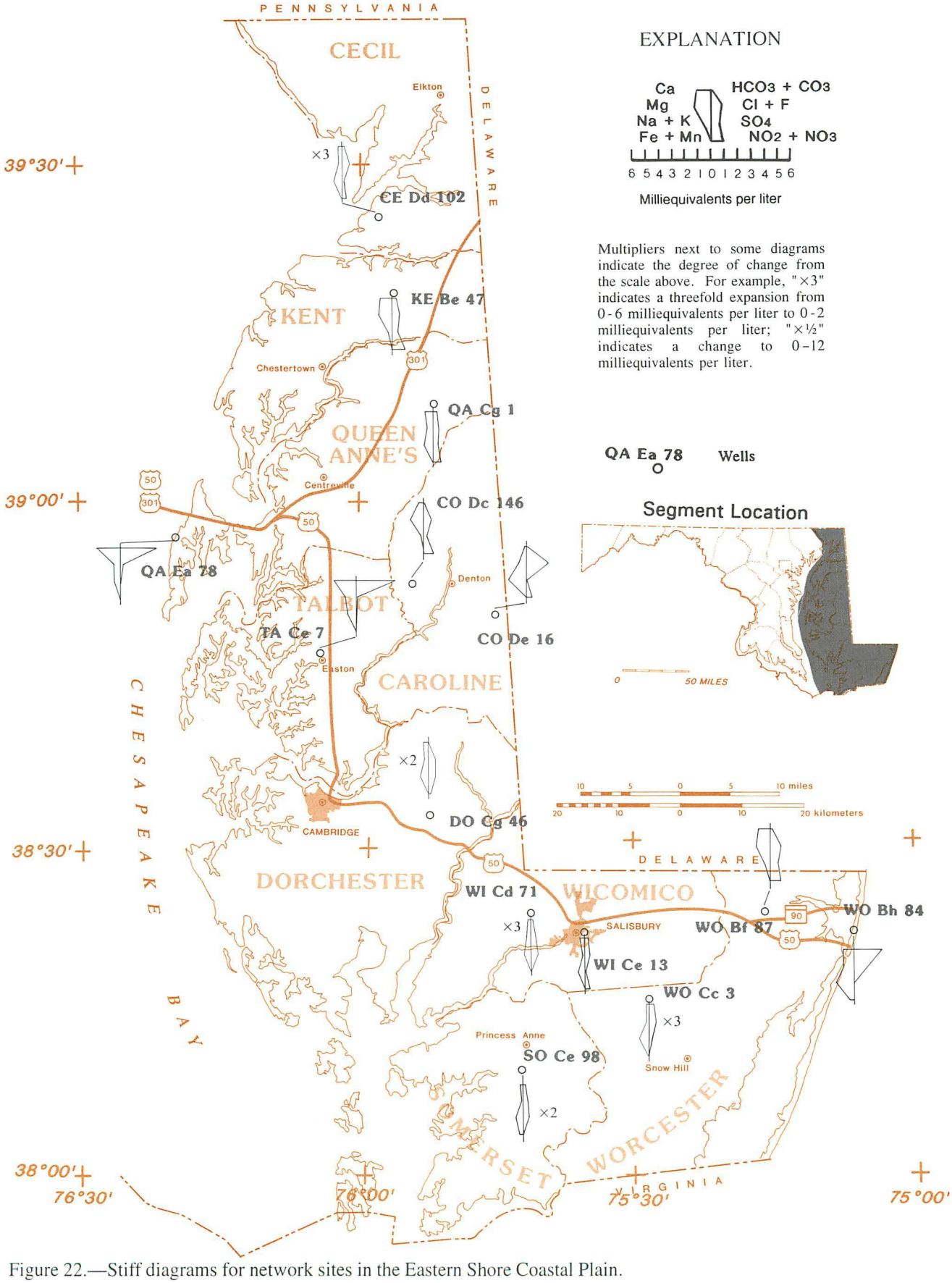
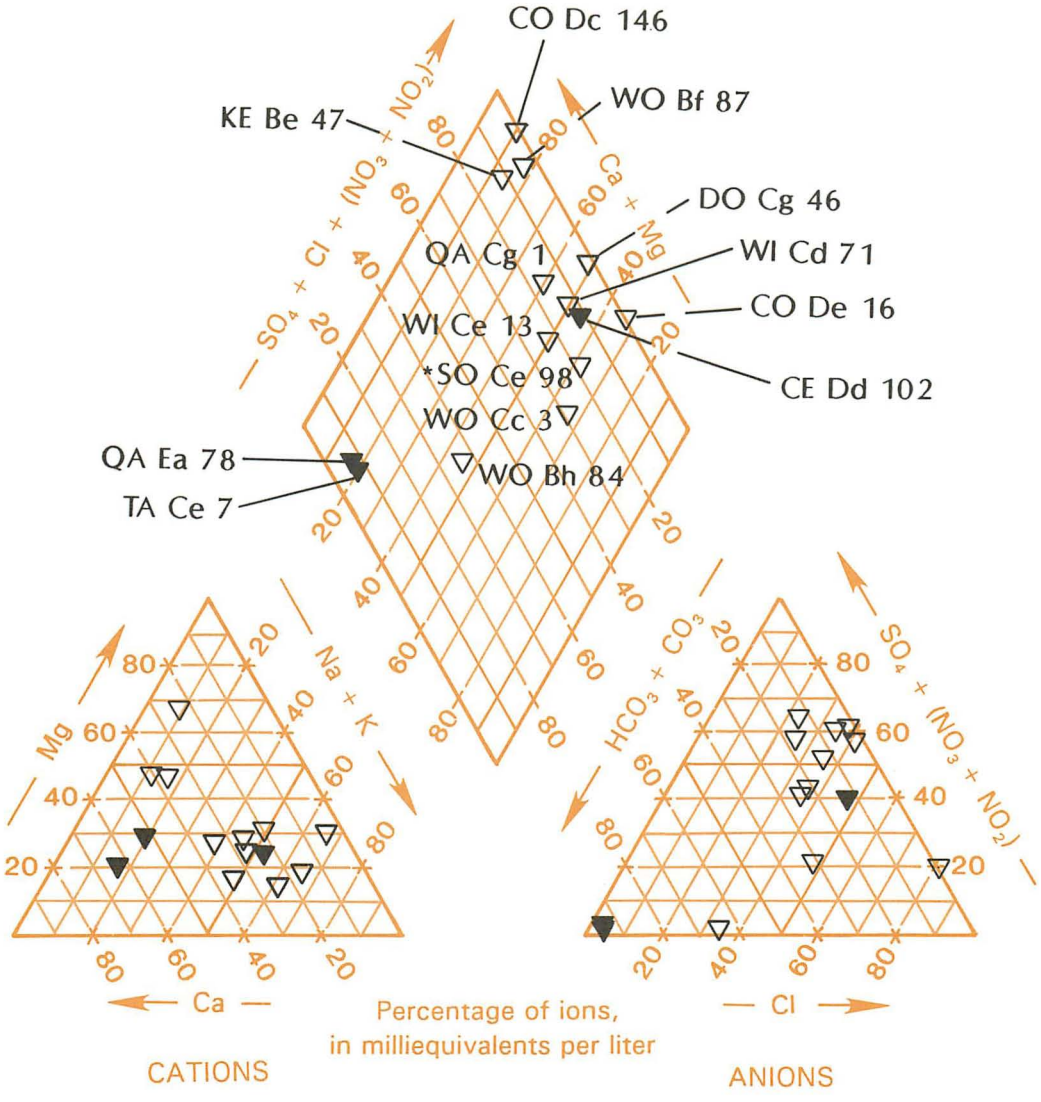


Figure 22.—Stiff diagrams for network sites in the Eastern Shore Coastal Plain.



EXPLANATION

WI Ce 13	Site number
▽	Unconfined aquifers
▼	Confined aquifers
*	Fe+Mn > 10% of cation percentage

Figure 23.—Major-ion chemistry of network sites in the Eastern Shore Coastal Plain.

Median nitrate concentrations for the Eastern Shore wells range from <0.10 mg/L to 14 mg/L (overall median: 1.7 mg/L). Samples from 12 of the 14 Eastern Shore wells had detectable levels of nitrate. Median nitrate concentrations at three sites, all in agricultural areas, exceeded 10 mg/L. Median chloride concentrations ranged from 4.4 mg/L to 86 mg/L. The overall median chloride concentration (13 mg/L) was the same as for the Western Shore Coastal Plain wells, and was higher than median chloride concentrations from either the Appalachian Plateau/Valley and Ridge or Piedmont/Blue Ridge segments.

Two wells in the Columbia aquifer (CO De 16 and KE Be 47) showed relatively large percent changes in sodium, calcium, magnesium, chloride, sulfate, nitrate, and other constituents between 1988 and 1992. These changes may be related to changes in agricultural practices during the study period, time of sample collection, depth to water, and other factors. Both wells are less than 25 feet deep, and are located within ten feet of cropland. Increases in major-ion concentrations have been correlated with agricultural practices such as lime and fertilizer applications in other areas of the Delmarva Peninsula (Denver, 1989).

Iron and manganese (overall median concentrations: 57 µg/L and 30 µg/L, respectively) were the major trace elements in samples from the Eastern Shore network sites. Median iron concentrations exceeded 300 µg/L in samples from five sites; median manganese concentrations exceeded 50 µg/L in samples from six sites. Most of these sites are completed in confined or semiconfined aquifers.

Four sites (QA Cg 1, TA Ce 7, WI Ce 13, WO Bh 84) were sampled at approximately 3-month intervals between May, 1990 and February, 1991 for major ions, nutrients, and field data. There was little overall change in major-ion chemistry or field parameters during that time. Well TA Ce 7, which is completed in a confined aquifer, had the most consistent specific conductance values. The other wells showed slightly more variation, but the variation was still low, and there was no consistent seasonal trend common to all the sites. Nitrate and ammonia concentrations varied little at most sites. Nitrate concentrations from well QA Cg 1, located in the town of Barclay in Queen Annes County, ranged from 8 mg/L to 12 mg/L, and also had 0.9 mg/L ammonia. Nitrate and ammonia concentrations in this well are discussed in the next section of this report.

Discussion of selected inorganic water-quality constituents

Several of the inorganic constituents analyzed in this study have adverse health effects at high concentrations. Nitrate and radon concentrations from several network sites exceeded the U.S. EPA's proposed or final MCLs. Other analytes such as chloride and iron can impart unpleasant taste, odor, or other aesthetic characteristics to drinking water when present in high concentrations. These analytes are discussed in this section in relation to land use, site characteristics, and other factors.

Nitrate

High nitrate concentrations in drinking water may cause methemoglobinemia ("blue baby" syndrome) in infants. This condition is characterized by a reduced ability of the blood to transport oxygen, and can lead to severe oxygen deficiency and even death (U.S. Environmental Protection Agency, 1990a). Other adverse health effects have been associated with nitrate ingestion from drinking water; however, data from laboratory studies have been inadequate to determine if nitrate can increase the risk of cancer in humans (U.S. Environmental Protection Agency, 1990a). Nitrogen is also the limiting nutrient in many aquatic environments, and excess nitrogen in surface waters can lead to algal growth and eutrophication (Manahan, 1991). For these reasons, the occurrence of nitrate and other nitrogen species has been studied extensively at local, state, and federal levels. The U.S. EPA has established an MCL of 10 mg/L for nitrate-plus-nitrite (as nitrogen) in public water supplies (U.S. Environmental Protection Agency, 1992).

Nitrate in ground water is derived from both natural and anthropogenic sources. Decomposition of naturally-occurring organic material releases nitrogen, but this is generally a small contribution to nitrate concentrations in ground water. Sources of anthropogenic nitrate include atmospheric deposition, fertilizers (such as manure, ammonium sulfate, urea), septic tank effluent, sewage sludge, and animal wastes (from feedlots, dairies, and poultry farms). Agriculture is the most extensive source of nitrate in ground water (Hallberg and Keeney, 1993). The availability of nitrogen sources and regional environmental factors are associated with nitrate concentrations in ground water in the United States (Spalding and Exner, 1993). The sources, distribution, and variability of nitrate in ground water are reviewed by Hallberg and Keeney (1993) and Keeney (1986).

Nitrogen is in the form of the ammonium ion (NH_4^+) in many anthropogenic sources of nitrate contamination. Nitrate is the stable form of nitrogen in oxygenated ground-water systems, however, and ammonium is microbially oxidized to nitrite (NO_2^-) and then to nitrate (NO_3^-). This process, called nitrification, is responsible for almost all of the nitrate entering the biosphere (Hallberg and Keeney, 1993), and is represented by the general reactions:

$$2NH_4^+ + 3O_2 \rightarrow 2NO_2^- + 2H_2O + 4H^+ + \text{energy}$$

$$2NO_2^- + O_2 \rightarrow 2NO_3^- + \text{energy (Denver, 1986)}$$

In oxygen-deficient environments, bacteria may use the oxygen in nitrate to oxidize organic carbon to carbon dioxide:

$$2.5C_{organic} + 2NO_3^- + 2H^+ \rightleftharpoons N_2 + 2.5CO_2 + H_2O$$
(Drever, 1982)

This denitrification process releases nitrogen gas. Nitrate reduction may also occur by chemical oxidation of reduced minerals such as pyrite (Postma and others, 1991).

The distribution of median nitrate concentrations from network sites is shown in Appendix D. Median nitrate concentrations at 16 sites (about 31%) were <0.1 mg/L. Eight sites (about 15%) exceeded 10 mg/L. Approximately 37% of the sites had median nitrate concentrations exceeding 3 mg/L.

The upgradient land-use category was determined for each site by identifying the major land use within a 1/4-mile radius of each site that was estimated to be upgradient (based on surface topography). Land use was determined from county land-use maps (Maryland Office of Planning, 1991), field inspection, and aerial photography. Because of the large number of land-use categories and the relatively small number of network sites, land uses were combined into six broad categories (tab. 9). Most land-use categories had less than 10 sites.

There are several problems in relating these data to land use. The network sites do not represent a true random sample, and include wells in unconfined and confined aquifers, in addition to springs. Many sites were downgradient from areas of multiple land uses. Furthermore, the 1/4-mile radius is arbitrary; the contributing area for many of the sites, especially the wells completed in confined aquifers, is probably outside the 1/4-mile radius. Therefore, observations on the relationship between land use and network water quality are strictly qualitative. Problems inherent in relating water quality to land use are discussed by Barringer and others (1990).

Nitrate concentrations from network sites are plotted with respect to their corresponding upgradient land-use category in figure 24. Land-use categories with the largest numbers of sites were forest (n=19) and cropland (n=16); overall median nitrate values for these categories were 0.11 and 9 mg/L, respectively. The highest nitrate concentrations were from wells and springs downgradient from cropland: nitrate exceeded 3 mg/L at 13 of 16 sites. The low nitrate concentrations in the 3 sites downgradient from cropland may reflect problems of land-use classification; for example, although the overall land use upgradient of well WI Cd 71 was cropland, most of the land within several hundred feet of the well is forest. Well CE Dd 102 (median nitrate: 1.9 mg/L) is completed in the (confined) Magothy Formation, and the recharge area is probably outside the 1/4-mile land-use radius. The maximum nitrate concentration for sites downgradient from forest was 1.8 mg/L.

Median nitrate concentrations are plotted against depth to the top of the open interval in figure 25. For Coastal Plain wells, the top of the open interval was defined as the top of the screened interval; for wells in the Piedmont, Blue Ridge, Valley and Ridge, and Appalachian Plateau (open-hole completions), the top of the open interval was defined as the depth of casing. Nitrate varied greatly among springs and wells with open intervals less than 50 feet below land surface. Concentrations tended to be lower in wells with deeper completion intervals; most of these wells are completed in confined aquifers or in anoxic zones of unconfined aquifers. There was no

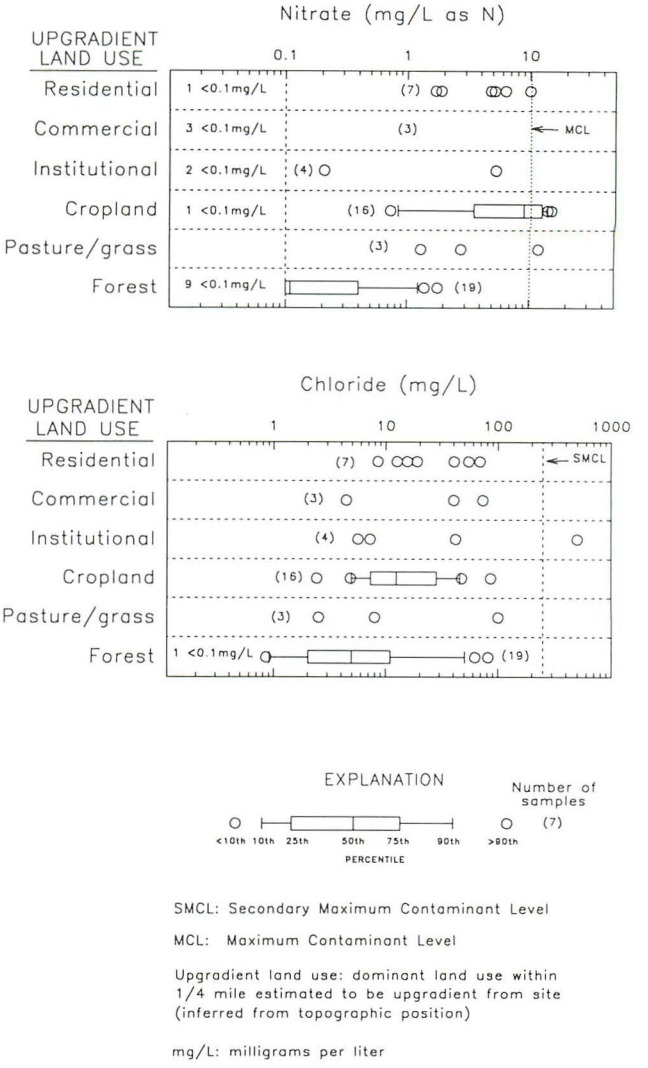


Figure 24.—Relationship between median nitrate and chloride concentrations and upgradient land use.

consistent relationship between nitrate concentration and well depth at network sites. Although nitrate concentrations tend to decrease with well depth on a national scale (Spalding and Exner, 1993), this is not always true in regional investigations. Nitrate concentrations in the surficial aquifer in the Delmarva Peninsula were not significantly higher in the shallower part of the aquifer than in the deeper part (Hamilton and others, 1993). High nitrate concentrations in the deeper part of the aquifer were attributed to deep flow paths in the aquifer and aerobic conditions throughout the aquifer. In the Piedmont, most of the ground water is stored in the saprolite; wells are typically cased through the saprolite and are set slightly below the top of bedrock, and most water enters the well through the fractures in the bedrock which receive recharge water from

Table 9.—Land-use categories used in network site characterizations (modified from Maryland Office of Planning, 1991).

Maryland Office of Planning		Number of network sites in category	Land-use category used in this report
Classification	Definition		
Low-density residential	Residential areas, 0.2 dwelling units to 2 dwelling units per acre	5	Residential
Medium-density residential	Residential areas, 2 dwelling units to 8 dwelling units per acre	2	
High-density residential	Residential areas with more than 8 dwelling units per acre	0	
Commercial/Industrial	Retail and wholesale service	3	Commercial
Institutional/open	Educational facilities, military installations, churches, government facilities	4	Institutional
Bare ground	Areas of exposed ground caused by construction or other cultural processes	0	--
Agricultural	Cropland	16	Cropland
	Pasture, grassland	3	Pasture/Grassland
	Orchards, vineyards	0	--
	Row and garden crops	0	
	Feeding operations	0	
	Agricultural buildings, training facilities, storage facilities	0	
Forest	Deciduous forest	15	Forest
	Mixed deciduous and evergreen forest	4	
	Evergreen forest	0	--
	Brush, cut-over timber stands, abandoned fields and pasture	0	
Extractive/barren	Surface mining activities	0	--
	Beaches	0	
	Bare exposed rock	0	
Wetlands	Forest or non-forested wetlands, including tidal flats, tidal and non-tidal marshes, upland swamps, and wet areas	0	--
Water	Rivers, waterways, reservoirs, ponds, bays, estuaries, and ocean	0	--

the overlying saprolite. Thus, there is little relationship between nitrate concentration and well depth or depth to top of the open interval in wells in the Piedmont.

Ammonia concentrations exceeded nitrate concentrations at several sites. Most wells with ammonia concentrations >0.1 mg/L had no detectable nitrate; conversely, most wells with detectable nitrate (>0.1 mg/L) had little or no detectable ammonia (figure 26). Samples from wells CH Cb 7 and QA Ea 78, which are both completed in confined aquifers, were anoxic, and it is reasonable to assume that any nitrate that may have been present in the recharging waters has been reduced. Many sites in unconfined aquifers with >0.1 mg/L ammonia also had low dissolved oxygen and high iron concentrations. Samples from carbonate and crystalline-rock aquifers had little or no detectable ammonia, which reflects the oxic conditions in these aquifers. Most samples with no detectable nitrate were anoxic, while oxic samples had a wide range of nitrate (fig. 27).

Well QA Cg 1 had relatively high concentrations of both ammonia and nitrate. The well, completed in the surficial aquifer on the Eastern Shore, is located in a residential area with a shallow (less than six feet below land surface) water table. Most of the houses have on-site septic systems, most of which are below the water table in the winter and spring (J. Nickerson, Queen Annes County Health Department, oral comm., 1996). Household wastewater is enriched in ammonia relative to nitrate (Siegrist, Witt, and Boyle, 1976; Robertson, Cherry, and Sudicky, 1991). The high nitrate and ammonia concentrations in the well are attributed to incomplete nitrification of the septic effluent. The low nitrite concentrations in the well are probably due to the rapid conversion of nitrite to nitrate. Most other network sites are several hundred feet from the nearest septic systems, and the impact of septic effluent on overall network water quality is believed to be minimal. Elsewhere, septic-system effluent has been associated with increased ground-water concentrations of chloride, sodium, calcium, sulfate, and alkalinity, and decreased pH and dissolved oxygen, although all these changes are not seen in all septic-effluent studies (Robertson, Cherry, and Sudicky, 1991; Hamilton and others, 1993).

Well AA Ad 104 had the highest ammonia (2.3 mg/L) and total organic carbon (TOC) (1.5-16 mg/L as C) concentrations of any network site; samples were anoxic (dissolved oxygen: 0.1-0.2 mg/L) and acidic (pH: 5.9-6.4). The well is completed

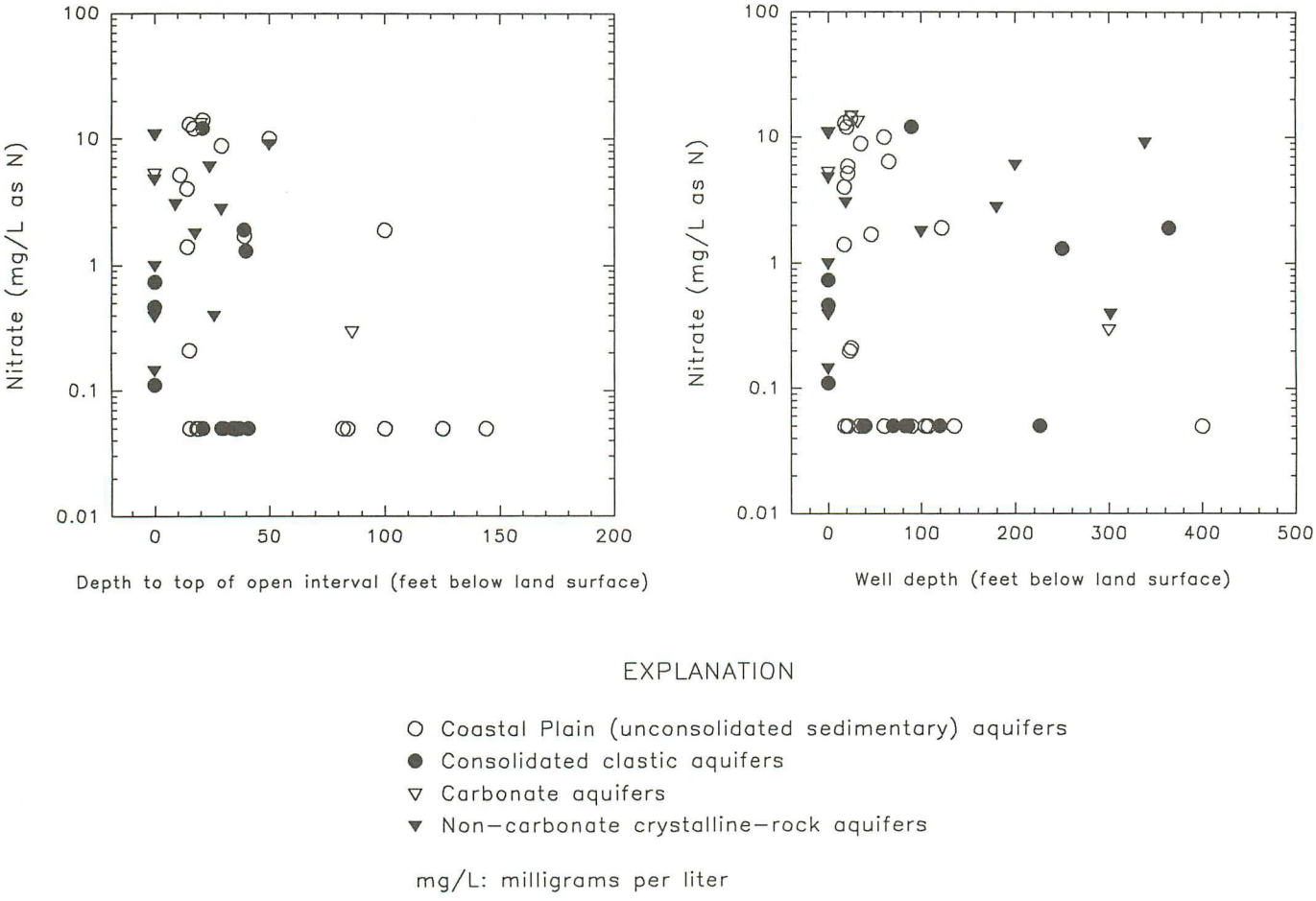


Figure 25.—Relationship between median nitrate concentrations and depth to top of open interval and well depth. Nitrate concentrations from springs are plotted at zero depth in both graphs. All non-detects are plotted as 0.05 mg/L.

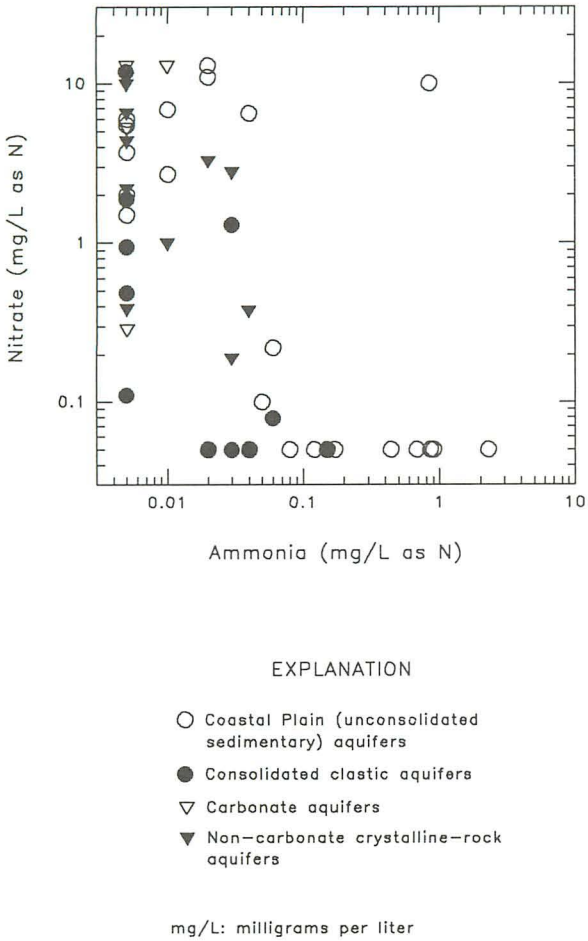


Figure 26.—Relationship between nitrate and ammonia concentrations. Nitrate and ammonia non-detects are plotted at 0.05 mg/L and 0.005 mg/L, respectively.

in the unconfined Patapsco aquifer, and is located on the eastern edge of the Baltimore-Washington International (BWI) Airport. One possible source of the high TOC may be drainage from deicing chemicals used at the airport. Ethylene and propylene glycol have been used as deicing agents at the airport (J. Brooks, BWI Airport, oral comm., 1996); microbial degradation of these compounds would decrease dissolved oxygen and pH (if the system was not buffered). Under these conditions, nitrate might be reduced to nitrogen gas or ammonia. The high TOC levels could be accounted for by incomplete degradation of the parent compounds. No volatile organics were detected in well samples; however, the samples were not analyzed for ethylene and propylene glycol during this study. The well is located next to State Route 162 (Aviation Boulevard). Calcium magnesium acetate, an organic deicing chemical that has been shown to cause reduced oxygen levels in surface water (Horner, 1988) could conceivably cause increased TOC, low dissolved oxygen, and low pH. However, State Route 162 has not been treated with this chemical (W. Dade, Maryland State Highway Administration, oral comm., 1996).

Chloride

Chloride concentrations greater than about 250 mg/L give drinking water a salty taste. Sources of chloride in ground water include atmospheric deposition, road salt, brackish-water intrusion, fertilizers (potassium chloride), and human and animal wastes. Because atmospheric concentrations of chloride are low (tab. 1), and there are no near-surface naturally-occurring salt deposits in Maryland, high chloride levels in shallow ground water usually indicate the effects of land-based human activity. Chloride is a relatively conservative ion; it does not enter into oxidation-reduction reactions, does not form complexes under most ground-water conditions, is not sorbed onto mineral surfaces, and is not involved in many significant biochemical reactions (Hem, 1985). As a result, chloride is

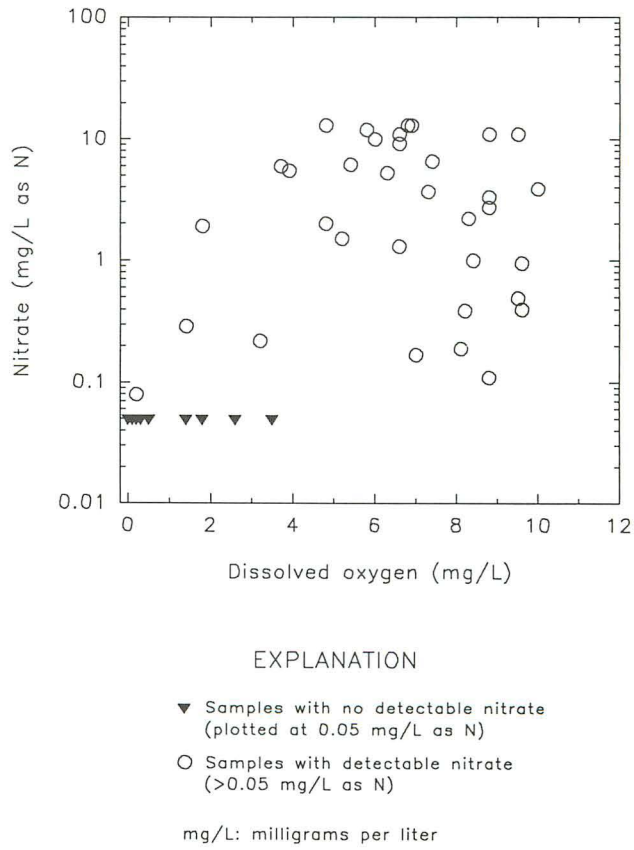


Figure 27.—Relationship between nitrate and dissolved oxygen concentrations.

affected little by chemical reactions once it enters ground water, and can be indicative of land use.

Road salt can have a major impact on ground-water quality (Davis, 1982; August and Graupensperger, 1989). In Maryland, state-maintained roads are treated with sodium chloride, calcium chloride, or magnesium chloride, depending upon the air temperature (C. Brown, Maryland State Highway Administration, oral comm., 1996). Historically, sodium chloride has been used most widely. Adverse effects of sodium chloride as a deicing agent include damage to roadside vegetation, soil compaction due to ion exchange, contamination of surface and ground water supplies, and damage to concrete and metal structures (Horner, 1988). Calcium magnesium acetate has been promoted recently as a more environmentally benign alternative to traditional deicing salts; however, it is more expensive than inorganic deicing salts.

Chloride concentrations from network sites are plotted against distance from the nearest paved road in figure 28. Confined aquifers and sites upgradient from roads had <20 mg/L chloride. Most sites with >20 mg/L chloride are less than 100 feet from roads. Several sites less than 100 feet from roads had low chloride; many of these are in confined aquifers, or are adjacent to local roads that probably receive little salt application. Well PG Bc 37, which had the highest chloride value of any network site, is adjacent to State Route 193 in College Park. This well also had high concentrations of iron and manganese, which is possibly related to the high sodium and chloride levels; this is discussed in the next section of this report. Chloride concentrations at sites downgradient from agricultural areas (fig. 24) may be showing the effects of application of animal wastes and fertilizers such as potassium chloride. Springs and wells less than 100 feet deep tended to have a wide range of chloride concentrations; lower concentrations were seen in deeper wells and wells with open intervals more than 60 feet below land surface. Most of the deep wells are in confined aquifers or are not located near likely chloride sources (fig. 29).

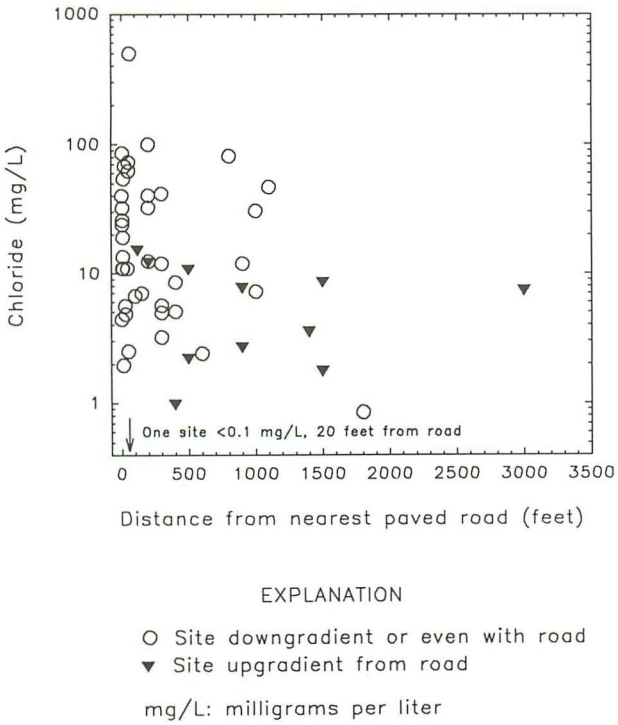


Figure 28.—Relationship between median chloride concentrations and distance to nearest paved road.

Iron

Iron is a significant component of ground water in many areas of Maryland (Overbeck, 1954; Otton, 1955; Slaughter, 1962; Hansen, 1972b). At concentrations above 100 µg/L, iron causes an unpleasant "irony" taste, and can cause staining of plumbing fixtures and laundry. Iron has two oxidation states, Fe^{2+} (ferrous or reduced form) and Fe^{3+} (ferric or oxidized form). The concentration and oxidation state of iron in ground water are affected by aquifer mineralogy, pH and oxidizing capacity of the water, microbiological activity, and other factors. Iron can form complex ions with other dissolved inorganic species, and can form stable complexes with organic material. A summary of the chemistry of iron in natural waters is presented in Hem (1985). Manganese is also an undesirable constituent of ground water in many areas of Maryland, and wells with high iron concentrations often have high manganese concentrations as well. At concentrations above 50 µg/L in water, manganese can deposit black oxide stains. The environmental chemistry of manganese is somewhat similar to iron. It has three oxidation states (Mn^{2+}, Mn^{3+}, and Mn^{4+}); in natural waters, however, it usually exists as the Mn^{2+} ion (Hem, 1985).

An "iron problem" experienced by many well owners in Maryland involves the presence of iron bacteria in well water. This is a common problem in wells in oxygenated ground-water environments. The bacteria derive energy from the oxidation of ferrous iron to ferric iron, the byproduct of which is a slimy, insoluble "mat" that can clog well screens and decrease well efficiency. Steel well casings are the source of much of this iron. The reaction provides relatively little energy per mole of Fe^{2+}, and large amounts of ferrous iron must be oxidized to meet the needs of the bacterial metabolic processes (Chapelle, 1993).

Most sites had <20 µg/L dissolved iron, although iron concentrations varied greatly among network sites. Most samples with iron concentrations >100 µg/L are anoxic (fig. 30). Iron concentrations from sites in crystalline-rock aquifers of the Piedmont and Blue Ridge provinces were low (fig. 14). Ground water in these aquifers is usually well-oxygenated because of the shallow depth of ground-water circulation; when the iron-bearing minerals are dissolved, the liberated iron is usually reprecipitated as ferric oxides and oxyhydroxides (Hem, 1985).

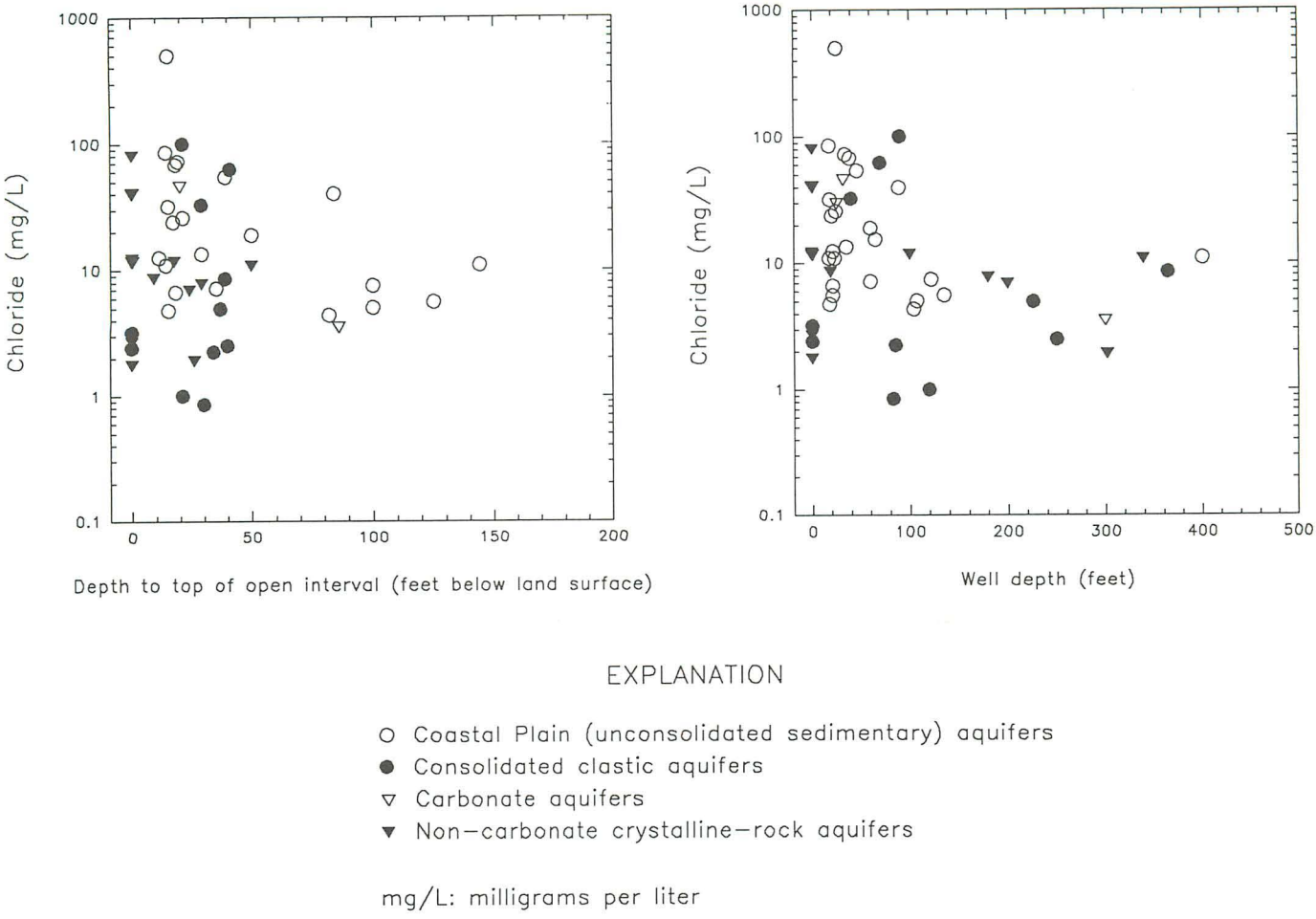


Figure 29.—Relationship of median chloride concentrations to depth to top of open interval and well depth. Chloride concentrations from springs are plotted at zero depth in both graphs.

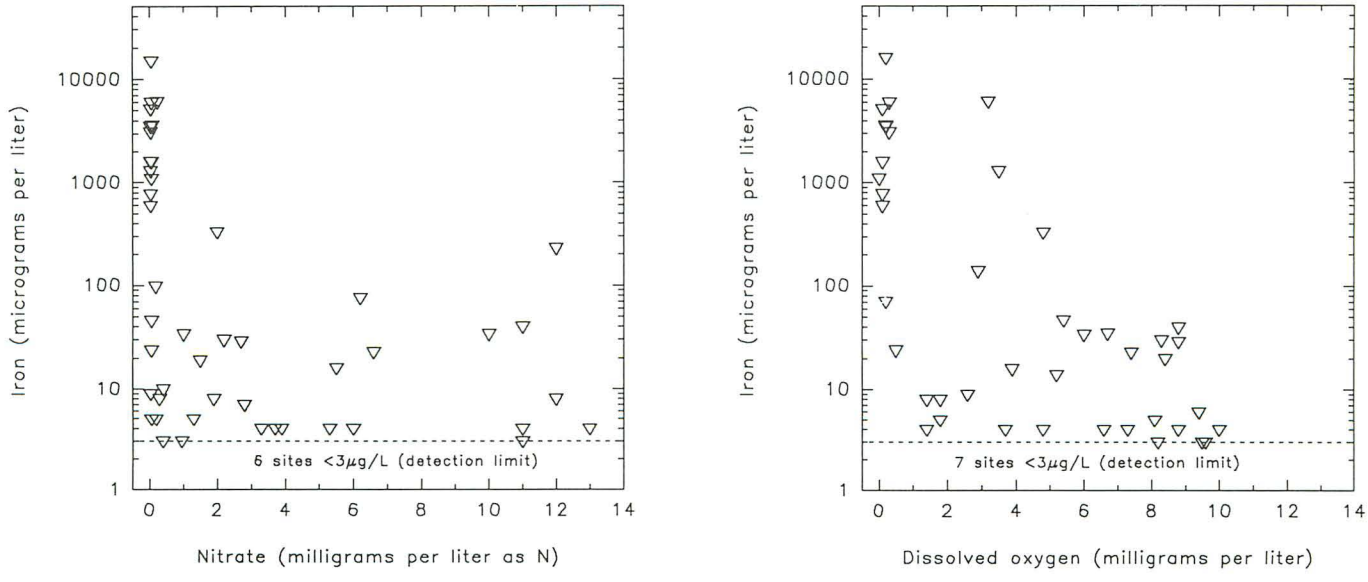


Figure 30.—Relationship of iron to nitrate and dissolved-oxygen concentrations. Sample-specific (not median) concentrations are plotted. Iron concentrations differ between graphs because dissolved oxygen was not measured in all samples.

Low iron concentrations in the carbonate aquifers are probably also due to oxic conditions and the lack of iron minerals. Iron concentrations varied among sites in the sedimentary aquifers of the Appalachian Plateau, Valley and Ridge, and Coastal Plain physiographic provinces. These aquifers commonly contain pyrite, siderite, hematite, ferric hydroxides, glauconite, and other iron-bearing minerals (Glaser, 1971; Hansen, 1972b). Oxygenated samples tended to have low iron concentrations.

Dissolved iron can occur in many different forms in ground water, and the concentration of each species in a sample can be determined in several ways. The most accurate method is to analyze for the individual species; when this is not feasible, alternate methods are used to evaluate speciation. Eh-pH (or pe-pH) diagrams can be constructed from thermodynamic data and specified solute concentrations that show the conditions for which the dissolved species and solid phases are stable (e.g., Garrels and Christ, 1965; Drever, 1982). These diagrams indicate, in theory, which dissolved and solid phases are stable under different conditions of Eh and pH. However, the field boundaries are very sensitive to the thermodynamic data and solute concentrations specified for their construction, and it is very difficult to use these diagrams to evaluate a group of analyses with widely ranging values of iron, bicarbonate, and sulfate. Iron speciation can also be estimated using geochemical speciation programs. Calculations performed on samples from the Maryland network using the computer code WATEQ4F suggest that most of the iron from anoxic samples is present as Fe^{2+} ion. For oxic samples, most of the iron is present as $Fe(OH)_2^+$ or $Fe(OH)_3$ (aqueous), both of which contain the oxidized (Fe^{3+}) form of iron. Iron concentrations from oxic samples are plotted against pH in figure 31. The lines represent equilibrium concentrations between $Fe(OH)_3$ (ferric hydroxide) and several of the major dissolved iron species. The data points scatter about the $Fe(OH)_3$ / $Fe(OH)_2^+$ boundary more than the equilibrium lines for the other dissolved oxic species, which supports the speciation calculated by WATEQ4F.

Four sites with oxygenated ground water had dissolved-iron concentrations >100 µg/L. This may be due to at least two factors. "Dissolved" iron was defined operationally in this study as the amount of iron passing a 0.45µ filter. Filter pore size and other factors have been shown to influence the concentrations of "dissolved" trace elements in water samples (Kennedy, Zellweger, and Jones, 1974; Taylor and Shiller, 1995; Horowitz and others, 1996). For example, colloidally-associated trace elements may pass through filters, and this additional iron would be included in the analysis for the "dissolved" amount. Alternately, some oxygen may have been introduced during sampling.

Samples from well PG Bc 37, screened in the Patuxent aquifer, had high iron and manganese concentrations (6,100-9,600 µg/L and 880-1,100 µg/L, respectively). Concentrations of aluminum, nickel, vanadium, cobalt, barium, and zinc were also elevated relative to other network sites. Samples were oxygenated, and appear to be greatly affected by road salt (270-300 mg/L sodium; 460-540 mg/L chloride). Iron hydroxide cements are reported in outcrop areas of the Patuxent aquifer (Glaser, 1971; Chapelle and Kean, 1985); however, oxygenated recharge water near the well would not support dissolved iron. The iron minerals also would not account for the relatively high levels of the other trace elements. The well is within 100 feet of State Route 193, a heavily-travelled road in College Park. Leaching experiments have suggested that roadside soils affected by sodium chloride from road salt may contribute trace metals to ground water via colloid-assisted transport (Amrhein, Strong, and Mosher, 1992; Amrheim, Mosher, and Strong, 1993). Trace-element concentrations in roadside soils have been shown to decrease with distance from roads

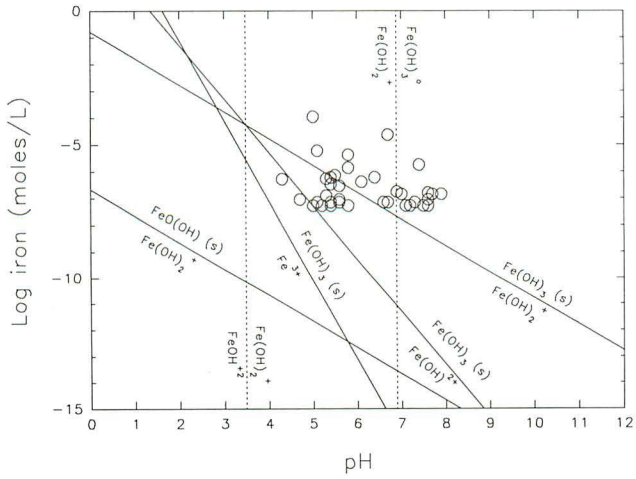


Figure 31.—Relationship of iron and pH to aqueous and solid phases of iron for oxic samples (modified from Chapelle and Kean, 1985).

and with depth below land surface, and have been related to traffic volume (Singer and Hanson, 1969; Lagerwerff and Specht, 1970). Road salt may have mobilized the iron, manganese, and other trace elements concentrations seen in the well samples, and the "dissolved" concentrations may be colloids that passed through the filter.

The relationship of iron to nitrate concentrations are shown in figure 30. Nitrate concentrations were greatest in samples with <100 µg/L iron, whereas nitrate concentrations were close to detection level for samples with iron concentrations >300 µg/L. In the absence of dissolved oxygen, nitrate may be reduced to nitrogen gas or ammonia to facilitate oxidation-reduction reactions (Drever, 1982).

Radon

Radon (^{222}Rn) is a colorless, odorless gas that has been linked to increased risk of lung cancer (National Research Council, 1988). The adverse effects of radon exposure were first noted with the increased incidence of lung cancer among underground uranium miners in the United States, Czechoslovakia, and Canada, and iron, zinc, and lead miners in Sweden (Nazaroff and Nero, 1988). Radon is formed from the radioactive decay of radium-226 (^{226}Ra) in the uranium-238 decay series (tab. 10). ^{222}Rn has a half-life of 3.8 days; two other radon isotopes (^{219}Rn and ^{220}Rn) are environmentally insignificant because their half-lives are <1 minute. In this report, the term "radon" refers to ^{222}Rn, and is reported in picocuries per liter (pCi/L), where 1 picocurie = 3.7×10^{-2} disintegrations per second. The proposed MCL of 300 pCi/L for radon (U.S. Environmental Protection Agency, 1992) has been the subject of debate (Stone, 1993).

Concern over the potential carcinogenic effects of radon gas and its daughter products has led to much research into the sources, distribution, and environmental behavior of radon. Most of the attention has focused on seepage of radon gas into homes from soils and bedrock that are enriched in radon precursors. However, ground-water radon concentrations are commonly several orders of magnitude higher than airborne radon concentrations, and radon in ground water may contribute significant amounts of airborne radon into homes as it escapes from the water. Several studies have been in general agreement with the commonly-cited estimate of 1 pCi/L in air per 10,000 pCi/L in water (Hess, Korsah, and Einloth, 1987; Prichard, 1987; Nazaroff and Nero, 1988). However, the relationship between airborne and ground-water radon concentrations in homes is complex, and is affected by residence volumes, air-exchange rates, water use, and other highly variable factors. Most of the risk associated with high radon levels in ground water appears to be due to inhalation of radon after it escapes from the water, rather than by direct ingestion (Nazaroff and Nero, 1988; Wanty and Nordstrom, 1993). The health effects and risks from radon in drinking water are reviewed in Cross, Harley, and Hofmann (1985).

Table 10.—^{238}U decay series (modified from Wanty and Schoen, 1991)

Radionuclide	Half-life
^{238}U	4.51×10^9 years
↓	
^{234}Th	24.1 days
↓	
^{234}Pa	1.17 minutes
↓	
^{234}U	2.47×10^5 years
↓	
^{230}Th	8.0×10^4 years
↓	
^{226}Ra	1,620 years
↓	
^{222}Rn	**3.82 days**
↓	
^{218}Po	3.05 minutes
↓	
^{214}Pb	26.8 minutes
↓	
^{214}Bi	19.7 minutes
↓	
^{214}Po	164 microseconds
↓	
^{210}Pb	21 years
↓	
^{210}Bi	5.01 days
↓	
^{210}Po	138.4 days
↓	
^{206}Pb	Stable

Radon is a noble gas and is not ionized in solution; it is chemically inert and is not directly affected by redox and pH conditions in ground water. However, the radon precursors uranium, thorium, and radium are strongly influenced by these conditions, which in turn can affect radon concentrations. Radon is affected by physical processes such as temperature and pressure, and volatilizes rapidly upon exposure to air.

Radon samples were obtained from 35 network sites (figs. 32-35); reliable radon samples could not be collected from the other sites. Only one sample was taken from each of the sampled sites. Concentrations ranged from <80 pCi/L (below detection level) to 7,000 pCi/L (median: 390 pCi/L). Radon concentrations from network sites are plotted by aquifer lithology in figure 36. Radon data retrieved from the USGS WATSTORE database for all ground-water samples in Maryland through 1993 are also shown in figure 36 for comparison. Most of the radon data in WATSTORE are from wells in Kent County (unconsolidated sedimentary aquifers) and Howard County (igneous and metamorphic aquifers).

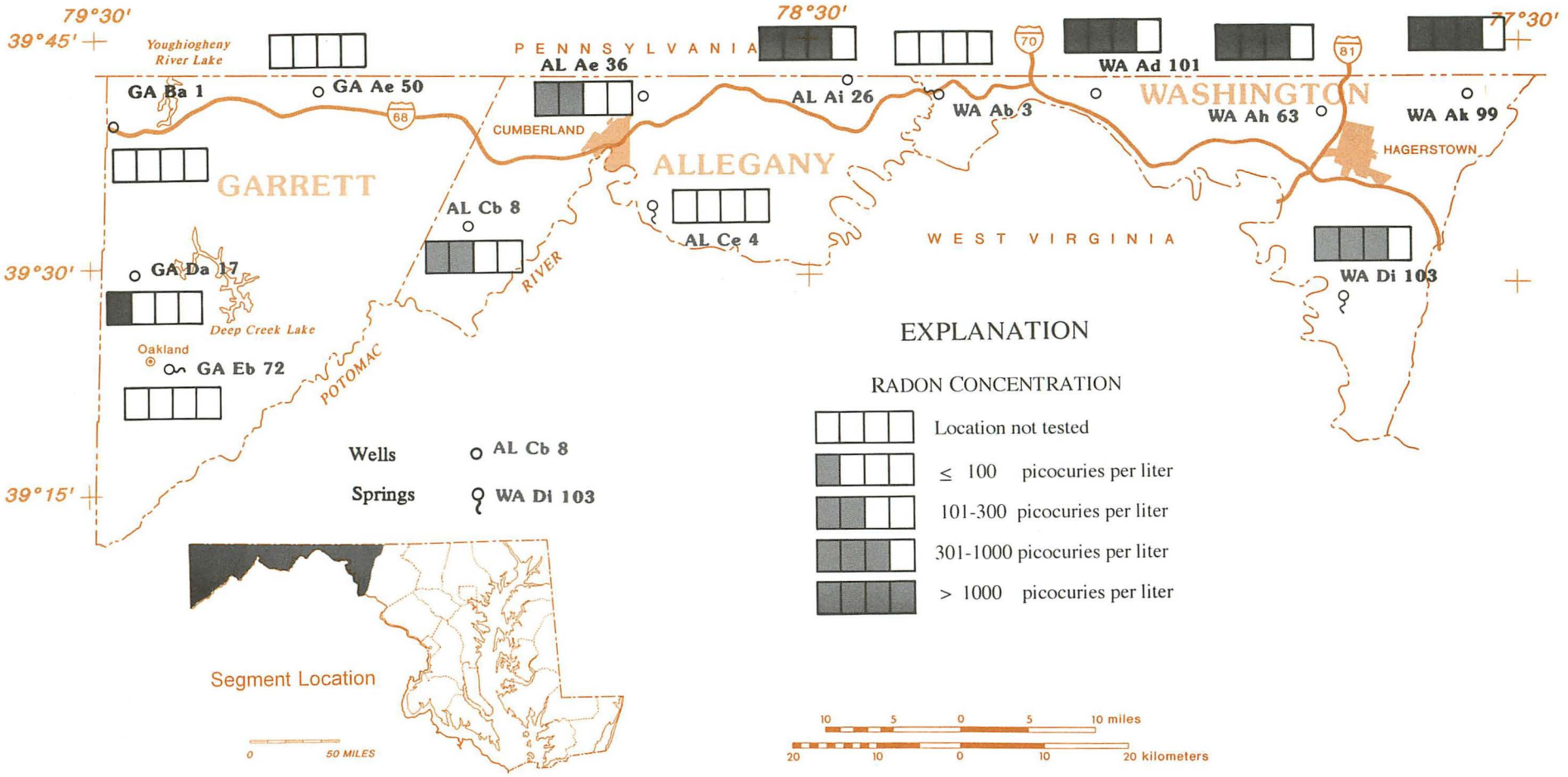


Figure 32.—Radon concentrations from network sites in the Appalachian Plateau and Valley and Ridge physiographic provinces.

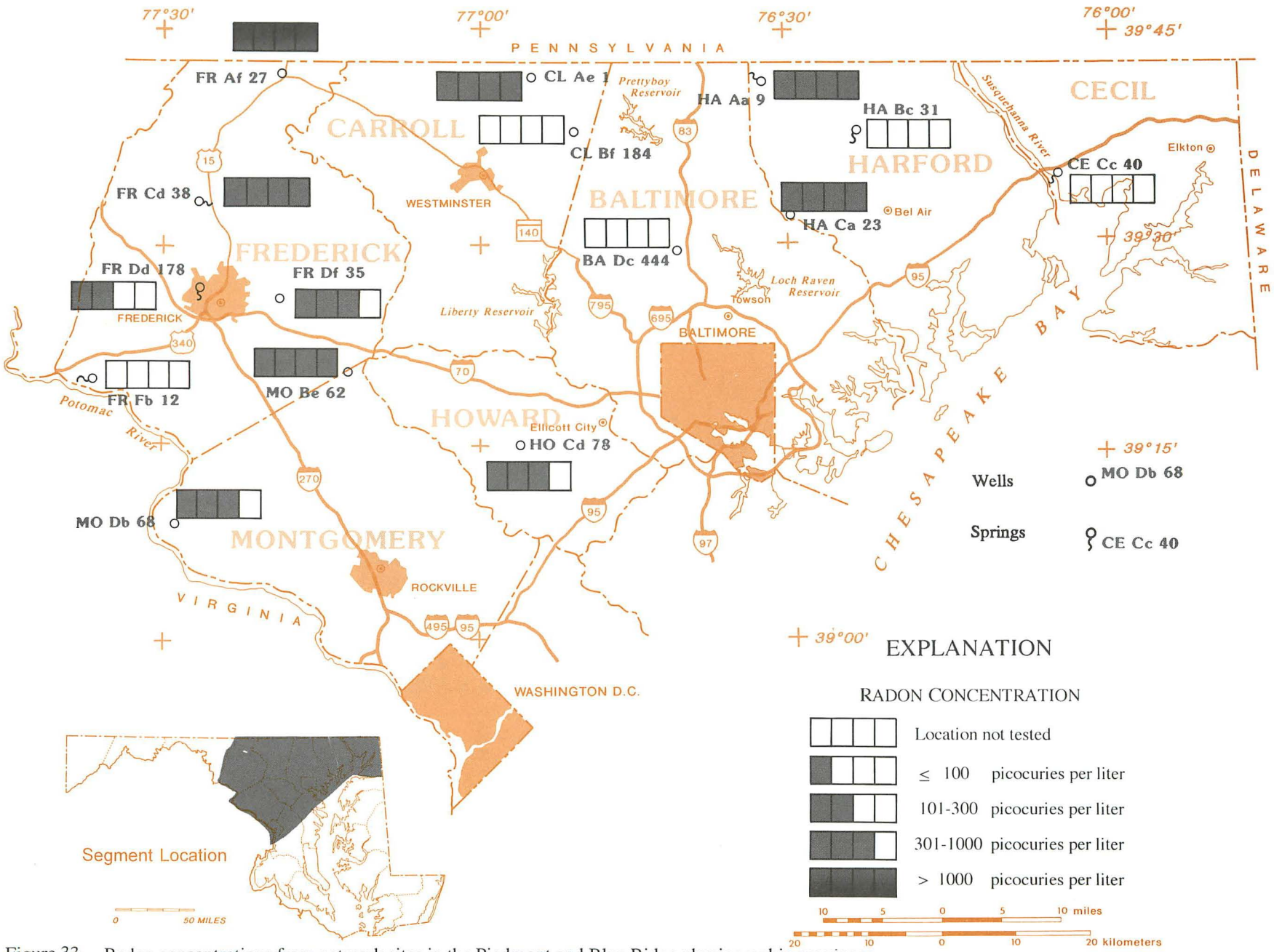


Figure 33.—Radon concentrations from network sites in the Piedmont and Blue Ridge physiographic provinces.

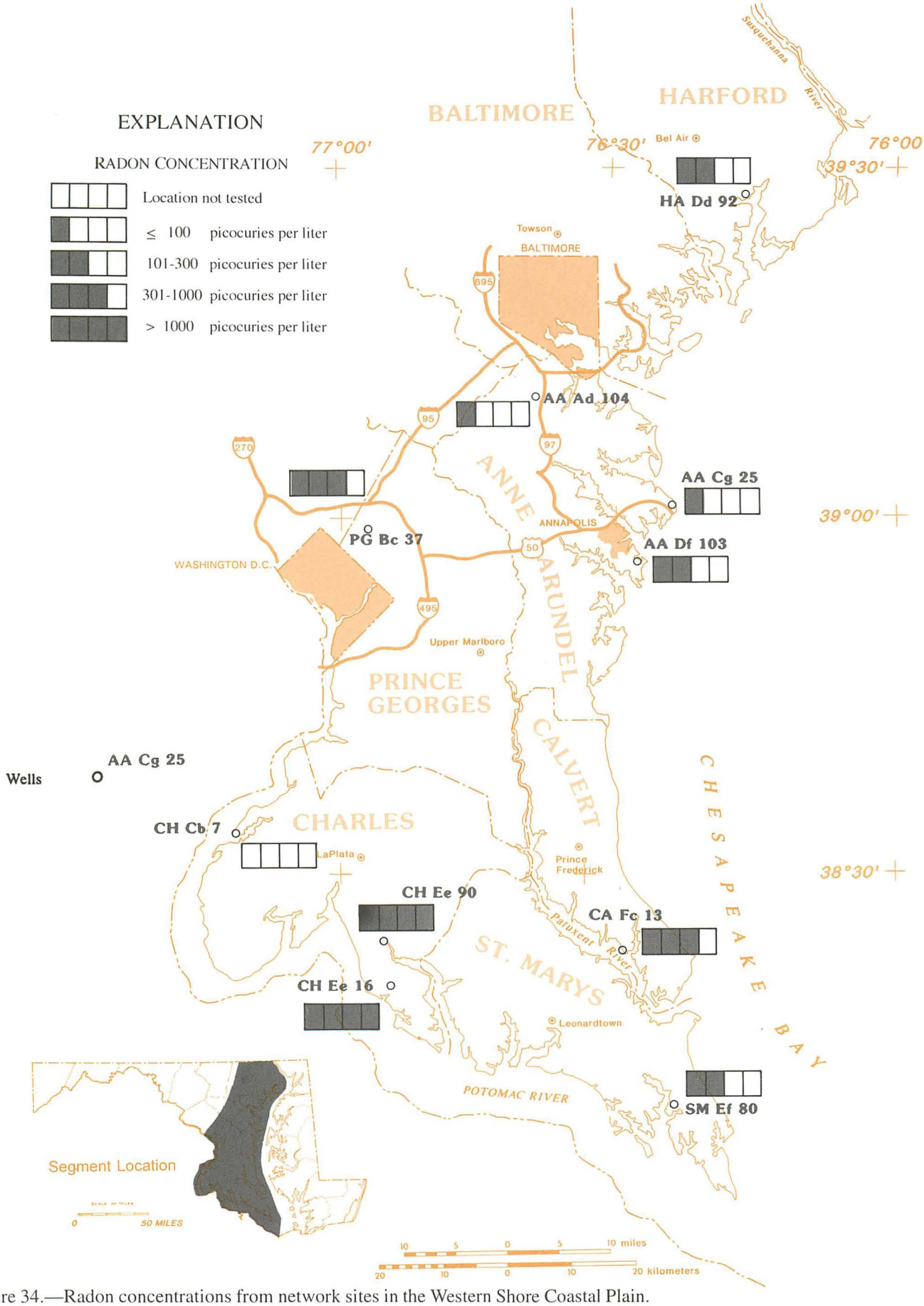


Figure 34.—Radon concentrations from network sites in the Western Shore Coastal Plain.

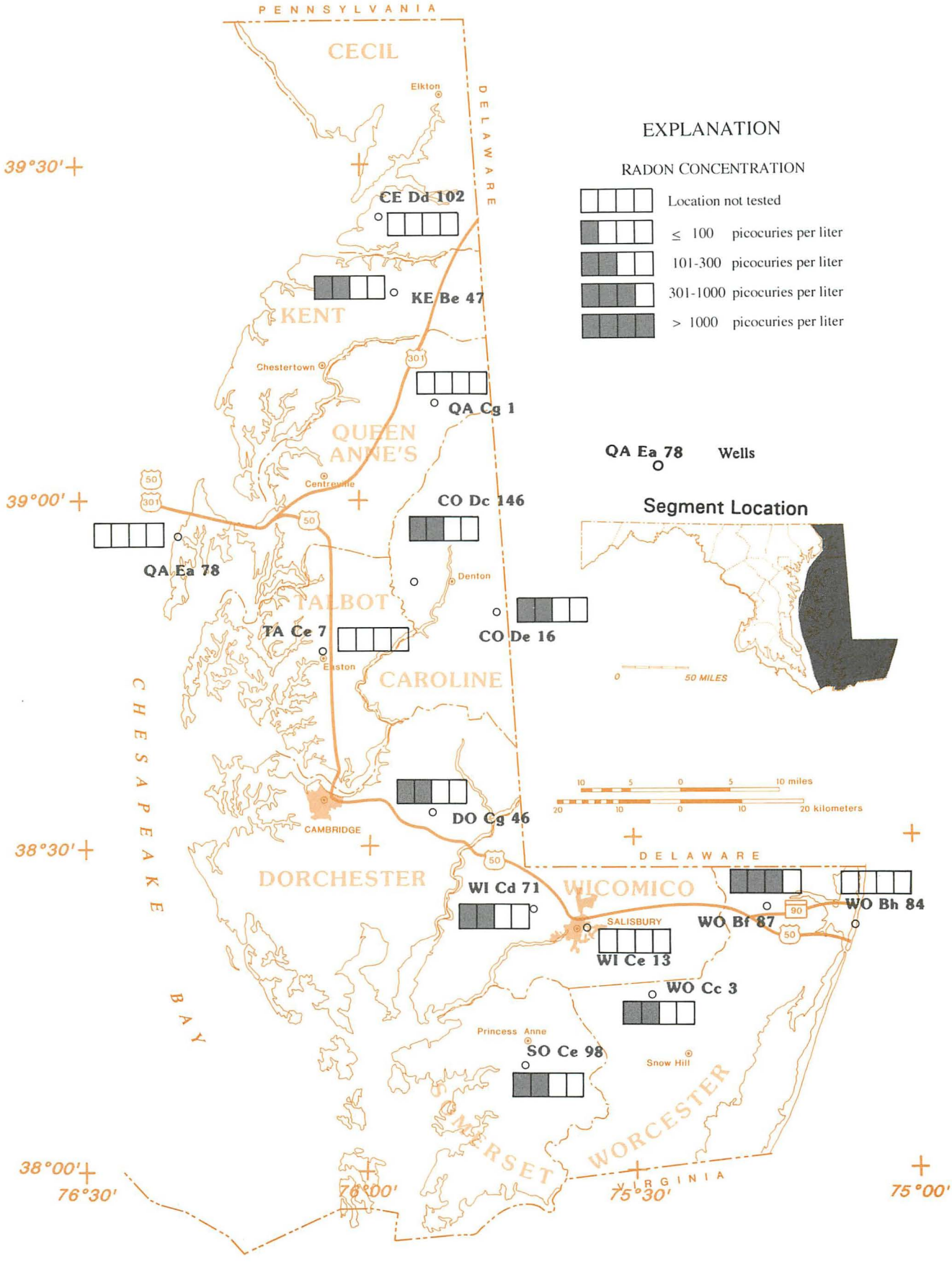


Figure 35.—Radon concentrations from network sites in the Eastern Shore Coastal Plain.

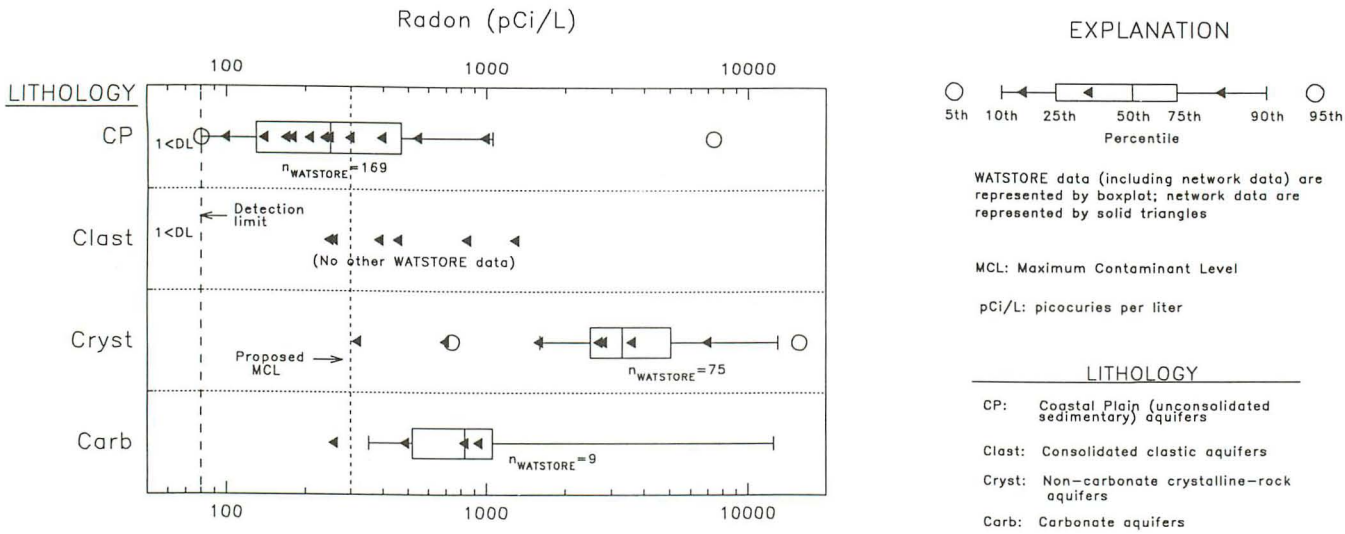


Figure 36.—Relationship of network-site and WATSTORE radon concentrations to aquifer lithology.

Although the sample size is small, some trends can be seen in the network data. Radon concentrations tended to be higher in samples from crystalline-rock aquifers than from other lithologies. This relationship has been observed elsewhere (Loomis, 1987; Michel, 1990; Paulsen, 1991). All network samples with more than 2,000 pCi/L radon were from crystalline-rock aquifers. There was considerable overlap in radon values from network sites in carbonate, consolidated clastic, and unconsolidated sedimentary aquifers. Radon concentrations in samples from the consolidated clastic aquifers ranged from <80 pCi/L to 1,300 pCi/L. Radon concentrations from the four network sites in carbonate aquifers ranged from 260 pCi/L to 940 pCi/L; these values are higher than values reported from limestones in Florida, South Carolina, and North Carolina (Michel, 1990). The carbonate aquifers in which network sites were established are comprised of shaly limestones, calcareous shales, and other lithologies, and they contain aluminosilicate minerals which probably provide much of the parent radionuclides. Radon concentrations showed a wider range in samples from the Western Shore than the Eastern Shore Coastal Plain, probably because of greater lithologic variability among aquifers sampled on the Western Shore.

The higher radon concentrations from sites in crystalline aquifers are due to geologic, geochemical, and hydrologic factors. Radon concentrations have been shown to correlate generally with rock type and uranium content of rocks (King, Michel, and Moore, 1982; Loomis, 1987). In general, ground-water radon concentrations are highest in granitic and metamorphic rocks, and lower in mafic and carbonate rocks (Michel, 1990). Radon concentrations in ground water are rarely accounted for by aqueous concentrations of radium (radon's parent radionuclide), but rather by radium concentrations in the parent rock, especially on rock and mineral surfaces (Wanty and Nordstrom, 1993). Radium may be retained on the mineral surfaces due to cation sorption, where decay would place radon directly into the water. This would be more likely to happen in less-weathered Piedmont aquifers than in the quartz sands that comprise many Coastal Plain aquifers (King, Michel, and Moore, 1982). Higher water/rock ratios typically found in unconsolidated aquifers compared to fractured crystalline aquifers may also account for the lower radon concentrations in sedimentary aquifers (Wanty and Schoen, 1991).

SYNTHETIC ORGANIC CHEMICALS

Pesticides

Concern over pesticide contamination of ground water has grown since the early 1970's, when the existence of organochlorine insecticides and other pesticides in ground water was documented (Richard and others, 1975). The extent of pesticide contamination has been documented at the national and regional level, and in several statewide surveys (Kimmel, 1984; Kross and others, 1990; U.S. Environmental Protection Agency, 1990b; Holden and others, 1992; Schock and others, 1992; Burkart and Kolpin, 1993; Koterba, Banks, and Shedlock, 1993). The results of some of these studies are compared to the Maryland network data in another section of this report. Pesticide contamination of ground water is reviewed by Hallberg (1989) and Ritter (1990).

Samples from 40 network sites were analyzed for one or more of three USGS schedules of pesticides: Schedule 1304 (phenoxy herbicides), Schedule 1331 (organochlorine and organophosphorus insecticides), and Schedule 1389 (triazine, acetanilide, and other herbicides and metabolites). These schedules include pesticides that are currently or have previously been widely used in Maryland (tab. 11). In addition, several fumigants were tested for in Schedule 1390 (volatile organic compounds). In this discussion, the term "pesticides" includes metabolites as well as the pesticides themselves. Pesticide sampling and detection data are shown in figures 37-40.

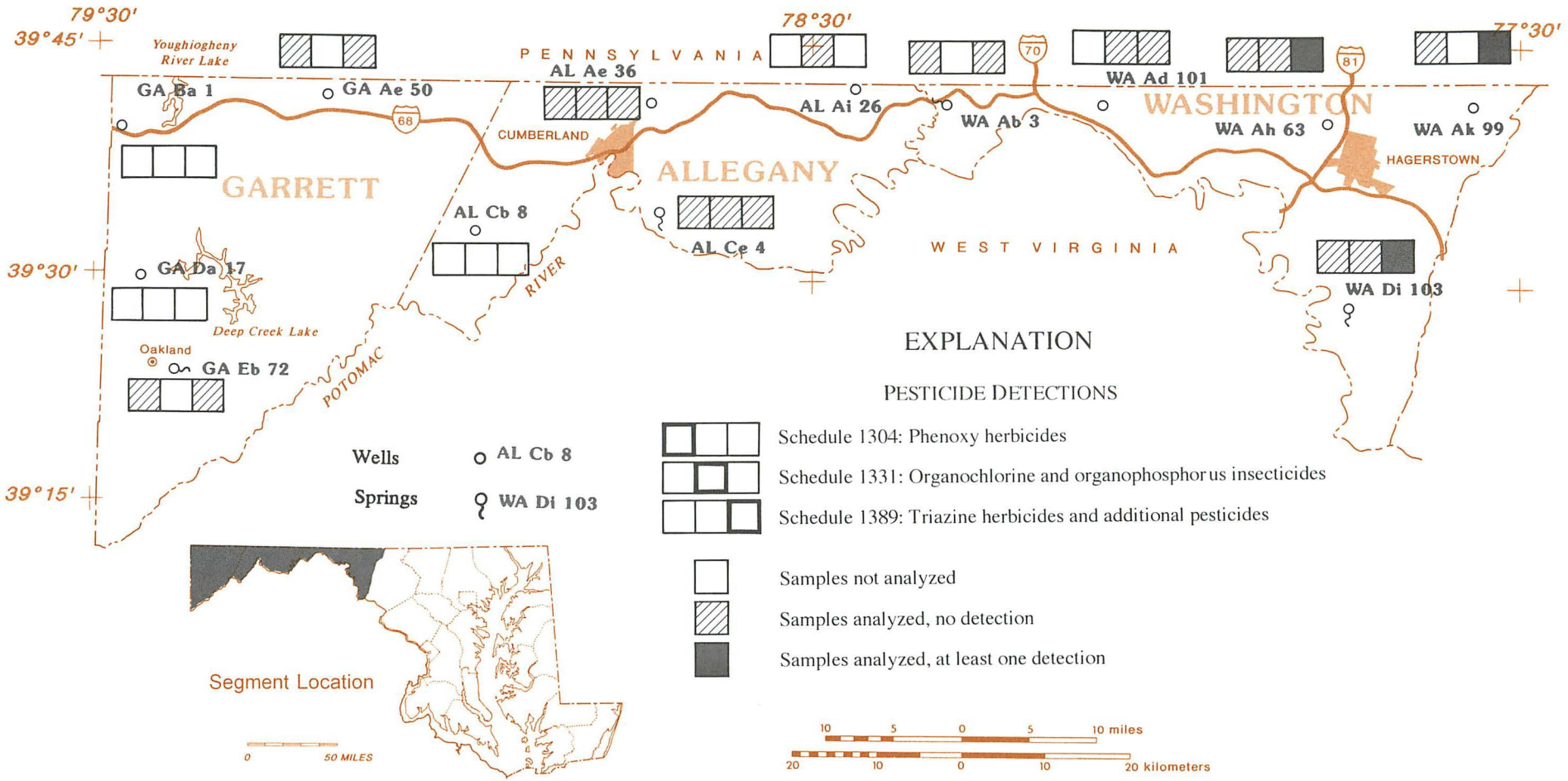


Figure 37.—Pesticide data from network sites in the Appalachian Plateau and Valley and Ridge physiographic provinces.

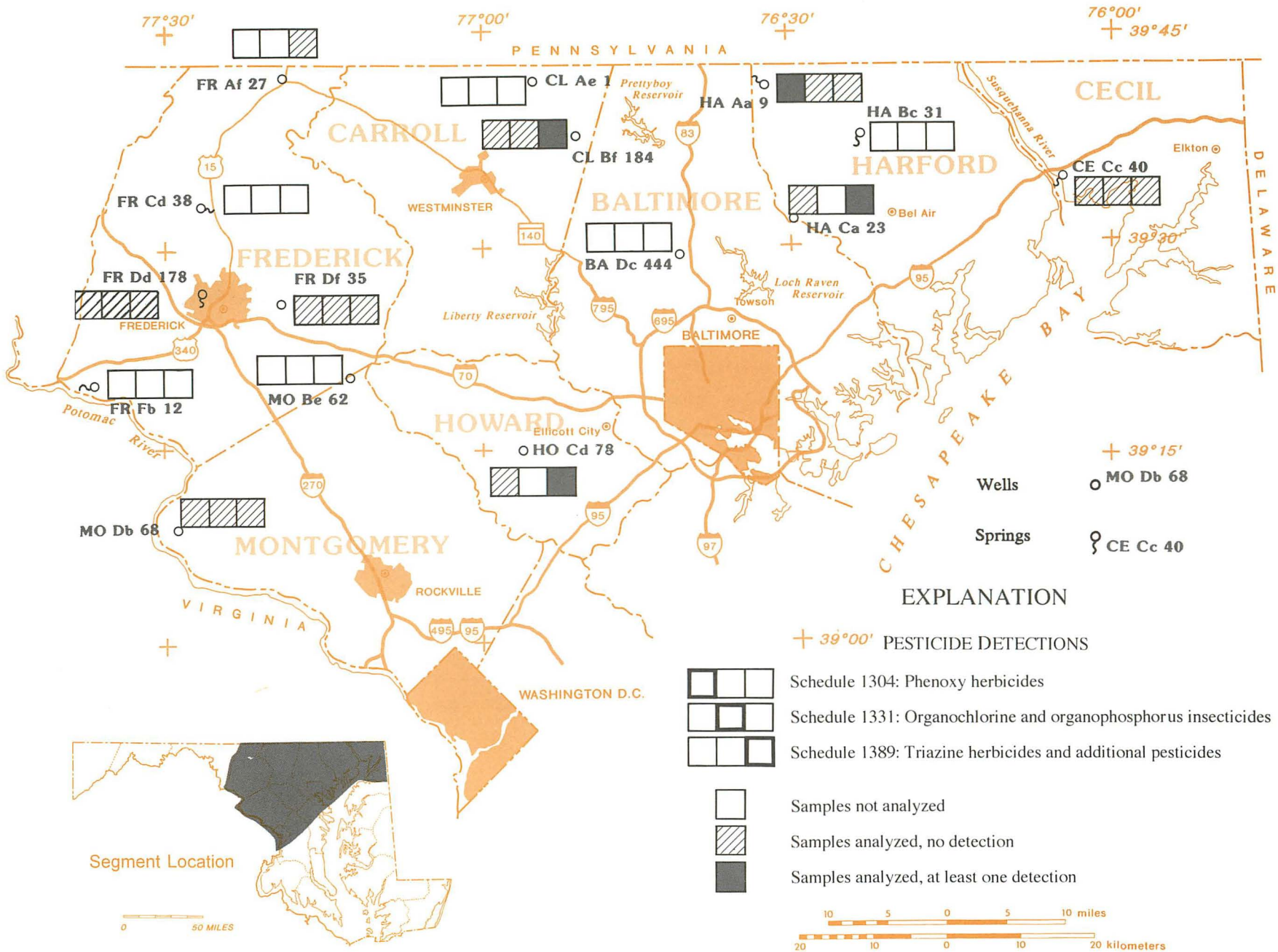


Figure 38.—Pesticide data from network sites in the Piedmont and Blue Ridge physiographic provinces.

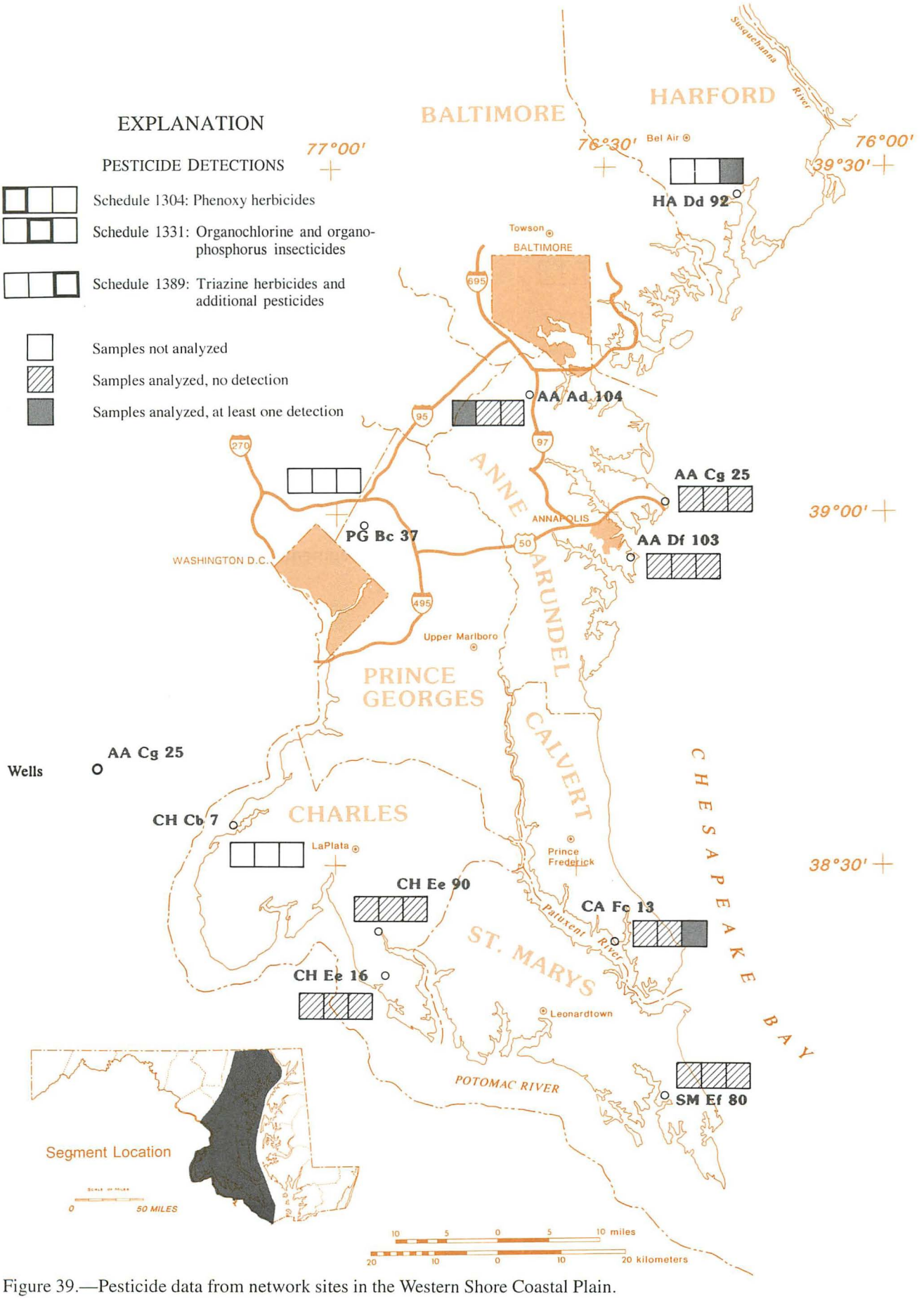


Figure 39.—Pesticide data from network sites in the Western Shore Coastal Plain.

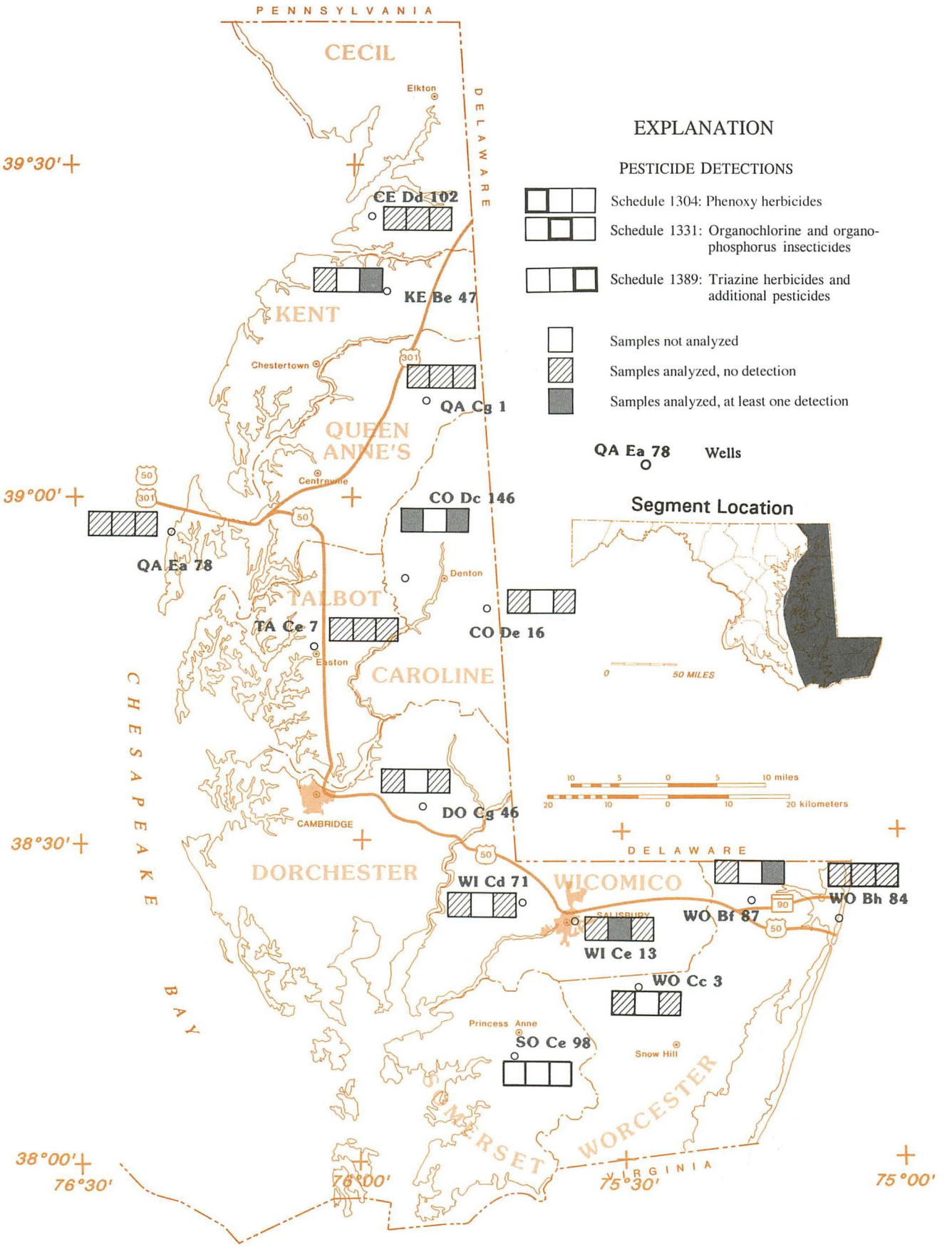


Figure 40.—Pesticide data from network sites in the Eastern Shore Coastal Plain.

Table 11.—Estimated pesticide usage in Maryland in 1988 and 1991

[Estimates are in pounds of active ingredient. Figures have been rounded to nearest 1,000 pounds. Pesticide types: H, herbicide; I, insecticide; P, preservative; N, nematicide; A, acaricide; F, fumigant. Source: Maryland Department of Agriculture (1990 and 1993)]

Pesticide	Type	1988 Usage (estimated)	1991 Usage (estimated)
Metolachlor*	H	1,810,000	1,441,000
Atrazine*	H	1,170,000	988,000
Alachlor*	H	569,000	323,000
Chromated copper arsenate	P	480,000	3,185,000
Linuron	H	355,000	215,000
2,4-D*	H	345,000	187,000
Chlorpyrifos	I	318,000	289,000
Simazine*	H	295,000	299,000
Carbofuran	N, I, F	260,000	20,000
Paraquat	H	250,000	130,000
Butylate*	H	240,000	73,000
Cyanazine*	H	225,000	112,000
Pendimethalin	H	210,000	165,000
Glyphosate	H	195,000	177,000
Oils	I, A	128,000	140,000
Bacillus thuringiensis	I	188,000	116,000
Malathion*	I	69,000	110,000
Permethrin	I	172,000	28,000
Trifluralin*	H	108,000	38,000

*Analyzed at network sites

Analysis of the network pesticide-detection data is difficult for several reasons. Because of annual adjustments in analytical costs and project funding, only 40 of the 52 sites were sampled for pesticides; those that were sampled were not all analyzed for the three schedules. The pesticide samples were taken in different years, usually in the late spring and early summer. Most of the pesticide analyses were from sites downgradient from either cropland or forest.

Fifteen different pesticides or metabolites were detected in samples from network sites (tab. 12). Concentrations ranged from 0.01 µg/L to 5.6 µg/L; most of the maximum concentrations detected at network sites were <1 µg/L (fig. 41). Results for the individual pesticide schedules are discussed below. Descriptive terminology and ranges for chemical and biological properties of pesticides are given in table 13.

Schedule 1304 includes four chlorophenoxy herbicides (tab. 14); three other analytes (dicamba, picloram, and sevin) that were analyzed at seven network sites for a different study are included in table 14, although these are not actually Schedule 1304 analytes. The Schedule 1304 compounds tend to have short soil longevities ($t_{1/2}$) (also called soil half-lives) and low soil reactivities (K_{oc}; an indication of the degree to which a compound is retained in the soil; also called soil sorption coefficients) (Wauchope and others, 1992). The compounds ionize in water; solubilities decrease and soil sorption coefficients increase with decreasing pH (Weber, 1994).

Thirty-six network sites were analyzed for Schedule 1304 analytes. Most of the sites tested were downgradient from either cropland or forest, and most sites were in Coastal Plain aquifers (fig. 42). Detections were reported from three network sites. Silvex, a herbicide used for controlling woody plants and brush, was detected in a well located adjacent to a heavily-traveled road near BWI Airport in Anne Arundel County. 2,4-D and 2,4-DP (also called dichlorprop) were both detected in a spring in northwest Harford County. The spring was sampled the following year for Schedule 1304 analytes, and none were detected. Dicamba was detected in a Caroline County well located between two fields in which corn, soy-

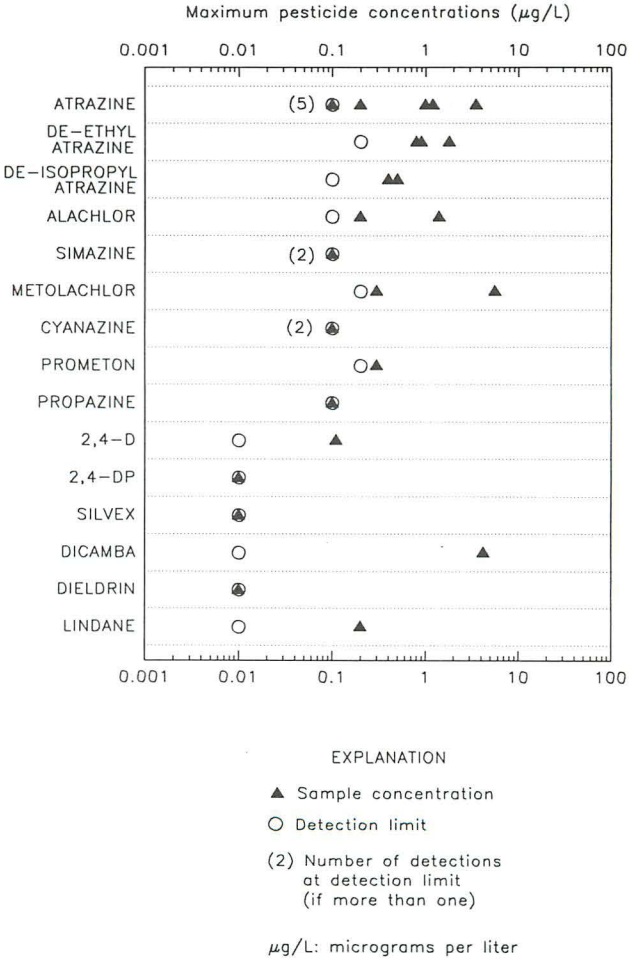


Figure 41.—Maximum pesticide concentrations from network sites in relation to pesticide detection limits

Table 12.—Chemical and environmental properties of selected pesticides detected at network sites

[Values are for 20-25°C. E: estimated. pK_A, negative log of the dissociation constant for ionizable compounds. Data not given for de-ethyl atrazine and de-isopropyl atrazine [metabolites]. Sources: Wauchope and others, 1992; Montgomery, 1993; Royal Society of Chemistry (1991)]

Compound	pK_A	Water solubility (mg/L)	Volatility (VP) (mm Hg)	Soil reactivity (K_{OC}) (mL/g)	Longevity ($t_{1/2}$) (days)
Atrazine	1.68	33	2.89×10^{-7}	100	60
Alachlor		240	1.4×10^{-5}	170	15
Simazine	1.7	6.2	2.21×10^{-8}	130	60
Metolachlor		530	3.135×10^{-5}	200	90
Cyanazine	1.1	170	1.6×10^{-9}	190	14
Prometon	4.27	720	7.73×10^{-6}	150	500
Propazine	1.85	8.6	1.31×10^{-7}	154	135
2,4-D	2.64-3.31	45 (sodium salt)	4.7×10^{-3}	$10^{1.68}$—$10^{2.73}$	15
2,4-DP (dichlorprop) (ester)	2.86	50E	3×10^{-6} E	1,000 E	10
Silvex (fenoprop)		140	--	--	--
Dicamba salt	1.91	400,000 (sodium salt)	0	2	14
Dieldrin		140	1.78×10^{-7}	$10^{4.08}$—$10^{4.55}$	868
Lindane		7	3.3×10^{-5}	1,100	400

Table 13.—Descriptive terminology and ranges for chemical and biological properties of organic pesticides (from Weber, 1994)

Descriptive terminology*	Basicity (pK_A)	Acidity (pK_A)	Water solubility (K_{sp}) (mg/L)	Volatility (vapor pressure) (mm Hg x 10^{-6})	Soil reactivity (K_{oc})	Longevity ($t_{1/2}$) (days)
Very low or very short	<2	>8	<10	<1	$<10^2$	<10
Low or short	2-4	6-8	10-10^2	1-10	10^2-10^3	10-30
Moderate	4-6	4-6	10^2-10^3	10-10^2	10^3-10^4	30-90
High or long	6-8	2-4	10^3-10^4	10^2-10^3	10^4-10^5	90-180
Very high or very long	>8	<2	$>10^4$	$>10^3$	$>10^5$	>180

* Adjectives describing the relative base or acid strength, water solubility, volatility, soil retention, or longevity.

Table 14.—Schedule 1304 analytes

Compound	Use	Chemical family	Detection limit (μg/L)	Number of sites with detections/ number of sites tested
2,4-D	Herbicide	Chlorophenoxy	0.01	1/36
2,4-DP	Herbicide	Chlorophenoxy	0.01	1/36
2,4,5-T	Herbicide	Chlorophenoxy	0.01	0/36
Silvex (fenoprop)	Herbicide	Chlorophenoxy	0.01	1/36
*Sevin (carbaryl)	Insecticide	Carbamate	0.5	0/8
*Picloram	Herbicide	Picolinic acid	0.01	0/7
*Dicamba	Herbicide	Benzoic acid	0.01	1/7

*Analytes are not in Schedule 1304 but were analyzed at some sites

beans, and wheat were grown at different times during the study period. 2,4-D, 2,4-DP, and dicamba are used widely in Maryland for the control of broad-leafed weeds in corn, soybeans, grain, and other crops (Maryland Department of Agriculture, 1993). No detections were reported from sites downgradient from forest, pasture/grassland, residential, or institutional land use, nor from sites in consolidated clastic aquifers or carbonate aquifers.

Schedule 1331 includes organochlorine and organophosphorus insecticides (tab. 15). These compounds tend to have low solubilities and moderate to high soil reactivities; soil longevities are variable (Wauchope and others, 1992). Many of these compounds are restricted or banned from use in the United States (U.S. Environmental Protection Agency, 1990c). Malathion has been widely used for mosquito control in Maryland; the others are not reported to be widely used (Maryland Department of Agriculture, 1990; 1993).

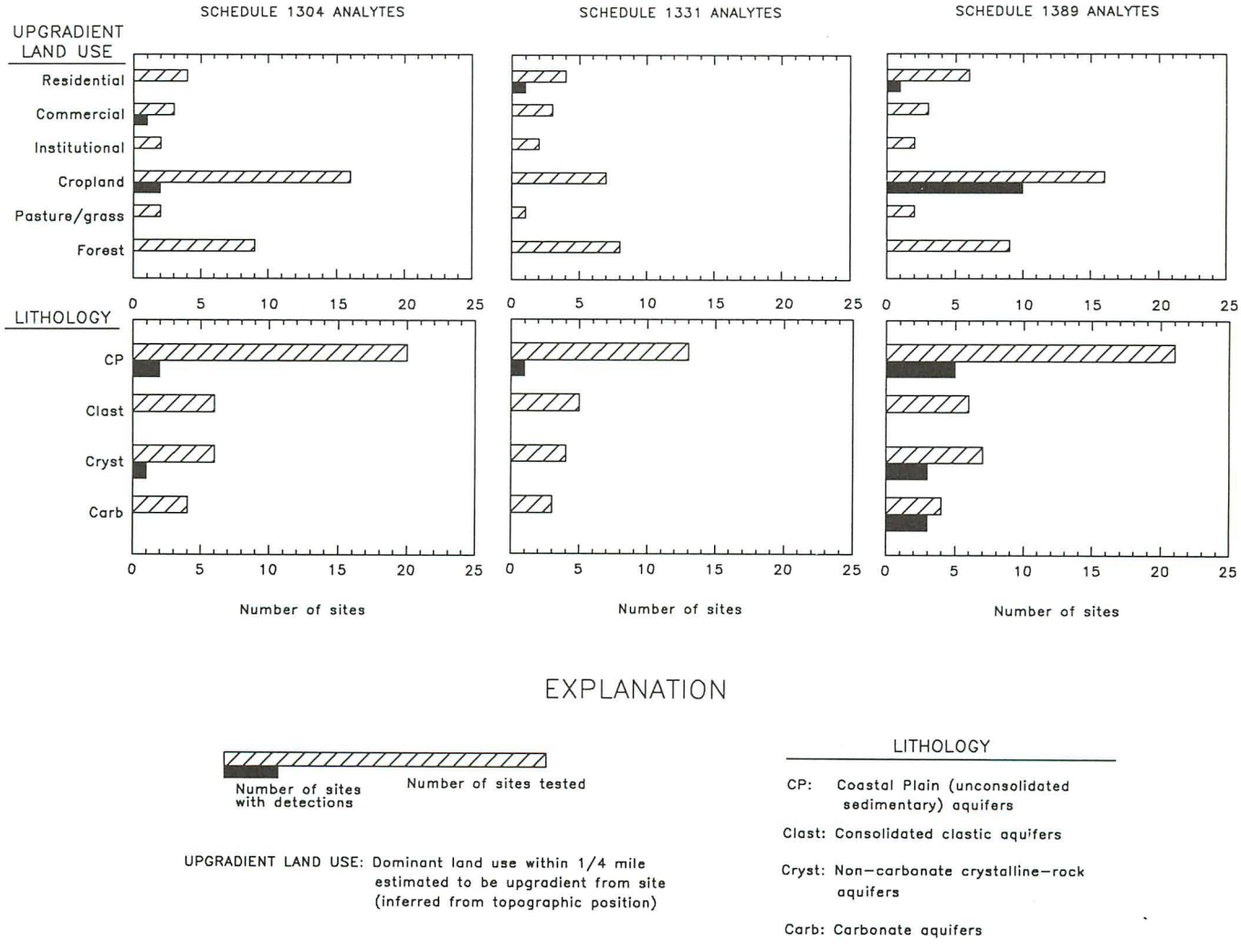


Figure 42.—Pesticide detections in relation to lithology and upgradient land use for sites tested for Schedules 1304, 1331, and/or 1389 analytes.

Table 15.—Schedule 1331 analytes

[Chemical families: PCB, polychlorinated biphenyl; PCN, polychlorinated naphthalene; OC, organochlorine; OP, organophosphorus]

Compound	Use	Chemical family	Detection limit (μg/L)	Number of sites with detections/ number of sites tested
PCBs (polychlorinated biphenyls)	Pesticide extender; manufacturing	PCB	0.1	0/25
PCNs (polychlorinated naphthalenes)	Manufacturing; insecticide	PCN	0.1	0/25
Aldrin	Insecticide	OC	0.01	0/25
Chlordane	Insecticide	OC	0.1	0/25
DDD	Insecticide	OC	0.01	0/25
DDE	Chemical research	OC	0.01	0/25
DDT	Insecticide	OC	0.01	0/25
Diazinon	Insecticide	OP	0.01	0/25
Dieldrin	Insecticide	OC	0.01	1/25
Endosulfan	Insecticide	OC	0.01	0/25
Endrin	Insecticide	OC	0.01	0/25
Ethion	Insecticide, acaricide	OP	0.01	0/25
Heptachlor	Insecticide	OC	0.01	0/25
Heptachlor epoxide	Metabolite	OC	0.01	0/25
Lindane	Insecticide	OC	0.01	1/25
Malathion	Insecticide	OP	0.01	0/25
Methoxychlor	Insecticide	OC	0.01	0/25
Methyl parathion	Insecticide	OP	0.01	0/25
Methyl trithion			0.01	0/25
Mirex	Insecticide	OC	0.01	0/25
Parathion	Insecticide, acaricide	OP	0.01	0/25
Perthane	Insecticide	OC	0.1	0/25
Toxaphene	Insecticide	OC	1.0	0/25
Trithion (carbophenothion)	Insecticide, miticide	OP	0.01	0/25

Twenty-five network sites were analyzed for Schedule 1331 analytes. Most of the sites tested were downgradient of cropland or forests, and most were in Coastal Plain aquifers. One site (well WI Ce 13, located in the city of Salisbury) had detections of the compounds dieldrin and lindane; no other sites had any detections of Schedule 1331 analytes. Dieldrin and lindane are immobile, long-lived organochlorine insecticides. Usage of dieldrin, an epoxide of aldrin, has been banned in the United States; lindane usage is restricted (U.S. Environmental Protection Agency, 1990c).

Schedule 1389 includes several herbicides that are widely used in Maryland, including atrazine, simazine, and cyanazine (triazine herbicides), metolachlor and alachlor (acetanilides), butylate, and trifluralin (tab. 16). The triazine herbicides tend to have low to moderate solubilities, soil reactivities, and soil longevities, although these are strongly dependent on the functional group for a particular triazine (Wauchope and others, 1992; Weber, 1994). The triazines ionize in solution; solubilities and soil reactivities increase with decreasing pH (Weber, 1994). Chemical characteristics of the other Schedule 1389 compounds vary because of the many chemical families that are represented.

Thirty-eight network sites were analyzed for Schedule 1389 analytes. Detections of at least one analyte were reported from 11 of the 38 sites tested. Most of these sites were downgradient of cropland or forest, and most were from Coastal Plain aquifers. Nine analytes were detected, including five triazine herbicides (atrazine, cyanazine, prometon, propazine, and simazine). Atrazine was the most frequently detected pesticide. Ten of the 11 sites with detections reported were downgradient from agricultural areas. Sixteen sites located downgradient from cropland were tested for Schedule 1389 analytes. Ten of these sites had one or more detections reported. One site with

Table 16.—Schedule 1389 analytes

Compound	Use	Chemical family	Detection limit (μg/L)	Number of sites with detections/ number of sites tested
Alachlor	Herbicide	Acetanilide	0.1-0.2	2/38
Ametryn	Herbicide	Triazine	0.1	0/38
Atrazine	Herbicide	Triazine	0.1	9/38
Cyanazine	Herbicide	Triazine	0.1-0.2	2/38
Bromacil	Herbicide	Uracil	0.2	0/9
Butachlor	Herbicide	Acetanilide	0.1	0/9
Butylate	Herbicide	Thiocarbamate	0.1	0/9
Carboxin	Fungicide	Anilide	0.2	0/9
Cycloate	Herbicide	Thiocarbamate	0.1	0/9
De-ethyl atrazine	Metabolite	Triazine	0.2	3/9
De-isopropyl atrazine	Metabolite	Triazine	0.2	2/9
Diphenamid	Herbicide	Acetamide	0.1	0/9
Hexazinone	Herbicide	Triazine	0.1-0.2	0/9
Metolachlor	Herbicide	Acetanilide	0.1-0.2	2/38
Metribuzin	Herbicide	Triazine	0.1	0/38
Prometon	Herbicide	Triazine	0.1-0.2	1/38
Prometryn	Herbicide	Triazine	0.1	0/38
Propazine	Herbicide	Triazine	0.1	1/38
Propachlor	Herbicide	Acetanilide	0.1	0/9
Simazine	Herbicide	Triazine	0.1	2/38
Simetryn	Herbicide	Triazine	0.1	0/38
Terbacil	Herbicide	Uracil	0.2	0/9
Trifluralin	Herbicide	Dinitroaniline	0.1	0/38
Vernolate	Herbicide	Thiocarbamate	0.1	0/9

cyanazine was located downgradient from a residential area. No detections were reported from sites downgradient from the other four land-use categories. Three of the four tested sites in carbonate aquifers reported detections; these three sites are all located in intensely-cropped agricultural areas of the Hagerstown Valley in Washington County. Well CL Bf 184 was tested for Schedule 1389 analytes five times; atrazine was detected at or slightly above the detection limit of 0.1 µg/L in each sample.

Several volatile organic compounds in Schedule 1390 are used as fumigants to control pests. None of these compounds was detected in network samples. Only two of these compounds (dichloropropene and methyl bromide) are reported to be used in Maryland (Maryland Department of Agriculture, 1990; 1993).

Twenty-three network sites were tested for all three schedules of pesticides. Seven of the 23 sites had at least one detection reported. Five out of seven sites downgradient from cropland reported detections of at least one pesticide (fig. 43). The other land-use classes had smaller proportions of sites with detections. Detections were reported from carbonate, metamorphic, and unconsolidated sedimentary aquifers.

The lack of pesticide analyses from all network sites and the lack of site-specific pesticide use data preclude a detailed analysis of the pesticide detection data. However, some observations can be made. Many of the detections were at or near detection levels; only one site exceeded the MCL for any pesticide. Pesticides from the triazine chemical family were detected more frequently than other chemical families. Atrazine was the most frequently detected pesticide. Atrazine, cyanazine, and simazine (triazines) and alachlor and metolachlor (acetanilides) are used widely in Maryland, and have short to moderate half-lives. The triazines propazine and prometon, which are also widely used, have much longer half-lives than the other triazines. All the detected triazines and acetanilides have low soil reactivities and low to moderate water solubilities. Only two organochlorine and organophosphorus insecticides (dieldrin and lindane) were detected, which may reflect the low reported usage of these compounds and their relatively high soil reactivities. Pesticide detections appear to be more closely linked to land use than aquifer lithology.

The triazine metabolites de-ethyl atrazine (DEA) and de-isopropyl atrazine (DIA) were added to Schedule 1389 in the last year of the study; nine sites were analyzed for these compounds. These metabolites were detected in all three samples in which the parent compounds were detected. This suggests that DEA and DIA may comprise a significant portion of pesticide residues found in shallow ground water. Studies that test only for the parent compounds and not the metabolites may not accurately evaluate the total impact of agricultural

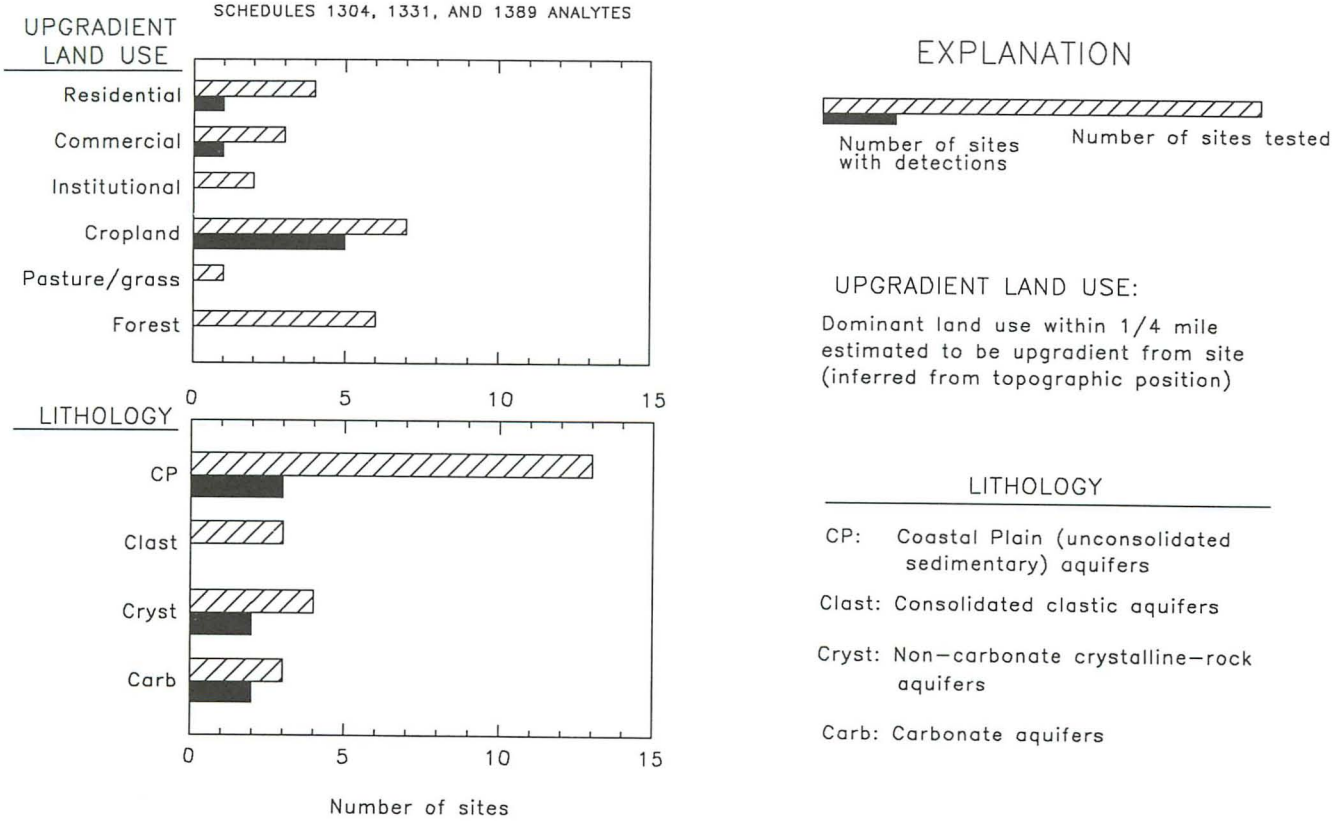


Figure 43.—Pesticide detections in relation to lithology and upgradient land use for sites tested for all three pesticide schedules (Schedules 1304, 1331, 1389).

chemicals in ground water. Metabolite detections often exceed detections of the parent compounds in Maryland and elsewhere (MGS unpublished data Burkart and Kolpin, 1993; Kolpin, Thurman, and Goolsby, 1996). More information is needed on the environmental behavior and health effects of pesticide metabolites in order to evaluate the significance of agricultural chemicals on ground-water quality.

Volatile Organic Compounds

Samples from 36 sites were tested for volatile organic compounds (USGS Schedule 1390) to check for major unknown point sources of contamination. Schedule 1390 data are presented in tables A6, A12, A18, and A24.

Chloroform was detected in two samples from spring WA Di 103; the concentrations (7.4 µg/L and 4.5 µg/L) were well below the MCL of 100 µg/L. Chloroform is used in the manufacture of chemicals and in fire extinguishers, spot removers, and various solvents (U.S. Environmental Protection Agency, 1994). The spring is on the grounds of the Antietam National Battlefield. Possible sources include maintenance/restoration operations at a nearby farmhouse and a maintenance shop next to the spring.

Dichlorodifluoromethane was detected in five samples from spring FR Dd 178; concentrations ranged from 6.4 µg/L to 16 µg/L. The spring issues from the Frederick Limestone, and is located near Fort Detrick Cancer Research Center in Frederick. Dichlorodifluoromethane, known commercially as Freon-12, Halon, and several other names, is used as a refrigerant and an aerosol propellant; it is a colorless, almost odorless gas that is non-corrosive, non-irritating, and has little if any toxic action (Windholz and others, 1983). The U.S. EPA has not established an MCL for this compound, although it is listed for eventual regulation. This compound and several others (trichloroethylene, chloroform, phenol, and pentachlorophenol) have been detected in several monitor and residential wells in the Fort Detrick area. Trichloroethylene and chloroform were not detected in the spring samples; phenol and pentachlorophenol were not tested for. The spring is separated from the suspected contaminant sources by Carroll Creek.

Vinyl chloride, also known as chloroethylene, was detected in two samples from well AA Cg 25; the concentrations (1.4 µg/L in both samples) were below the MCL of 2 µg/L. Vinyl chloride, which has been listed by the U.S. EPA as a carcinogen, is used to make polyvinyl chloride (PVC), which is used to manufacture a variety of plastic and vinyl products (U.S. Environmental Protection Agency, 1994). The well casing may be the source of the vinyl chloride; small amounts of vinyl chloride can enter water from contact with PVC materials such as plastic pipes and well casings (U.S. Environmental Protection Agency, 1994).

Chloroform, methylene chloride, and trichloroethylene were detected in four Eastern Shore wells in samples collected for the USGS NAWQA pilot study of the Delmarva Peninsula. Reporting levels for most Schedule 1390 analytes from the NAWQA study were an order of magnitude lower than reporting levels for the Maryland ground-water-quality network, and the concentrations of the reported detections were between the two project reporting levels. All detections were below MCLs. There are no obvious sources for these detections near the wells. The methylene chloride detections may be due to sample contamination after the time of collection (W.S.L. Banks, USGS, oral comm., 1992). Trichloroethylene is used mainly as a solvent.

NETWORK DATA IN RELATION TO OTHER GROUND-WATER-QUALITY SURVEYS

Several national and statewide studies of pesticide and nitrate occurrence in ground water have been conducted. The data collected from the Maryland network cannot be rigorously compared to any of these studies because of the differences in site selection methods, sample size, and other factors; however, a brief comparison of the study results may put findings of the Maryland network in perspective.

NATIONAL PESTICIDE SURVEY

The National Pesticide Survey (NPS) was conducted by the U.S. EPA between 1988 and 1990 to provide "a statistically reliable assessment of the frequency and concentration of selected pesticides, pesticide degradates, and nitrate in drinking-water wells" in the United States (U.S. Environmental Protection Agency, 1990b). Approximately 1,300 community water system wells and rural domestic wells were sampled for 101 pesticides, 25 pesticide degradates, and nitrate. The survey was not designed to provide estimates of pesticide contamination at the local, county, or state levels.

Pesticide and nitrate detection data from the NPS and the Maryland network are compared in table 17. The table includes analytes that were routinely analyzed for both studies that were detected in either one or both studies at concentrations exceeding the minimum reporting limits of the NPS. Minimum reporting limits for nitrate and most pesticides were lower for the Maryland ground-water-quality network than for the NPS; to facilitate comparison between the data sets, analytes

detected in the Maryland network whose concentrations were below the minimum reporting limits of the NPS are not included in table 17, nor are detections of analytes from the NPS where the NPS minimum reporting limits were lower than those of the Maryland ground-water-quality network.

Atrazine was the most frequently detected pesticide among those common to both studies. (DCPA acid metabolites, the most frequently detected analytes in the National Pesticide Survey, were not analyzed in the Maryland network.) Atrazine concentrations exceeded 0.12 µg/L at about 11% of the Maryland network sites (four of 38 sites), compared to estimated detection rates of 1.7% and 0.7% in community water system wells and rural domestic wells, respectively, from the NPS. The percentages of wells with nitrate concentrations exceeding 0.15 mg/L and 10 mg/L was also greater in the Maryland ground-water quality network than in the National Pesticide Survey. The small sample size for the Maryland network may give misleading detection percentages, especially for pesticide detections; however, the differences are probably due partly to the types of sites that were sampled. The Maryland network focused on the unconfined aquifers, which are more susceptible to ground-water contamination than confined aquifers. The NPS design stipulated that specified numbers of wells be sampled from areas of varying degrees of aquifer vulnerability, as determined by seven factors of the DRASTIC aquifer-vulnerability classification system (Aller and others, 1987). The higher detection rates in the Maryland network may also be related to well depth: at least 50% of the rural domestic wells and 74% of the community water system wells from the National Pesticide Survey were estimated to be more than 100 feet deep, compared to less than 10% of the Maryland network wells.

NATIONAL ALACHLOR WELL WATER SURVEY

A nationwide survey of alachlor occurrence in private, rural domestic wells was conducted by the Monsanto Company, in cooperation with the U.S. EPA. The primary goal of the

Table 17.—Detection rates for nitrate and pesticides from the U.S. Environmental Protection Agency National Pesticide Survey (NPS) and the Maryland ground-water-quality network

[Table includes only those pesticides that were analyzed in both studies and that were detected in either one or both studies. See text for additional information. <, less than; >, greater than. Source: U.S. Environmental Protection Agency (1990b)]

		Estimated percentage of NPS wells with analyte detections greater than NPS minimum reporting limits		Maryland ground-water-quality network sites with analyte detections greater than NPS minimum reporting limits	
Analyte	NPS minimum reporting limit	Community water-supply wells	Rural domestic wells	Detection percentage	Number of detections/ number analyzed
Alachlor	0.5 µg/L	0	<0.1	3	1/38
Atrazine	0.12 µg/L	1.7	0.7	11	4/38
Lindane	0.043 µg/L	0	0.1	4	1/25
Metolachlor	0.75 µg/L	0	0	3	1/38
Prometon	0.15 µg/L	0.5	0.2	3	1/30
Simazine	0.38 µg/L	1.1	0.2	0	0/38
Nitrate*	0.15 mg/L as N	52.1	57.0	65	34/52
Nitrate* > 10 mg/L as N		1.2	2.4	15	8/52

*Nitrate concentrations include nitrate+nitrite

National Alachlor Well Water Survey (NAWWS) was to determine the proportion of wells with detectable levels of alachlor. In counties where alachlor is sold, 1,430 wells in 89 counties were sampled from mid-1987 through 1989. Analytes included alachlor, metolachlor, atrazine, cyanazine, simazine, and nitrate (Holden and others, 1992). Survey methods were similar to those of the NPS.

Pesticide detection data from the NAWWS and the Maryland network are presented in table 18. As with the NPS, atrazine detections were higher than other pesticides, and the detection rates from the Maryland network were higher than the estimated detection percentages from the NAWWS. The higher detection rates in the Maryland network result from many of the same reasons as the differences observed in comparison to the NPS. An estimated 12.1% of the NAWWS target population wells are less than 50 feet deep, compared to 58% of the Maryland network sites (wells and springs) that were sampled for NAWWS analytes. The NAWWS wells were classified into one of three ground-water vulnerability categories, with wells in shallow unconfined aquifers classified as most vulnerable. Approximately 17% of wells in the high-vulnerability category had atrazine detections, whereas the overall estimated detection rate was less than 12%.

Nitrate detection data from the NAWWS and the Maryland ground-water-quality network are presented in table 19. Three-quarters of the NAWWS target population was estimated to have nitrate concentrations <3 mg/L, compared to approximately 63% of the Maryland network sites. A higher percentage of Maryland network sites than NAWWS wells exceeded the MCL of 10 mg/L for nitrate (15% versus 4.9%). High-vulnerability wells in the NAWWS had a higher estimated percentage of nitrate MCL exceedance (about 8%) than all NAWWS wells, but this rate is still lower than the exceedence rate for the Maryland network sites.

ILLINOIS STATE AGRICULTURAL-CHEMICALS PILOT STUDY

The Illinois State Water Survey and Illinois State Geological Survey conducted a pilot study of the occurrence of agricultural chemicals in rural, private wells in Illinois. The pilot study was conducted to evaluate components of an experimental design for a statewide survey proposed by McKenna and others (1989), and "to begin to determine the frequency of occurrence and range of concentrations of agricultural chemicals in rural, private wells in representative hydrogeological settings" (Schock and others, 1992). An additional goal of the pilot study was to test the hypothesis that the depth to the uppermost aquifer material is a major factor in determining the susceptibility of ground water to contamination from agricultural chemicals. A total of 240 wells were sampled for 38 agricultural chemicals (including nitrate). Forty-eight wells were sampled in each of five areas that represented different hydrogeological environments.

Table 18.—Detection rates for pesticides from the National Alachlor Well Water Survey and the Maryland ground-water-quality network

[≥, greater than or equal to. Source: Holden and others (1992)]

	National Alachlor Well Water Survey			Maryland ground-water-quality network					
	Estimated percentage of wells with detections			Detections ≥0.1 μg/L			Detections ≥0.2 μg/L		
Analyte	≥DL*	≥0.1 μg/L	≥0.2 μg/L	Number of sites with detections	Number of sites tested‡	Percentage	Number of sites with detections	Number of sites tested‡	Percentage
Alachlor	0.78%	0.36%	0.32%	2	32	6%	2	38	5%
Atrazine	11.68	2.32	1.11	9	38	24	4	38	11
Cyanazine	0.28	0.08	0	2	29	7	0	38	0
Metolachlor	1.02	0.40	0.40	2	29	7	2	38	5
Simazine	1.60	0.10	0.01	2	38	5	0	38	0

* DL: detection limit. Includes detections that were below reporting limits for samples from the Maryland network.

‡ Different sample sizes between the 0.1 μg/L and 0.2 μg/L columns reflect a change in reporting limits for alachlor, cyanazine, and metolachlor from the U.S. Geological Survey National Water Quality Laboratory.

Table 19.—Detection rates for nitrate from the National Alachlor Well Water Survey and the Maryland ground-water-quality network

[<, less than; >, greater than. Source: Holden and others (1992)]

	National Alachlor Well Water Survey	Maryland ground-water-quality network	
Nitrate concentration* (mg/L as N)	Estimated percentage of wells	Number of analyses	Detection percentage
<0.1	47.7%	16	31%
0.1-3	28.7	17	33
3-10	18.7	11	21
>10	4.9	8	15

* Nitrate concentration includes nitrate-plus-nitrite for both networks

Pesticide detection data from the Illinois pilot study and the Maryland network are given in table 20. As with the NPS, DCPA metabolites had the highest detection rate of all analytes in the Illinois study; these were not analyzed for in the Maryland network. Of the pesticides that were routinely tested in both studies, atrazine had the highest detection rate in the Illinois study and the Maryland network. The atrazine detection rate was higher in the Illinois pilot study than in the NPS or NAWWS in part probably because 60% of the wells in the Illinois survey were less than 50 feet deep; the other surveys had a larger proportion of deeper wells. Alachlor and metolachlor were not detected in wells from the Illinois pilot study, nor were metribuzin or simazine detected in samples from the Maryland network at levels above the minimum reporting limits of the Illinois pilot survey.

Nitrate concentrations exceeded 10 mg/L in comparable proportions of sites in both studies. Wells in the Illinois pilot study that were less than 50 feet deep had a higher percentage of nitrate concentrations >10 mg/L than wells deeper than 50 feet. In the Maryland network, 7 of 29 sites less than 50 feet deep (including springs) had median nitrate concentrations >10 mg/L; only one of 23 wells greater than 50 feet deep exceeded 10 mg/L nitrate. The detection rate for nitrate concentrations between 0.03 mg/L and 10 mg/L was not reported for the Illinois pilot study.

DELMARVA PENINSULA STUDIES

Ground-water quality of the Delmarva Peninsula of Delaware, Maryland, and Virginia has been studied extensively by the USGS and state and county agencies. Approximately half of the land use on the peninsula is agricultural, and the impact of this activity on ground-water quality has been documented in several studies (Bachman, 1984b; Denver, 1986, 1989; Hamilton, Shedlock, and Phillips, 1989; Hamilton and others, 1993; Koterba, Banks, and Shedlock, 1993).

Summary nitrate data from two water-quality assessments of the Delmarva Peninsula are given in table 21, along with data from the Maryland network. The Delmarva Peninsula "pre-1987" data in table 21 were compiled during a retrospective ground-water-quality assessment of the entire Delmarva Peninsula (Hamilton, Shedlock, and Phillips, 1989). These data were evaluated as part of the pilot National Water-Quality Assessment (NAWQA) study of the Delmarva Peninsula. Available nitrate data through 1987 were compiled for 3,730 wells obtained from five national, state, and county data bases. Data from wells in both unconfined and confined aquifers were included. The second Delmarva Peninsula data set ("NAWQA data" in tab. 21) represents nitrate values collected in 1988 through 1990 during the pilot NAWQA study. These data are derived from 64 wells in an areal network and 39 wells in a transect network as described in Hamilton and others (1993). Unlike the pre-1987 data, all the NAWQA data are from wells completed in the surficial aquifer. Seven of the NAWQA sites are also part of the Maryland ground-water-quality network; data from these sites are included in both data sets. The percentage of nitrate concentrations ≤3 mg/L in the pre-1987 assessment and the Maryland network data (62% and 63%, respectively) are higher than the percentage from the NAWQA data (47%). The lower percentage for the NAWQA data probably reflects the higher percentage of agricultural land, and the inclusion of domestic wells in the samples. The proportion of samples with nitrate concentrations >10 mg/L was lower for the pre-1987 assessment (7%) than from either the NAWQA data or the Maryland network data (both about 15%). The lower percentage of samples exceeding 10 mg/L in the pre-

Table 20.—Detection rates for nitrate and pesticides from the Illinois State Agricultural-Chemicals Pilot Study (IACPS) and the Maryland ground-water-quality network.

[Table includes only those pesticides that were routinely analyzed in both studies and that were detected in either one or both studies. Detections from the Maryland network whose concentrations were below IACPS minimum reporting limits are not included. See text for additional information. <, less than; >, greater than. Source: Schock and others, 1992]

		IACPS wells		Maryland ground-water-quality network sites with analyte detections greater than IACPS minimum reporting limits	
Analyte	IACPS minimum reporting limits	Detection percentage	Number of detections/number analyzed	Detection percentage	Number of detections/number analyzed
Alachlor	0.75 μg/L	0%	0/240	3%	1/38
Atrazine	0.15 μg/L	4.6	11/240	11	4/38
Metolachlor	0.75 μg/L	0	0/240	3	1/38
Metribuzin	0.40 μg/L	<1	2/240	0	0/38
Simazine	0.15 μg/L	<1	2/240	0	0/38
Nitrate* > 10 mg/L as N		17.5	42/240	15	8/52

*Nitrate concentrations include nitrate-plus-nitrite for both studies

Table 21.—Detection rates for nitrate from Delmarva Peninsula studies and the Maryland ground-water-quality network

[<, less than; >, greater than. Sources: Hamilton, Shedlock, and Phillips (1989) and Hamilton and others (1993)]

	Delmarva Peninsula				Maryland ground-water-quality network	
	Pre-1987 data		NAWQA data			
Nitrate* (mg/L as N)	Number of analyses	Detection percentage‡	Number of analyses	Detection percentage‡	Number of analyses	Detection percentage‡
<0.2	1088	29%	34	33%	18	35%
0.2-3.0	1239	33	14	14	15	29
>3.0-10	1126	30	40	39	11	21
>10	277	7	15	15	8	15
Total number	3730	100	103	100	52	100

* Nitrate concentration includes nitrate-plus-nitrite for all studies
‡ Class percentages do not add to 100% due to rounding errors

1987 data relative to the NAWQA data and the Maryland network data probably reflects the influence of samples from the confined aquifers. In each of the three data sets, however, the order of the proportion of nitrate samples is the same: the <3 mg/L grouping contains the largest proportion of samples, followed by the 3-10 mg/L grouping; the >10 mg/L grouping contains the smallest percentage of samples.

Pesticide detection data from the NAWQA wells and several additional wells in the deeper aquifers of the Delmarva Peninsula were evaluated by Koterba, Banks, and Shedlock (1993). Atrazine was the most frequently detected analyte, followed by cyanazine, simazine, alachlor, and dicamba.

NETWORK WATER-QUALITY DATA IN RELATION TO DRINKING-WATER REGULATIONS AND HEALTH ADVISORIES

The U.S. EPA has established drinking-water regulations and health advisories for selected inorganic, organic, radionuclide, and microbiological contaminants. Data from the Maryland ground-water-quality network are reviewed with respect to three categories of regulations and advisories: Maximum Contaminant Levels (MCLs), Drinking Water Equivalent Levels (DWELs), and Secondary Maximum Contaminant Levels (SMCLs). An MCL is the maximum permissible level of a contaminant in water which is delivered to any user of a public water system. A DWEL is a lifetime exposure concentration protective of adverse, non-cancerous health effects that assumes all of the exposure to a contaminant is from a drinking-water source. An SMCL is a non-enforceable level of a contaminant at which the taste, odor, color, or other aesthetic quality of drinking water may be adversely affected (U.S. Environmental Protection Agency, 1992). In the following discussion, MCLs, DWELs, and SMCLs are compared to the concentrations of dissolved (filtered) constituents in network samples. Several of the parameters with high exceedance rates from network samples are discussed elsewhere in this report.

INORGANIC CONTAMINANTS

MCLs and/or DWELs have been established for 20 of the inorganic constituents and one radionuclide (radon) that were routinely analyzed in network samples. Table 22 summarizes the water-quality data from the network sites with respect to the MCLs and DWELs for these parameters. Ten of the 52 network sites had at least one sample that exceeded the final MCL of 10 mg/L for nitrate-plus-nitrite. One site exceeded the proposed MCL of 0.001 mg/L for beryllium. Nineteen of 35 sites sampled for radon exceeded the proposed MCL of 300 pCi/L. No other MCLs were exceeded in samples from the network sites. Samples from ten sites exceeded the Guidance DWEL for sodium (20 mg/L); no other DWELs were exceeded by samples taken from network sites.

SMCLs have been established for eleven of the constituents that were routinely analyzed in network samples (tab. 23). Over half of the sites had samples with pH values below the acceptable pH range. This reflects the relatively acidic nature of shallow ground water in many areas of Maryland, especially the Piedmont and the Coastal Plain. Dissolved iron and manganese were above the SMCL in 29% and 37%, respectively, of network sites. Samples from three of the four wells in confined aquifers exceeded the SMCL for iron. Samples from four sites exceeded the SMCL for color; two of these sites (WO Bh 84 and HA Dd 92) also had high iron and low dissolved-oxygen concentrations, and the high color-unit values may be due to precipitation of ferric hydroxide upon exposure to the atmosphere. The two samples with dissolved-aluminum concentrations >200 µg/L have pH's at or below 5.0; at higher pH values, aluminum is very insoluble (Drever, 1982). Well PG Bc 37 had TDS >500 mg/L, resulting from high sodium and chloride concentrations.

ORGANIC CONTAMINANTS

Sixty-nine of the organic compounds that were analyzed in samples from network sites have either an established MCL, DWEL, or both. Table 24 summarizes the organic-compound water-quality data from network sites with respect to MCLs and DWELs. Sixteen of these compounds were detected. One site had an atrazine detection that exceeded the MCL of 3.0 µg/L; all other detections of organic compounds were at or below the established MCLs and DWELs.

Table 22.—Maryland ground-water-quality network data with respect to U.S. Environmental Protection Agency Maximum Contaminant Levels (MCLs) and Drinking Water Equivalent Levels (DWELs) for inorganic analytes

[Table includes analytes that have an established MCL or DWEL and that were routinely analyzed in network samples. F, final; P, proposed; D, draft; L, listed for regulation; R, under review; TT, treatment technique; -, none proposed. Source: U.S. Environmental Protection Agency (1992)]

		Maximum Contaminant Levels				Drinking Water Equivalent Levels			
Parameter	Number of sites tested	Status	MCL	Number of sites >MCL*	Percent of sites >MCL	Status	DWEL	Number of sites >DWEL*	Percent of sites >DWEL
Antimony	10	P	6 µg/L	0	0	F	15 µg/L	0	0
Arsenic	51	R	50 µg/L	0	0	D	-	-	-
Barium	52	F	2 mg/L	0	0	F	2 mg/L	0	0
Beryllium	52	P	1 µg/L	1	2	D	200 µg/L	0	0
Boron	10	L	-	-	-	D	3 mg/L	0	0
Cadmium	52	F	5 µg/L	0	0**	F	20 µg/L	0	0
Chromium (total)	51	F	100 µg/L	0	0	F	200 µg/L	0	0
Copper	52	F	TT†	0	0	-	-	-	-
Fluoride	52	F	4 mg/L	0	0	-	-	-	-
Lead (at tap)	52	F	TT††	0	0	-	-	-	-
Mercury (inorganic)	47	F	2 µg/L	0	0	F	10 µg/L	0	0
Molybdenum	52	L	-	-	-	F	200 µg/L	0	0
Nickel	52	P	100 µg/L	0	0	F	600 µg/L	0	0
Nitrate plus nitrite (both as N)‡‡	52	F	10 mg/L (as N)	10	19	F	-	-	-
Selenium	51	F	50 µg/L	0	0	-	-	-	-
Sodium	52	-	-	-	-	D	20 mg/L‡	10	19
Strontium	11	L	-	-	-	D	90 mg/L	0	0
Sulfate	52	P	400/500 mg/L	0	0	-	-	-	-
Vanadium	52	L	-	-	-	D	110 µg/L	0	0
Zinc	52	L	-	-	-	F	11 mg/L	0	0
Radon	35	P	300 pCi/L	19	54	-	-	-	-

* Number of sites with at least one sample greater than the indicated MCL or DWEL for the dissolved concentration of analyte, except as noted.
** One sample was reported as <10 µg/L
† Copper action level=1.3 mg/L
†† Lead action level=15 µg/L
‡ Guidance
‡‡ Network sites were analyzed for total nitrate-plus-nitrite (as N)

Table 23.—Maryland ground-water-quality network data with respect to U.S. Environmental Protection Agency final Secondary Maximum Contaminant Levels (SMCLs)

[Table includes analytes that have an established final SMCL that were routinely analyzed in network samples. Source: U.S. Environmental Protection Agency (1992)]

Parameter	SMCL	Number of sites tested	Number of sites >SMCL*	Percent of sites >SMCL
Aluminum	50-200 μg/L	52	2†	4
Chloride	250 mg/L	52	1	2
Color	15 color units	51	4	8
Copper	1 mg/L	52	0	0
Fluoride††	2 mg/L	52	0	0
Iron	300 μg/L	52	15	29
Manganese	50 μg/L	52	19	37
pH	6.5-8.5	52	30‡	58
Sulfate	250 mg/L	52	0	0
Total dissolved solids	500 mg/L	52	1	2
Zinc	5 mg/L	52	0	0

* Number of sites with at least one sample greater than the indicated SMCL for the dissolved concentration of analytes

† Number of sites with aluminum >200 μg/L

†† Under review

‡ Number of sites with pH<6.5

Table 24.—Maryland ground-water-quality network data with respect to U.S. Environmental Protection Agency Maximum Contaminant Levels (MCLs) and Drinking Water Equivalent Levels (DWELs) for organic analytes

[Table includes analytes that have an established MCL or DWEL that were routinely analyzed in network samples. Some minimum reporting levels differ between samples for the same analytes. Status classifications: F. final: P. proposed; L. listed for regulation; -, none proposed. Source: U.S. Environmental Protection Agency (1992)]

			Maximum Contaminant Levels				Drinking Water Equivalent Levels			
Parameter	Number of sites tested	Number of sites with detections	Status	MCL (mg/L)	Number of sites >MCL†	Percent of sites >MCL	Status	DWEL (mg/L)	Number of sites >DWEL†	Percent of sites >DWEL
Alachlor	38	2	F	0.002	0	0	F	0.4	0	0
Aldrin	25	0	-	-	-	-	D	0.001	0	0
Ametryn	38	0	-	-	-	-	F	0.3	0	0
Atrazine	38	9	F	0.003	1	3	F	0.2	0	0
Benzene	17	0	F	0.005	0	0	F	-	-	-
Bromacil	9	0	L	-	-	-	F	5	0	0
Bromodichloromethane	36	0	L	0.1	0	0	D	0.7	0	0
Bromoform	36	0	L	0.1	0	0	D	0.7	0	0
Butylate	9	0	-	-	-	-	F	2	0	0
Carbaryl (sevin)	8	0	-	-	-	-	F	4	0	0
Carbon tetrachloride	36	0	F	0.005	0	0	F	0.03	0	0
Carboxin	9	0	-	-	-	-	F	4	0	0
Chlordane	25	0	F	0.002	0	0	F	0.002	0	0
Chlorodibromomethane	36	0	L	0.1	0	0	D	0.7	0	0
Chloroform	36	3	L	0.1	0	0	D	0.4	0	0
Chlorotoluene o-	12	0	L	-	-	-	F	0.7	0	0
Chlorotoluene p-	12	0	L	-	-	-	F	0.7	0	0
Cyanazine	38	2	L	-	-	-	F	0.07	0	0
2,4-D	36	1	F	0.07	0	0	F	0.4	0	0

Table 24.—Maryland ground-water-quality network data with respect to U.S. Environmental Protection Agency Maximum Contaminant Levels (MCLs) and Drinking Water Equivalent Levels (DWELs) for oranic analytes-Continued

Parameter	Number of sites tested	Number of sites with detections	Maximum Contaminant Levels				Drinking Water Equivalent Levels			
			Status	MCL (mg/L)	Number of sites >MCL†	Percent of sites >MCL	Status	DWEL (mg/L)	Number of sites >DWEL†	Percent of sites >DWEL
Diazinon	36	0	-	-	-	-	F	0.003	0	0
Dicamba	7	1	L	-	-	-	F	1	0	0
Dichlorobenzene o-	36	0	F	0.6	0	0	F	3	0	0
Dichlorobenzene m-	36	0	F	0.6	0	0	F	3	0	0
Dichlorobenzene p-	36	0	F	0.075	0	0	F	4	0	0
Dichlorodifluoromethane	36	1	L	-	-	-	F	5	0	0
Dichloroethane (1,2-)	36	0	F	0.005	0	0	F	-	-	-
Dichloroethylene (1,1-)	36	0	F	0.007	0	0	F	0.4	0	0
Dichloroethylene (cis-1,2-)	9	0	F	0.07	0	0	F	0.4	0	0
Dichloroethylene (trans-1,2-)	29	0	F	0.1	0	0	F	0.6	0	0
Dichloromethane (methylene chloride)	36	2	P	0.005	0	0	F	2	0	0
Dichloropropane (1,2-)	36	0	F	0.005	0	0	F	-	-	-
Dichloropropene (1,3-)	22	0	L	-	-	-	F	0.01	0	0
Dieldrin	25	1	-	-	-	-	F	0.002	0	0
Diphenamid	9	0	-	-	-	-	F	1	0	0
Endrin	25	0	P	0.002	0	0	F	0.01	0	0
Ethylbenzene	36	0	F	0.7	0	0	F	3	0	0
Fluorotrichloromethane	36	0	L	-	-	-	F	10	0	0
Heptachlor	25	0	F	0.0004	0	0	F	0.02	0	0
Heptachlor epoxide	25	0	F	0.0002	0	0	F	0.0004	0	0
Hexachlorobutadiene	9	0	L	-	-	-	F	0.07	0	0

Table 24.—Maryland ground-water-quality network data with respect to U.S. Environmental Protection Agency Maximum Contaminant Levels (MCLs) and Drinking Water Equivalent Levels (DWELs) for organic analytes-Continued

Parameter	Number of sites tested	Number of sites with detections	Maximum Contaminant Levels				Drinking Water Equivalent Levels			
			Status	MCL (mg/L)	Number of sites >MCL†	Percent of sites >MCL	Status	DWEL (mg/L)	Number of sites >DWEL†	Percent of sites >DWEL
Hexazinone	9	0	-	-	-	-	F	1	0	0
Lindane	25	1	F	0.0002	0	0	F	0.01	0	0
Malathion	25	0	-	-	-	-	D	0.8	0	0
Methoxychlor	25	0	F	0.04	0	0	F	0.2	0	0
Methyl parathion	25	0	-	-	-	-	F	0.009	0	0
Metolachlor	38	2	L	-	-	-	F	5	0	0
Metribuzin	38	0	L	-	-	-	F	0.9	0	0
Naphthalene	9	0	-	-	-	-	F	0.1	0	0
Picloram	7	0	P	0.5	0	0	F	2	0	0
Polychlorinated biphenyls (PCBs)	25	0	F	0.0005	0	0	P	-	-	-
Prometon	38	1	L	-	-	-	F	0.5*	0	0
Propachlor	9	0	-	-	-	-	F	0.5	0	0
Propazine	38	1	-	-	-	-	F	0.7	0	0
Sevin (see Carbaryl)	-	-	-	-	-	-	-	-	-	-
Simazine	38	2	P	0.004	0	0	F	0.2	0	0
Styrene	36	0	F	0.1	0	0	F	7	0	0
2,4,5-T	36	0	L	-	-	-	F	0.35	0	0
Terbacil	9	0	-	-	-	-	F	0.4	0	0
Tetrachloroethane (1,1,1,2-)	12	0	L	-	-	-	F	1	0	0
Tetrachloroethylene	36	0	F	0.005	0	0	F	0.5	0	0
Toluene	36	0	F	1	0	0	F	7	0	0

Table 24.—Maryland ground-water-quality network data with respect to U.S. Environmental Protection Agency Maximum Contaminant Levels (MCLs) and Drinking Water Equivalent Levels (DWELs) for organic analytes-Continued

			Maximum Contaminant Levels				Drinking Water Equivalent Levels			
Parameter	Number of sites tested	Number of sites with detections	Status	MCL (mg/L)	Number of sites >MCL†	Percent of sites >MCL	Status	DWEL (mg/L)	Number of sites >DWEL†	Percent of sites >DWEL
Toxaphene	25	0	F	0.003	0	0	F	0.0035	0	0
Trichlorobenzene (1,2,4-)	9	0	P	0.07	0	0	F	0.4	0	0
Trichloroethane (1,1,1-)	36	0	F	0.2	0	0	F	1	0	0
Trichloroethane (1,1,2-)	36	0	P	0.005	0	0	F	0.1	0	0
Trichloroethylene	36	1	F	0.005	0	0	F	0.3	0	0
Trichloropropane (1,2,3-)	16	0	L	-	-	-	F	0.2	0	0
Trifluralin	38	0	L	-	-	-	F	0.3	0	0
Vinyl chloride	36	1	F	0.002	0	0	F	-	-	-
Xylenes	36	0	F	10	0	0	F	60	0	0

* Under review

† Number of sites with at least one sample greater than the indicated MCL or DWEL

SUMMARY AND CONCLUSIONS

A statewide network of wells and springs was established to document ground-water-quality conditions in unconfined (water-table) aquifers in Maryland. Forty-two wells and ten springs were sampled between 1987 and 1992. In addition to sites in unconfined aquifers, four wells are completed in confined aquifers in areas where salt-water intrusion may pose a problem, or where the unconfined aquifer is not an important source of ground water. Sites were sampled in all of Maryland's physiographic provinces (Appalachian Plateau, Valley and Ridge, Blue Ridge, Piedmont, and Coastal Plain).

All sites were tested for major ions, nutrients, trace elements, and field parameters. Most sites were sampled for one or more schedules of pesticides, including chlorophenoxy herbicides, organochlorine and organophosphorus insecticides, triazine herbicides, and other pesticides, and also for a suite of volatile organic compounds. Seasonal samples were taken from several sites to investigate temporal changes in shallow ground-water quality. All samples were analyzed by the USGS NWQL.

Thirteen sites (nine wells and four springs) were sampled in the Appalachian Plateau and Valley and Ridge physiographic provinces. Samples from the consolidated clastic aquifers were calcium-bicarbonate waters, with relatively high TDS and pH values near neutrality, which reflect the amount of calcium carbonate in the aquifers. Samples from the carbonate aquifers in the Hagerstown Valley were also calcium-bicarbonate waters, and tended to be closer to calcite saturation than the samples in the consolidated clastic aquifers. Cation and silica concentrations and pH values suggest that kaolinite is the stable silicate mineral phase for all sites in carbonate, crystalline, and most unconsolidated and consolidated clastic aquifers.

Fifteen sites (nine wells and six springs) were sampled in the Piedmont and Blue Ridge physiographic provinces. Eleven sites are in non-carbonate crystalline-rock aquifers (including one well completed in saprolite), two are in Triassic (consolidated clastic) aquifers, and two are in carbonate aquifers (one in limestone, one in marble). Samples were enriched in calcium relative to other cations, or had a mixed-cation type. Anion composition was mixed. Samples from non-carbonate crystalline aquifers were lower in TDS and pH than samples from consolidated clastic or carbonate aquifers. Samples from the carbonate and consolidated clastic aquifers had calcium-bicarbonate or calcium-magnesium-bicarbonate waters, and were at or near saturation with respect to calcite.

Ten wells were sampled in the Western Shore Coastal Plain, including one well completed in a confined aquifer. Samples tended to be enriched in sodium and calcium relative to magnesium; iron was the dominant cation at one site. Bicarbonate was the major anion at four of the sites; chloride or sulfate was the major ion at the other sites. Samples from nine of the 10 sites had soft to moderately hard water.

Fourteen wells were sampled in the Eastern Shore Coastal Plain, including three wells completed in confined aquifers. Major-ion composition was variable. The low median pH and hardness values seen in samples from these wells reflect the low reactivity of the aquifer minerals (predominantly quartz and feldspars). Samples from two of the confined wells were anoxic (defined in this report as <1 mg/L dissolved oxygen), had near-neutral pH's, and had no detectable nitrate; the third confined-aquifer well exhibited water quality similar to samples from wells in unconfined aquifers (low pH, oxic water, and nitrate as the dominant nitrogen species).

There was little variation in the major-ion chemistry of most of the sites that were sampled seasonally. However, the sampling frequency may have been insufficient to detect trends.

Factors affecting the distribution of nitrate, chloride, iron, and radon are discussed. Overall median nitrate from sites downgradient from cropland was 9 mg/L, compared to 0.11 mg/L for sites downgradient from forested land. Nitrate concentrations tended to be lower in wells with deeper completion intervals but varied widely for springs and wells with shallow completion intervals; there was no consistent relationship between nitrate concentrations and well depth. Most wells with ammonia concentrations >0.1 mg/L had no detectable nitrate; conversely, most wells with detectable nitrate (>0.1 mg/L) had little or no detectable ammonia. One well with significant amounts of both nitrate and ammonia is thought to be influenced by septic contamination near the well. Evaluation of the effects of septic contamination on other water-quality analytes for all network sites was not possible because of the small number of sites near septic systems. Nitrate concentrations varied greatly in samples with <100 µg/L dissolved iron, whereas nitrate concentrations were close to detection level for samples with iron concentrations >300 µg/L. Most samples with no detectable nitrate were anoxic, while oxic samples had a wide range of nitrate.

Most Maryland network sites with more than 20 mg/L chloride are within 100 feet of a paved road, although not all such sites had high chloride concentrations. Many of these sites are also downgradient from agricultural areas, and may be showing the effect of potassium chloride fertilizers. Springs and shallow wells had a wide range of chloride concentrations; lower concentrations were seen in wells with open intervals greater than 60 feet deep.

Iron concentrations varied greatly among network sites; most sites had <20 µg/L dissolved iron. Wells and springs in crystalline and carbonate aquifers had low iron concentrations probably due to high dissolved-oxygen levels. Iron concentrations varied widely in unconsolidated and consolidated clastic aquifers; most samples with high iron concentrations (>100 µg/L) were anoxic. Speciation calculations suggest that Fe^{2+} is the major dissolved iron species in anoxic aquifers, while $Fe(OH)_2^+$ or $Fe(OH)_3$ (aqueous) were the dominant species in

oxic samples. Some of the dissolved-iron concentrations in oxic samples may be due to colloidal iron passing the 0.45μ filter.

Radon samples were obtained from 35 network sites. Samples from network sites in crystalline-rock aquifers tended to have higher radon concentrations than samples from other lithologies. All network sites with >2,000 pCi/L radon are in crystalline-rock aquifers. There was considerable overlap in radon values from network sites in carbonate, and consolidated and unconsolidated clastic aquifers. Radon concentrations showed a wider range in samples from the Western Shore than the Eastern Shore Coastal Plain, which probably reflects the greater lithologic variability among aquifers sampled on the Western Shore.

Forty sites were sampled for one or more schedules of pesticides; 15 different pesticides were detected, although not all schedules were tested at each of the 40 sites. Pesticide data are not conclusive because of limited sampling, the length of time over which sampling occurred, and other factors. Many of the detections were at or near detection levels. Atrazine was the most frequently detected pesticide. Pesticide detections appear to be more closely linked to land use than to aquifer lithology. Limited data on the triazine metabolites de-ethyl atrazine and de-isopropyl atrazine suggest that pesticide metabolites may comprise a significant portion of synthetic organic chemicals in shallow ground water. Samples were not tested for several widely used pesticides in Maryland, including linuron, chlorpyrifos, glyphosate, and pendimethalin.

Network data were compared to pesticide and nitrate data from the National Pesticide Survey, the National Alachlor Well Water Survey, the Illinois State Agricultural-Chemicals Pilot Study, and two Delmarva Peninsula studies. The comparisons are not definitive because the other studies had more rigorous designs and larger sample sizes than the Maryland network, and the analytes differed from study to study. Data were compared for analytes in common between the Maryland network and the other studies. For the pesticides in common, atrazine was the most frequently detected pesticide in the Maryland network, the National Pesticide Survey, the National Alachlor Well Water Survey, and the Illinois Agricultural-Chemicals Pilot Study. The detection rate was higher in the Maryland network than in the other studies; this is probably due partly to the higher percentage of unconfined aquifers and shallower wells tested in the Maryland network. The percentages of nitrate detections at specified concentrations were higher in the Maryland network than the National Pesticide Survey and the National Alachlor Well Water Survey. The percentage of samples with nitrate concentrations >10 mg/L in the Illinois State Agricultural-Chemicals Pilot Study was similar to that of the Maryland network. Nitrate concentrations from two data sets from the Delmarva Peninsula were compared to the Maryland network data. Differences in the percent of nitrate detections at specified nitrate concentrations probably reflect the influence of aquifer type (confined or unconfined), specified well population, and land use for each data set.

Drinking-water regulations and health advisories have been established for many of the analytes tested at network sites. Ten of the 52 sites had at least one nitrate sample exceeding the MCL of 10 mg/L. Nineteen of 35 sites exceeded radon's proposed MCL of 300 pCi/L. One sample exceeded the proposed MCL for beryllium. Over half the sites had pH values outside the 6.5-8.5 pH range (the secondary MCL for pH). Twenty-nine percent and 37% of sites exceeded the secondary MCL for iron (300 μg/L) and manganese (50 μg/L), respectively. Only one site had a pesticide concentration greater than an MCL (atrazine); no other MCLs were exceeded for synthetic organic compounds.

The data presented in this report are insufficient to address many specific issues; for example, the results are not directly applicable to private water wells, most of which are deeper and closer to septic systems than most network sites. The data have identified some water-quality trends, and will provide a basis for long-term monitoring of ground-water quality at network sites.

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APPENDICES

APPENDIX A.
WATER-QUALITY DATA FROM NETWORK SITES

1. The data are organized by segments corresponding to groupings of physiographic provinces:

   Segment I: Appalachian Plateau and Valley and Ridge physiographic provinces
   Segment II: Piedmont and Blue Ridge physiographic provinces
   Segment III: Western Shore Coastal Plain
   Segment IV: Eastern Shore Coastal Plain

2. Some of the network sites have been sampled by other projects, and all the data are not included. Some sites have extensive monthly data for pH, specific conductance, and nutrients. The additional data are presented and discussed more completely in reports for those projects, and are referenced in the report.

3. Most of the network sites were analyzed for total, rather than dissolved (filtered) nitrogen and phosphorus species. Because of the way data are reported from the U.S. Geological Survey National Water Quality Laboratory, these values are not included in the total-dissolved-solids (TDS) column. Samples with significant nitrate concentrations may have anomalously low TDS values compared to residue-upon-evaporation and specific conductance values. In the report, nitrate concentrations have been added to the laboratory-reported TDS values to give a more accurate value of total dissolved solids.

4. Tables A3, A9, A15, and A21 (Schedule 1304 analyses) also contain data for the pesticides Sevin, Picloram, and Dicamba. These are technically not included in Schedule 1304, but are included in these tables because several samples were analyzed for these additional compounds.

Table A1.—Major ions, nutrients, field parameters, and other chemical-quality data from wells and springs in Segment I

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Site type	Record number	Date	Time	Water level (feet below land surface)	Discharge (gal/min)	Specific conductance (µS/cm)	pH	Temperature, air (deg. C)	Temperature, water (deg. C)	Color, (platinum-cobalt units)
AL Ae 36	Well	99101025	08-27-91	1120	--	2.7	572	7.2	26.5	13.5	1
		99200695	07-28-92	1545	--	5.0	610	7.6	27.0	13.5	1
AL Ai 26	Well	99101028	08-27-91	1735	--	5.0	190	6.6	26.0	13.0	1
		99200696	07-28-92	1200	--	10	192	6.8	23.5	12.5	1
AL Cb 8	Well	99100947	07-09-91	1137	--	2.0	386	7.6	21.0	10.0	3
		99200671	07-08-92	1035	46.40	1.0	406	7.1	20.5	11.0	<1
AL Ce 4	Spring	99001090	09-26-90	1010	--	30	184	7.5	17.0	13.0	<1
		99100164	12-11-90	1545	--	34	186	7.6	7.5	12.5	1
		99100359	03-18-91	1315	--	40	187	7.5	12.0	12.5	2
		99100814	06-12-91	1725	--	20	185	7.6	28.5	13.0	--
		99200669	07-06-92	1210	--	33	197	7.6	25.0	13.5	<1
GA Ae 50	Well	99100810	06-11-91	1612	--	6.0	753	7.0	25.5	12.5	4
GA Ba 1	Well	99100812	06-12-91	1115	--	5.3	382	6.7	21.5	13.0	5
		99200753	08-31-92	1530	--	--	335	6.7	23.0	13.5	2
GA Da 17	Well	99100828	06-18-91	1126	--	4.3	118	6.2	20.0	10.0	2
		99200670	07-07-92	1605	75.00	2.0	133	6.4	22.5	11.5	13
GA Eb 72	Spring	97801015	08-09-78	1545	--	25	25	6.9	--	8.5	5
		99001088	09-25-90	1325	--	20	52	4.9	18.0	10.0	2
		99100163	12-11-90	0900	--	27	45	5.4	-0.5	10.0	1
		99100360	03-18-91	1720	--	60	53	5.1	6.5	9.5	1
		99100813	06-12-91	1340	--	19	52	5.0	22.0	9.0	--
		99200668	07-06-92	1515	--	19	55	5.1	21.0	9.0	<1
WA Ab 3	Spring	99001091	09-27-90	1225	--	1.5	40	6.5	17.5	14.5	<1
		99100165	12-12-90	1135	--	3.5	51	6.3	3.5	11.0	1
		99100361	03-19-91	1205	--	6.0	49	6.0	8.5	9.0	1
		99100826	06-17-91	1518	--	0.5	45	5.8	29.5	13.5	1
		99200697	07-28-92	0940	--	8.0	57	5.4	19.5	13.0	<1
WA Ad 101	Well	99101026	08-26-91	1415	33.90	5.0	195	7.5	28.5	13.5	<1
		99200699	07-27-92	1300	29.40	4.3	200	7.3	22.5	13.5	1
WA Ah 63	Well	99100915	07-08-91	1616	17.60	0.8	592	7.3	30.5	13.0	1
		99200698	07-27-92	1610	6.50	0.8	774	7.1	25.0	12.5	<1
WA Ak 99	Well	99100815	06-13-91	1606	--	2.0	662	7.2	26.0	12.5	2
		99200700	07-27-92	1015	--	1.0	794	7.1	24.5	14.5	1
WA Di 103	Spring	99100001	10-04-90	1210	--	3.0	563	7.3	18.5	12.5	<1
		99100166	12-12-90	1445	--	15	557	7.2	14.0	12.5	1
		99100362	03-19-91	1505	--	12	508	7.1	9.5	12.5	2
		99100825	06-17-91	1150	--	3.5	512	7.3	26.0	13.5	2
		99200667	07-08-92	1400	--	7.5	551	7.3	29.0	12.5	<1

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Dissolved oxygen (mg/L)	Hardness, total (mg/L as $CaCO_3$	Calcium, dissolved (mg/L)	Magne-sium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Bicar-bonate, total (mg/L)	Alka-linity, total (mg/L as $CaCO_3$)
AL Ae 36	08-27-91	0.1	290	93	13	17	0.90	281	230
	07-28-92	0.1	280	89	13	16	0.90	278	228
AL Ai 26	08-27-91	0.2	78	15	9.8	7.8	0.60	126	103
	07-28-92	0.9	72	14	8.9	7.9	0.60	115	94
AL Cb 8	07-09-91	2.6	220	60	18	0.70	1.6	250	207
	07-08-92	2.9	220	58	18	0.80	1.6	217	178
AL Ce 4	09-26-90	--	99	35	2.7	1.8	0.80	106	87
	12-11-90	8.4	96	34	2.6	1.8	0.80	104	85
	03-18-91	7.2	96	34	2.6	1.8	0.70	105	86
	06-12-91	8.8	--	34	--	--	0.70	110	90
	07-06-92	8.0	93	33	2.6	1.8	0.70	105	86
GA Ae 50	06-11-91	--	370	100	29	20	2.7	244	200
GA Ba 1	06-12-91	3.5	170	49	11	7.1	1.1	96	79
	08-31-92	2.3	130	40	8.1	6.0	1.1	94	77
GA Da 17	06-18-91	0.1	46	10	5.2	0.90	1.2	48	39
	07-07-92	0.2	46	9.7	5.4	0.70	1.3	56	46
GA Eb 72	08-09-78	--	11	2.6	1.2	0.80	1.0	--	--
	09-25-90	--	14	3.6	1.2	1.7	1.0	4	3
	12-11-90	9.5	13	3.4	1.2	1.5	1.0	2	2
	03-18-91	9.9	15	3.8	1.3	1.5	1.0	1	1
	06-12-91	9.5	--	3.7	--	--	0.90	2	2
	07-06-92	9.7	15	3.8	1.4	1.8	1.0	1	1
WA Ab 3	09-27-90	--	13	3.0	1.3	1.9	1.2	7	6
	12-12-90	9.1	15	3.5	1.6	1.8	1.6	5	4
	03-19-91	10.1	15	3.4	1.5	1.6	1.3	3	3
	06-17-91	9.6	13	3.0	1.4	1.8	1.2	7	6
	07-28-92	8.4	18	4.0	1.9	1.9	1.4	6	5
WA Ad 101	08-26-91	--	93	28	5.5	7.5	0.80	120	98
	07-27-92	1.4	86	25	5.8	7.0	0.90	106	87
WA Ah 63	07-08-91	4.8	300	100	11	9.8	5.1	263	216
	07-27-92	6.6	380	130	14	13	4.4	289	237
WA Ak 99	06-13-91	6.8	350	92	30	16	2.8	326	267
	07-27-92	6.9	360	97	29	16	2.7	324	266
WA Di 103	10-04-90	--	280	74	24	11	2.3	263	216
	12-12-90	5.8	300	77	27	5.9	2.0	267	219
	03-19-91	5.7	270	69	24	4.9	1.8	246	201
	06-17-91	6.6	270	69	24	7.9	2.1	250	205
	07-08-92	6.8	270	70	23	5.9	2.1	240	197

Table A1.—Major ions, nutrients, field parameters, and other chemical-quality data from wells and springs in Segment I—Continued

(µS/cm, microsiemens per centimeter at 25 deg. C.; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L as SiO_2)	Solids, residue on evaporation, dissolved (mg/L)	Solids, sum of dissolved constituents (mg/L)	Nitrite, total (mg/L as N)	Nitrate plus nitrite, total (mg/L as N)
AL Ae 36	08-27-91	61	33	0.10	17	386	376	<0.010	<0.050
	07-28-92	58	32	<0.10	17	364	364	<0.010	<0.050
AL Ai 26	08-27-91	3.2	1.0	0.10	24	104	129	0.010	0.079
	07-28-92	2.6	0.70	0.10	23	120	118	<0.010	<0.050
AL Cb 8	07-09-91	13	0.20	0.10	5.9	217	223	<0.010	<0.050
	07-08-92	15	4.3	0.10	6.3	206	211	<0.010	0.051
AL Ce 4	09-26-90	10	0.10	<0.10	11	103	114	<0.010	0.100
	12-11-90	12	<0.10	0.20	11	122	--	<0.010	0.100
	03-18-91	11	1.4	<0.10	10	106	113	0.010	0.140
	06-12-91	11	--	0.10	--	--	--	<0.010	0.110
	07-06-92	10	<0.10	<0.10	11	106	--	<0.010	0.120
GA Ae 50	06-11-91	22	100	0.10	5.3	485	399	0.150	12.0
GA Ba 1	06-12-91	5.8	73	0.30	7.4	213	205	<0.010	<0.050
	08-31-92	4.7	52	0.20	7.2	196	168	<0.010	<0.050
GA Da 17	06-18-91	14	5.2	<0.10	6.4	62	72	<0.010	<0.050
	07-07-92	11	4.7	<0.10	6.1	62	76	<0.010	<0.050
GA Eb 72	08-09-78	6.3	2.5	<0.10	4.2	32	20	--	0.420
	09-25-90	10	3.7	<0.10	4.5	31	28	<0.010	0.500
	12-11-90	11	3.2	<0.10	4.6	33	27	<0.010	0.400
	03-18-91	12	3.1	<0.10	4.1	19	27	<0.010	0.440
	06-12-91	11	--	0.10	--	--	--	<0.010	0.490
	07-06-92	11	3.7	<0.10	4.6	22	28	<0.010	0.510
WA Ab 3	09-27-90	5.5	1.9	<0.10	11	33	29	<0.010	1.00
	12-12-90	12	3.5	<0.10	7.8	39	34	<0.010	0.600
	03-19-91	12	2.4	<0.10	6.7	26	31	0.010	0.430
	06-17-91	6.2	1.9	<0.10	9.8	16	29	<0.010	0.950
	07-28-92	10	2.5	<0.10	7.9	36	33	<0.010	0.730
WA Ad 101	08-26-91	2.7	0.80	<0.10	24	124	128	<0.010	<0.050
	07-27-92	17	1.2	<0.10	22	166	131	<0.010	0.130
WA Ah 63	07-08-91	35	23	0.10	7.1	362	321	<0.010	13.0
	07-27-92	42	38	0.10	8.5	470	392	<0.010	17.0
WA Ak 99	06-13-91	21	46	0.20	8.4	429	377	<0.010	13.0
	07-27-92	30	48	0.20	8.2	448	390	<0.010	14.0
WA Di 103	10-04-90	32	17	0.40	11	328	301	<0.010	2.10
	12-12-90	27	12	0.50	11	334	294	<0.010	12.0
	03-19-91	30	12	0.30	10	292	273	0.010	9.60
	06-17-91	27	12	0.40	11	308	276	<0.010	11.0
	07-08-92	30	14	0.40	11	292	274	<0.010	11.0

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Ammonia, total (mg/L as N)	Phosphorus, total (mg/L)	Ortho-phosphate, total (mg/L as P)	Aluminum, total (µg/L)	Aluminum, dissolved (µg/L)	Boron, total (µg/L)	Iron, total (µg/L)	Iron, dissolved (µg/L)
AL Ae 36	08-27-91	0.150	<0.010	0.020	<10	<10	20	770	780
	07-28-92	0.180	<0.010	0.020	--	--	--	610	590
AL Ai 26	08-27-91	0.060	0.030	<0.010	400	<10	100	4600	3600
	07-28-92	0.080	0.030	<0.010	--	--	--	9300	2900
AL Cb 8	07-09-91	0.040	<0.010	<0.010	<10	<10	<10	90	9
	07-08-92	0.030	<0.010	<0.010	--	--	--	170	11
AL Ce 4	09-26-90	<0.010	0.040	0.050	<10	--	<10	<10	<3
	12-11-90	0.020	0.060	0.070	--	--	--	<10	<3
	03-18-91	0.020	0.080	0.040	--	--	--	10	3
	06-12-91	<0.010	0.070	0.070	<10	<10	--	<10	<3
	07-06-92	0.010	0.070	0.060	--	--	--	10	<3
GA Ae 50	06-11-91	<0.010	<0.020	<0.010	<10	<10	<10	<10	8
GA Ba 1	06-12-91	0.030	0.020	<0.010	50	<10	20	4200	1300
	08-31-92	0.080	0.020	0.040	--	--	--	3700	2100
GA Da 17	06-18-91	0.040	0.050	0.010	490	<10	100	21000	5200
	07-07-92	0.040	0.050	<0.010	--	--	--	16000	8600
GA Eb 72	08-09-78	--	<0.010	--	--	--	--	20	30
	09-25-90	<0.010	<0.010	0.020	70	--	50	30	<3
	12-11-90	0.020	<0.010	<0.010	--	--	--	<10	<3
	03-18-91	0.020	<0.010	<0.010	--	--	--	10	<3
	06-12-91	<0.010	<0.010	<0.010	60	80	--	<10	<3
	07-06-92	0.010	<0.010	<0.010	--	--	--	<10	<3
WA Ab 3	09-27-90	<0.010	<0.010	<0.010	<10	--	<10	<10	<3
	12-12-90	0.020	<0.010	0.020	--	--	--	<10	5
	03-19-91	0.020	<0.010	<0.010	--	--	--	20	4
	06-17-91	<0.010	<0.010	<0.010	--	<10	--	<10	3
	07-28-92	0.020	<0.010	0.010	--	--	--	40	6
WA Ad 101	08-26-91	0.020	0.020	0.010	90	<10	20	230	<3
	07-27-92	0.010	0.020	0.020	--	--	--	80	4
WA Ah 63	07-08-91	<0.010	0.010	0.010	60	<10	90	90	4
	07-27-92	0.010	<0.010	<0.010	--	--	--	60	<3
WA Ak 99	06-13-91	0.010	0.010	<0.010	<10	<10	40	<10	<3
	07-27-92	<0.010	<0.010	0.010	--	--	--	20	<3
WA Di 103	10-04-90	0.010	<0.010	<0.010	90	--	10	90	<3
	12-12-90	0.020	<0.010	<0.010	--	--	--	20	5
	03-19-91	0.020	<0.010	<0.010	--	--	--	40	3
	06-17-91	<0.010	<0.010	<0.010	--	<10	--	<10	4
	07-08-92	0.020	<0.010	<0.010	--	--	--	20	<3

Table A1.—Major ions, nutrients, field parameters, and other chemical-quality data from wells and springs in Segment I—Continued

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Manganese, total (µg/L)	Manganese, dissolved (µg/L)	Zinc, total (µg/L)	Organic carbon, total (mg/L as C)	Radon-222, total (pCi/L)
AL Ae 36	08-27-91	1000	1100	310	0.7	--
	07-28-92	940	1000	--	0.6	250
AL Ai 26	08-27-91	1300	1300	30	0.2	--
	07-28-92	1300	1200	--	0.5	390
AL Cb 8	07-09-91	<10	10	100	0.2	--
	07-08-92	80	8	--	0.2	260
AL Ce 4	09-26-90	<10	<1	--	0.1	--
	12-11-90	<10	2	--	0.2	--
	03-18-91	<10	<1	--	0.1	--
	06-12-91	<10	<1	<10	0.3	--
	07-06-92	<10	<1	--	0.3	--
GA Ae 50	06-11-91	80	58	<10	0.7	--
GA Ba 1	06-12-91	890	930	<10	0.2	--
	08-31-92	770	780	--	0.2	--
GA Da 17	06-18-91	520	560	130	0.7	--
	07-07-92	570	570	--	0.4	<80
GA Eb 72	08-09-78	40	40	--	--	--
	09-25-90	40	49	--	0.7	--
	12-11-90	40	42	--	0.2	--
	03-18-91	70	62	--	0.3	--
	06-12-91	40	52	30	0.3	--
	07-06-92	50	44	--	0.3	--
WA Ab 3	09-27-90	<10	<1	--	0.6	--
	12-12-90	<10	2	--	0.7	--
	03-19-91	<10	<1	--	0.5	--
	06-17-91	<10	<1	<10	0.3	--
	07-28-92	<10	1	--	0.4	--
WA Ad 101	08-26-91	30	13	<10	0.1	--
	07-27-92	<10	1	--	0.1	460
WA Ah 63	07-08-91	<10	<1	<10	0.7	--
	07-27-92	<10	<1	--	0.6	830
WA Ak 99	06-13-91	<10	<1	<10	0.6	--
	07-27-92	<10	<1	--	0.4	940
WA Di 103	10-04-90	<10	<1	--	1.3	--
	12-12-90	<10	1	--	0.6	--
	03-19-91	<10	<1	--	--	--
	06-17-91	<10	<1	<10	0.6	--
	07-08-92	<10	<1	--	0.8	490

Table A2.—Trace-element and other water-quality data from wells and springs in Segment I

(Concentrations in micrograms per liter, except as noted; <, less than)

Site number	Date	Specific conductance (microsiemens per centimeter at 25 deg.C)	pH (field)	Color, (platinum-cobalt units)	Dissolved oxygen, (milligrams per liter)	Aluminum, total	Aluminum, dissolved	Arsenic, dissolved	Barium, dissolved	Beryllium, dissolved	Boron, total
AL Ae 36	08-27-91	572	7.2	1	0.1	<10	<10	1	300	<0.5	20
AL Ai 26	08-27-91	190	6.6	1	0.2	400	<10	7	140	<0.5	100
AL Cb 8	07-09-91	386	7.6	3	2.6	<10	<10	<1	160	<0.5	<10
AL Ce 4	06-12-91	185	7.6	--	8.8	<10	<10	<1	17	<0.5	--
GA Ae 50	06-11-91	753	7.0	4	--	<10	<10	<1	110	<0.5	<10
GA Ba 1	06-12-91	382	6.7	5	3.5	50	<10	<1	340	<0.5	20
GA Da 17	06-18-91	118	6.2	2	0.1	490	<10	<1	120	0.8	100
GA Eb 72	06-12-91	52	5.0	--	9.5	60	80	<1	61	<0.5	--
WA Ab 3	06-17-91	45	5.8	1	9.6	--	<10	<1	33	<0.5	--
WA Ad 101	08-26-91	195	7.5	<1	--	90	<10	<1	100	<0.5	20
WA Ah 63	07-08-91	592	7.3	1	4.8	60	<10	<1	42	<0.5	90
WA Ak 99	06-13-91	662	7.2	2	6.8	<10	<10	<1	48	<0.5	40
WA Di 103	06-17-91	512	7.3	2	6.6	--	<10	<1	40	<0.5	--

Site number	Cadmium, dissolved	Chromium, dissolved	Cobalt, dissolved	Copper, dissolved	Iron, total	Iron, dissolved	Lead, dissolved	Lithium, dissolved	Manganese, total	Manganese, dissolved	Mercury, dissolved
AL Ae 36	<1.0	1	<1	<1	770	780	<1	26	1000	1100	<0.1
AL Ai 26	<1.0	1	2	<1	4600	3600	<1	23	1300	1300	<0.1
AL Cb 8	<1.0	<1	3	1	90	9	<1	7	<10	10	<0.1
AL Ce 4	<1.0	<1	2	<1	<10	<3	<1	4	<10	<1	<0.1
GA Ae 50	1.0	<1	1	10	<10	8	2	9	80	58	<0.1
GA Ba 1	<1.0	<1	3	<1	4200	1300	2	7	890	930	<0.1
GA Da 17	<1.0	<1	<1	1	21000	5200	<1	16	520	560	<0.1
GA Eb 72	<1.0	<1	2	1	<10	<3	<1	<4	40	52	<0.1
WA Ab 3	<1.0	<1	<1	1	<10	3	<1	<4	<10	<1	<0.1
WA Ad 101	<1.0	<1	<1	2	230	<3	<1	26	30	13	<0.1
WA Ah 63	<1.0	<1	<1	<1	90	4	<1	4	<10	<1	--
WA Ak 99	<1.0	<1	<1	1	<10	<3	<1	5	<10	<1	<0.1
WA Di 103	<1.0	<1	1	1	<10	4	<1	9	<10	<1	<0.1

Table A2.—Trace-element and other water-quality data from wells and springs in Segment I—Continued

(Concentrations in micrograms per liter, except as noted; <, less than)

Site number	Molybdenum, dissolved	Nickel, dissolved	Selenium, dissolved	Vanadium, dissolved	Zinc, total	Zinc, dissolved
AL Ae 36	<1	<1	<1	<1	310	360
AL Ai 26	<1	1	<1	<1	30	33
AL Cb 8	<1	<1	<1	<1	100	94
AL Ce 4	<1	2	<1	<1	<10	<3
GA Ae 50	4	3	<1	<1	<10	7
GA Ba 1	<1	5	<1	<1	<10	9
GA Da 17	<1	6	<1	<1	130	74
GA Eb 72	<1	4	<1	<1	30	24
WA Ab 3	<1	2	<1	<1	<10	<3
WA Ad 101	<1	<1	<1	<1	<10	17
WA Ah 63	<1	<1	<1	<1	<10	6
WA Ak 99	<1	<1	<1	<1	<10	4
WA Di 103	<1	1	<1	<1	<10	<3

Table A3.—Schedule 1304 analyses from wells and springs in Segment I

(Concentrations are total amounts, in micrograms per liter)

Site number	Date	2,4-D	2,4-DP	2,4,5-T	Silvex	Sevin	Picloram	Dicamba
AL Ae 36	07-28-92	<0.01	<0.01	<0.01	<0.01	--	--	--
AL Ce 4	06-12-91	<0.01	<0.01	<0.01	<0.01	--	--	--
GA Ae 50	06-11-91	<0.01	<0.01	<0.01	<0.01	--	--	--
GA Eb 72	06-12-91	<0.01	<0.01	<0.01	<0.01	--	--	--
WA Ab 3	06-17-91	<0.01	<0.01	<0.01	<0.01	--	--	--
WA Ah 63	07-27-92	<0.01	<0.01	<0.01	<0.01	--	--	--
WA Ak 99	06-13-91	<0.01	<0.01	<0.01	<0.01	--	--	--
WA Di 103	06-17-91	<0.01	<0.01	<0.01	<0.01	--	--	--

Table A4.—Schedule 1331 analyses from wells and springs in Segment I

(All concentrations are dissolved amounts, in micrograms per liter)

Site number	Date	PCB	PCN	Aldrin	Chlordane	DDD	DDE	DDT	Diazinon	Dieldrin
AL Ae 36	08-27-91	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
AL Ai 26	08-27-91	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
AL Ce 4	07-06-92	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
WA Ad 101	08-26-91	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
WA Ah 63	07-27-92	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
WA Di 103	07-08-92	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01

Site number	Endosulfan	Endrin	Ethion	Heptachlor	Heptachlor epoxide	Lindane	Malathion	Methoxychlor
AL Ae 36	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
AL Ai 26	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
AL Ce 4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
WA Ad 101	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
WA Ah 63	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
WA Di 103	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Site number	Methyl parathion	Methyl trithion	Mirex	Parathion	Perthane	Toxaphene	Trithion
AL Ae 36	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
AL Ai 26	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
AL Ce 4	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
WA Ad 101	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
WA Ah 63	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
WA Di 103	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01

Table A5.—Schedule 1389 analyses from wells and springs in Segment I

(All concentrations are total amounts, in micrograms per liter)

Site number	Date	Alachlor	Ametryn	Atrazine	Cyanazine	Bromacil	Butachlor	Butylate	Carboxin
AL Ae 36	07-28-92	<0.10	<0.10	<0.10	<0.20	<0.20	<0.10	<0.10	<0.20
AL Ce 4	06-12-91	<0.20	<0.10	<0.10	<0.20	<0.20	<0.10	<0.10	<0.20
GA Ae 50	06-11-91	<0.20	<0.10	<0.10	<0.20	<0.20	<0.10	<0.10	<0.20
GA Eb 72	06-12-91	<0.20	<0.10	<0.10	<0.20	<0.20	<0.10	<0.10	<0.20
WA Ab 3	06-17-91	<0.20	<0.10	<0.10	<0.20	<0.20	<0.10	<0.10	<0.20
WA Ah 63	07-27-92	<0.10	<0.10	3.5	<0.20	<0.20	<0.10	<0.10	<0.20
WA Ak 99	06-13-91	<0.20	<0.10	1.2	<0.20	<0.20	<0.10	<0.10	<0.20
WA Di 103	06-17-91	<0.20	<0.10	1.0	<0.20	<0.20	<0.10	<0.10	<0.20

Site number	Cycloate	De-ethyl atrazine	De-isopropyl atrazine	Diphenamid	Hexazinone	Metolachlor	Metribuzin	Prometon
AL Ae 36	<0.10	<0.20	<0.20	<0.10	<0.20	<0.20	<0.10	<0.20
AL Ce 4	<0.10	<0.20	<0.20	<0.10	<0.20	<0.20	<0.10	<0.20
GA Ae 50	<0.10	<0.20	<0.20	<0.10	<0.20	<0.20	<0.10	<0.20
GA Eb 72	<0.10	<0.20	<0.20	<0.10	<0.20	<0.20	<0.10	<0.20
WA Ab 3	<0.10	<0.20	<0.20	<0.10	<0.20	<0.20	<0.10	<0.20
WA Ah 63	<0.10	0.90	<0.20	<0.10	<0.20	5.6	<0.10	0.30
WA Ak 99	<0.10	1.8	0.50	<0.10	<0.20	<0.20	<0.10	<0.20
WA Di 103	<0.10	0.80	0.40	<0.10	<0.20	<0.20	<0.10	<0.20

Site number	Prometryn	Propazine	Propachlor	Simazine	Simetryne	Terbacil	Trifluralin	Vernolate
AL Ae 36	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<0.10	<0.10
AL Ce 4	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<0.10	<0.10
GA Ae 50	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<0.10	<0.10
GA Eb 72	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<0.10	<0.10
WA Ab 3	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<0.10	<0.10
WA Ah 63	<0.10	0.10	<0.10	0.10	<0.10	<0.20	<0.10	<0.10
WA Ak 99	<0.10	<0.10	<0.10	0.10	<0.10	<0.20	<0.10	<0.10
WA Di 103	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<0.10	<0.10

Table A6.—Schedule 1390 analyses from wells and springs in Segment I

(Concentrations are total amounts, in micrograms per liter; <, less than)

Site number	Date	Acrolein	Acrylo-nitrile	Benzene	Bromo-benzene	Bromoform	n-Butyl benzene	sec-Butyl benzene	tert-Butyl benzene
AL Ae 36	07-28-92	<20	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
AL Ce 4	06-12-91	--	--	<3.0	--	<3.0	--	--	--
GA Ae 50	06-11-91	--	--	<3.0	--	<3.0	--	--	--
GA Ba 1	08-31-92	<20	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
GA Eb 72	06-12-91	--	--	<3.0	--	<3.0	--	--	--
WA Ab 3	06-17-91	--	--	<3.0	--	<3.0	--	--	--
WA Ak 99	06-13-91	--	--	<3.0	--	<3.0	--	--	--
WA Di 103	06-17-91	--	--	<3.0	--	<3.0	--	--	--
	07-08-92	<20	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Site number	Carbon tetra-chloride	Chloro-benzene	Chloro-dibromo-methane	Chloro-ethane	2-Chloro-ethyl-vinyl-ether	Chloro-form	o-Chloro-toluene	p-Chloro-toluene	Dibromo-chloro-propane	1,2-Dibromo-ethane
AL Ae 36	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
AL Ce 4	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
GA Ae 50	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
GA Ba 1	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
GA Eb 72	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
WA Ab 3	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
WA Ak 99	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
WA Di 103	<3.0	<3.0	<3.0	<3.0	<3.0	7.4	--	--	--	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	4.5	<3.0	<3.0	<3.0	<3.0

Site number	Dibromo-methane	1,2-Dichloro-benzene	1,3-Dichloro-benzene	1,4-Dichloro-benzene	Dichloro-bromo-methane	Dichloro-difluoro-methane	1,1-Dichloro-ethane	1,2-Dichloro-ethane	1,2-trans-Dichloro-ethene
AL Ae 36	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
AL Ce 4	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
GA Ae 50	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
GA Ba 1	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
GA Eb 72	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
WA Ab 3	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
WA Ak 99	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
WA Di 103	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Table A6.—Schedule 1390 analyses from wells and springs in Segment I—Continued

(Concentrations are total amounts, in micrograms per liter; <, less than)

Site number	cis-1,2-Dichloroethene	1,1-Dichloroethylene	1,2-Dichloropropane	1,3-Dichloropropane	2,2-Dichloropropane	1,1-Dichloropropene	1,3-Dichloropropene	cis-1,3-Dichloropropene	trans-1,3-Dichloropropene
AL Ae 36	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0
AL Ce 4	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
GA Ae 50	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
GA Ba 1	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0
GA Eb 72	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
WA Ab 3	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
WA Ak 99	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
WA Di 103	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0

Site number	Ethylbenzene	Hexachlorobutadiene	Isopropylbenzene	p-Isopropyl toluene	Methylbromide	Methylchloride	Methylene chloride	Naphthalene	n-Propylbenzene
AL Ae 36	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
AL Ce 4	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
GA Ae 50	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
GA Ba 1	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
GA Eb 72	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
WA Ab 3	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
WA Ak 99	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
WA Di 103	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Site number	Styrene	1,1,2,2-Tetrachloroethane	1,1,1,2-Tetrachloroethane	Tetrachloroethylene	Toluene	1,2,3-Trichlorobenzene	1,2,4-Trichlorobenzene	1,1,1-Trichloroethane	1,1,2-Trichloroethane
AL Ae 36	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
AL Ce 4	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
GA Ae 50	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
GA Ba 1	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
GA Eb 72	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
WA Ab 3	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
WA Ak 99	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
WA Di 103	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Table A6.—Schedule 1390 analyses from wells and springs in Segment I—Continued

(Concentrations are total amounts, in micrograms per liter; <, less than)

Site number	Trichloro-ethylene	Trichloro-fluoromethane	1,2,3-Trichloro-propane	1,2,4-Trimethyl-benzene	1,3,5-Trimethyl-benzene	Vinyl chloride	Xylene
AL Ae 36	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0	<3.0
AL Ce 4	<3.0	<3.0	--	--	--	<1.0	<3.0
GA Ae 50	<3.0	<3.0	--	--	--	<1.0	<3.0
GA Ba 1	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0	<3.0
GA Eb 72	<3.0	<3.0	--	--	--	<1.0	<3.0
WA Ab 3	<3.0	<3.0	--	--	--	<1.0	<3.0
WA Ak 99	<3.0	<3.0	--	--	--	<1.0	<3.0
WA Di 103	<3.0	<3.0	--	--	--	<1.0	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0	<3.0

Table A7.—Major ions, nutrients, field parameters, and other chemical-quality data from wells and springs in Segment II

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Site type	Record number	Date	Time	Water level (feet below land surface)	Discharge (gal/min)	Specific conductance (µS/cm)	pH	Temperature, air (deg. C)	Temperature, water (deg. C)	Color, (platinum-cobalt units)
BA Dc 444	Well	98900015	10-26-88	1408	44.25	8.6	280	8.0	10.0	12.0	--
		98900571	04-13-89	1504	43.13	6.0	267	7.5	15.0	13.0	--
		98900917	06-14-89	1550	36.56	8.1	266	7.4	20.5	12.0	--
		99000018	10-12-89	1305	39.41	7.5	259	7.7	17.5	12.0	--
		99000858	06-20-90	1146	37.62	8.8	261	7.9	24.5	12.5	--
		99100829	06-19-91	1407	38.36	7.7	261	7.9	20.0	12.5	1
		99200555	05-27-92	1400	41.91	7.2	279	7.9	17.5	12.5	<1
CE Cc 40	Spring	98103150	08-13-81	1330	--	--	190	5.4	--	13.0	--
		98900387	02-21-89	1145	--	4.8	291	5.3	9.0	11.0	--
		99000573	05-07-90	1015	--	5.0	306	5.5	15.0	12.0	--
		99100610	05-20-91	1038	--	4.6	322	5.4	17.5	11.5	1
		99200549	05-21-92	1450	--	3.8	351	5.3	27.0	11.5	--
CL Ae 1	Well	97501303	08-12-75	1430	--	--	--	--	--	--	1
		99200552	05-26-92	1515	--	1.4	109	5.3	9.5	13.0	<1
CL Bf 184	Well	98800766	09-22-88	1355	2.26	1.7	181	6.5	21.0	11.5	--
		98900403	02-28-89	1335	0.90	15	198	6.8	2.0	11.5	--
		98900919	06-19-89	1336	0.22	8.2	193	6.2	28.0	12.5	--
		98901190	09-20-89	1300	1.15	11	194	6.4	21.0	11.5	--
		99000843	06-19-90	1240	0.37	34	181	6.7	24.5	12.0	--
		99100614	05-22-91	1145	0.30	48	194	6.4	29.0	12.0	1
		99200521	05-13-92	1155	1.32	10	206	6.4	24.0	12.0	--
FR Af 27	Well	98900706	05-03-89	1415	1.35	12	497	7.3	16.0	14.0	--
		99000514	04-16-90	1537	0.99	17	496	7.5	16.0	13.5	--
		99100435	04-17-91	1522	0.56	1.3	450	7.7	24.5	13.0	5
		99200515	05-11-92	1455	1.15	6.3	517	7.8	22.5	14.0	--
FR Cd 38	Spring	98203520	05-11-82	1300	--	--	--	6.7	--	12.0	--
		98900536	03-03-89	1120	--	17	21	5.5	5.5	10.5	--
		99000512	04-16-90	1750	--	--	25	5.1	19.0	11.5	--
		99100433	04-16-91	1130	--	--	25	5.2	21.5	11.0	2
		99200516	05-11-92	1645	--	--	26	5.3	23.0	11.5	<1
FR Dd 178	Spring	98103143	08-21-81	1345	--	--	510	7.2	--	15.0	--
		98900404	02-28-89	1635	--	300	585	6.9	1.5	12.0	--
		98900705	05-04-89	1150	--	--	587	7.1	18.0	13.0	--
		98900918	06-16-89	1340	--	--	578	7.2	20.0	13.0	--
		98901220	09-27-89	1300	--	119	545	6.7	15.0	13.5	--
		99000510	04-17-90	1040	--	--	601	7.4	13.5	13.0	--
		99100436	04-17-91	1105	--	180	560	7.3	--	13.0	1
		99200517	05-12-92	1050	--	314	620	7.3	19.0	13.0	5
FR Df 35	Well	98800767	09-28-88	1350	60.32	8.6	122	6.8	27.5	13.0	--
		98900466	03-28-89	1215	58.83	5.5	128	6.6	24.0	15.0	--
		99000001	10-02-89	1355	61.22	7.5	123	6.6	21.0	12.5	--
		99000666	05-22-90	1536	57.29	4.3	133	6.9	15.5	12.5	--
		99100914	07-10-91	1630	58.29	3.8	123	6.7	22.0	13.0	--
		99200519	05-12-92	1815	59.37	5.3	146	6.6	22.0	12.5	5

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Dissolved oxygen (mg/L)	Hardness, total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Bicarbonate, total (mg/L)	Alkalinity, total (mg/L as $CaCO_3$)
BA Dc 444	10-26-88	8.0	140	30	15	1.6	1.4	172	141
	04-13-89	5.9	140	31	14	1.6	1.5	168	138
	06-14-89	1.5	140	31	14	1.6	1.5	168	138
	10-12-89	--	140	32	14	1.7	1.5	167	137
	06-20-90	--	140	32	15	1.6	1.5	166	137
	06-19-91	1.4	150	34	15	1.8	1.5	176	144
	05-27-92	1.3	140	32	14	1.6	1.5	160	131
CE Cc 40	08-13-81	--	46	9.6	5.4	8.6	0.60	--	--
	02-21-89	--	79	16	9.4	17	1.0	16	13
	05-07-90	--	82	17	9.5	20	0.80	10	8
	05-20-91	--	86	18	10	25	1.0	12	10
	05-21-92	8.4	90	18	11	22	0.90	10	9
CL Ae 1	08-12-75	--	16	3.0	2.0	1.8	0.40	--	--
	05-26-92	8.3	28	5.3	3.6	7.2	0.80	6	5
CL Bf 184	09-22-88	6.1	77	22	5.3	4.0	0.60	38	31
	02-28-89	--	71	21	4.5	3.7	0.60	43	35
	06-19-89	6.5	78	23	4.9	3.9	0.50	42	35
	09-20-89	--	77	23	4.8	3.9	0.50	41	34
	06-19-90	--	84	25	5.3	3.9	0.50	43	35
	05-22-91	6.0	83	25	4.9	4.1	0.60	43	36
	05-13-92	6.8	86	26	5.1	3.5	0.50	36	30
FR Af 27	05-03-89	1.6	220	55	20	21	0.40	220	180
	04-16-90	--	220	55	20	19	0.30	217	178
	04-17-91	1.8	220	57	19	21	0.30	217	178
	05-11-92	7.4	230	59	19	19	0.40	210	172
FR Cd 38	05-11-82	--	4	0.58	0.62	0.90	0.80	--	--
	03-03-89	--	5	0.78	0.65	1.1	1.2	5	4
	04-16-90	--	5	0.83	0.77	1.3	1.3	3	3
	04-16-91	8.2	5	0.80	0.81	1.4	1.4	7	6
	05-11-92	--	5	0.75	0.83	1.2	1.4	6	5
FR Dd 178	08-21-81	--	230	78	9.1	10	1.7	--	--
	02-28-89	--	250	83	11	18	2.1	247	203
	05-04-89	--	250	81	11	20	2.1	242	198
	06-16-89	--	260	85	11	19	2.0	242	198
	09-27-89	--	240	81	10	17	2.1	239	196
	04-17-90	--	280	91	12	21	1.9	243	199
	04-17-91	6.3	260	85	11	22	1.9	243	199
	05-12-92	6.2	270	90	11	20	2.1	237	194
FR Df 35	09-28-88	8.7	67	16	6.5	1.7	0.90	80	65
	03-28-89	9.7	63	15	6.1	1.7	0.60	78	64
	10-02-89	--	61	15	5.8	1.7	0.50	76	62
	05-22-90	--	63	15	6.3	1.9	0.50	82	67
	07-10-91	9.7	--	--	--	--	--	74	61
	05-12-92	9.4	73	18	6.7	1.6	0.40	82	67

Table A7.—Major ions, nutrients, field parameters, and other chemical-quality data from wells and springs in Segment II—Continued

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L as SiO_2)	Solids, residue on evaporation, dissolved (mg/L)	Solids, sum of dissolved constituents (mg/L)	Nitrite, total (mg/L as N)	Nitrite, dissolved (mg/L as N)
BA Dc 444	10-26-88	2.2	3.6	0.10	8.9	--	147	--	--
	04-13-89	1.6	3.2	0.10	8.8	--	144	--	--
	06-14-89	2.0	3.3	0.10	9.2	--	145	--	--
	10-12-89	<1.0	3.3	0.10	9.1	--	--	--	--
	06-20-90	1.3	4.8	0.20	9.1	--	147	--	--
	06-19-91	1.3	4.0	<0.10	9.0	150	153	<0.010	--
	05-27-92	2.2	4.6	<0.10	9.0	138	144	<0.010	--
CE Cc 40	08-13-81	0.60	37	<0.10	22	134	89	--	--
	02-21-89	2.3	91	0.10	20	--	165	--	--
	05-07-90	1.0	82	0.60	23	--	159	--	--
	05-20-91	0.70	80	0.20	21	220	162	<0.010	--
	05-21-92	0.40	92	<0.10	22	250	171	<0.010	--
CL Ae 1	08-12-75	0.50	2.0	0.10	5.4	--	19	--	--
	05-26-92	0.90	22	<0.10	5.6	64	49	<0.010	--
CL Bf 184	09-22-88	3.4	11	<0.10	9.6	--	75	--	--
	02-28-89	4.1	10	0.10	9.2	--	74	--	--
	06-19-89	4.0	11	<0.10	9.9	--	78	--	--
	09-20-89	4.0	10	<0.10	9.9	--	76	--	--
	06-19-90	21	16	<0.10	10	--	103	--	--
	05-22-91	4.0	11	<0.10	9.9	137	81	<0.010	--
	05-13-92	3.9	12	<0.10	10	135	79	<0.010	--
FR Af 27	05-03-89	73	7.0	0.20	27	--	312	--	--
	04-16-90	63	8.2	<0.10	27	310	299	--	--
	04-17-91	66	8.8	0.10	25	331	304	<0.010	--
	05-11-92	74	8.8	0.20	27	316	311	<0.010	--
FR Cd 38	05-11-82	3.0	1.3	<0.10	6.3	16	17	--	--
	03-03-89	2.4	1.0	0.10	6.3	--	16	--	--
	04-16-90	2.7	2.2	<0.10	6.6	9	17	--	--
	04-16-91	16	12	0.10	6.2	32	42	<0.010	--
	05-11-92	2.2	1.8	<0.10	6.6	<1	18	<0.010	--
FR Dd 178	08-21-81	16	25	<0.10	8.7	290	257	--	--
	02-28-89	21	39	0.10	9.2	--	305	--	--
	05-04-89	20	42	0.10	8.8	--	304	--	--
	06-16-89	21	41	0.10	9.1	--	307	--	--
	09-27-89	20	36	0.10	9.2	--	293	--	--
	04-17-90	28	50	<0.10	9.6	349	333	--	--
	04-17-91	20	45	<0.10	8.5	332	313	<0.010	--
	05-12-92	23	50	0.20	9.2	338	322	<0.010	--
FR Df 35	09-28-88	0.50	1.5	<0.10	10	--	76	--	--
	03-28-89	0.20	1.4	0.10	11	--	74	--	--
	10-02-89	<1.0	1.5	0.10	11	--	--	--	--
	05-22-90	<1.0	2.9	<0.10	11	--	--	--	--
	07-10-91	--	2.4	--	--	--	--	--	--
	05-12-92	0.40	2.7	<0.10	11	88	81	<0.010	--

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Nitrate plus nitrite, total (mg/L as N)	Nitrate plus nitrite, dissolved (mg/L as N)	Ammonia, total (mg/L as N)	Ammonia, dissolved (mg/L as N)	Phosphorus, total (mg/L)	Phosphorus, dissolved (mg/L)	Ortho-phosphate, total (mg/L as P)
BA Dc 444	10-26-88	0.300	--	--	--	0.010	--	--
	04-13-89	0.300	--	--	--	<0.010	--	--
	06-14-89	0.300	--	--	--	<0.010	--	--
	10-12-89	0.300	--	--	--	<0.010	--	--
	06-20-90	0.300	--	--	--	<0.010	--	--
	06-19-91	0.290	--	<0.010	--	<0.010	--	<0.010
	05-27-92	0.290	--	<0.010	--	0.010	--	<0.010
CE Cc 40	08-13-81	--	--	--	--	--	--	--
	02-21-89	1.00	--	--	--	<0.010	--	--
	05-07-90	1.00	--	--	--	<0.010	--	--
	05-20-91	1.00	--	0.010	--	<0.010	--	<0.010
	05-21-92	0.720	--	0.020	--	0.010	--	0.020
CL Ae 1	08-12-75	1.40	--	--	--	0.010	--	--
	05-26-92	2.20	--	<0.010	--	0.030	--	<0.010
CL Bf 184	09-22-88	7.00	--	--	--	<0.010	--	--
	02-28-89	9.10	--	--	--	0.020	--	--
	06-19-89	8.90	--	--	--	0.010	--	--
	09-20-89	8.70	--	--	--	0.020	--	--
	06-19-90	9.90	--	--	--	0.030	--	--
	05-22-91	10.0	--	<0.010	--	0.020	--	0.010
	05-13-92	10.0	--	0.040	--	0.020	--	0.020
FR Af 27	05-03-89	1.70	--	--	--	<0.010	--	--
	04-16-90	1.90	--	--	--	<0.010	--	--
	04-17-91	1.90	--	<0.010	--	0.020	--	<0.010
	05-11-92	1.90	--	0.020	--	<0.010	--	<0.010
FR Cd 38	05-11-82	--	--	--	--	--	--	--
	03-03-89	0.300	--	--	--	<0.010	--	--
	04-16-90	0.400	--	--	--	<0.010	--	--
	04-16-91	0.390	--	<0.010	--	<0.010	--	<0.010
	05-11-92	0.410	--	0.030	--	<0.010	--	0.010
FR Dd 178	08-21-81	--	--	--	--	--	--	--
	02-28-89	5.60	--	--	--	0.020	--	--
	05-04-89	5.10	--	--	--	0.020	--	--
	06-16-89	5.30	--	--	--	0.030	--	--
	09-27-89	5.30	--	--	--	0.020	--	--
	04-17-90	5.30	--	--	--	0.030	--	--
	04-17-91	5.30	--	<0.010	--	0.020	--	0.010
	05-12-92	5.60	--	0.040	--	0.010	--	0.020
FR Df 35	09-28-88	0.400	--	--	--	0.150	--	--
	03-28-89	0.300	--	--	--	0.010	--	--
	10-02-89	0.400	--	--	--	0.140	--	--
	05-22-90	0.400	--	--	--	0.090	--	--
	07-10-91	0.400	--	--	--	0.100	--	--
	05-12-92	0.380	--	0.040	--	0.110	--	0.110

Table A7.—Major ions, nutrients, field parameters, and other chemical-quality data from wells and springs in Segment II—Continued

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Ortho-phosphate, dissolved (mg/L as P)	Aluminum, total (µg/L)	Aluminum, dissolved (µg/L)	Boron, total (µg/L)	Iron, total (µg/L)	Iron, dissolved (µg/L)	Manganese, total (µg/L)	Manganese, dissolved (µg/L)
BA Dc 444	10-26-88	--	20	--	<10	820	13	<10	1
	04-13-89	--	120	--	30	640	12	<10	<1
	06-14-89	--	<10	--	<10	240	12	<10	3
	10-12-89	--	<10	--	<10	180	6	<10	<1
	06-20-90	--	<10	--	<10	290	15	<10	<1
	06-19-91	--	--	<10	--	3100	8	<10	3
	05-27-92	--	--	--	--	490	4	<10	<1
CE Cc 40	08-13-81	--	<100	<100	--	220	<10	<10	2
	02-21-89	--	30	--	20	50	20	10	8
	05-07-90	--	<10	--	<10	50	9	<10	7
	05-20-91	--	--	10	--	<10	34	<10	6
	05-21-92	--	--	--	--	40	20	10	40
CL Ae 1	08-12-75	--	--	--	--	50	--	<10	--
	05-26-92	--	20	20	<10	120	30	40	5
CL Bf 184	09-22-88	--	<10	--	20	5800	86	20	4
	02-28-89	--	40	--	<10	90	34	<10	4
	06-19-89	--	140	--	<10	510	30	<10	7
	09-20-89	--	<10	--	<10	320	19	10	3
	06-19-90	--	<10	--	<10	760	18	10	5
	05-22-91	--	--	<10	--	710	34	<10	5
	05-13-92	--	--	--	--	1400	19	20	4
FR Af 27	05-03-89	--	70	--	230	1000	11	<10	<1
	04-16-90	--	40	--	150	12000	14	40	8
	04-17-91	--	--	<10	--	5400	8	40	2
	05-11-92	--	--	--	--	140	27	10	<1
FR Cd 38	05-11-82	--	<100	<100	--	180	15	20	2
	03-03-89	--	30	--	<10	<10	<3	<10	3
	04-16-90	--	<10	--	<10	<10	6	<10	6
	04-16-91	--	--	<10	--	20	3	<10	7
	05-11-92	--	--	--	--	<10	<3	<10	6
FR Dd 178	08-21-81	--	200	100	--	140	10	10	<10
	02-28-89	--	<10	<10	<10	1000	13	10	1
	05-04-89	--	--	10	130	20	<3	<10	<1
	06-16-89	--	20	<10	<10	60	5	10	1
	09-27-89	--	<10	<10	<10	80	4	40	<1
	04-17-90	--	<10	--	<10	50	12	<10	<1
	04-17-91	--	--	--	--	70	<3	<10	<1
	05-12-92	--	--	--	--	30	3	10	<1
FR Df 35	09-28-88	--	150	--	<10	400	14	140	3
	03-28-89	--	10	--	<10	110	26	<10	3
	10-02-89	--	90	--	<10	360	12	80	3
	05-22-90	--	<10	<10	<10	20	10	110	<1
	07-10-91	--	--	--	--	--	--	--	--
	05-12-92	--	--	--	--	220	6	70	<1

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Zinc, total (µg/L)	Organic Carbon, total (mg/L as C)	Radon-222, total (pCi/L)
BA Dc 444	10-26-88	<10	4.0	--
	04-13-89	10	0.3	--
	06-14-89	<10	0.3	--
	10-12-89	10	0.4	--
	06-20-90	--	0.1	--
	06-19-91	--	0.3	--
	05-27-92	--	0.5	--
CE Cc 40	08-13-81	20	--	--
	02-21-89	20	0.9	--
	05-07-90	--	<0.1	--
	05-20-91	--	<0.1	--
	05-21-92	--	0.2	--
CL Ae 1	08-12-75	--	--	--
	05-26-92	30	0.2	7000
CL Bf 184	09-22-88	20	3.1	--
	02-28-89	<10	3.3	--
	06-19-89	10	0.5	--
	09-20-89	<10	0.3	--
	06-19-90	--	<0.1	--
	05-22-91	--	0.3	--
	05-13-92	--	<0.1	--
FR Af 27	05-03-89	<10	0.4	--
	04-16-90	<10	0.1	1300
	04-17-91	--	0.4	--
	05-11-92	--	0.2	--
FR Cd 38	05-11-82	40	--	--
	03-03-89	<10	--	--
	04-16-90	<10	0.4	--
	04-16-91	--	0.7	1600
	05-11-92	--	0.9	--
FR Dd 178	08-21-81	10	--	--
	02-28-89	10	0.5	--
	05-04-89	<10	0.5	--
	06-16-89	<10	0.4	--
	09-27-89	<10	0.4	--
	04-17-90	<10	<0.1	260
	04-17-91	--	0.8	--
	05-12-92	--	0.3	--
FR Df 35	09-28-88	20	3.5	--
	03-28-89	30	0.3	--
	10-02-89	20	0.4	--
	05-22-90	--	0.3	320
	07-10-91	--	0.2	--
	05-12-92	--	0.3	--

Table A7.—Major ions, nutrients, field parameters, and other chemical-quality data from wells and springs in Segment II—Continued

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Site type	Record number	Date	Time	Water level (feet below land surface)	Discharge (gal/min)	Specific conductance (µS/cm)	pH	Temperature, air (deg. C)	Temperature, water (deg. C)	Color, (platinum-cobalt units)
FR Fb 12	Spring	98103065	08-21-81	1130	--	--	385	6.5	--	15.0	--
		98303112	06-16-83	0945	--	4.0	335	6.9	28.0	12.5	--
		98900654	04-27-89	1015	--	4.0	358	6.6	21.0	12.5	--
		99000509	04-17-90	1330	--	7.0	346	6.4	8.0	12.0	--
		99100434	04-16-91	1435	--	11	334	6.5	25.0	12.5	1
		99200518	05-12-92	1305	--	7.5	358	6.3	22.0	12.5	5
HA Aa 9	Spring	98900385	02-16-89	1500	--	10	140	5.5	5.0	10.5	--
		99000523	04-24-90	1115	--	12	153	5.5	21.5	11.0	--
		99100437	04-18-91	1120	--	15	162	5.4	13.0	11.0	1
		99200600	06-15-92	0900	--	8.0	157	5.2	21.5	11.5	<1
HA Bc 31	Spring	98902105	02-16-89	1300	--	4.0	27	5.7	6.5	10.5	--
		99001670	04-24-90	1400	--	4.0	27	5.6	23.5	11.5	--
		99101467	04-18-91	1415	--	10	26	5.6	15.0	11.0	1
		99200857	06-15-92	1045	--	--	32	5.6	23.5	11.0	<1
HA Ca 23	Well	97400797	07-03-74	1210	--	--	--	--	--	--	0
		98800765	09-21-88	1145	6.64	0.8	119	6.2	24.0	12.0	--
		98900608	04-20-89	1200	5.84	10	117	6.2	16.5	12.5	--
		98900916	06-14-89	1130	4.02	8.5	112	6.3	19.0	12.5	--
		98901191	09-21-89	1230	5.74	8.9	114	6.0	27.5	13.0	--
		99000859	06-20-90	1538	5.26	0.8	117	6.0	--	13.0	--
		99100615	05-22-91	1555	6.60	1.0	114	6.1	31.0	13.0	1
		99200597	06-15-92	1330	7.80	9.2	129	6.2	27.0	13.5	<1
HO Cd 78	Well	98800219	03-17-88	1230	8.24	0.5	83	5.6	7.5	10.0	--
		98800473	06-09-88	1125	7.99	1.0	84	5.5	13.0	10.0	--
		98800740	09-14-88	1135	9.49	1.0	74	5.4	21.0	13.0	--
		98900230	12-22-88	0910	9.84	1.0	81	4.6	--	12.5	--
		98900525	04-05-89	1400	8.38	1.5	93	7.2	13.0	9.5	--
		98901044	06-29-89	1510	7.33	1.2	92	4.9	20.5	11.5	--
		99101101	09-10-91	1310	9.74	0.9	94	5.4	23.0	14.5	<1
		99200605	06-23-92	1500	9.32	0.9	98	5.4	23.0	12.0	<1
MO Be 62	Well	99300395	06-21-93	1030	34.43	6.6	83	5.3	25.5	13.9	3
MO Db 68	Well	97800998	07-13-78	1300	15.27	150	235	7.6	--	14.0	0
		98900014	10-11-88	1603	18.40	1.7	224	7.6	15.5	12.5	--
		98900465	03-27-89	1600	12.43	6.0	223	7.4	21.0	13.0	--
		98900957	06-26-89	1355	13.85	7.8	224	7.1	31.0	13.5	--
		98901189	09-19-89	1440	17.54	8.3	266	7.5	16.5	13.0	--
		99000678	05-23-90	1600	13.23	8.0	231	7.6	20.0	13.5	--
		99100564	05-15-91	1418	15.31	10	227	7.7	27.0	13.5	--
		99200584	06-08-92	1210	17.12	7.5	245	7.6	28.5	13.5	5

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Dissolved oxygen (mg/L)	Hardness, total (mg/L as $CaCO_3$	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Bicarbonate, total (mg/L)	Alkalinity, total (mg/L as $CaCO_3$)
FR Fb 12	08-21-81	--	130	33	11	15	1.4	--	--
	06-16-83	--	120	31	11	14	1.2	--	--
	04-27-89	--	130	31	12	17	1.4	52	43
	04-17-90	--	120	30	11	15	1.3	41	34
	04-16-91	--	120	30	11	18	1.2	38	32
	05-12-92	10.0	120	30	10	16	1.3	40	33
HA Aa 9	02-16-89	--	48	8.3	6.5	5.3	1.4	10	8
	04-24-90	--	49	8.7	6.7	5.5	1.6	5	4
	04-18-91	9.5	55	9.5	7.6	5.9	1.7	7	6
	06-15-92	9.4	49	8.4	6.9	5.1	1.2	5	5
HA Bc 31	02-16-89	--	8	1.4	1.1	2.2	0.50	21	17
	04-24-90	5.6	8	1.4	1.0	2.1	0.60	10	9
	04-18-91	6.7	8	1.5	1.1	2.2	0.50	9	8
	06-15-92	8.1	9	1.7	1.1	2.2	0.40	9	7
HA Ca 23	07-03-74	--	25	4.9	3.0	6.3	1.8	--	--
	09-21-88	7.1	36	7.4	4.3	6.5	1.9	23	19
	04-20-89	6.9	35	7.3	4.1	6.6	2.1	22	18
	06-14-89	7.2	32	6.7	3.7	6.3	2.0	20	16
	09-21-89	--	33	6.9	3.8	6.5	1.9	21	17
	06-20-90	--	35	7.6	4.0	6.6	2.0	21	17
	05-22-91	7.4	35	7.4	3.9	7.1	2.1	20	16
	06-15-92	9.2	37	7.8	4.2	7.2	2.1	22	18
HO Cd 78	03-17-88	9.2	23	4.1	3.2	3.5	1.6	--	--
	06-09-88	9.4	25	4.4	3.5	3.3	1.5	--	--
	09-14-88	10.9	24	4.2	3.4	3.5	2.1	--	--
	12-22-88	8.7	24	4.3	3.1	3.4	1.4	9	7
	04-05-89	7.7	28	4.9	3.9	3.5	1.5	9	7
	06-29-89	8.6	27	4.7	3.8	3.4	1.6	10	8
	09-10-91	8.8	31	5.4	4.2	3.7	1.8	12	10
	06-23-92	7.7	30	5.1	4.2	3.7	1.6	8	7
MO Be 62	06-21-93	--	26	3.0	4.4	3.2	1.3	6	5
MO Db 68	07-13-78	--	110	34	6.8	6.3	0.60	--	--
	10-11-88	2.7	110	33	7.4	5.8	0.40	139	114
	03-27-89	6.2	100	31	6.4	5.4	0.50	141	115
	06-26-89	7.2	110	33	6.9	6.0	0.40	136	113
	09-19-89	--	110	33	6.7	5.8	0.40	141	116
	05-23-90	--	110	34	7.0	5.9	0.40	140	115
	05-15-91	6.6	--	--	--	--	--	140	115
	06-08-92	6.6	110	35	6.6	6.1	0.40	144	118

Table A7.—Major ions, nutrients, field parameters, and other chemical-quality data from wells and springs in Segment II—Continued

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L as SiO_2)	Solids, residue on evaporation, dissolved (mg/L)	Solids, sum of dissolved constituents (mg/L)	Nitrite, total (mg/L as N)	Nitrite, dissolved (mg/L as N)
FR Fb 12	08-21-81	39	32	<0.10	21	250	180	--	--
	06-16-83	55	30	0.10	23	230	220	--	--
	04-27-89	47	40	0.10	20	--	194	--	--
	04-17-90	39	42	<0.10	25	238	184	--	--
	04-16-91	38	41	<0.10	20	212	178	<0.010	--
	05-12-92	45	43	<0.10	21	226	186	<0.010	--
HA Aa 9	02-16-89	3.0	10	0.10	9.7	--	49	--	--
	04-24-90	2.5	12	<0.10	11	109	50	--	--
	04-18-91	3.6	13	0.20	9.1	102	54	<0.010	--
	06-15-92	2.5	18	<0.10	9.2	114	54	<0.010	--
HA Bc 31	02-16-89	0.40	2.4	0.10	10	--	28	--	--
	04-24-90	<1.0	3.2	<0.10	10	16	--	--	--
	04-18-91	0.40	2.5	<0.10	9.2	17	22	<0.010	--
	06-15-92	0.30	3.0	<0.10	9.7	16	23	<0.010	--
HA Ca 23	07-03-74	0.20	4.2	0.20	22	--	73	--	--
	09-21-88	1.1	7.3	0.10	21	--	61	--	--
	04-20-89	<1.0	6.5	0.10	22	--	--	--	--
	06-14-89	<1.0	6.5	0.10	22	--	--	--	--
	09-21-89	<1.0	6.8	0.10	22	--	--	--	--
	06-20-90	1.1	9.6	0.20	22	--	63	--	--
	05-22-91	1.4	7.5	<0.10	23	81	62	<0.010	--
	06-15-92	1.2	7.7	<0.10	21	102	62	<0.010	--
HO Cd 78	03-17-88	4.0	8.1	0.10	12	--	54	--	<0.010
	06-09-88	3.9	8.7	0.30	13	--	56	--	<0.010
	09-14-88	3.6	8.4	<0.10	13	--	55	--	<0.010
	12-22-88	3.4	8.5	<0.10	13	--	55	--	<0.010
	04-05-89	4.0	8.9	0.10	12	--	57	--	<0.010
	06-29-89	4.0	8.8	0.10	12	--	59	--	0.010
	09-10-91	5.5	13	<0.10	13	48	52	<0.010	--
	06-23-92	5.0	12	<0.10	12	66	47	<0.010	--
MO Be 62	06-21-93	2.9	7.9	<0.10	6.7	44	45	--	<0.010
MO Db 68	07-13-78	2.3	3.3	<0.10	21	164	148	--	--
	10-11-88	0.90	2.3	<0.10	22	--	140	--	--
	03-27-89	1.0	2.3	0.10	20	--	136	--	--
	06-26-89	<1.0	2.4	0.10	23	--	--	--	--
	09-19-89	<1.0	2.5	0.10	22	--	--	--	--
	05-23-90	<1.0	3.7	<0.10	22	--	--	--	--
	05-15-91	--	--	--	--	--	--	--	--
	06-08-92	1.8	2.5	<0.10	22	156	145	<0.010	--

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Nitrate plus nitrite, total (mg/L as N)	Nitrate plus nitrite, dissolved (mg/L as N)	Ammonia, total (mg/L as N)	Ammonia, dissolved (mg/L as N)	Phosphorus, total (mg/L)	Phosphorus, dissolved (mg/L)	Ortho-phosphate, total (mg/L as P)
FR Fb 12	08-21-81	--	--	--	--	--	--	--
	06-16-83	--	6.30	--	--	--	0.120	--
	04-27-89	3.90	--	--	--	0.090	--	--
	04-17-90	4.80	--	--	--	0.080	--	--
	04-16-91	4.40	--	<0.010	--	0.090	--	0.060
	05-12-92	4.90	--	0.030	--	0.100	--	0.100
HA Aa 9	02-16-89	5.80	--	--	--	0.010	--	--
	04-24-90	11.0	--	--	--	0.010	--	--
	04-18-91	11.0	--	<0.010	--	<0.010	--	<0.010
	06-15-92	11.0	--	0.020	--	0.020	--	0.010
HA Bc 31	02-16-89	0.200	--	--	--	0.020	--	--
	04-24-90	0.100	--	--	--	0.030	--	--
	04-18-91	0.097	--	<0.010	--	0.020	--	0.020
	06-15-92	0.190	--	0.030	--	0.020	--	0.020
HA Ca 23	07-03-74	3.80	--	--	--	0.020	--	--
	09-21-88	4.60	--	--	--	<0.010	--	--
	04-20-89	6.70	--	--	--	0.010	--	--
	06-14-89	5.80	--	--	--	0.020	--	--
	09-21-89	5.30	--	--	--	0.020	--	--
	06-20-90	6.30	--	--	--	0.020	--	--
	05-22-91	6.60	--	<0.010	--	<0.010	--	<0.010
	06-15-92	6.40	--	0.020	--	0.010	--	0.010
HO Cd 78	03-17-88	--	2.90	--	<0.010	--	<0.010	--
	06-09-88	--	3.00	--	<0.010	--	<0.010	--
	09-14-88	--	2.80	--	<0.010	--	0.010	--
	12-22-88	--	3.00	--	0.010	--	<0.010	--
	04-05-89	--	3.20	--	<0.010	--	<0.010	--
	06-29-89	--	3.50	--	0.010	--	<0.010	--
	09-10-91	3.30	--	0.020	--	0.010	--	<0.010
	06-23-92	3.10	--	0.020	--	<0.010	--	<0.010
MO Be 62	06-21-93	--	2.80	--	0.030	--	0.080	--
MO Db 68	07-13-78	0.860	--	--	--	0.050	--	--
	10-11-88	1.40	--	--	--	0.060	--	--
	03-27-89	1.00	--	--	--	0.070	--	--
	06-26-89	1.30	--	--	--	0.070	--	--
	09-19-89	1.20	--	--	--	0.050	--	--
	05-23-90	1.30	--	--	--	0.060	--	--
	05-15-91	1.40	--	--	--	0.060	--	--
	06-08-92	1.30	--	0.030	--	0.090	--	0.060

Table A7.—Major ions, nutrients, field parameters, and other chemical-quality data from wells and springs in Segment II—Continued

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Ortho-phosphate, dissolved (mg/L as P)	Aluminum, total (µg/L)	Aluminum, dissolved (µg/L)	Boron, total (µg/L)	Iron, total (µg/L)	Iron, dissolved (µg/L)	Manganese, total (µg/L)	Manganese, dissolved (µg/L)
FR Fb 12	08-21-81	--	200	200	--	160	10	<10	<10
	06-16-83	0.120	--	<100	--	--	6	--	<1
	04-27-89	--	--	<10	50	<10	4	<10	<1
	04-17-90	--	<10	--	30	30	5	<10	<1
	04-16-91	--	--	--	--	40	7	<10	<1
	05-12-92	--	--	--	--	40	4	<10	<1
HA Aa 9	02-16-89	--	20	--	10	30	3	<10	8
	04-24-90	--	40	--	<10	30	<3	10	13
	04-18-91	--	--	30	--	40	3	10	13
	06-15-92	--	--	--	--	40	<3	10	10
HA Bc 31	02-16-89	--	<10	--	<10	<10	8	<10	2
	04-24-90	--	300	--	<10	200	16	<10	3
	04-18-91	--	--	--	--	110	16	<10	3
	06-15-92	--	--	<10	--	20	5	<10	2
HA Ca 23	07-03-74	--	--	--	--	70	--	20	--
	09-21-88	--	<10	--	<10	470	210	50	48
	04-20-89	--	<10	--	20	170	10	<10	7
	06-14-89	--	<10	--	<10	50	16	<10	15
	09-21-89	--	<10	--	<10	370	6	<10	4
	06-20-90	--	30	--	<10	5700	30	30	18
	05-22-91	--	--	<10	--	2800	23	<10	8
	06-15-92	--	--	--	--	200	<3	<10	6
HO Cd 78	03-17-88	--	--	<10	--	--	4	--	3
	06-09-88	--	--	10	--	--	<3	--	3
	09-14-88	<0.010	--	<10	--	--	10	--	5
	12-22-88	<0.010	--	<10	--	--	7	--	6
	04-05-89	<0.010	--	10	--	--	5	--	4
	06-29-89	<0.010	--	20	--	--	8	--	4
	09-10-91	--	40	10	50	40	4	10	4
	06-23-92	--	--	--	--	40	<3	<10	3
MO Be 62	06-21-93	0.060	--	<10	--	10	7	<10	7
MO Db 68	07-13-78	--	--	--	--	200	50	<10	<10
	10-11-88	--	20	--	<10	6200	15	70	5
	03-27-89	--	<10	--	20	100	12	<10	2
	06-26-89	--	<10	--	<10	40	10	<10	1
	09-19-89	--	10	--	<10	80	22	<10	<1
	05-23-90	--	<10	<10	<10	420	5	<10	1
	05-15-91	--	--	--	--	--	--	--	--
	06-08-92	--	--	--	--	570	<3	<10	<1

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Zinc, total (µg/L)	Organic carbon, total (mg/L as C)	Radon-222, total (pCi/L)
FR Fb 12	08-21-81	10	--	--
	06-16-83	--	--	--
	04-27-89	30	1.3	--
	04-17-90	<10	0.9	--
	04-16-91	--	1.0	--
	05-12-92	--	1.2	--
HA Aa 9	02-16-89	20	0.1	--
	04-24-90	20	--	2800
	04-18-91	--	0.4	--
	06-15-92	--	0.5	--
HA Bc 31	02-16-89	<10	0.2	--
	04-24-90	<10	0.2	--
	04-18-91	--	0.8	--
	06-15-92	--	0.4	--
HA Ca 23	07-03-74	--	--	--
	09-21-88	20	0.9	--
	04-20-89	20	0.8	--
	06-14-89	<10	0.7	--
	09-21-89	10	0.2	--
	06-20-90	--	<0.1	2700
	05-22-91	--	<0.1	--
	06-15-92	--	0.1	--
HO Cd 78	03-17-88	--	<0.1	--
	06-09-88	--	<0.1	--
	09-14-88	--	3.3	--
	12-22-88	--	<0.1	--
	04-05-89	--	--	--
	06-29-89	--	0.4	--
	09-10-91	<10	0.2	--
	06-23-92	--	<0.1	700
MO Be 62	06-21-93	--	<0.1	3600
MO Db 68	07-13-78	--	--	--
	10-11-88	<10	2.9	--
	03-27-89	<10	0.3	--
	06-26-89	<10	0.6	--
	09-19-89	10	0.3	--
	05-23-90	--	0.3	850
	05-15-91	--	--	--
	06-08-92	--	0.1	--

Table A8.—Trace-element and other water-quality data from wells and springs in Segment II

(Concentrations in micrograms per liter, except as noted; <, less than)

Site number	Date	Specific conductance microseimens per centimeter at 25 deg. C)	pH (field)	Color, (platinum-cobalt units)	Dissolved oxygen (milligrams per liter)	Aluminum, total	Aluminum, dissolved	Arsenic, dissolved	Barium, dissolved	Beryllium, dissolved	Boron, total
BA Dc 444	06-19-91	261	7.9	1	1.4	--	<10	<1	28	0.7	--
CE Cc 40	08-13-81	190	5.4	--	--	<100	<100	--	--	--	--
	05-20-91	322	5.4	1	--	--	10	<1	65	0.7	--
CL Ae 1	05-26-92	109	5.3	<1	8.3	20	20	<1	13	<0.5	<10
CL Bf 184	05-22-91	194	6.4	1	6.0	--	<10	<1	7	<0.5	--
FR Af 27	04-17-91	450	7.7	5	1.8	--	<10	4	76	<0.5	--
FR Cd 38	05-11-82	--	6.7	--	--	<100	<100	--	--	--	--
	04-16-91	25	5.2	2	8.2	--	<10	<1	24	<0.5	--
FR Dd 178	08-21-81	510	7.2	--	--	200	100	--	--	--	--
	02-28-89	585	6.9	--	--	<10	<10	<1	54	<0.5	<10
	05-04-89	587	7.1	--	--	--	10	<1	53	<0.5	130
	06-16-89	578	7.2	--	--	20	<10	<1	52	<0.5	<10
	09-27-89	545	6.7	--	--	<10	<10	<1	52	<0.5	<10
FR Df 35	05-22-90	133	6.9	--	--	<10	<10	<1	47	<0.5	<10
FR Fb 12	08-21-81	385	6.5	--	--	200	200	--	--	--	--
	06-16-83	335	6.9	--	--	--	<100	--	--	--	--
	04-27-89	358	6.6	--	--	--	<10	<1	29	<0.5	50
HA Aa 9	04-18-91	162	5.4	1	9.5	--	30	<1	40	<0.5	--
HA Bc 31	06-15-92	32	5.6	<1	8.1	--	<10	<1	<2	0.7	--
HA Ca 23	05-22-91	114	6.1	1	7.4	--	<10	<1	9	<0.5	--
HO Cd 78	09-10-91	94	5.4	<1	8.8	40	10	<1	57	<0.5	50
MO Be 62	06-21-93	83	5.3	3	--	--	<10	<1	13	<0.5	--
MO Db 68	05-23-90	231	7.6	--	--	<10	<10	<1	120	<0.5	<10

(Concentrations in micrograms per liter, except as noted; <, less than)

Site number	Date	Cadmium, dis-solved	Chro-mium, dis-solved	Cobalt, dis-solved	Copper, dis-solved	Iron, total	Iron, dis-solved	Lead, total	Lead, dis-solved	Lithium, dis-solved	Manga-nese, total	Manga-nese, dis-solved
BA Dc 444	06-19-91	<1.0	<1	<1	1	3100	8	--	2	<4	<10	3
CE Cc 40	08-13-81	--	--	--	--	220	<10	7	--	--	<10	2
	05-20-91	<1.0	<1	2	3	<10	34	1	2	<4	<10	6
CL Ae 1	05-26-92	<1.0	<1	<1	10	120	30	--	2	<4	40	5
CL Bf 184	05-22-91	<1.0	<1	<1	<1	710	34	--	<1	<4	<10	5
FR Af 27	04-17-91	<1.0	<1	1	<1	5400	8	--	1	34	40	2
FR Cd 38	05-11-82	--	--	--	--	180	15	--	--	--	20	2
	04-16-91	<1.0	<1	1	1	20	3	--	1	<4	<10	7
FR Dd 178	08-21-81	--	--	--	--	140	10	7	--	--	10	<10
	02-28-89	<1.0	<1	<1	3	1000	13	--	<5	7	10	1
	05-04-89	3.0	2	1	14	20	<3	--	<1	<4	<10	<1
	06-16-89	<1.0	2	1	1	60	5	--	<1	5	10	1
	09-27-89	<1.0	1	<1	13	80	4	--	<1	6	40	<1
FR Df 35	05-22-90	<1.0	<1	<1	1	20	10	--	<1	<4	110	<1
FR Fb 12	08-21-81	--	--	--	--	160	10	8	--	--	<10	<10
	06-16-83	--	--	--	--	--	6	--	--	--	--	<1
	04-27-89	<1.0	<1	<1	7	<10	4	--	<5	<4	<10	<1
HA Aa 9	04-18-91	<1.0	2	7	1	40	3	--	<1	<4	10	13
HA Bc 31	06-15-92	<1.0	<1	<1	2	20	5	--	<1	<4	<10	2
HA Ca 23	05-22-91	<1.0	<1	<1	1	2800	23	--	1	<4	<10	8
HO Cd 78	09-10-91	<1.0	<1	<1	1	40	4	--	<1	<4	10	4
MO Be 62	06-21-93	<1.0	<1	<1	17	10	7	--	5	<4	<10	7
MO Db 68	05-23-90	<1.0	<1	<1	<1	420	5	--	<1	7	<10	1

Table A8.—Trace-element and other water-quality data from wells and springs in Segment II—Continued

(Concentrations in micrograms per liter, except as noted; <, less than)

Site number	Date	Mercury, dissolved	Molybdenum, dissolved	Nickel, dissolved	Selenium, dissolved	Vanadium, dissolved	Zinc, total	Zinc, dissolved
BA Dc 444	06-19-91	<0.1	1	2	<1	<1	--	<3
CE Cc 40	08-13-81	--	--	--	--	--	20	--
	05-20-91	<0.1	<1	8	<1	<1	--	16
CL Ae 1	05-26-92	0.1	<1	1	<1	<1	30	28
CL Bf 184	05-22-91	<0.1	<1	2	<1	<1	--	3
FR Af 27	04-17-91	<0.1	6	<1	1	7	--	<3
FR Cd 38	05-11-82	--	--	--	--	--	40	--
	04-16-91	<0.1	<1	1	<1	<1	--	7
FR Dd 178	08-21-81	--	--	--	--	--	10	--
	02-28-89	0.3	4	<1	<1	<1	10	<3
	05-04-89	<0.1	1	2	<1	<1	<10	5
	06-16-89	<0.1	<1	2	<1	<1	<10	4
	09-27-89	<0.1	<1	2	<1	<1	<10	7
FR Df 35	05-22-90	0.1	<1	2	<3	1	--	13
FR Fb 12	08-21-81	--	--	--	--	--	10	--
	06-16-83	--	--	--	--	--	--	--
	04-27-89	<0.1	<1	2	<1	<1	30	12
HA Aa 9	04-18-91	<0.1	<1	4	<1	<1	--	20
HA Bc 31	06-15-92	<0.1	<1	<1	<1	<1	--	8
HA Ca 23	05-22-91	<0.1	2	3	<1	<1	--	4
HO Cd 78	09-10-91	<0.1	<1	1	<1	<1	<10	6
MO Be 62	06-21-93	<0.1	<1	5	<1	<1	--	23
MO Db 68	05-23-90	0.1	<1	<1	<1	2	--	6

Table A9.—Schedule 1304 analyses from wells and springs in Segment II

(Concentrations are total amounts, in micrograms per liter)

Site number	Date	2,4-D	2,4-DP	2,4,5-T	Silvex	Sevin	Picloram	Dicamba
CE Cc 40	05-07-90	<0.01	<0.01	<0.01	<0.01	--	--	--
CL Bf 184	05-22-91	<0.01	<0.01	<0.01	<0.01	--	--	--
FR Dd 178	04-17-91	<0.01	<0.01	<0.01	<0.01	--	--	--
FR Df 35	05-22-90	<0.01	<0.01	<0.01	<0.01	--	--	--
HA Aa 9	04-24-90	0.11	0.01	<0.01	<0.01	--	--	--
	04-18-91	<0.01	<0.01	<0.01	<0.01	--	--	--
HA Ca 23	05-22-91	<0.01	<0.01	<0.01	<0.01	--	--	--
HO Cd 78	08-23-88	<0.01	<0.01	<0.01	<0.01	<0.5	--	--
MO Db 68	05-23-90	<0.01	<0.01	<0.01	<0.01	--	--	--

Table A10.—Schedule 1331 analyses from wells and springs in Segment II

(All concentrations are dissolved amounts, in micrograms per liter)

Site number	Date	PCB	PCN	Aldrin	Chlordane	DDD	DDE	DDT	Diazinon	Dieldrin
CE Cc 40	05-07-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
CL Bf 184	06-19-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
FR Dd 178	04-17-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
FR Df 35	05-22-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
HA Aa 9	06-15-92	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
MO Db 68	05-23-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01

Site number	Endosulfan	Endrin	Ethion	Heptachlor	Heptachlor epoxide	Lindane	Malathion	Methoxychlor
CE Cc 40	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CL Bf 184	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
FR Dd 178	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
FR Df 35	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
HA Aa 9	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MO Db 68	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Site number	Methyl parathion	Methyl trithion	Mirex	Parathion	Perthane	Toxaphene	Trithion
CE Cc 40	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
CL Bf 184	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
FR Dd 178	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
FR Df 35	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
HA Aa 9	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
MO Db 68	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01

Table A11.—Schedule 1389 analyses from wells and springs in Segment II

(All concentrations are total amounts, in micrograms per liter)

Site number	Date	Alachlor	Ametryn	Atrazine	Cyanazine	Bromacil	Butachlor	Butylate	Carboxin
CE Cc 40	02-21-89	<0.10	<0.10	<0.10	<0.10	--	--	--	--
CL Bf 184	09-22-88	<0.10	<0.10	0.10	<0.10	--	--	--	--
	02-28-89	<0.10	<0.10	0.10	<0.10	--	--	--	--
	06-19-89	<0.10	<0.10	0.20	<0.10	--	--	--	--
	09-20-89	<0.10	<0.10	0.10	<0.10	--	--	--	--
	06-19-90	<0.10	<0.10	0.10	<0.10	--	--	--	--
FR Af 27	05-03-89	<0.10	<0.10	<0.10	<0.10	--	--	--	--
FR Dd 178	04-17-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--
FR Df 35	05-22-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--
HA Aa 9	04-24-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--
HA Ca 23	09-21-88	<0.10	<0.10	<0.10	<0.10	--	--	--	--
	04-20-89	<0.10	<0.10	<0.10	<0.10	--	--	--	--
	06-14-89	<0.10	<0.10	0.10	<0.10	--	--	--	--
HO Cd 78	08-23-88	<0.10	<0.10	<0.10	0.10	--	--	--	--
MO Db 68	05-23-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--

Site number	Cycloate	De-ethyl atrazine	De-isopropyl atrazine	Diphenamid	Hexazinone	Metolachlor	Metribuzin	Prometon
CE Cc 40	--	--	--	--	--	<0.10	<0.10	<0.10
CL Bf 184	--	--	--	--	--	<0.10	<0.10	<0.10
	--	--	--	--	--	<0.10	<0.10	<0.10
	--	--	--	--	--	<0.10	<0.10	<0.10
	--	--	--	--	--	<0.10	<0.10	<0.10
	--	--	--	--	--	<0.10	<0.10	<0.10
FR Af 27	--	--	--	--	--	<0.10	<0.10	<0.10
FR Dd 178	--	--	--	--	--	<0.10	<0.10	<0.10
FR Df 35	--	--	--	--	--	<0.10	<0.10	<0.10
HA Aa 9	--	--	--	--	--	<0.10	<0.10	<0.10
HA Ca 23	--	--	--	--	--	<0.10	<0.10	<0.10
	--	--	--	--	--	<0.10	<0.10	<0.10
	--	--	--	--	--	<0.10	<0.10	<0.10
HO Cd 78	--	--	--	--	--	0.30	<0.10	<0.10
MO Db 68	--	--	--	--	--	<0.10	<0.10	<0.10

Site number	Prometryn	Propazine	Propachlor	Simazine	Simetryne	Terbacil	Trifluralin	Vernolate
CE Cc 40	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
CL Bf 184	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
FR Af 27	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
FR Dd 178	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
FR Df 35	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
HA Aa 9	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
HA Ca 23	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
HO Cd 78	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
MO Db 68	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--

Table A12.—Schedule 1390 analyses from wells and springs in Segment II

(Concentrations are total amounts, in micrograms per liter; <, less than)

Site number	Date	Acrolein	Acrylo-nitrile	Benzene	Bromo-benzene	Bromoform	n-Butyl benzene	sec-Butyl benzene	tert-Butyl benzene
CE Cc 40	05-21-92	<20	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
CL Bf 184	05-13-92	<20	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
FR Af 27	05-11-92	<20	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
FR Dd 178	02-28-89	--	--	<3.0	--	<3.0	--	--	--
	05-04-89	--	--	<3.0	--	<3.0	--	--	--
	06-16-89	--	--	<3.0	--	<3.0	--	--	--
	09-27-89	--	--	<3.0	--	<3.0	--	--	--
	04-17-90	--	--	<3.0	--	<3.0	--	--	--
FR Df 35	05-22-90	--	--	<3.0	--	<3.0	--	--	--
FR Fb 12	04-27-89	--	--	<3.0	--	<3.0	--	--	--
HA Ca 23	05-22-91	--	--	<3.0	--	<3.0	--	--	--
MO Db 68	05-23-90	--	--	<3.0	--	<3.0	--	--	--

Site number	Carbon tetra-chloride	Chloro-benzene	Chloro-dibromo-methane	Chloro-ethane	2-Chloro-ethyl-vinyl-ether	Chloro-form	o-Chloro-toluene	p-Chloro-toluene	Dibromo-chloro-propane	1,2-Dibromo-ethane
CE Cc 40	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
CL Bf 184	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
FR Af 27	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
FR Dd 178	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
FR Df 35	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
FR Fb 12	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
HA Ca 23	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
MO Db 68	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0

Site number	Dibromo-methane	1,2-Dichloro-benzene	1,3-Dichloro-benzene	1,4-Dichloro-benzene	Dichloro-bromo-methane	Dichloro-difluoro-methane	1,1-Dichloro-ethane	1,2-Dichloro-ethane	1,2-trans-Dichloro-ethene
CE Cc 40	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
CL Bf 184	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
FR Af 27	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
FR Dd 178	--	<3.0	<3.0	<3.0	<3.0	16	<3.0	<3.0	<3.0
	--	<3.0	<3.0	<3.0	<3.0	11	<3.0	<3.0	<3.0
	--	<3.0	<3.0	<3.0	<3.0	16	<3.0	<3.0	<3.0
	--	<3.0	<3.0	<3.0	<3.0	6.4	<3.0	<3.0	<3.0
	--	<3.0	<3.0	<3.0	<3.0	8.9	<3.0	<3.0	<3.0
FR Df 35	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
FR Fb 12	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
HA Ca 23	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
MO Db 68	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Table A12.—Schedule 1390 analyses from wells and springs in Segment II—Continued

(Concentrations are total amounts, in micrograms per liter; <, less than)

Site number	cis-1,2-Dichloro-ethene	1,1-Dichloro-ethylene	1,2-Dichloro-propane	1,3-Dichloro-propane	2,2-Dichloro-propane	1,1-Dichloro-propene	1,3-Dichloro-propene	cis-1,3-Dichloro-propene	trans-1,3-Dichloro-propene
CE Cc 40	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0
CL Bf 184	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0
FR Af 27	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0
FR Dd 178	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
FR Df 35	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
FR Fb 12	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
HA Ca 23	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
MO Db 68	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0

Site number	Ethyl-benzene	Hexa-chloro-butadiene	Isopropyl-benzene	p-Isopropyl toluene	Methyl-bromide	Methyl-chloride	Methylene chloride	Naphth-alene	n-Propyl-benzene
CE Cc 40	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
CL Bf 184	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
FR Af 27	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
FR Dd 178	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
FR Df 35	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
FR Fb 12	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
HA Ca 23	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
MO Db 68	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--

Site number	Styrene	1,1,2,2-Tetra-chloro-ethane	1,1,1,2-Tetra-chloro-ethane	Tetra-chloro-ethylene	Toluene	1,2,3-Trichloro-benzene	1,2,4-Trichloro-benzene	1,1,1-Trichloro-ethane	1,1,2-Trichloro-ethane
CE Cc 40	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
CL Bf 184	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
FR Af 27	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
FR Dd 178	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
FR Df 35	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
FR Fb 12	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
HA Ca 23	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
MO Db 68	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0

(concentrations are total amounts, in micrograms per liter; <, less than)

Site number	Trichloro-ethylene	Trichloro-fluoromethane	1,2,3-Trichloro-propane	1,2,4-Trimethyl-benzene	1,3,5-Trimethyl-benzene	Vinyl chloride	Xylene
CE Cc 40	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0	<3.0
CL Bf 184	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0	<3.0
FR Af 27	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0	<3.0
FR Dd 178	<3.0	<3.0	--	--	--	<1.0	<3.0
	<3.0	<3.0	--	--	--	<1.0	<3.0
	<3.0	<3.0	--	--	--	<1.0	<3.0
	<3.0	<3.0	--	--	--	<1.0	<3.0
	<3.0	<3.0	--	--	--	<1.0	<3.0
FR Df 35	<3.0	<3.0	--	--	--	<1.0	<3.0
FR Fb 12	<3.0	<3.0	--	--	--	<1.0	<3.0
HA Ca 23	<3.0	<3.0	--	--	--	<1.0	<3.0
MO Db 68	<3.0	<3.0	--	--	--	<1.0	<3.0

Table A13.—Major ions, nutrients, field parameters, and other chemical-quality data from wells in Segment III

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Record number	Date	Time	Water level (feet below land surface)	Discharge (gal/min)	Specific conductance (µS/cm)	pH	Temperature, air (deg. C)	Temperature, water (deg. C)	Color, (platinum-cobalt units)
AA Ad 104	98800075	12-07-87	1245	9.05	1.7	292	6.4	10.0	14.0	--
	98800296	03-15-88	1220	7.80	1.5	321	6.3	2.0	9.5	--
	98800390	05-17-88	1100	7.58	1.4	330	6.0	21.0	10.0	--
	98800606	07-11-88	1325	9.21	1.7	415	6.1	32.5	13.0	--
	99000239	12-26-89	1145	7.17	1.0	384	5.9	1.0	14.5	--
	99000923	07-19-90	1030	5.53	1.2	630	6.1	30.5	15.0	--
	99100845	06-26-91	1120	6.99	1.0	610	6.2	24.0	13.5	--
	99200547	05-21-92	1005	9.31	1.0	552	6.2	20.5	12.0	5
AA Cg 25	98800173	02-10-88	1230	16.86	1.5	134	6.3	5.0	13.0	--
	98800604	07-13-88	1310	15.90	1.6	111	6.4	28.0	14.0	--
	98900316	01-24-89	1340	16.30	1.4	105	6.4	14.0	13.5	--
	99000706	05-24-90	1630	15.64	1.3	133	6.2	22.0	13.5	--
	99100563	05-14-91	1617	15.64	0.9	132	6.3	--	14.0	--
	99200529	05-19-92	1050	15.88	0.7	139	6.3	22.0	14.5	--
AA Df 103	98800162	02-11-88	1230	24.57	0.7	260	5.8	4.0	11.5	--
	98800603	07-21-88	1140	24.54	1.4	308	5.6	27.0	14.0	--
	98900319	01-25-89	1215	25.06	1.5	243	5.5	6.0	13.0	--
	99000704	05-24-90	1130	23.27	1.2	258	5.4	18.0	13.5	--
	99100562	05-14-91	1230	23.43	0.8	246	5.4	26.0	14.5	1
	99200528	05-19-92	1340	24.19	0.7	251	5.4	21.5	14.5	<1
CA Fc 13	98700561	09-01-87	1400	28.72	0.8	610	7.1	27.5	16.0	--
	98800079	12-09-87	1130	30.05	1.0	501	7.2	17.5	15.5	--
	98800348	03-15-88	1135	27.87	0.7	688	7.1	1.5	15.0	--
	98800512	06-22-88	1125	27.63	1.0	596	7.1	37.0	14.5	--
	98900218	12-14-88	1315	30.27	0.5	572	6.7	--	15.0	--
	99000872	07-02-90	0830	24.38	0.9	531	7.1	24.5	16.5	--
	99101063	09-09-91	1031	30.07	0.6	561	7.3	26.5	16.0	1
	99200651	06-29-92	1038	29.18	5.0	620	7.1	26.5	16.5	<1
CH Cb 7	98800360	05-11-88	1400	87.52	6.0	290	6.8	21.0	14.0	--
	99000070	10-18-89	1430	--	6.0	304	7.5	21.0	16.0	--
	99000930	07-23-90	1500	85.34	8.5	293	7.6	34.0	15.5	--
	99100843	06-25-91	1520	87.00	9.2	293	7.7	26.5	15.5	7
	99200595	06-17-92	1310	82.39	6.7	315	7.7	24.5	16.0	--
CH Ee 16	96200118	12-13-61	1200	--	--	121	6.5	--	15.5	30
	98800074	12-08-87	1400	15.67	1.8	401	7.4	10.0	15.0	--
	98800205	03-09-88	1220	13.76	1.3	295	7.1	16.0	12.0	--
	98800392	05-19-88	1125	14.68	1.0	207	6.3	23.0	13.0	--
	98800668	07-28-88	1125	19.73	1.5	260	6.6	23.0	14.0	--
	99000609	05-09-90	1335	15.34	1.3	260	7.0	25.5	15.0	--
	99100557	05-09-91	1325	18.92	0.6	194	6.6	19.5	14.5	2
	99200648	06-30-92	0935	--	0.5	221	6.5	25.5	16.0	<1
CH Ee 90	98900830	06-05-89	1645	4.60	--	269	5.8	26.0	14.0	--
	99000603	05-08-90	1359	4.35	1.3	255	5.8	28.0	15.5	--
	99100553	05-08-91	1350	5.29	0.3	232	5.6	27.0	13.5	45
	99200649	06-29-92	1630	5.28	0.8	237	5.6	26.0	15.0	<1
HA Dd 92	98800381	04-07-88	1300	13.22	6.0	292	6.1	9.0	14.0	2
	98800602	07-19-88	1040	11.45	1.7	360	6.1	29.5	15.0	--
	98900241	01-17-89	1050	12.31	1.5	361	5.9	0.5	16.0	--
	99000900	07-10-90	1005	11.10	1.2	427	5.9	32.0	15.0	--
	99100611	05-20-91	1409	8.87	1.1	420	6.0	25.5	15.0	8
	99200548	05-21-92	1315	10.77	1.0	449	5.9	19.0	15.5	70
PG Bc 37	99000520	04-23-90	1455	9.82	1.2	1710	5.0	18.0	11.5	--
	99100613	05-21-91	1647	10.80	1.0	1710	5.0	26.0	12.5	6
SM Ef 80	98800206	02-24-88	1200	17.46	1.5	258	5.6	3.0	10.0	--
	99000606	05-09-90	0930	14.40	1.2	166	5.4	20.5	13.0	--
	99100555	05-09-91	1004	17.62	0.7	166	5.6	18.5	13.0	7
	99200650	06-29-92	1335	18.22	0.7	161	5.2	28.0	15.5	<1

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Dissolved oxygen (mg/L)	Hardness, total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L)	Magne-sium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Bicar-bonate, total (mg/L)	Alkalinity, total (mg/L as $CaCO_3$)
AA Ad 104	12-07-87	--	87	28	4.2	25	3.2	93	76
	03-15-88	--	76	23	4.5	28	3.2	82	67
	05-17-88	--	77	23	4.7	30	1.8	69	57
	07-11-88	--	94	29	5.2	38	3.5	82	67
	12-26-89	--	89	27	5.3	38	3.0	94	77
	07-19-90	--	110	35	6.1	82	3.2	121	99
	06-26-91	0.1	--	--	--	--	--	127	104
	05-21-92	0.2	120	35	8.3	50	3.4	121	99
AA Cg 25	02-10-88	--	31	8.5	2.4	3.6	3.5	68	56
	07-13-88	0.2	31	8.4	2.5	3.2	3.1	68	56
	01-24-89	--	30	8.2	2.3	3.4	3.5	92	75
	05-24-90	--	32	8.7	2.4	3.7	3.2	61	50
	05-14-91	0.1	--	--	--	--	--	67	55
	05-19-92	0.4	30	8.2	2.3	3.3	3.4	68	56
AA Df 103	02-11-88	--	69	17	6.4	18	4.4	23	19
	07-21-88	5.1	79	19	7.6	20	3.8	25	20
	01-25-89	--	79	19	7.7	21	4.4	21	17
	05-24-90	--	62	15	6.0	21	3.6	21	17
	05-14-91	5.6	56	14	5.2	18	3.3	20	17
	05-19-92	5.2	53	13	5.0	20	3.3	20	17
CA Fc 13	09-01-87	6.6	320	110	10	8.7	6.9	341	280
	12-09-87	5.9	320	120	5.1	10	3.1	--	--
	03-15-88	4.9	360	130	8.2	11	6.5	--	--
	06-22-88	6.1	300	110	6.7	9.7	4.1	--	--
	12-14-88	4.9	300	110	5.4	9.5	3.7	--	--
	07-02-90	--	270	94	8.3	8.7	4.0	289	237
	09-09-91	6.5	290	110	4.9	10	2.8	310	254
	06-29-92	5.5	300	110	5.5	10	3.2	320	262
CH Cb 7	05-11-88	--	14	2.8	1.7	63	2.7	166	136
	10-18-89	--	13	2.7	1.4	63	--	--	--
	07-23-90	--	12	2.5	1.5	62	2.8	170	140
	06-25-91	0.1	13	2.7	1.5	65	2.6	165	135
	06-17-92	0.1	12	2.6	1.4	60	3.0	173	142
CH Ee 16	12-13-61	--	46	16	1.5	3.6	3.1	--	--
	12-08-87	--	170	61	5.2	5.7	5.0	178	146
	03-09-88	--	130	43	4.3	5.7	3.9	106	86
	05-19-88	--	82	26	4.1	4.6	2.3	66	54
	07-28-88	--	110	37	5.2	4.5	3.3	113	92
	05-09-90	--	110	37	4.0	5.5	3.2	110	90
	05-09-91	6.7	87	28	4.1	4.4	2.8	70	57
	06-30-92	7.2	100	33	4.4	6.6	5.0	88	72
CH Ee 90	06-05-89	--	88	25	6.3	12	5.6	36	29
	05-08-90	--	82	24	5.4	9.7	5.0	39	32
	05-08-91	3.9	73	21	4.9	12	5.2	26	21
	06-29-92	3.0	67	19	4.8	11	5.9	23	19
HA Dd 92	04-07-88	0	61	9.8	8.9	35	1.0	--	58
	07-19-88	--	71	12	9.9	34	1.5	67	55
	01-17-89	--	74	13	10	38	1.1	60	49
	07-10-90	--	84	14	12	46	0.8	59	48
	05-20-91	0.2	82	13	12	54	0.7	60	49
	05-21-92	0.2	78	13	11	49	0.8	61	50
PG Bc 37	04-23-90	--	77	15	9.5	270	4.4	17	13
	05-21-91	3.2	81	16	10	300	5.1	10	9
SM Ef 80	02-24-88	--	80	24	4.9	4.9	6.6	6	5
	05-09-90	--	60	19	3.0	1.9	3.2	15	12
	05-09-91	3.7	61	18	4.0	3.1	2.8	8	7
	06-29-92	1.6	61	16	5.1	2.4	0.9	7	6

Table A13.—Major ions, nutrients, field parameters, and other chemical-quality data from wells in Segment III—Continued

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L as SiO_2)	Solids, residue on evaporation, dissolved (mg/L)	Solids, sum of dissolved constituents (mg/L)	Nitrite, total (mg/L as N)	Nitrite, dissolved (mg/L as N)
AA Ad 104	12-07-87	19	44	0.20	6.2	187	178	--	--
	03-15-88	19	50	0.20	4.9	--	174	--	--
	05-17-88	20	56	0.20	5.0	--	176	--	--
	07-11-88	15	81	<0.10	4.8	--	220	--	--
	12-26-89	12	65	0.10	6.0	--	204	--	--
	07-19-90	13	100	<0.10	4.2	--	305	--	--
	06-26-91	--	130	--	--	--	--	--	--
	05-21-92	6.3	95	<0.10	4.1	304	265	0.020	--
AA Cg 25	02-10-88	4.5	6.1	0.60	27	99	105	--	--
	07-13-88	3.8	4.6	0.50	2.8	--	79	--	--
	01-24-89	6.9	5.5	0.60	27	--	118	--	--
	05-24-90	3.8	5.1	0.30	27	--	100	--	--
	05-14-91	--	5.0	--	--	--	--	--	--
	05-19-92	4.1	5.0	0.70	26	88	102	<0.010	--
AA Df 103	02-11-88	11	53	0.10	18	162	140	--	--
	07-21-88	10	77	0.10	16	--	166	--	--
	01-25-89	9.6	67	0.10	16	--	155	--	--
	05-24-90	9.3	56	<0.10	17	--	139	--	--
	05-14-91	9.2	23	<0.10	16	193	99	<0.010	--
	05-19-92	15	49	<0.10	17	142	132	<0.010	--
CA Fc 13	09-01-87	19	13	0.20	20	377	397	--	--
	12-09-87	13	14	0.30	23	390	384	--	--
	03-15-88	23	15	0.10	22	--	426	--	0.010
	06-22-88	16	14	0.30	22	--	382	--	0.010
	12-14-88	16	13	0.20	22	--	374	--	--
	07-02-90	12	14	<0.10	19	--	302	--	--
	09-09-91	18	12	0.20	20	360	330	<0.010	--
	06-29-92	20	10	0.20	23	340	339	<0.010	--
CH Cb 7	05-11-88	9.9	7.1	0.90	33	--	203	--	--
	10-18-89	8.0	8.1	--	32	196	--	--	--
	07-23-90	8.0	11	0.80	33	187	206	--	--
	06-25-91	7.8	11	0.90	33	202	206	<0.010	--
	06-17-92	6.6	12	0.80	33	194	205	<0.010	--
CH Ee 16	12-13-61	6.0	6.2	1.4	62	126	127	--	--
	12-08-87	19	11	1.3	72	274	270	--	--
	03-09-88	32	11	1.6	69	--	223	--	--
	05-19-88	23	10	1.2	72	--	176	--	--
	07-28-88	18	8.6	1.0	73	--	206	--	--
	05-09-90	19	11	1.4	66	--	201	--	--
	05-09-91	18	12	1.3	74	168	179	<0.010	--
	06-30-92	22	11	1.3	67	178	194	<0.010	--
CH Ee 90	06-05-89	54	12	0.10	12	--	145	--	--
	05-08-90	47	10	<0.10	11	--	131	--	--
	05-08-91	42	13	<0.10	13	137	124	<0.010	--
	06-29-92	43	14	<0.10	15	124	124	<0.010	--
HA Dd 92	04-07-88	23	55	0.20	34	209	208	--	--
	07-19-88	20	63	0.30	33	--	214	--	--
	01-17-89	29	68	0.20	34	--	230	--	--
	07-10-90	27	84	0.10	33	--	250	--	--
	05-20-91	53	75	0.20	32	242	273	<0.010	--
	05-21-92	46	69	<0.10	33	298	255	<0.010	--
PG Bc 37	04-23-90	20	460	<0.10	10	886	807	--	--
	05-21-91	25	540	0.20	9.9	956	919	<0.010	--
SM Ef 80	02-24-88	49	9.0	0.10	6.1	153	107	--	--
	05-09-90	43	4.7	<0.10	3.9	--	86	--	--
	05-09-91	30	5.2	<0.10	5.9	101	73	<0.010	--
	06-29-92	39	6.1	<0.10	7.0	80	80	<0.010	--

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Nitrate plus nitrite, total (mg/L as N)	Nitrate plus nitrite, dissolved (mg/L as N)	Ammonia, total (mg/L as N)	Phosphorus, total (mg/L as P)	Ortho-phosphate, total (mg/L as P)	Ortho-phosphate, dissolved (mg/L as P)	Aluminum, total (µg/l)
AA Ad 104	12-07-87	<0.100	0.027	--	0.050	--	0.026	--
	03-15-88	0.300	--	--	--	--	--	180
	05-17-88	0.200	--	--	<0.010	--	--	240
	07-11-88	<0.100	--	--	0.030	--	--	160
	12-26-89	<0.100	--	--	0.070	--	--	270
	07-19-90	<0.100	--	--	0.020	--	--	220
	06-26-91	0.120	--	--	0.020	--	--	--
	05-21-92	<0.050	--	2.30	0.030	0.030	--	--
AA Cg 25	02-10-88	<0.100	--	--	0.390	--	--	--
	07-13-88	<0.100	--	--	0.470	--	--	20
	01-24-89	<0.100	--	--	0.990	--	--	<10
	05-24-90	<0.100	--	--	1.70	--	--	<10
	05-14-91	<0.050	--	--	0.310	--	--	--
	05-19-92	<0.050	--	0.080	1.70	1.00	--	--
AA Df 103	02-11-88	1.80	--	--	0.140	--	--	--
	07-21-88	1.90	--	--	0.090	--	--	270
	01-25-89	1.90	--	--	0.060	--	--	150
	05-24-90	1.50	--	--	0.050	--	--	110
	05-14-91	1.60	--	<0.010	0.040	0.010	--	--
	05-19-92	1.60	--	<0.010	0.050	0.050	--	--
CA Fc 13	09-01-87	9.10	9.20	--	0.160	--	0.133	--
	12-09-87	8.60	9.30	--	--	--	0.150	--
	03-15-88	9.40	9.20	--	--	--	--	<10
	06-22-88	8.20	9.20	--	0.130	--	--	40
	12-14-88	8.10	8.50	--	0.140	--	--	10
	07-02-90	7.50	--	--	0.130	--	--	20
	09-09-91	8.40	--	0.010	0.150	0.050	--	--
	06-29-92	6.90	--	0.010	0.130	0.140	--	--
CH Cb 7	05-11-88	<0.100	--	--	1.70	--	--	--
	10-18-89	--	--	--	--	--	--	--
	07-23-90	<0.100	--	--	1.60	--	--	220
	06-25-91	<0.050	--	0.680	1.60	1.60	--	--
	06-17-92	<0.050	--	0.670	1.80	1.80	--	--
CH Ee 16	12-13-61	--	--	--	--	--	--	<50
	12-08-87	0.200	0.170	--	1.20	--	0.250	--
	03-09-88	0.100	--	--	0.040	--	--	20
	05-19-88	0.200	--	--	1.40	--	--	80
	07-28-88	0.100	--	--	1.60	--	--	110
	05-09-90	0.200	--	--	1.40	--	--	40
	05-09-91	0.100	--	0.050	1.60	1.50	--	--
	06-30-92	0.440	--	0.190	2.90	0.880	--	--
CH Ee 90	06-05-89	4.80	--	--	0.060	--	--	580
	05-08-90	5.70	--	--	0.020	--	--	370
	05-08-91	5.50	--	<0.010	<0.010	<0.010	--	--
	06-29-92	4.80	--	<0.010	0.040	0.020	--	--
HA Dd 92	04-07-88	0.100	--	--	0.160	--	--	--
	07-19-88	<0.100	--	--	0.040	--	--	<10
	01-17-89	<0.100	--	--	0.020	--	--	20
	07-10-90	<0.100	--	--	0.010	--	--	<10
	05-20-91	<0.050	--	0.120	<0.010	<0.010	--	--
	05-21-92	<0.050	--	0.100	0.010	<0.010	--	--
PG Bc 37	04-23-90	0.200	--	--	<0.010	--	--	240
	05-21-91	0.220	--	0.060	<0.010	<0.010	--	--
SM Ef 80	02-24-88	8.00	--	--	0.030	--	--	--
	05-09-90	5.70	--	--	0.020	--	--	10
	05-09-91	6.00	--	<0.010	<0.010	<0.010	--	--
	06-29-92	3.00	--	0.020	0.020	0.020	--	--

Table A13.—Major ions, nutrients, field parameters, and other chemical-quality data from wells in Segment III—Continued

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Aluminum, dissolved (µg/L)	Boron, total (µg/L)	Iron, total (µg/L)	Iron, dissolved (µg/L)	Manganese, total (µg/L)	Manganese, dissolved (µg/L)	Zinc, total (µg/L)	Organic carbon, total (mg/L as C)	Radon-222, total (pCi/L)
AA Ad 104	12-07-87	140	--	1600	1600	140	140	--	--	--
	03-15-88	--	20	1300	1300	170	170	<10	--	--
	05-17-88	--	20	1100	1000	190	180	<10	12	--
	07-11-88	--	20	2700	2800	160	160	<10	11	--
	12-26-89	--	40	2600	1500	190	170	20	12	--
	07-19-90	--	<10	1900	1800	220	220	--	13	<80
	06-26-91	--	--	--	--	--	--	--	16	--
	05-21-92	--	--	3400	3600	310	310	--	1.5	--
AA Cg 25	02-10-88	--	--	13000	15000	350	380	--	--	--
	07-13-88	--	20	14000	16000	360	360	<10	4.2	--
	01-24-89	--	<10	13000	15000	370	360	<10	1.7	--
	05-24-90	<10	20	16000	15000	380	400	--	--	100
	05-14-91	--	--	--	--	--	--	--	--	--
	05-19-92	--	--	13000	15000	330	350	--	0.2	--
AA Df 103	02-11-88	--	--	13000	520	30	9	--	--	--
	07-21-88	--	10	1500	19	20	13	10	2.0	--
	01-25-89	--	20	760	21	10	12	<10	1.5	--
	05-24-90	<10	20	650	19	10	12	--	0.5	300
	05-14-91	--	--	280	5	<10	11	--	0.3	--
	05-19-92	--	--	510	14	30	9	--	0.5	--
CA Fc 13	09-01-87	<10	--	--	<3	--	4	--	--	--
	12-09-87	<10	--	20	7	<10	<1	--	--	--
	03-15-88	--	20	<10	<3	<10	<1	<10	<0.1	--
	06-22-88	--	30	50	<3	<10	<1	20	0.3	--
	12-14-88	--	50	30	8	<10	<1	30	13	--
	07-02-90	--	20	<10	6	<10	2	<10	0.4	--
	09-09-91	--	--	50	5	<10	<1	--	0.5	--
	06-29-92	--	--	30	<3	<10	<1	--	0.3	1000
CH Cb 7	05-11-88	--	--	1800	370	60	55	--	--	--
	10-18-89	--	--	--	650	--	47	--	0.5	--
	07-23-90	--	250	1800	460	40	43	--	0.6	--
	06-25-91	<10	--	820	600	30	41	--	0.5	--
	06-17-92	--	--	730	620	30	39	--	0.5	--
CH Ee 16	12-13-61	--	--	1400	--	150	--	<50	--	--
	12-08-87	<10	--	350	98	20	23	--	--	--
	03-09-88	--	30	140	140	<10	5	<10	0.7	--
	05-19-88	--	<10	480	31	70	59	<10	1.7	--
	07-28-88	--	<10	920	230	120	110	30	7.0	--
	05-09-90	--	20	600	25	30	25	--	0.7	1200
	05-09-91	--	--	630	35	80	87	--	0.8	--
	06-30-92	--	--	4600	190	170	120	--	2.6	--
CH Ee 90	06-05-89	--	30	1900	57	20	11	20	3.6	--
	05-08-90	--	20	1200	9	20	7	--	2.6	1800
	05-08-91	<10	--	600	16	10	16	--	1.7	--
	06-29-92	--	--	1600	7	30	13	--	1.6	--
HA Dd 92	04-07-88	--	--	6600	6300	180	180	--	1.5	--
	07-19-88	--	<10	6300	7000	200	200	<10	--	--
	01-17-89	--	<10	5700	6500	190	190	<10	--	--
	07-10-90	--	20	4000	4300	170	200	--	1.5	140
	05-20-91	<10	--	3200	3500	230	180	--	1.3	--
	05-21-92	--	--	2800	2900	190	180	--	26	--
PG Bc 37	04-23-90	--	20	12000	9600	880	800	50	1.2	550
	05-21-91	280	--	8000	6100	1100	970	--	1.5	--
SM Ef 80	02-24-88	--	--	80	13	10	14	--	--	--
	05-09-90	--	10	20	8	10	7	--	1.2	250
	05-09-91	20	--	60	4	20	18	20	1.3	--
	06-29-92	--	--	30	9	20	22	--	0.8	--

Table A14.—Trace-element and other water-quality data from wells in Segment III

(Concentrations in micrograms per liter, except as noted; <, less than)

Site number	Date	Specific conductance (microsiemens per centimeter at 25 deg. C)	pH (field)	Color, (platinum-cobalt units)	Dissolved oxygen (milligrams per liter)	Aluminum, total	Aluminum, dissolved	Antimony, dissolved	Arsenic, dissolved	Barium, dissolved	Beryllium, dissolved	Boron, total
AA Ad 104	12-07-87	292	6.4	--	--	--	140	1	--	29	<0.5	--
AA Cg 25	05-24-90	133	6.2	--	--	<10	<10	--	1	29	<0.5	20
AA Df 103	05-24-90	258	5.4	--	--	110	<10	--	<1	31	<0.5	20
CA Fc 13	09-01-87	610	7.1	--	6.6	--	<10	<1	<1	32	<0.5	--
	12-09-87	501	7.2	--	5.9	--	<10	<1	<1	14	<0.5	--
CH Cb 7	06-25-91	293	7.7	7	0.1	--	<10	--	<1	14	<0.5	--
CH Ee 16	12-08-87	401	7.4	--	--	--	<10	1	2	12	<0.5	--
CH Ee 90	05-08-91	232	5.6	45	3.9	--	<10	--	<1	29	<0.5	--
HA Dd 92	05-20-91	420	6.0	8	0.2	--	<10	--	2	47	0.7	--
PG Bc 37	05-21-91	1710	5.0	6	3.2	--	280	--	<1	330	0.8	--
SM Ef 80	05-09-91	166	5.6	7	3.7	--	20	--	<1	15	<0.5	--

Site number	Boron, dissolved	Cadmium, dissolved	Chromium, dissolved	Cobalt, dissolved	Copper, dissolved	Iron, total	Iron, dissolved	Lead, dissolved	Lithium, dissolved	Manganese, total	Manganese, dissolved
AA Ad 104	50	<1.0	--	1	2	1600	1600	<5	<4	140	140
AA Cg 25	--	<1.0	<1	1	1	16000	15000	<1	8	380	400
AA Df 103	--	<1.0	5	<1	5	650	19	<1	<4	10	12
CA Fc 13	30	1.0	<10	1	2	--	<3	<5	<4	--	4
	30	<1.0	<5	2	19	20	7	<5	11	<10	<1
CH Cb 7	--	<1.0	<1	1	<1	820	600	<1	<4	30	41
CH Ee 16	40	<1.0	<1	<1	2	350	98	<5	23	20	23
CH Ee 90	--	<1.0	<1	<1	1	600	16	<1	<4	10	16
HA Dd 92	--	<1.0	<1	10	<1	3200	3500	<1	<4	230	180
PG Bc 37	--	<10	<1	140	1	8000	6100	5	<4	1100	970
SM Ef 80	--	<1.0	<1	2	5	60	4	<1	<4	20	18

Table A14.—Trace-element and other water-quality data from wells in Segment III—Continued

(Concentrations in micrograms per liter, except as noted; <, less than)

Site number	Mercury, dissolved	Molybdenum, dissolved	Nickel, dissolved	Selenium, dissolved	Strontium, dissolved	Vanadium, dissolved	Zinc, total	Zinc, dissolved
AA Ad 104	--	<1	<1	--	73	5	--	19
AA Cg 25	0.3	<1	1	<2	--	<1	--	4
AA Df 103	<0.1	<1	3	<1	--	<1	--	13
CA Fc 13	--	<1	3	2	440	<1	--	12
	--	2	2	2	470	<1	--	8
CH Cb 7	<0.1	<1	<1	<1	--	<1	--	<3
CH Ee 16	--	2	4	1	250	<1	--	14
CH Ee 90	<0.1	<1	5	<1	--	<1	--	8
HA Dd 92	--	<1	13	<1	--	5	--	9
PG Bc 37	<0.1	<1	46	<1	--	25	--	62
SM Ef 80	<0.1	<1	2	<1	--	<1	20	13

Table A15.—Schedule 1304 analyses from wells in Segment III

(Concentrations are total amounts, in micrograms per liter)

Site number	Date	2,4-D	2,4-DP	2,4,5-T	Silvex	Sevin	Picloram	Dicamba
AA Ad 104	12-07-87	<0.01	<0.01	<0.01	0.01	--	--	--
AA Cg 25	05-24-90	<0.01	<0.01	<0.01	<0.01	--	--	--
AA Df 103	05-24-90	<0.01	<0.01	<0.01	<0.01	--	--	--
CA Fc 13	09-01-87	<0.01	<0.01	<0.01	<0.01	--	--	--
	12-14-88	<0.01	<0.01	<0.01	<0.01	--	--	--
CH Ee 16	12-08-87	<0.01	<0.01	<0.01	<0.01	--	--	--
CH Ee 90	05-08-90	<0.01	<0.01	<0.01	<0.01	--	--	--
SM Ef 80	05-09-91	<0.01	<0.01	<0.01	<0.01	--	--	--

Table A16.—Schedule 1331 analyses from wells in Segment III

(All concentrations are dissolved amounts, in micrograms per liter)

Site number	Date	PCB	PCN	Aldrin	Chlordane	DDD	DDE	DDT	Diazinon	Dieldrin
AA Ad 104	12-07-87	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.10	<0.01
AA Cg 25	05-24-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
AA Df 103	05-24-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
CA Fc 13	09-01-87	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
	12-14-88	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
CH Ee 16	12-08-87	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
CH Ee 90	05-08-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
SM Ef 80	05-09-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01

Site number	Endosulfan	Endrin	Ethion	Heptachlor	Heptachlor epoxide	Lindane	Malathion	Methoxychlor
AA Ad 104	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.10	<0.01
AA Cg 25	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
AA Df 103	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CA Fc 13	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CH Ee 16	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
CH Ee 90	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SM Ef 80	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Site number	Methyl parathion	Methyl trithion	Mirex	Parathion	Perthane	Toxaphene	Trithion
AA Ad 104	<0.10	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
AA Cg 25	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
AA Df 103	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
CA Fc 13	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
CH Ee 16	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
CH Ee 90	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
SM Ef 80	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01

Table A17.—Schedule 1389 analyses from wells in Segment III

(All concentrations are total amounts, in micrograms per liter)

Site number	Date	Alachlor	Ametryn	Atrazine	Cyanazine	Bromacil	Butachlor	Butylate	Carboxin
AA Ad 104	12-07-87	<0.10	<0.10	<0.10	<0.10	--	--	--	--
AA Cg 25	05-24-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--
AA Df 103	05-24-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--
CA Fc 13	09-01-87	0.20	<0.10	0.10	<0.10	--	--	--	--
	12-14-88	<0.10	<0.10	0.10	<0.10	--	--	--	--
CH Ee 16	12-08-87	<0.10	<0.10	<0.10	<0.10	--	--	--	--
CH Ee 90	05-08-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--
HA Dd 92	07-19-88	<0.10	<0.10	<0.10	0.10	--	--	--	--
	01-17-89	<0.10	<0.10	<0.10	<0.10	--	--	--	--
SM Ef 80	02-24-88	<0.10	<0.10	<0.10	<0.10	--	--	--	--

Site number	Cycloate	De-ethyl atrazine	De-isopropyl atrazine	Diphenamid	Hexazinone	Metolachlor	Metribuzin	Prometon
AA Ad 104	--	--	--	--	--	<0.10	<0.10	<0.10
AA Cg 25	--	--	--	--	--	<0.10	<0.10	<0.10
AA Df 103	--	--	--	--	--	<0.10	<0.10	<0.10
CA Fc 13	--	--	--	--	--	<0.10	<0.10	<0.10
	--	--	--	--	--	<0.10	<0.10	<0.10
CH Ee 16	--	--	--	--	--	<0.10	<0.10	<0.10
CH Ee 90	--	--	--	--	--	<0.10	<0.10	<0.10
HA Dd 92	--	--	--	--	--	<0.10	<0.10	<0.10
	--	--	--	--	--	<0.10	<0.10	<0.10
SM Ef 80	--	--	--	--	--	<0.10	<0.10	<0.10

Site number	Prometryn	Propazine	Propachlor	Simazine	Simetryne	Terbacil	Trifluralin	Vernolate
AA Ad 104	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
AA Cg 25	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
AA Df 103	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
CA Fc 13	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
CH Ee 16	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
CH Ee 90	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
HA Dd 92	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
SM Ef 80	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--

Table A18.—Schedule 1390 analyses from wells in Segment III

(Concentrations are total amounts, in micrograms per liter; <, less than)

Site number	Date	Acrolein	Acrylo-nitrile	Benzene	Bromo-benzene	Bromoform	n-Butyl benzene	sec-Butyl benzene	tert-Butyl benzene
AA Ad 104	12-07-87	--	--	<3.0	--	<3.0	--	--	--
AA Cg 25	05-24-90	--	--	<3.0	--	<3.0	--	--	--
	05-19-92	<20	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
AA Df 103	05-24-90	--	--	<3.0	--	<3.0	--	--	--
CA Fc 13	09-01-87	--	--	<3.0	--	<3.0	--	--	--
CH Cb 7	06-17-92	<20	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
CH Ee 16	12-08-87	--	--	<3.0	--	<3.0	--	--	--
CH Ee 90	06-29-92	<20	<20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
PG Bc 37	04-23-90	--	--	<3.0	--	<3.0	--	--	--

Site number	Carbon tetra-chloride	Chloro-benzene	Chloro-dibromo-methane	Chloro-ethane	2-Chloro-ethyl-vinyl-ether	Chloro-form	o-Chloro-toluene	p-Chloro-toluene	Dibromo-chloro-propane	1,2-Dibromo-ethane
AA Ad 104	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	--
AA Cg 25	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
AA Df 103	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
CA Fc 13	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	--
CH Cb 7	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
CH Ee 16	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	--
CH Ee 90	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
PG Bc 37	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0

Site number	Dibromo-methane	1,2-Dichloro-benzene	1,3-Dichloro-benzene	1,4-Dichloro-benzene	Dichloro-bromo-methane	Dichloro-difluoro-methane	1,1-Dichloro-ethane	1,2-Dichloro-ethane	1,2-trans-Dichloro-ethene
AA Ad 104	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
AA Cg 25	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
AA Df 103	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
CA Fc 13	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
CH Cb 7	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
CH Ee 16	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
CH Ee 90	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
PG Bc 37	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0

Table A18.—Schedule 1390 analyses from wells in Segment III—Continued

(Concentrations are total amounts, in micrograms per liter; <, less than)

Site number	cis-1,2-Dichloro-ethene	1,1-Dichloro-ethylene	1,2-Dichloro-propane	1,3-Dichloro-propane	2,2-Dichloro-propane	1,1-Dichloro-propene	1,3-Dichloro-propene	cis-1,3-Dichloro-propene	trans-1,3-Dichloro-propene
AA Ad 104	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
AA Cg 25	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0
AA Df 103	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
CA Fc 13	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
CH Cb 7	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0
CH Ee 16	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
CH Ee 90	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	<3.0	<3.0
PG Bc 37	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0

Site number	Ethyl-benzene	Hexa-chloro-butadiene	Isopropyl-benzene	p-Isopropyl toluene	Methyl-bromide	Methyl-chloride	Methylene chloride	Naphth-alene	n-Propyl-benzene
AA Ad 104	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
AA Cg 25	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
AA Df 103	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
CA Fc 13	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
CH Cb 7	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
CH Ee 16	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
CH Ee 90	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
PG Bc 37	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--

Site number	Styrene	1,1,2,2-Tetra-chloro-ethane	1,1,1,2-Tetra-chloro-ethane	Tetra-chloro-ethylene	Toluene	1,2,3-Trichloro-benzene	1,2,4-Trichloro-benzene	1,1,1-Trichloro-ethane	1,1,2-Trichloro-ethane
AA Ad 104	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
AA Cg 25	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
AA Df 103	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
CA Fc 13	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
CH Cb 7	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
CH Ee 16	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
CH Ee 90	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
PG Bc 37	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0

(Concentrations are total amounts, in micrograms per liter; <, less than)

Site number	Trichloro-ethylene	Trichloro-fluoromethane	1,2,3-Trichloro-propane	1,2,4-Trimethyl-benzene	1,3,5-Trimethyl-benzene	Vinyl chloride	Xylene
AA Ad 104	<3.0	<3.0	--	--	--	<3.0	<3.0
AA Cg 25	<3.0	<3.0	--	--	--	1.4	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	1.4	<3.0
AA Df 103	<3.0	<3.0	--	--	--	<1.0	<3.0
CA Fc 13	<3.0	<3.0	--	--	--	<3.0	<3.0
CH Cb 7	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0	<3.0
CH Ee 16	<3.0	<3.0	--	--	--	<3.0	<3.0
CH Ee 90	<3.0	<3.0	<3.0	<3.0	<3.0	<1.0	<3.0
PG Bc 37	<3.0	<3.0	--	--	--	<1.0	<3.0

Table A19.—Major ions, nutrients, field parameters, and other chemical-quality data from wells in Segment IV

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Record number	Date	Time	Water level (feet below land surface)	Discharge (gal/min)	Specific conductance (µS/cm)	pH	Temperature, air (deg C)	Temperature, water (deg C)	Color, (platinum-cobalt units)
CO Dc 146	98901001	06-27-89	1040	0.51	1.0	181	5.5	34.0	14.5	--
	99100732	05-30-91	1410	7.65	0.9	238	5.1	34.0	14.0	1
	99200527	05-18-92	1521	6.63	0.9	232	4.9	26.0	14.0	<1
CO De 16	98801318	07-19-88	0900	8.80	--	384	4.3	27.5	22.0	--
	99100730	05-30-91	1057	5.47	--	274	4.4	33.0	17.0	--
	99200569	06-02-92	1335	5.63	0.9	321	4.4	23.0	17.5	<1
CE Dd 102	99101138	09-13-91	1145	--	--	62	5.1	24.0	14.5	<1
	99200585	06-09-92	1015	--	--	65	5.0	22.5	15.0	<1
DO Cg 46	98901107	07-26-89	1330	2.20	0.5	109	5.0	32.0	16.5	--
	99100729	05-29-91	1620	2.97	0.9	99	5.0	32.0	14.5	1
	99200530	05-18-92	1300	2.57	--	99	4.8	26.0	14.0	<1
KE Be 47	98800728	07-13-88	1000	14.40	0.5	373	5.1	34.5	15.0	--
	99100977	08-19-91	1533	11.85	0.7	269	6.0	31.0	15.0	5
	99200583	06-09-92	1220	13.52	0.7	303	5.9	24.0	14.0	3
QA Cg 1	99000865	06-26-90	1120	4.64	8.0	214	5.8	24.0	15.5	--
	99000975	08-16-90	1515	3.78	8.9	204	5.6	32.5	16.0	--
	99100121	11-20-90	1615	5.35	6.9	187	5.8	10.0	15.5	--
	99100259	02-20-91	1740	4.30	10	185	5.7	13.0	15.5	--
	99200582	06-09-92	1600	--	7.3	252	5.8	24.5	16.0	5
QA Ea 78	98401317	07-31-84	1140	24.00	12	302	7.6	--	15.0	--
	99000767	06-12-90	1135	13.10	1.2	309	7.6	24.0	16.0	2
	99100726	05-28-91	1447	12.15	0.9	307	7.8	29.5	16.0	5
	99200419	04-02-92	1028	12.80	6.7	320	7.7	4.5	15.0	10
SO Ce 98	99200601	06-16-92	1155	5.59	7.1	72	5.8	23.5	16.0	<1
TA Ce 7	99000764	06-13-90	1125	15.88	1.2	340	7.7	27.5	17.5	4
	99000974	08-16-90	1215	25.94	10	340	7.7	29.0	16.5	--
	99100120	11-20-90	1232	11.56	9.3	334	7.7	12.0	16.0	--
	99100258	02-20-91	1350	5.93	0.8	334	7.7	15.5	18.0	--
	99200531	05-18-92	1050	10.20	6.7	360	7.8	22.5	16.5	<1
WI Cd 71	98800774	07-21-88	1200	5.00	1.2	48	4.7	38.0	15.0	--
	99100979	08-20-91	1525	3.85	0.9	47	5.2	27.5	16.0	2
	99200570	06-02-92	1035	2.86	0.9	52	5.1	17.0	13.5	<1
WI Ce 13	98102490	05-13-81	1430	3.50	30	104	5.1	--	15.0	0
	99000732	05-30-90	1623	3.72	1.2	131	5.8	21.0	16.0	--
	99000973	08-16-90	0930	5.19	1.0	139	5.8	26.5	16.5	--
	99100119	11-20-90	0908	3.27	63	144	5.6	7.0	15.5	--
	99100257	02-20-91	0950	3.48	0.9	146	5.8	18.0	15.5	--
	99200571	06-02-92	0855	3.70	1.0	146	5.8	15.5	15.5	<1
WO Bf 87	98901089	07-13-89	0930	6.34	0.5	313	5.6	25.0	16.0	--
	99100978	08-20-91	1046	7.05	0.6	299	5.8	28.0	18.5	2
	99200575	06-01-92	1220	4.51	0.8	333	5.7	22.5	14.5	5
WO Bh 84	97300556	04-18-73	1518	--	150	338	7.9	--	--	--
	98600168	04-08-86	1440	--	33	350	6.6	24.0	15.5	--
	98600384	08-27-86	1505	5.16	50	365	6.9	32.0	16.0	--
	98700593	08-24-87	1440	5.54	50	332	6.7	24.0	16.0	--
	98800918	09-07-88	1345	5.31	50	356	7.0	--	16.0	--
	98901252	09-21-89	1205	4.38	48	351	6.9	28.0	16.0	--
	99001121	06-12-90	1615	3.52	1.3	356	6.9	20.5	16.5	48
	99001123	08-15-90	1840	4.05	1.0	319	6.6	27.0	16.5	--
	99100355	11-19-90	1420	3.15	0.8	343	6.7	11.0	15.0	--
	99100256	02-19-91	1716	4.14	0.8	360	6.9	11.5	15.5	--
	99200574	06-01-92	1415	3.91	1.0	379	6.9	22.0	16.5	200
WO Cc 3	98800782	07-26-88	1630	5.30	0.9	53	5.5	26.0	14.5	--
	99100728	05-29-91	1330	--	0.9	50	5.6	32.5	14.0	--
	99200573	06-01-92	1643	3.67	0.9	55	5.5	21.0	13.0	<1

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Dissolved oxygen (mg/L)	Hardness, total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L)	Magnesium, dissolved (mg/L)	Sodium, dissolved (mg/L)	Potassium, dissolved (mg/L)	Bicarbonate, total (mg/L)	Alkalinity, total (mg/L as $CaCO_3$)
CO Dc 146	06-27-89	8.8	70	8.3	12	3.2	2.5	5	4
	05-30-91	9.8	89	9.4	16	2.5	3.7	3	2
	05-18-92	9.8	79	8.5	14	2.3	3.3	2	2
CO De 16	07-19-88	8.8	62	4.4	12	39	4.6	1	1
	05-30-91	--	--	--	--	--	--	1	1
	06-02-92	8.7	40	2.6	8.1	34	4.0	1	1
CE Dd 102	09-13-91	4.8	11	2.4	1.3	5.0	1.6	5	4
	06-09-92	4.3	10	2.1	1.2	4.7	1.2	4	3
DO Cg 46	07-26-89	0.5	25	4.9	3.0	7.2	2.0	2	2
	05-29-91	0.1	22	4.6	2.5	7.8	1.7	1	1
	05-18-92	0.5	19	4.1	2.1	7.1	1.5	1	1
KE Be 47	07-13-88	7.3	150	22	22	11	1.7	11	9
	08-19-91	9.6	110	19	14	6.0	2.4	20	17
	06-09-92	9.1	110	21	14	6.2	3.1	23	18
QA Cg 1	06-26-90	--	47	10	5.4	14	6.4	16	13
	08-16-90	--	48	11	5.0	14	6.2	15	12
	11-20-90	--	41	9.2	4.3	12	6.0	16	13
	02-20-91	2.9	41	9.4	4.3	12	6.3	15	12
	06-09-92	8.7	61	14	6.2	13	8.1	23	19
QA Ea 78	07-31-84	0	130	41	7.3	11	3.6	--	--
	06-12-90	--	140	44	7.3	12	3.5	200	164
	05-28-91	0	140	45	7.4	12	3.9	201	165
	04-02-92	--	140	43	7.3	11	3.7	--	--
SO Ce 98	06-16-92	0.3	10	2.6	0.83	6.7	0.9	7	6
TA Ce 7	06-13-90	--	150	42	12	16	5.2	225	184
	08-16-90	--	150	41	12	15	5.3	228	187
	11-20-90	--	140	38	12	14	5.4	220	180
	02-20-91	0.3	150	40	12	15	5.8	221	181
	05-18-92	0.2	150	40	12	14	5.7	213	175
WI Cd 71	07-21-88	1.8	9	1.5	1.2	3.7	1.4	4	3
	08-20-91	6.1	8	1.4	1.2	3.6	1.5	2	1
	06-02-92	3.5	10	1.6	1.4	3.7	1.4	4	3
WI Ce 13	05-13-81	--	23	6.5	1.7	12	1.7	--	--
	05-30-90	--	28	8.1	1.9	12	1.7	17	14
	08-16-90	--	30	8.7	2.0	13	1.8	17	14
	11-20-90	--	30	8.6	2.0	13	1.8	19	15
	02-20-91	5.3	31	8.9	2.2	13	1.9	18	15
	06-02-92	5.4	29	8.3	2.0	12	1.8	18	15
WO Bf 87	07-13-89	6.9	110	20	14	11	2.5	9	7
	08-20-91	7.2	100	19	13	10	2.9	10	9
	06-01-92	7.8	110	21	15	9.9	2.4	10	9
WO Bh 84	04-18-73	--	88	17	11	30	8.1	--	--
	04-08-86	--	90	18	11	29	9.1	--	--
	08-27-86	--	88	17	11	29	8.7	--	--
	08-24-87	--	84	17	10	35	8.5	--	--
	09-07-88	--	88	17	11	32	9.1	--	--
	09-21-89	--	84	17	10	30	11	--	115
	06-12-90	--	76	14	10	31	10	152	125
	08-15-90	--	79	15	10	32	11	157	129
	11-19-90	--	79	16	9.6	29	10	149	122
	02-19-91	0.3	86	18	10	32	11	153	126
	06-01-92	0.3	93	19	11	30	11	148	121
WO Cc 3	07-26-88	0.1	6	1.3	0.64	6.3	0.9	17	14
	05-29-91	0.3	--	--	--	--	--	7	6
	06-01-92	0.5	7	1.5	0.89	5.6	1.2	9	7

Table A19.—Major ions, nutrients, field parameters, and other chemical-quality data from wells in Segment IV—Continued

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Sulfate, dissolved (mg/L)	Chloride, dissolved (mg/L)	Fluoride, dissolved (mg/L)	Silica, dissolved (mg/L as SiO_2)	Solids, residue on evaporation, dissolved (mg/L)	Solids, sum of dissolved constituents (mg/L)	Nitrite, total (mg/L as N)	Nitrite, dissolved (mg/L as N)
CO Dc 146	06-27-89	13	14	<0.10	12	--	117	--	<0.010
	05-30-91	9.8	26	<0.10	12	135	81	0.010	--
	05-18-92	12	24	<0.10	13	128	78	0.030	--
CO De 16	07-19-88	1.2	100	0.10	15	--	191	--	<0.010
	05-30-91	--	--	--	--	--	--	--	--
	06-02-92	1.3	72	<0.10	13	166	135	<0.010	--
CE Dd 102	09-13-91	2.5	7.2	<0.10	11	30	34	<0.010	--
	06-09-92	2.8	7.8	<0.10	12	50	34	<0.010	--
DO Cg 46	07-26-89	18	12	<0.10	18	--	68	--	<0.010
	05-29-91	14	9.5	<0.10	21	66	61	<0.010	--
	05-18-92	15	11	<0.10	21	68	62	<0.010	--
KE Be 47	07-13-88	35	77	0.10	13	--	204	--	<0.010
	08-19-91	22	26	<0.10	10	178	110	0.010	--
	06-09-92	24	22	<0.10	9.9	188	112	<0.010	--
QA Cg 1	06-26-90	7.0	19	0.10	18	--	89	--	--
	08-16-90	14	19	<0.10	19	--	96	--	--
	11-20-90	9.4	17	<0.10	18	--	84	<0.010	--
	02-20-91	12	17	<0.10	19	--	87	<0.010	--
	06-09-92	23	19	<0.10	20	158	115	0.020	--
QA Ea 78	07-31-84	12	4.1	0.10	23	--	205	--	--
	06-12-90	<1.0	7.9	0.20	24	186	--	--	--
	05-28-91	0.20	5.9	0.10	24	197	199	0.010	--
	04-02-92	<0.10	5.3	0.20	25	193	--	<0.010	--
SO Ce 98	06-16-92	12	7.2	<0.10	22	60	59	<0.010	--
TA Ce 7	06-13-90	3.1	4.7	0.30	56	239	250	--	--
	08-16-90	4.0	4.4	0.20	58	--	252	--	--
	11-20-90	4.4	3.2	0.20	58	--	243	<0.010	--
	02-20-91	2.8	4.7	0.30	53	--	242	<0.010	--
	05-18-92	3.1	4.3	<0.10	60	232	244	<0.010	--
WI Cd 71	07-21-88	11	3.6	0.10	12	--	37	--	<0.010
	08-20-91	8.2	4.8	<0.10	11	33	33	<0.010	--
	06-02-92	10	5.3	<0.10	11	42	36	<0.010	--
WI Ce 13	05-13-81	4.0	9.8	<0.10	26	94	78	--	--
	05-30-90	2.7	17	<0.10	25	--	77	--	--
	08-16-90	2.3	17	<0.10	26	--	80	--	--
	11-20-90	3.5	16	<0.10	25	--	79	<0.010	--
	02-20-91	3.2	15	<0.10	25	--	78	<0.010	--
	06-02-92	2.7	15	<0.10	25	100	76	<0.010	--
WO Bf 87	07-13-89	33	30	0.10	12	--	185	--	<0.010
	08-20-91	35	32	<0.10	10	181	127	<0.010	--
	06-01-92	34	34	<0.10	10	188	131	<0.010	--
WO Bh 84	04-18-73	6.0	39	0.30	33	--	210	--	0.006
	04-08-86	12	36	<0.10	36	228	208	--	--
	08-27-86	13	40	0.10	35	212	240	--	--
	08-24-87	5.5	38	0.10	37	214	229	--	--
	09-07-88	9.5	38	0.10	36	210	227	--	--
	09-21-89	<1.0	36	0.10	35	198	--	--	--
	06-12-90	<1.0	40	0.20	34	206	--	--	--
	08-15-90	<1.0	40	0.10	34	--	--	--	--
	11-19-90	1.1	43	0.10	34	--	222	<0.010	--
	02-19-91	<1.0	44	0.10	34	--	--	<0.010	--
	06-01-92	<0.10	45	<0.10	34	208	--	<0.010	--
WO Cc 3	07-26-88	4.8	6.5	<0.10	23	--	54	--	<0.010
	05-29-91	--	6.7	--	--	--	--	--	--

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Nitrate plus nitrite, total (mg/L as N)	Nitrate plus nitrite, dissolved (mg/L as N)	Ammonia, total (mg/L as N)	Ammonia, dissolved (mg/L as N)	Phosphorus, total (mg/L as P)	Ortho-phosphate, total (mg/L as P)	Ortho-phosphate, dissolved (mg/L as P)
CO Dc 146	06-27-89	--	11.0	--	0.020	--	--	0.070
	05-30-91	15.0	--	<0.010	--	<0.010	<0.010	--
	05-18-92	12.0	--	0.040	--	0.040	0.050	--
CO De 16	07-19-88	--	2.70	--	0.010	--	--	<0.010
	05-30-91	4.00	--	--	--	0.010	--	--
	06-02-92	6.60	--	0.030	--	0.020	<0.010	--
CE Dd 102	09-13-91	2.00	--	<0.010	--	<0.010	<0.010	--
	06-09-92	1.80	--	0.030	--	0.030	0.010	--
DO Cg 46	07-26-89	--	<0.100	--	0.860	--	--	<0.010
	05-29-91	1.40	--	<0.010	--	<0.010	<0.010	--
	05-18-92	1.40	--	<0.010	--	0.030	<0.010	--
KE Be 47	07-13-88	--	3.70	--	<0.010	--	--	<0.010
	08-19-91	14.0	--	0.020	--	<0.020	<0.010	--
	06-09-92	16.0	--	0.030	--	0.030	0.010	--
QA Cg 1	06-26-90	12.0	--	--	--	0.020	--	--
	08-16-90	11.0	--	--	--	<0.010	--	--
	11-20-90	9.50	--	0.910	--	<0.010	<0.010	--
	02-20-91	8.00	--	0.790	--	<0.010	<0.010	--
	06-09-92	10.0	--	0.850	--	0.020	<0.010	--
QA Ea 78	07-31-84	--	<0.100	--	--	--	--	0.040
	06-12-90	<0.100	--	--	--	0.040	--	--
	05-28-91	<0.050	--	0.910	--	0.180	0.180	--
	04-02-92	<0.050	--	0.930	--	0.150	0.180	--
SO Ce 98	06-16-92	<0.050	--	0.040	--	<0.010	0.010	--
TA Ce 7	06-13-90	<0.100	--	--	--	<0.010	--	--
	08-16-90	<0.100	--	--	--	<0.010	--	--
	11-20-90	<0.050	--	0.220	--	<0.010	<0.010	--
	02-20-91	<0.100	--	0.150	--	<0.010	<0.010	--
	05-18-92	0.140	--	0.150	--	0.020	<0.010	--
WI Cd 71	07-21-88	--	<0.100	--	0.020	--	--	0.010
	08-20-91	0.067	--	<0.010	--	<0.010	<0.010	--
	06-02-92	0.064	--	0.020	--	0.020	<0.010	--
WI Ce 13	05-13-81	5.40	--	--	--	0.020	--	--
	05-30-90	6.20	--	--	--	0.010	--	--
	08-16-90	6.70	--	--	--	<0.010	--	--
	11-20-90	7.20	--	0.040	--	0.020	<0.010	--
	02-20-91	6.00	--	<0.010	--	<0.010	<0.010	--
	06-02-92	6.50	--	0.040	--	0.020	<0.010	--
WO Bf 87	07-13-89	--	13.0	--	0.020	--	--	<0.010
	08-20-91	13.0	--	<0.010	--	0.010	<0.010	--
	06-01-92	13.0	--	0.020	--	0.030	0.010	--
WO Bh 84	04-18-73	--	0.270	--	--	--	--	--
	04-08-86	--	<0.100	--	--	--	--	0.260
	08-27-86	--	<0.100	--	--	--	--	0.210
	08-24-87	--	<0.100	--	--	--	--	0.190
	09-07-88	--	<0.100	--	--	--	--	0.200
	09-21-89	--	<0.100	--	--	--	--	0.230
	06-12-90	<0.100	--	--	--	0.200	--	--
	08-15-90	<0.100	--	--	--	0.230	--	--
	11-19-90	<0.100	--	0.530	--	0.280	0.270	--
	02-19-91	<0.100	--	0.440	--	0.110	0.020	--
	06-01-92	<0.050	--	0.450	--	0.250	0.230	--
WO Cc 3	07-26-88	--	<0.100	--	0.170	--	--	0.100
	05-29-91	0.057	--	--	--	0.030	--	--
	06-01-92	0.057	--	0.030	--	0.020	<0.010	--

Table A19.—Major ions, nutrients, field parameters, and other chemical-quality data from wells in Segment IV—Continued

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Aluminum, total (µg/L)	Aluminum, dissolved (µg/L)	Boron, total (µg/L)	Iron, total (µg/L)	Iron, dissolved (µg/L)	Manganese, total (µg/L)	Manganese, dissolved (µg/L)
CO Dc 146	06-27-89	--	30	--	--	40	--	57
	05-30-91	120	--	80	20	8	30	29
	05-18-92	--	--	--	230	<3	30	21
CO De 16	07-19-88	--	530	--	--	29	--	88
	05-30-91	--	--	--	--	--	--	--
	06-02-92	--	--	--	60	22	30	28
CE Dd 102	09-13-91	10	20	<10	300	330	20	14
	06-09-92	--	--	--	330	310	20	12
DO Cg 46	07-26-89	--	<10	--	--	24	--	92
	05-29-91	80	--	<10	<10	6	80	81
	05-18-92	--	--	--	30	5	90	74
KE Be 47	07-13-88	--	<10	--	--	4	--	84
	08-19-91	--	--	--	170	26	280	290
	06-09-92	--	--	--	50	23	800	780
QA Cg 1	06-26-90	<10	<10	40	1000	230	80	66
	08-16-90	<10	10	30	270	73	60	65
	11-20-90	<10	--	50	350	190	60	58
	02-20-91	--	--	--	340	140	50	59
	06-09-92	--	--	--	250	190	90	76
QA Ea 78	07-31-84	--	<100	--	--	1500	--	29
	06-12-90	<10	<10	40	1600	1100	30	31
	05-28-91	<10	--	<10	1600	1400	30	28
	04-02-92	20	--	40	1600	1600	230	32
SO Ce 98	06-16-92	--	<10	--	3000	3100	30	29
TA Ce 7	06-13-90	<10	10	90	2200	46	<10	2
	08-16-90	30	<10	160	240	61	<10	2
	11-20-90	<10	--	120	210	65	10	2
	02-20-91	--	--	--	5800	200	<10	5
	05-18-92	--	--	--	170	71	20	2
WI Cd 71	07-21-88	--	20	--	--	5	--	9
	08-20-91	--	--	--	100	<3	<10	3
	06-02-92	--	--	--	10	<3	<10	4
WI Ce 13	05-13-81	--	--	--	1900	200	30	20
	05-30-90	<10	<10	<10	1300	76	<10	11
	08-16-90	30	<10	60	3000	50	<10	9
	11-20-90	<10	--	10	6600	43	20	8
	02-20-91	--	--	--	6600	39	<10	11
	06-02-92	--	--	--	2500	47	20	14
WO Bf 87	07-13-89	--	<10	--	--	<4	--	7
	08-20-91	--	--	--	110	<3	<10	1
	06-01-92	--	--	--	10	<3	<10	3
WO Bh 84	04-18-73	--	--	--	11000	--	120	--
	04-08-86	--	--	--	--	6400	--	75
	08-27-86	--	--	--	--	6300	--	78
	08-24-87	--	--	--	--	6100	--	80
	09-07-88	--	--	--	--	6100	--	80
	09-21-89	--	--	--	--	5900	--	78
	06-12-90	<10	<10	90	6000	6000	80	110
	08-15-90	<10	20	80	6000	5900	80	87
	11-19-90	<10	--	110	6100	5600	90	72
	02-19-91	--	--	--	6000	6100	60	81
	06-01-92	--	--	--	5600	6000	90	80
WO Cc 3	07-26-88	--	<10	--	--	1600	--	150
	05-29-91	--	--	--	--	--	--	--
	06-01-92	--	--	--	100	110	<10	9

(µS/cm, microsiemens per centimeter at 25 deg. C; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picocuries per liter; <, less than)

Site number	Date	Zinc, total (µg/L)	Organic carbon, total (mg/L as C)	Radon-222 total (pCi/L)
CO Dc 146	06-27-89	--	--	210
	05-30-91	20	0.7	--
	05-18-92	--	1.0	--
CO De 16	07-19-88	--	--	170
	05-30-91	--	1.6	--
	06-02-92	--	0.5	--
CE Dd 102	09-13-91	90	--	--
	06-09-92	--	0.2	--
DO Cg 46	07-26-89	--	--	240
	05-29-91	<10	0.6	--
	05-18-92	--	2.7	--
KE Be 47	07-13-88	--	--	250
	08-19-91	--	0.4	--
	06-09-92	--	0.7	--
QA Cg 1	06-26-90	--	0.4	--
	08-16-90	--	0.5	--
	11-20-90	--	0.8	--
	02-20-91	50	0.5	--
	06-09-92	--	0.7	--
QA Ea 78	07-31-84	--	--	--
	06-12-90	--	0.9	--
	05-28-91	<10	1.1	--
	04-02-92	<10	--	--
SO Ce 98	06-16-92	--	0.4	300
TA Ce 7	06-13-90	--	0.3	--
	08-16-90	--	10	--
	11-20-90	--	0.7	--
	02-20-91	90	1.0	--
	05-18-92	--	0.6	--
WI Cd 71	07-21-88	--	--	180
	08-20-91	--	0.8	--
	06-02-92	--	0.9	--
WI Ce 13	05-13-81	--	--	--
	05-30-90	--	0.2	--
	08-16-90	--	0.2	--
	11-20-90	--	0.9	--
	02-20-91	370	0.3	--
	06-02-92	--	0.1	--
WO Bf 87	07-13-89	--	--	400
	08-20-91	--	0.7	--
	06-01-92	--	0.9	--
WO Bh 84	04-18-73	--	--	--
	04-08-86	--	--	--
	08-27-86	--	--	--
	08-24-87	--	--	--
	09-07-88	--	--	--
	09-21-89	--	--	--
	06-12-90	--	2.4	--
	08-15-90	--	2.4	--
	11-19-90	--	3.1	--
	02-19-91	<10	2.7	--
	06-01-92	--	2.0	--
WO Cc 3	07-26-88	--	--	250
	05-29-91	--	--	--
	06-01-92	--	0.7	--

Table A20.—Trace-element and other water-quality data from wells in Segment IV

(Concentrations in micrograms per liter, except as noted; <, less than)

Site number	Date	Specific conductance (microsiemens per centimeter at 25 deg. C)	pH (field)	Color, (platinum-cobalt units)	Dissolved oxygen (milligrams per liter)	Aluminum, total	Aluminum, dissolved	Antimony, dissolved	Arsenic, dissolved	Barium, dissolved	Beryllium, dissolved	Boron, total
CE Dd 102	09-13-91	62	5.1	<1	4.8	10	20	--	<1	28	<0.5	<10
CO Dc 146	06-27-89	181	5.5	--	8.8	--	30	<1	<1	170	0.6	--
CO De 16	07-19-88	384	4.3	--	8.8	--	530	<1	<1	1300	2	--
DO Cg 46	07-26-89	109	5.0	--	0.5	--	<10	<1	<1	67	1	--
KE Be 47	07-13-88	373	5.1	--	7.3	--	<10	<1	<1	130	<0.5	--
QA Cg 1	06-26-90	214	5.8	--	--	<10	<10	--	<1	210	0.8	40
	08-16-90	204	5.6	--	--	<10	10	--	<1	210	0.9	30
QA Ea 78	07-31-84	302	7.6	--	0	--	<100	--	--	90	--	--
	06-12-90	309	7.6	2	--	<10	<10	--	5	67	<0.5	40
SO Ce 98	06-16-92	72	5.8	<1	0.3	--	<10	--	1	10	0.8	--
TA Ce 7	06-13-90	340	7.7	4	--	<10	10	--	<1	3	<0.5	90
	08-16-90	340	7.7	--	--	30	<10	--	<1	7	<0.5	160
WI Cd 71	07-21-88	48	4.7	--	1.8	--	20	<1	<1	49	<0.5	--
WI Ce 13	05-30-90	131	5.8	--	--	<10	<10	--	<1	61	<0.5	<10
	08-16-90	139	5.8	--	--	30	<10	--	<1	63	<0.5	60
WO Bf 87	07-13-89	313	5.6	--	6.9	--	<10	<1	<1	61	<0.5	--
WO Bh 84	06-12-90	356	6.9	48	--	<10	<10	--	<1	79	<0.5	90
	08-15-90	319	6.6	--	--	<10	20	--	<1	82	<0.5	80
WO Cc 3	07-26-88	53	5.5	--	0.1	--	<10	<1	<1	37	<0.5	--

Site number	Boron, dissolved	Cadmium, dissolved	Chromium, dissolved	Cobalt, dissolved	Copper, dissolved	Iron, total	Iron, dissolved	Lead, dissolved	Lithium, dissolved	Manganese, total	Manganese, dissolved
CE Dd 102	--	<1.0	2	2	2	300	330	<1	<4	20	14
CO Dc 146	<10	<1.0	<5	3	<10	--	40	<10	<4	--	57
CO De 16	<10	<1.0	<5	10	<10	--	29	<10	<4	--	88
DO Cg 46	20	<1.0	<5	<3	<10	--	24	<10	4	--	92
KE Be 47	<10	<1.0	<5	<3	50	--	4	<10	<4	--	84
QA Cg 1	--	<1.0	<1	<1	260	1000	230	<1	<4	80	66
	--	2.0	<1	1	150	270	73	<1	4	60	65
QA Ea 78	--	--	--	--	--	--	1500	--	--	--	29
	--	<1.0	<1	1	1	1600	1100	<1	15	30	31
SO Ce 98	--	<1.0	<1	<1	<1	3000	3100	<1	5	30	29
TA Ce 7	--	<1.0	<1	<1	3	2200	46	1	19	<10	2
	--	<1.0	<1	<1	4	240	61	<1	15	<10	2
WI Cd 71	<10	<1.0	<5	<3	<10	--	5	<10	<4	--	9
WI Ce 13	--	1.0	<1	<1	240	1300	76	2	<4	<10	11
	--	1.0	<1	<1	230	3000	50	1	<4	<10	9
WO Bf 87	<10	<1.0	<5	<3	<10	--	<4	<10	<4	--	7
WO Bh 84	--	3.0	<1	<1	4	6000	6000	<1	5	80	110
	--	3.0	<1	<1	1	6000	5900	<1	5	80	87
WO Cc 3	<10	<1.0	<5	<3	<10	--	1600	<10	<4	--	150

Table A20.—Trace-element and other water-quality data from wells in Segment IV—Continued

(Concentrations in micrograms per liter, except as noted; <, less than)

Site number	Mercury, dissolved	Molybdenum, dissolved	Nickel, dissolved	Selenium, dissolved	Strontium, dissolved	Vanadium, dissolved	Zinc, total	Zinc, dissolved
CE Dd 102	<0.1	<1	<1	<1	--	<1	90	81
CO Dc 146	<0.1	<10	<10	2	140	<6	--	11
CO De 16	<0.1	<10	10	<1	160	<6	--	64
DO Cg 46	<0.1	<10	<10	<1	55	<6	--	23
KE Be 47	<0.1	<10	<10	14	250	<6	--	30
QA Cg 1	<0.1	<1	5	<1	--	<1	--	79
	<0.1	<1	4	<1	--	<1	--	79
QA Ea 78	--	--	--	--	130	--	--	--
	0.1	<1	<1	<1	--	<1	--	<3
SO Ce 98	<0.1	<1	1	<1	--	3	--	8
TA Ce 7	<0.1	<1	1	<1	--	<1	--	3
	<0.1	<1	<1	<1	--	<1	--	7
WI Cd 71	<0.1	<10	<10	<1	43	<6	--	<3
WI Ce 13	<0.1	<1	1	<1	--	<1	--	280
	<0.1	<1	<1	<1	--	<1	--	310
WO Bf 87	<0.1	<10	<10	2	220	<6	--	5
WO Bh 84	0.2	<1	<1	<1	--	<1	--	<3
	<0.1	<1	1	<1	--	4	--	3
WO Cc 3	<0.1	<10	<10	<1	30	<6	--	3

Table A21.—Schedule 1304 analyses from wells in Segment IV

(Concentrations are total amounts, in micrograms per liter)

Site number	Date	2,4-D	2,4-DP	2,4,5-T	Silvex	Sevin	Picloram	Dicamba
CE Dd 102	06-09-92	<0.01	<0.01	<0.01	<0.01	--	--	--
CO Dc 146	06-27-89	<0.01	<0.01	<0.01	<0.01	<0.5	<0.01	4.2
CO De 16	07-19-88	<0.01	<0.01	<0.01	<0.01	<0.5	<0.01	<0.01
DO Cg 46	07-26-89	<0.01	<0.01	<0.01	<0.01	<0.5	<0.01	<0.01
KE Be 47	07-13-88	<0.01	<0.01	<0.01	<0.01	<0.5	<0.01	<0.01
QA Cg 1	06-26-90	<0.01	<0.01	<0.01	<0.01	--	--	--
	08-16-90	<0.01	<0.01	<0.01	<0.01	--	--	--
QA Ea 78	06-12-90	<0.01	<0.01	<0.01	<0.01	--	--	--
TA Ce 7	06-13-90	<0.01	<0.01	<0.01	<0.01	--	--	--
	08-16-90	<0.01	<0.01	<0.01	<0.01	--	--	--
WI Cd 71	07-21-88	<0.01	<0.01	<0.01	<0.01	<0.5	<0.01	<0.01
WI Ce 13	05-30-90	<0.01	<0.01	<0.01	<0.01	--	--	--
	08-16-90	<0.01	<0.01	<0.01	<0.01	--	--	--
WO Bf 87	07-13-89	<0.01	<0.01	<0.01	<0.01	<0.5	<0.01	<0.01
WO Bh 84	06-12-90	<0.01	<0.01	<0.01	<0.01	--	--	--
	08-15-90	<0.01	<0.01	<0.01	<0.01	--	--	--
WO Cc 3	07-26-88	<0.01	<0.01	<0.01	<0.01	<0.5	<0.01	<0.01

Table A22.—Schedule 1331 analyses from wells in Segment IV

(All concentrations are dissolved amounts, in micrograms per liter)

Site number	Date	PCB	PCN	Aldrin	Chlordane	DDD	DDE	DDT	Diazinon	Dieldrin
CE Dd 102	09-13-91	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
	06-09-92	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
QA Cg 1	06-26-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
	08-16-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
QA Ea 78	06-12-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
TA Ce 7	06-13-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
	08-16-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
WI Ce 13	05-30-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	0.01
	08-16-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	0.01
WO Bh 84	06-12-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
	08-15-90	<0.1	<0.10	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01

Site number	Endosulfan	Endrin	Ethion	Heptachlor	Heptachlor epoxide	Lindane	Malathion	Methoxychlor
CE Dd 102	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
QA Cg 1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
QA Ea 78	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
TA Ce 7	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
WI Ce 13	<0.01	<0.01	<0.01	<0.01	<0.01	0.20	<0.01	<0.01
	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.01
WO Bh 84	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Site number	Methyl parathion	Methyl trithion	Mirex	Parathion	Perthane	Toxaphene	Trithion
CE Dd 102	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
QA Cg 1	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
QA Ea 78	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
TA Ce 7	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
WI Ce 13	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
WO Bh 84	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01
	<0.01	<0.01	<0.01	<0.01	<0.10	<1.0	<0.01

Table A23.—Schedule 1389 analyses from wells in Segment IV

(All concentrations are total amounts, in micrograms per liter)

Site number	Date	Alachlor	Ametryn	Atrazine	Cyanazine	Bromacil	Butachlor	Butylate	Carboxin
CE Dd 102	06-09-92	<0.10	<0.10	<0.10	<0.20	<0.20	<0.10	<0.10	<0.20
CO Dc 146	06-27-89	<0.10	<0.10	0.10	<0.10	--	--	--	--
CO De 16	07-19-88	<0.10	<0.10	<0.10	<0.10	--	--	--	--
DO Cg 46	07-26-89	<0.10	<0.10	<0.10	<0.10	--	--	--	--
KE Be 47	07-13-88	<0.10	<0.10	0.10	<0.10	--	--	--	--
QA Cg 1	06-26-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--
	08-16-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--
QA Ea 78	06-12-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--
TA Ce 7	06-13-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--
	08-16-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--
WI Cd 71	07-21-88	<0.10	<0.10	<0.10	<0.10	--	--	--	--
WI Ce 13	05-30-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--
	08-16-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--
WO Bf 87	07-13-89	1.4	<0.10	0.10	<0.10	--	--	--	--
WO Bh 84	06-12-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--
	08-15-90	<0.10	<0.10	<0.10	<0.10	--	--	--	--
WO Cc 3	07-26-88	<0.10	<0.10	<0.10	<0.10	--	--	--	--

Site number	Cycloate	De-ethyl atrazine	De-isopropyl atrazine	Diphenamid	Hexazinone	Metolachlor	Metribuzin	Prometon
CE Dd 102	<0.10	<0.20	<0.20	<0.10	<0.20	<0.20	<0.10	<0.20
CO Dc 146	--	--	--	--	--	<0.10	<0.10	<0.10
CO De 16	--	--	--	--	--	<0.10	<0.10	<0.10
DO Cg 46	--	--	--	--	--	<0.10	<0.10	<0.10
KE Be 47	--	--	--	--	--	<0.10	<0.10	<0.10
QA Cg 1	--	--	--	--	--	<0.10	<0.10	<0.10
	--	--	--	--	--	<0.10	<0.10	<0.10
QA Ea 78	--	--	--	--	--	<0.10	<0.10	<0.10
TA Ce 7	--	--	--	--	--	<0.10	<0.10	<0.10
	--	--	--	--	--	<0.10	<0.10	<0.10
WI Cd 71	--	--	--	--	--	<0.10	<0.10	<0.10
WI Ce 13	--	--	--	--	--	<0.10	<0.10	<0.10
	--	--	--	--	--	<0.10	<0.10	<0.10
WO Bf 87	--	--	--	--	--	<0.10	<0.10	<0.10
WO Bh 84	--	--	--	--	--	<0.10	<0.10	<0.10
	--	--	--	--	--	<0.10	<0.10	<0.10
WO Cc 3	--	--	--	--	--	<0.10	<0.10	<0.10

Table A23.—Schedule 1389 analyses from wells in Segment IV—Continued

(All concentrations are total amounts, in micrograms per liter)

Site number	Prometryn	Propazine	Propachlor	Simazine	Simetryne	Terbacil	Trifluralin	Vernolate
CE Dd 102	<0.10	<0.10	<0.10	<0.10	<0.10	<0.20	<0.10	<0.10
CO Dc 146	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
CO De 16	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
DO Cg 46	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
KE Be 47	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
QA Cg 1	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
QA Ea 78	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
TA Ce 7	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
WI Cd 71	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
WI Ce 13	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
WO Bf 87	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
WO Bh 84	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--
WO Cc 3	<0.10	<0.10	--	<0.10	<0.10	--	<0.10	--

Table A24.—Schedule 1390 analyses from wells in Segment IV

(Concentrations are total amounts, in micrograms per liter; <, less than)

Site number	Date	Acrolein	Acrylo-nitrile	Benzene	Bromo-benzene	Bromoform	n-Butyl benzene	sec-Butyl benzene	tert-Butyl benzene
CO Dc 146	06-27-89	--	--	<0.2	<0.2	<0.2	--	--	--
CO De 16	07-19-88	--	--	<0.2	--	<0.2	--	--	--
DO Cg 46	07-26-89	--	--	<0.2	<0.2	<0.2	--	--	--
KE Be 47	07-13-88	--	--	<0.2	--	<0.2	--	--	--
QA Cg 1	06-26-90	--	--	<3.0	--	<3.0	--	--	--
	08-16-90	--	--	<3.0	--	<3.0	--	--	--
QA Ea 78	06-12-90	--	--	<3.0	--	<3.0	--	--	--
TA Ce 7	06-13-90	--	--	<3.0	--	<3.0	--	--	--
	08-16-90	--	--	<3.0	--	<3.0	--	--	--
WI Cd 71	07-21-88	--	--	<0.2	--	<0.2	--	--	--
WI Ce 13	05-30-90	--	--	<3.0	--	<3.0	--	--	--
	08-16-90	--	--	<3.0	--	<3.0	--	--	--
WO Bf 87	07-13-89	--	--	<0.2	<0.2	<0.2	--	--	--
WO Bh 84	06-12-90	--	--	<3.0	--	<3.0	--	--	--
	08-15-90	--	--	<3.0	--	<3.0	--	--	--
WO Cc 3	07-26-88	--	--	<0.2	--	<0.2	--	--	--

Site number	Carbon tetra-chloride	Chloro-benzene	Chloro-dibromo-methane	Chloro-ethane	2-Chloro-ethyl-vinyl-ether	Chloro-form	o-Chloro-toluene	p-Chloro-toluene	Dibromo-chloro-propane	1,2-Dibromo-ethane
CO Dc 146	<0.2	<0.20	<0.2	<0.2	--	<0.2	<0.2	<0.2	--	<0.2
CO De 16	<0.2	<0.20	<0.2	<0.2	--	<0.2	--	--	--	<0.2
DO Cg 46	<0.2	<0.20	<0.2	<0.2	--	<0.2	<0.2	<0.2	--	<0.2
KE Be 47	<0.2	<0.20	<0.2	<0.2	--	<0.2	--	--	--	--
QA Cg 1	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
QA Ea 78	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
TA Ce 7	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
WI Cd 71	<0.2	<0.20	<0.2	<0.2	--	0.8	--	--	--	<0.2
WI Ce 13	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
WO Bf 87	<0.2	<0.20	<0.2	<0.2	--	<0.2	<0.2	<0.2	--	<0.2
WO Bh 84	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	--	--	--	<3.0
WO Cc 3	<0.2	<0.20	<0.2	<0.2	--	0.7	--	--	--	--

Table A24.—Schedule 1390 analyses from wells in Segment IV—Continued

(Concentrations are total amounts, in micrograms per liter; <, less than)

Site number	Dibromo-methane	1,2-Dichloro-benzene	1,3-Dichloro-benzene	1,4-Dichloro-benzene	Dichloro-bromo-methane	Dichloro-difluoro-methane	1,1-Dichloro-ethane	1,2-Dichloro-ethane	1,2-trans-Dichloro-ethene
CO Dc 146	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	--
CO De 16	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	--
DO Cg 46	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	--
KE Be 47	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	--
QA Cg 1	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
QA Ea 78	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
TA Ce 7	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
WI Cd 71	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	--
WI Ce 13	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
WO Bf 87	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	--
WO Bh 84	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
	--	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
WO Cc 3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	--

Site number	cis-1,2-Dichloro-ethene	1,1-Dichloro-ethylene	1,2-Dichloro-propane	1,3-Dichloro-propane	2,2-Dichloro-propane	1,1-Dichloro-propene	1,3-Dichloro-propene	cis-1,3-Dichloro-propene	trans-1,3-Dichloro-propene
CO Dc 146	--	<0.2	<0.2	<0.2	<0.2	<0.2	--	<0.2	<0.2
CO De 16	--	<0.2	<0.2	--	--	--	--	<0.2	<0.2
DO Cg 46	--	<0.2	<0.2	<0.2	<0.2	<0.2	--	<0.2	<0.2
KE Be 47	--	<0.2	<0.2	--	--	--	--	<0.2	<0.2
QA Cg 1	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
QA Ea 78	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
TA Ce 7	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
WI Cd 71	--	<0.2	<0.2	--	--	--	--	<0.2	<0.2
WI Ce 13	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
WO Bf 87	--	<0.2	<0.2	<0.2	<0.2	<0.2	--	<0.2	<0.2
WO Bh 84	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
	--	<3.0	<3.0	--	--	--	<3.0	<3.0	<3.0
WO Cc 3	--	<0.2	<0.2	--	--	--	--	<0.2	<0.2

(Concentrations are total amounts, in micrograms per liter; <, less than)

Site number	Ethyl-benzene	Hexa-chloro-butadiene	Isopropyl-benzene	p-Isopropyl toluene	Methyl-bromide	Methyl-chloride	Methylene chloride	Naphth-alene	n-Propyl-benzene
CO Dc 146	<0.2	--	--	--	<0.2	<0.2	0.2	--	--
CO De 16	<0.2	--	--	--	<0.2	<0.2	<0.2	--	--
DO Cg 46	<0.2	--	--	--	<0.2	<0.2	<0.2	--	--
KE Be 47	<0.2	--	--	--	<0.2	<0.2	<0.2	--	--
QA Cg 1	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
QA Ea 78	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
TA Ce 7	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
WI Cd 71	<0.2	--	--	--	<0.2	<0.2	<0.2	--	--
WI Ce 13	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
WO Bf 87	<0.2	--	--	--	<0.2	<0.2	0.3	--	--
WO Bh 84	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
	<3.0	--	--	--	<3.0	<3.0	<3.0	--	--
WO Cc 3	<0.2	--	--	--	<0.2	<0.2	<0.2	--	--

Site number	Styrene	1,1,2,2-Tetra-chloro-ethane	1,1,1,2-Tetra-chloro-ethane	Tetra-chloro-ethylene	Toluene	1,2,3-Trichloro-benzene	1,2,4-Trichloro-benzene	1,1,1-Trichloro-ethane	1,1,2-Trichloro-ethane
CO Dc 146	<0.2	<0.2	<0.2	<0.2	<0.2	--	--	<0.2	<0.2
CO De 16	<0.2	<0.2	--	<0.2	<0.2	--	--	<0.2	<0.2
DO Cg 46	<0.2	<0.2	<0.2	<0.2	<0.2	--	--	<0.2	<0.2
KE Be 47	<0.2	<0.2	--	<0.2	<0.2	--	--	<0.2	<0.2
QA Cg 1	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
QA Ea 78	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
TA Ce 7	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
WI Cd 71	<0.2	<0.2	--	<0.2	<0.2	--	--	<0.2	<0.2
WI Ce 13	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
WO Bf 87	<0.2	<0.2	<0.2	<0.2	<0.2	--	--	<0.2	<0.2
WO Bh 84	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
	<3.0	<3.0	--	<3.0	<3.0	--	--	<3.0	<3.0
WO Cc 3	<0.2	<0.2	--	<0.2	<0.2	--	--	<0.2	<0.2

Table A24.—Schedule 1390 analyses from wells in Segment IV—Continued

(Concentrations are total amounts, in micrograms per liter; <, less than)

Site number	Trichloro-ethylene	Trichloro-fluoromethane	1,2,3-Trichloro-propane	1,2,4-Trimethyl-benzene	1,3,5-Trimethyl-benzene	Vinyl chloride	Xylene
CO Dc 146	0.2	<0.2	<0.2	--	--	<0.2	<0.2
CO De 16	<0.2	<0.2	<0.2	--	--	<0.2	<0.2
DO Cg 46	<0.2	<0.2	<0.2	--	--	<0.2	<0.2
KE Be 47	<0.2	<0.2	<0.2	--	--	<0.2	<0.2
QA Cg 1	<3.0	<3.0	--	--	--	<1.0	<3.0
	<3.0	<3.0	--	--	--	<1.0	<3.0
QA Ea 78	<3.0	<3.0	--	--	--	<1.0	<3.0
TA Ce 7	<3.0	<3.0	--	--	--	<1.0	<3.0
	<3.0	<3.0	--	--	--	<1.0	<3.0
WI Cd 71	<0.2	<0.2	<0.2	--	--	<0.2	<0.2
WI Ce 13	<3.0	<3.0	--	--	--	<1.0	<3.0
	<3.0	<3.0	--	--	--	<1.0	<3.0
WO Bf 87	<0.2	<0.2	<0.2	--	--	<0.2	<0.2
WO Bh 84	<3.0	<3.0	--	--	--	<1.0	<3.0
	<3.0	<3.0	--	--	--	<1.0	<3.0
WO Cc 3	<0.2	<0.2	<0.2	--	--	<0.2	<0.2

APPENDIX B

Table B1.—Well characteristics, aquifer data, and land-use information for wells in the Maryland ground-water-quality network

Well number	Permit number	Completion date	Altitude of land surface (ft)	Topographic setting	Depth of well (ft)	Use of water
Segment I						
AL Ae 36	AL-81-0022	08-21-1982	700	V	40	S
AL Ai 26	AL-73-1058	10-20-1980	1250	H	83	H
AL Cb 8	AL-01-2926	10-20-1953	2000	S	86	R
GA Ae 50	GA-73-0233	06-12-1973	2400	S	90	T
GA Ba 1	GA-00-5557	04-08-1950	2010	S	70	H
GA Da 17	GA-67-0179	08- -1966	2430	H	226	R
WA Ad 101	WA-72-0225	04-10-1972	560	S	120	H
WA Ah 63	WA-02-5774	12-06-1956	515	V	25	U
WA Ak 99	WA-71-0019	08-01-1970	670	V	32	H,S
Segment II						
BA Dc 444	BA-81-4198	10-09-1985	390	S	300	U
CL Ae 1	CL-01-0525	08-25-1952	1005	W	100	T
CL Bf 184	CL-73-6466	11-16-1977	790	V	339	U
FR Af 27	FR-73-7155	08-29-1979	385	G	365	U
FR Df 35	FR-73-0852	05-26-1973	570	H	302	U
HA Ca 23	HA-73-1630	06-25-1974	470	S	200	U
HO Cd 78	HO-81-2386	03-31-1988	426	W	19	U
MO Be 62	MO-73-0083	02-07-1973	805	H	180	U
MO Db 68	MO-73-1869	05-30-1978	260	V	250	U

Topographic setting

V Valley
H Hilltop
S Hillside
F Flat
W Upland draw
G Floodplain

Use of water

S Stock
H Domestic
R Recreation
T Institutional
U Unused
I Irrigation
F Fire

Table B1.—Well characteristics, aquifer data, and land-use information for wells in the Maryland ground-water-quality network—Continued

Well	Geologic unit	Casing				Openings			Aquifer type	Upgradient land use
		Depth (ft)	Diameter (in)	Finish	Depth of grout (ft)	Diameter (inches)	Interval (ft)	Finish		
Segment I										
AL Ae 36	Mahantango Fm.	29	6	ST	24	--	29-40	OH	U	6
AL Ai 26	Jennings Fm.	30	6	ST	30	--	30-83	OH	U	6
AL Cb 8	Conemaugh Fm.	34	5-5/8	ST	--	--	34-86	OH	U	6
GA Ae 50	Conemaugh Fm.	21	6	ST	21	--	21-90	OH	U	5
GA Ba 1	Conemaugh Fm.	41	5-5/8	ST	--	--	41-70	OH	U	6
GA Da 17	Allegheny/ Pottsville Fm.	37	6	ST	--	--	37-226	OH	U	6
WA Ad 101	Romney Fm.	21	6-1/4	ST	20	--	21-120	OH	U	6
WA Ah 63	Rockdale Run Fm.	--	--	ST	--	--	--	OH	U	4
WA Ak 99	Tomstown Fm.	20	6	ST	20	--	20-32	OH	U	4
Segment II										
BA Dc 444	Cockeysville Marble	86	6	ST	34	--	86-300	OH	U	6
CL Ae 1	Marburg Schist	17.5	6	ST	--	--	17.5-100	OH	U	6
CL Bf 184	Prettyboy Schist	50	6	ST	48	--	50-339	OH	U	4
FR Af 27	Gettysburg Shale	39	6	ST	39	--	39-365	OH	U	1
FR Df 35	Urbana Fm.	26	6	ST	26	--	26-302	OH	U	6
HA Ca 23	Loch Raven Schist	24	6	ST	24	--	24-200	OH	U	4
HO Cd 78	Loch Raven Schist (saprolite)	9	3	PL	8	3	9-19	PL	U	4
MO Be 62	Ijamsville Fm.	29	6	ST	27	--	29-180	OH	U	5
MO Db 68	New Oxford Conglomerate	40	6	ST	35	--	40-250	OH	U	5

Casing finish
PL Plastic
C Cement
ST Steel

Openings finish
PL Slotted plastic
BR Brass screen
C Cement
OH Open hole

Aquifer type
U Unconfined
S Semiconfined
C Confined

Upgradient land use
1 Residential
2 Commercial
3 Institutional
4 Cropland
5 Pasture/grassland
6 Forest

Table B1.—Well characteristics, aquifer data, and land-use information for wells in the Maryland ground-water-quality network—Continued

Well number	Permit number	Completion date	Altitude of land surface (ft)	Topo-graphic setting	Depth of well (ft)	Use of water	Geologic unit
Segment III							
AA Ad 104	AA-81-2760	05-10-1984	77	F	29	U	Patapsco Fm.
AA Cg 25	AA-74-1240	09-15-1979	17	F	107	U	Aquia Fm.
AA Df 103	AA-73-3315	09-01-1974	27	F	46	U	Aquia Fm.
CA Fc 13	CA-81-2391	07-15-1986	47	F	35	U	Chesapeake Group
CH Cb 7	CH-01-1908	03-03-1952	36	F	400	U	Potomac Group
CH Ee 16	--	pre-1946	40	S	23	U	Maryland Point Fm.
CH Ee 90	CH-81-0606	08-22-1983	7	G	21	U	Nanjemoy Fm.
HA Dd 92	HA-81-4137	02-05-1988	20	F	38	U	Talbot Fm.
PG Bc 37	PG-81-0661	09-22-1984	170	H	25	U	Patuxent Fm.
SM Ef 80	--	--	40	F	21	U	Omar Fm.
Segment IV							
CO Dc 146	CO-81-1524	06-15-1988	45	F	20	U	Pensauken Fm
CO De 16	CO-81-1530	06-16-1988	61	F	17	U	Beaverdam Fm.
CE Dd 102	CE-81-1895	05-01-1986	70	S	122	I	Magothy Fm.
DO Cg 46	DO-88-0090	05-01-1989	18	F	17	U	Beaverdam Fm.
KE Be 47	KE-81-0943	06-22-1988	66	F	24	U	Pensauken Fm.
QA Cg 1	QA-00-3949	06-10-1949	69	F	60	F	Pensauken Fm.
QA Ea 78	QA-81-0474	07-31-1984	12	F	135	U	Aquia Fm.
SO Ce 98	S0-81-1912	10-23-1990	15	F	60	U	Beaverdam Fm.
TA Ce 7	--	pre-1949	13	F	104	U	Calvert Fm.
WI Cd 71	WI-88-0650	05-17-1989	35	F	18	U	Beaverdam Fm.
WI Ce 13	--	08- -1942	7	F	65	U	Pensauken Fm.
WO Bf 87	WO-81-2672	04-27-1989	33	F	18	U	Beaverdam Fm.
WO Bh 84	WO-73-0095	04 -15-1973	5	F	89	U	Beaverdam Fm.
WO Cc 3	WO-81-2286	06-07-1988	30	G	21	U	Beaverdam Fm.

Well	Casing Depth (ft)	Casing Dia-meter (in)	Casing Fin-ish	Casing Depth of grout (ft)	Openings Diameter (in)	Openings Interval (ft)	Openings Fin-ish	Aquifer type	Upgra-dient land use
Segment III									
AA Ad 104	19	4	PL	15	4	19-29	PL	U	2
AA Cg 25	100	3	PL	73	3	100-107	PL	U	6
AA Df 103	39	4	PL	20	2	39-46	PL	S	1
CA Fc 13	29	3.5	PL	23	3.5	29-34	PL	U	4
CH Cb 7	400	8	ST	--	7.5	144-167	BR	C	6
CH Ee 16	--	42	C	--	--	--	C	U	6
CH Ee 90	11	4	PL	5	2	11-16	PL	U	1
HA Dd 92	28	4	PL	15	4	18-28	PL	S	1
PG Bc 37	15	4	PL	15	4	15-25	PL	U	3
SM Ef 80	--	42	C	--	--	--	C	U	4
Segment IV									
CO Dc 146	17	2	PL	17	2	17-20	PL	S	4
CO De 16	14	2	PL	14	2	14-17	PL	U	4
CE Dd 102	100	4	PL	90	3	100-122	ST	C	4
DO Cg 46	14	2	PL	14	2	14-17	PL	U	6
KE Be 47	21	2	PL	21	2	21-24	PL	U	4
QA Cg 1	50	4	--	--	--	50-60	--	U	1
QA Ea 78	125	4	PL	--	4	125-135	PL	C	3
SO Ce 98	35	6	PL	26	6	35-55	PL	S	3
TA Ce 7	82	4	--	--	--	82-89	ST	C	2
WI Cd 71	15	2	PL	15	2	15-18	PL	U	4
WI Ce 13	--	16	ST	--	--	-65	ST	U	1
WO Bf 87	15	2	PL	15	2	15-18	PL	U	4
WO Bh 84	84	4	PL	50	4	84-89	PL	S	2
WO Cc 3	18	2	PL	18	2	18-21	PL	S	6

Table B2.—Spring characteristics, aquifer data, and land-use information for springs in the Maryland ground-water-quality network

Spring number	Altitude of land surface (ft)	Topographic setting	Use of water	Geologic unit	Improvements	Upgradient land use
Segment I						
AL Ce 4	710	V	P,Z	Marcellus/ Needmore Shale	Collecting basin; springhouse	6
GA Eb 72	2410	S	U	Jennings Fm.	Collecting basin	6
WA Ab 3	910	S	S	Hampshire Fm.	Collecting basin; springhouse	4
WA Di 103	470	S	S	Conococheague Limestone	Collecting basin; springhouse	4
Segment II						
CE Cc 40	180	S	Z	James Run Fm.	Steel discharge pipe	6
FR Cd 38	690	S	T	Weverton Fm.	Collecting basin with roof	6
FR Dd 178	315	V	Q	Frederick Fm.	Springhouse	3
FR Fb 12	300	S	P	Granodiorite and Biotite Granite Gneiss	Steel discharge pipe	1
HA Aa 9	690	S	S	Prettyboy Schist	Collecting basin in covered pit	4
HA Bc 31	280	V	U	Wissahickon Boulder Gneiss	None	6

Topographic setting

V Valley
S Hillside

Use of water

U Unused
P Public supply
S Stock
Z Used by passers-by
Q Aquaculture
T Institutional

Upgradient land use

1 Residential
2 Commercial
3 Institutional
4 Cropland
5 Pasture/grassland
6 Forest

APPENDIX C

LOCATIONS OF NETWORK SITES:

Segment I: Appalachian Plateau and Valley and Ridge Physiographic Provinces

Segment II: Piedmont and Blue Ridge Physiographic Provinces

Segment III: Western Shore Coastal Plain

Segment IV: Eastern Shore Coastal Plain

● **Well location**

Spring location

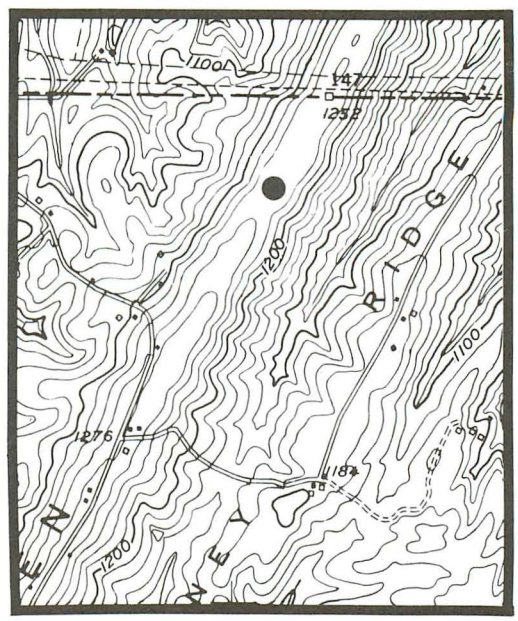
Base maps from U.S. Geological Survey 7-1/2 minute quadrangles.

SCALE 1:24000

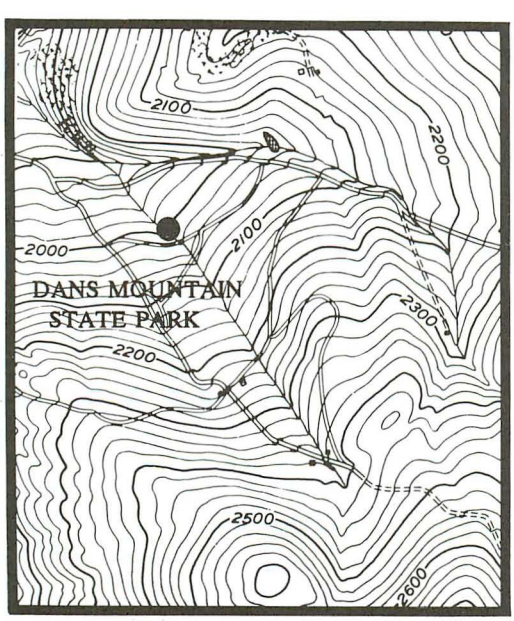
1 inch = 2000 feet

Segment I: Appalachian Plateau and Valley and Ridge Physiographic Provinces

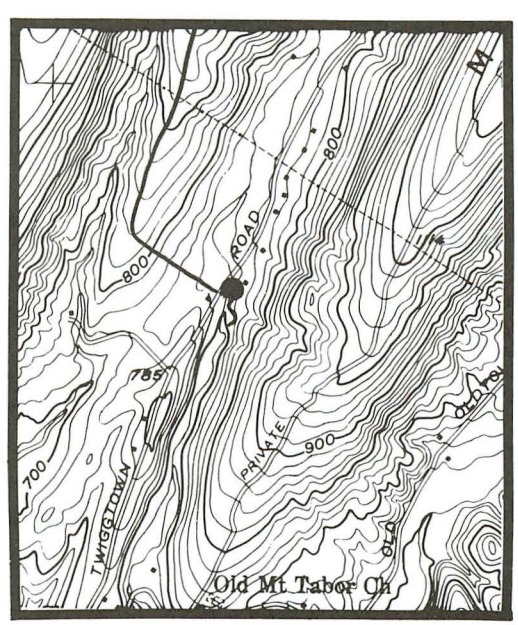
Well AL Ae 36.
Evitts Creek quadrangle.



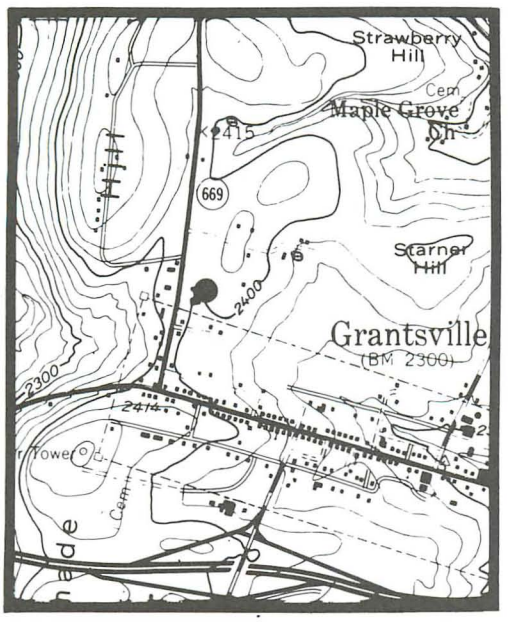
Well AL Ai 26.
Artemas quadrangle.



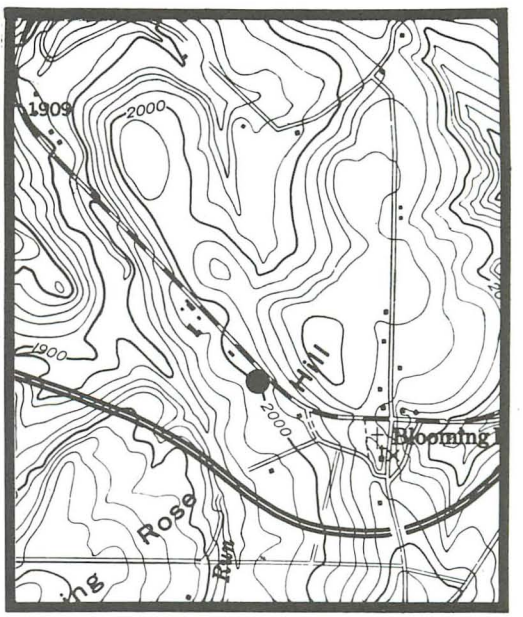
Well AL Cb 8.
Lonaconing quadrangle.



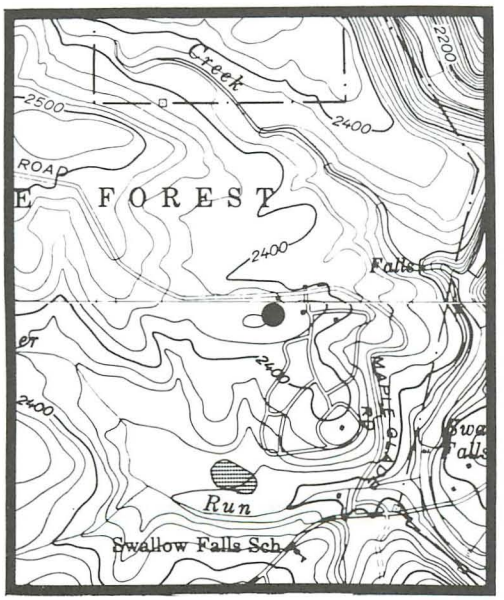
Spring AL Ce 4.
Patterson Creek quadrangle.



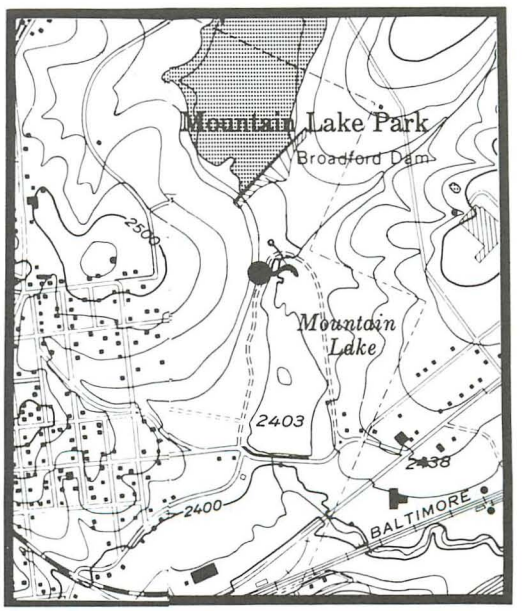
Well GA Ae 50.
Grantsville quadrangle.



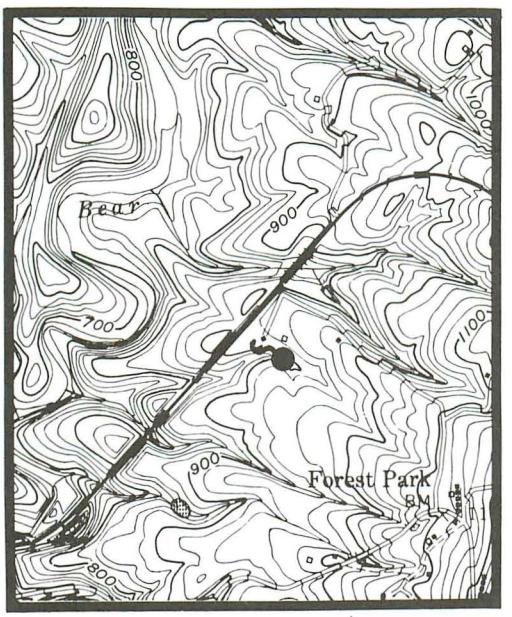
Well GA Ba 1.
Friendsville quadrangle.



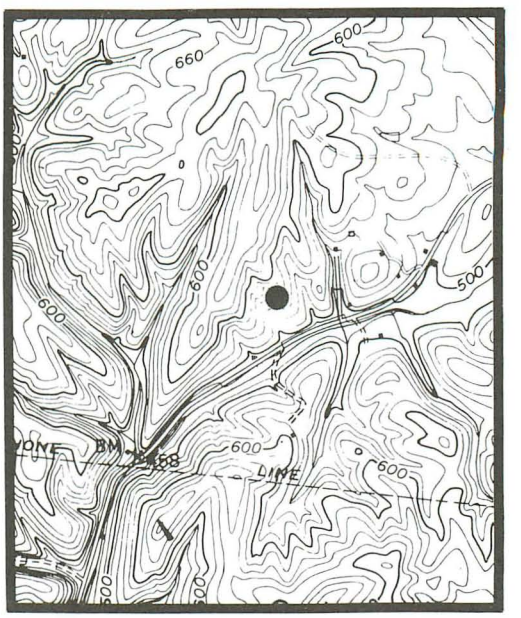
Well GA Da 17.
Oakland and Sang Run quadrangles.



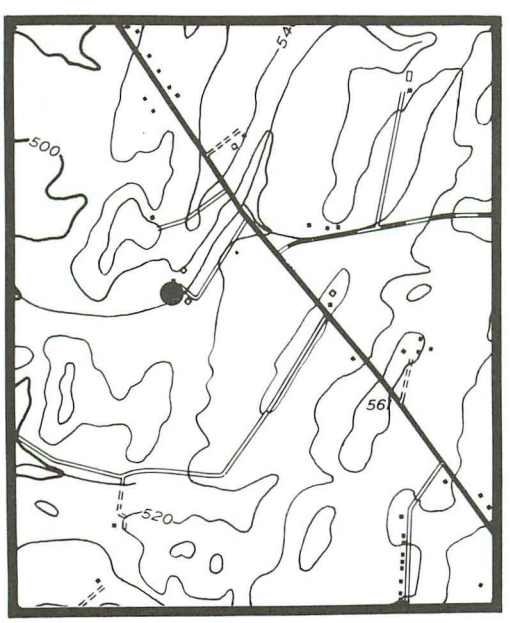
Spring GA Eb 72.
Deer Park and Oakland quadrangles.



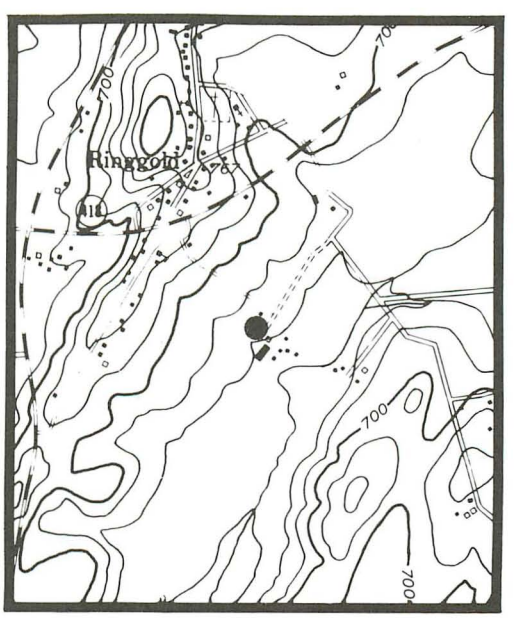
Spring WA Ab 3.
Bellegrove quadrangle.



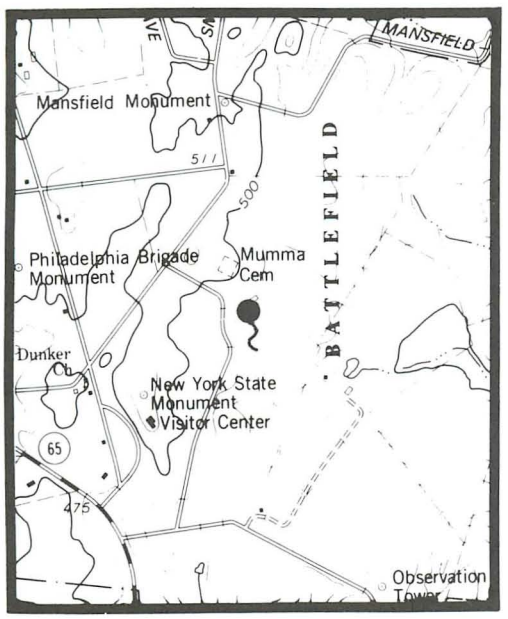
Well WA Ad 101.
Cherry Run quadrangle.



Well WA Ah 63.
Mason-Dixon quadrangle.

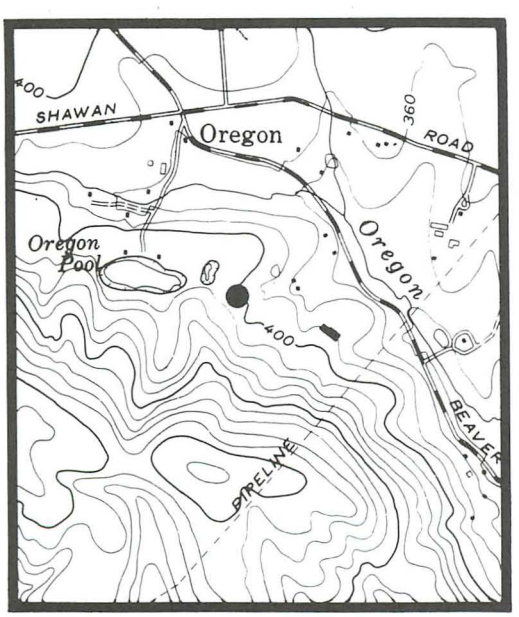


Well WA Ak 99.
Smithsburg quadrangle.

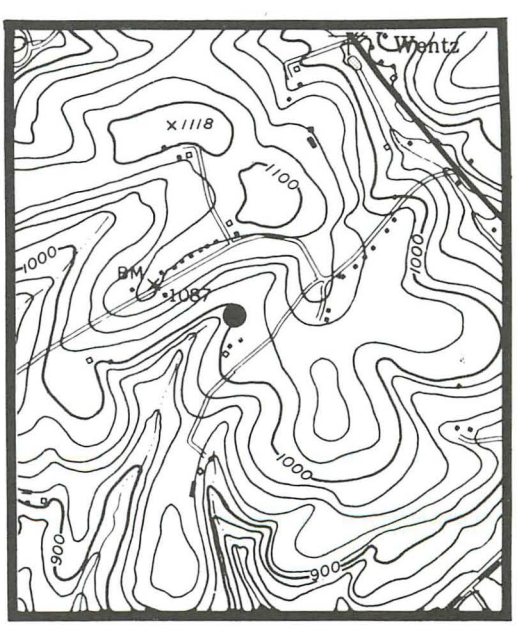


Spring WA Di 103.
Keedysville quadrangle.

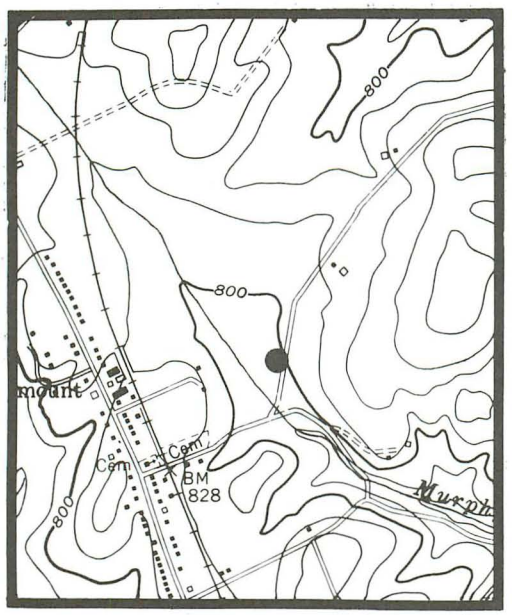
Segment II: Piedmont and Blue Ridge Physiographic Provinces



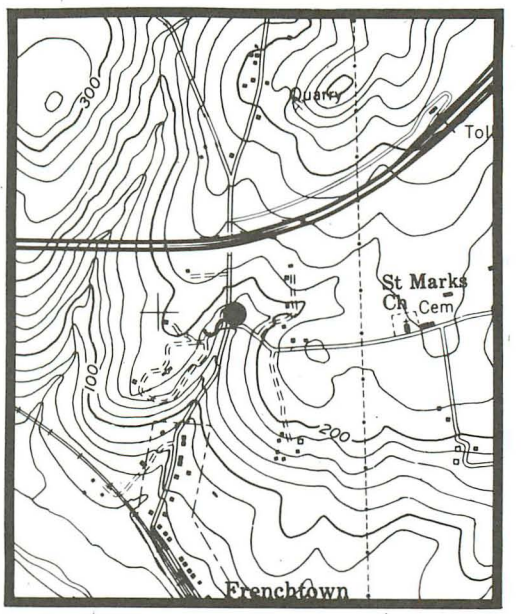
Well BA Dc 444.
Cockeysville quadrangle.



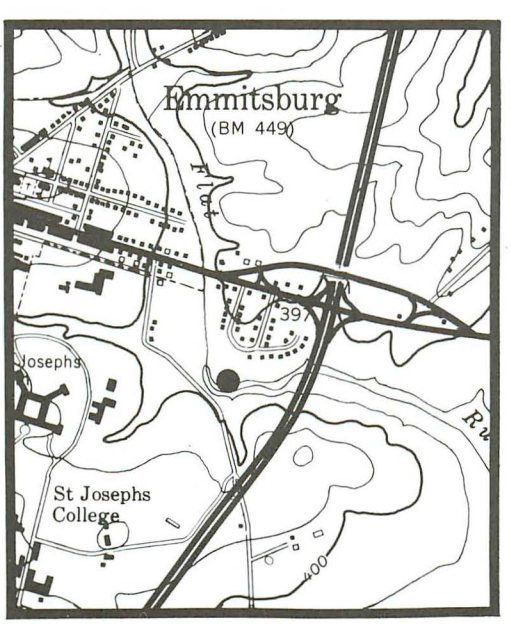
Well CL Ae 1.
Manchester quadrangle.



Well CL Bf 184.
Lineboro quadrangle.

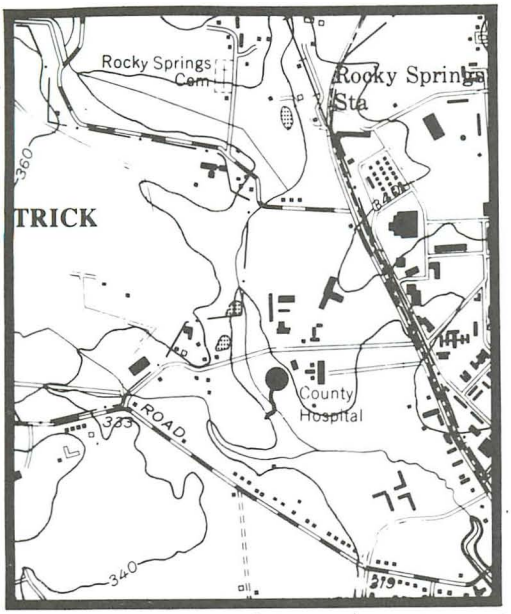


Spring CE Cc 40.
Havre de Grace quadrangle.

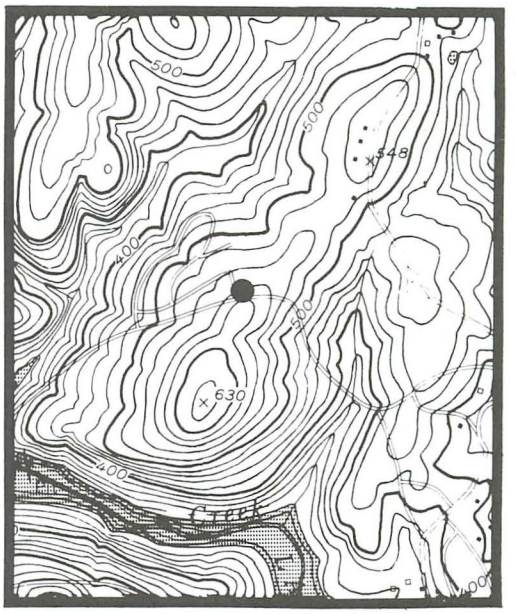


Well FR Af 27.
Emmitsburg quadrangle.

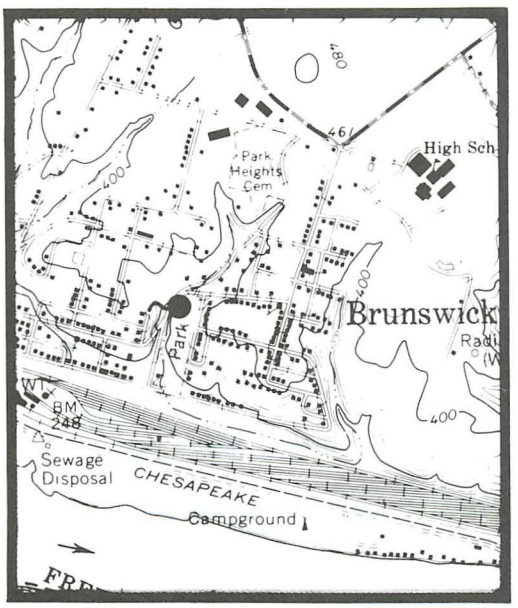
Spring FR Cd 38.
Catoctin Furnace quadrangle.



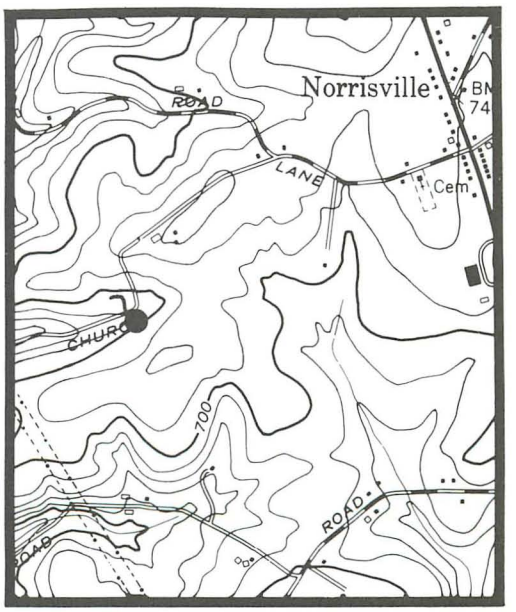
Spring FR Dd 178.
Frederick quadrangle.



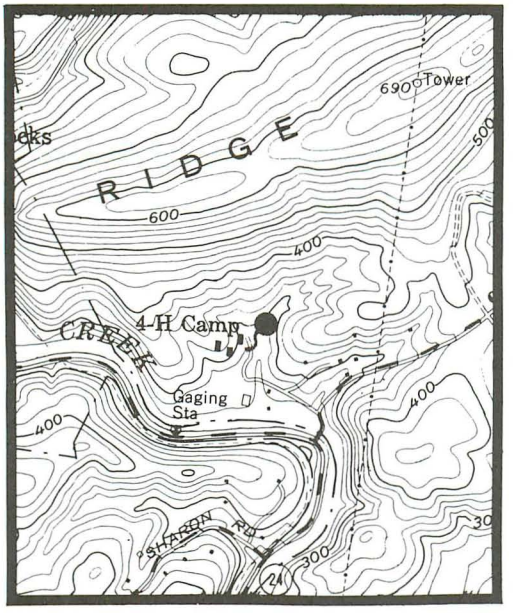
Well FR Df 35.
Walkersville quadrangle.



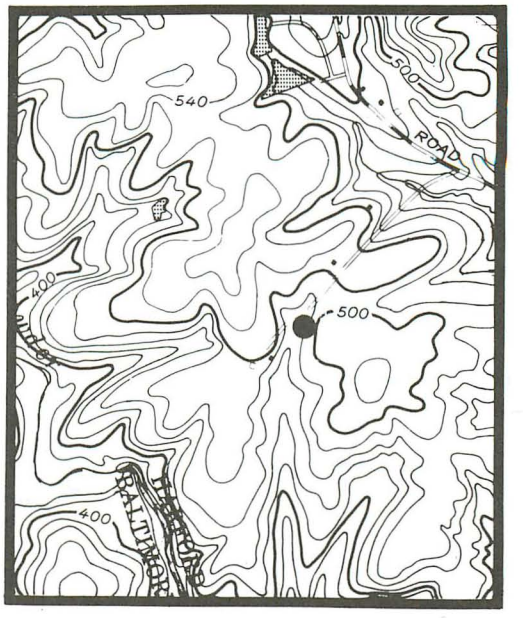
Spring FR Fb 12.
Point of Rocks quadrangle.



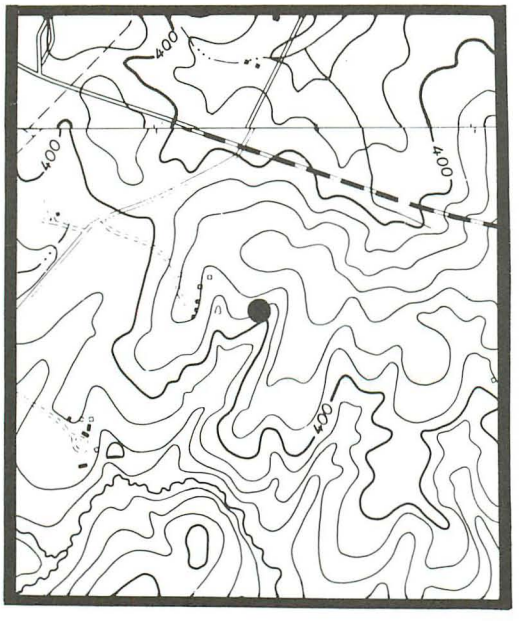
Spring HA Aa 9.
Norrisville quadrangle.



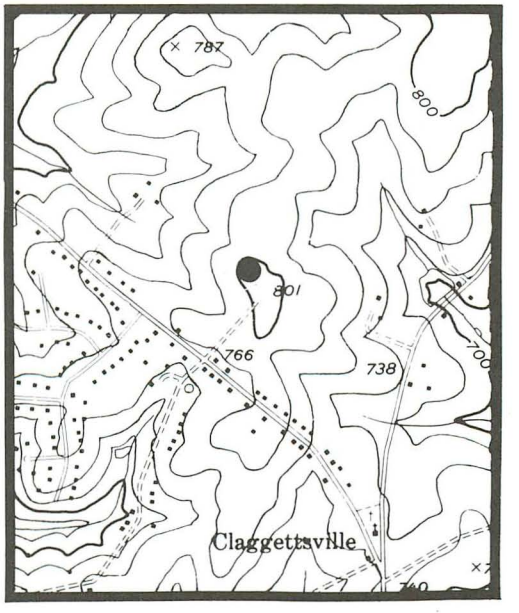
Spring HA Bc 31.
Fawn Grove quadrangle.



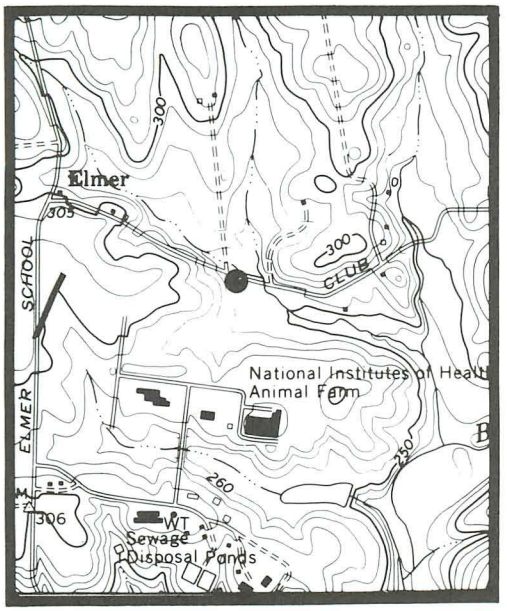
Well HA Ca 23.
Phoenix quadrangle.



Well HO Cd 78.
Clarksville and Sykesville quadrangles.

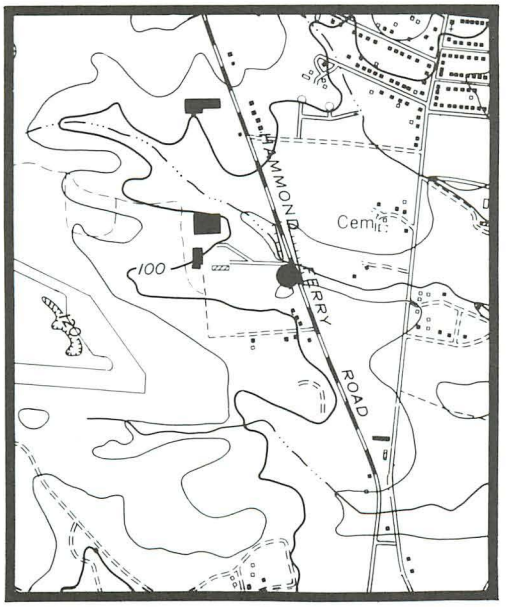


Well MO Be 62.
Damascus quadrangle.

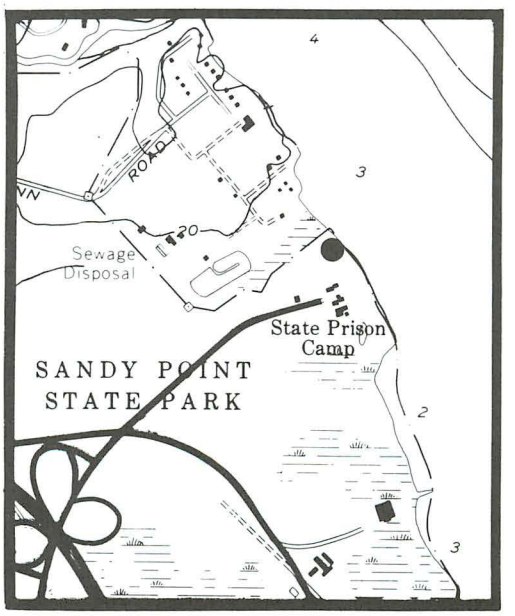


Well MO Db 68.
Poolesville quadrangle.

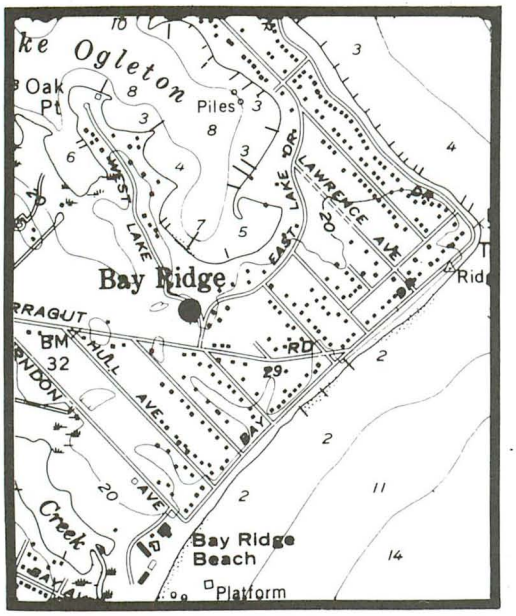
Segment III: Western Shore Coastal Plain



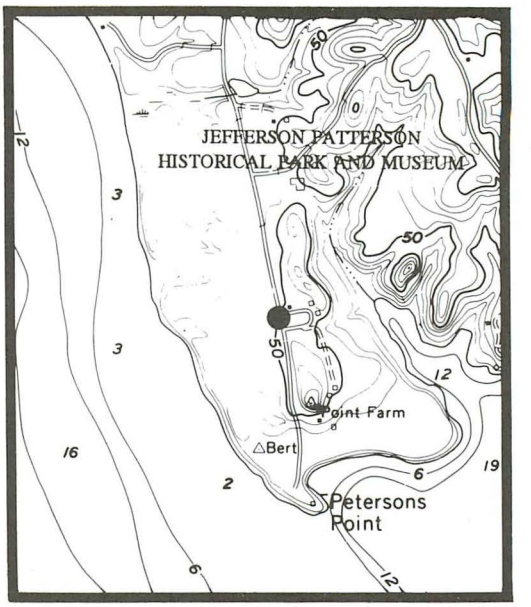
Well AA Ad 104.
Relay quadrangle.



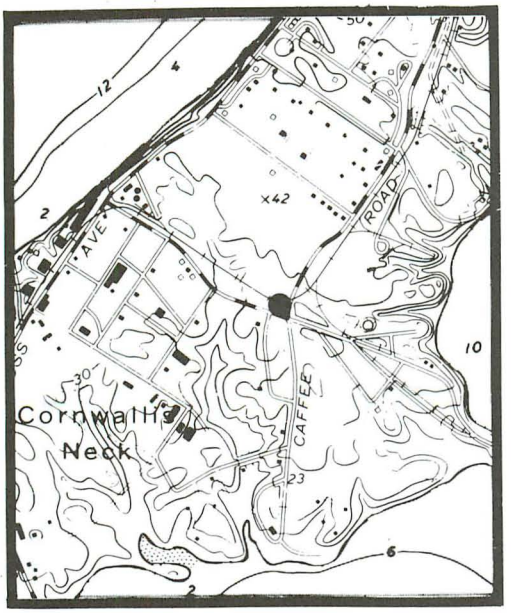
Well AA Cg 25.
Gibson Island quadrangle.



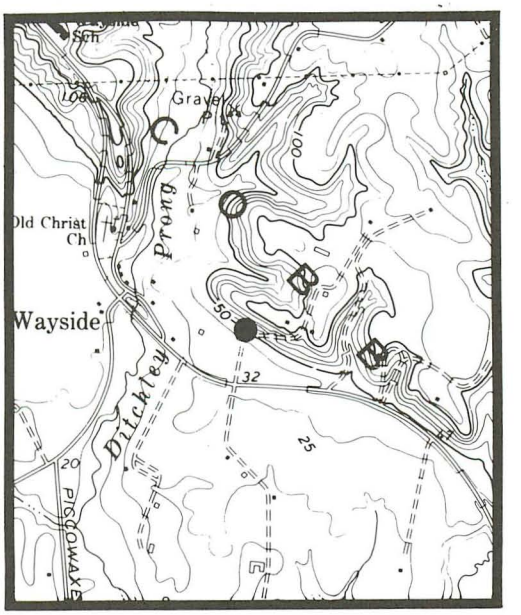
Well AA Df 103.
Annapolis quadrangle.



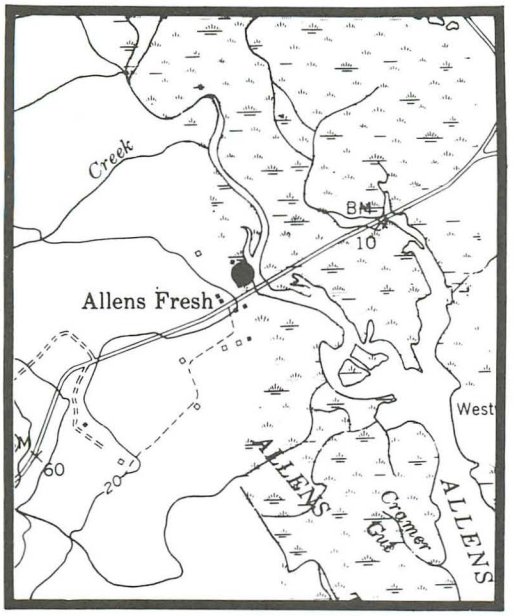
Well CA Fc 13.
Broomes Island quadrangle.



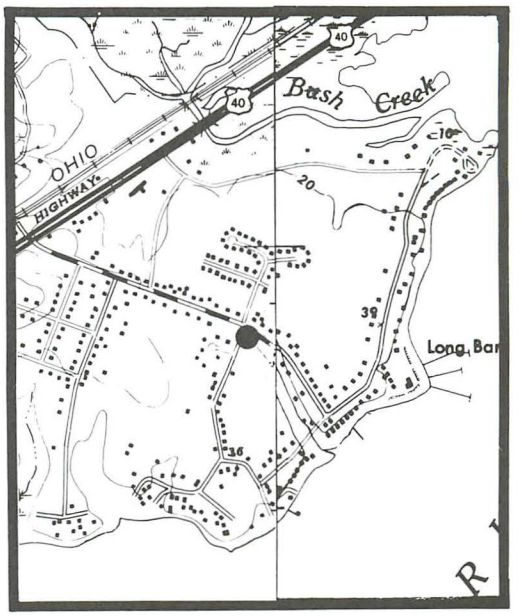
Well CH Cb 7.
Indian Head quadrangle.



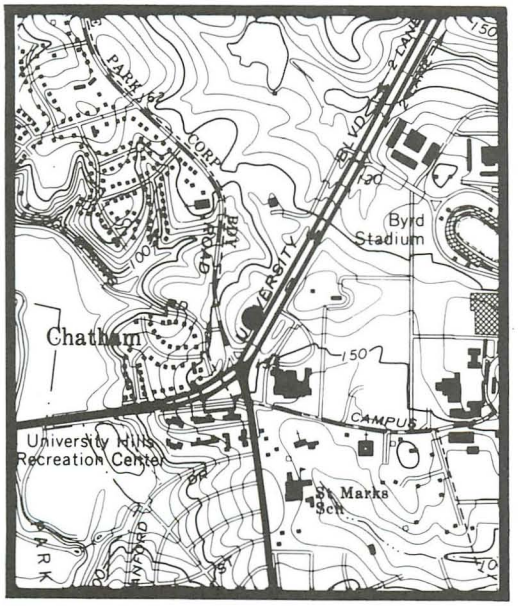
Well CH Ee 16.
Colonial Beach North quadrangle.



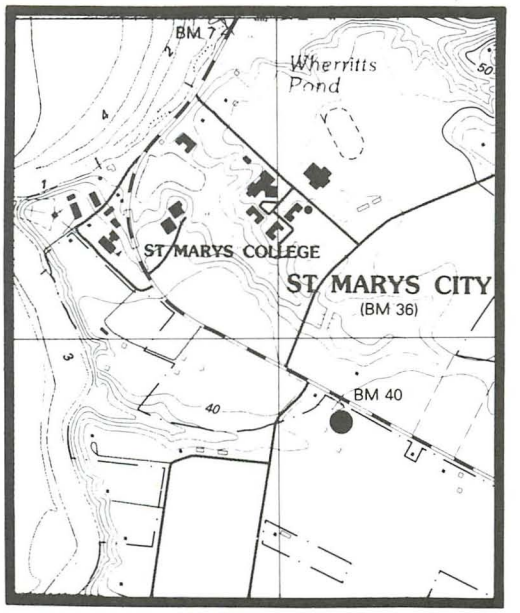
Well CH Ee 90.
Popes Creek quadrangle.



Well HA Dd 92.
Edgewood and Perryman quadrangles.

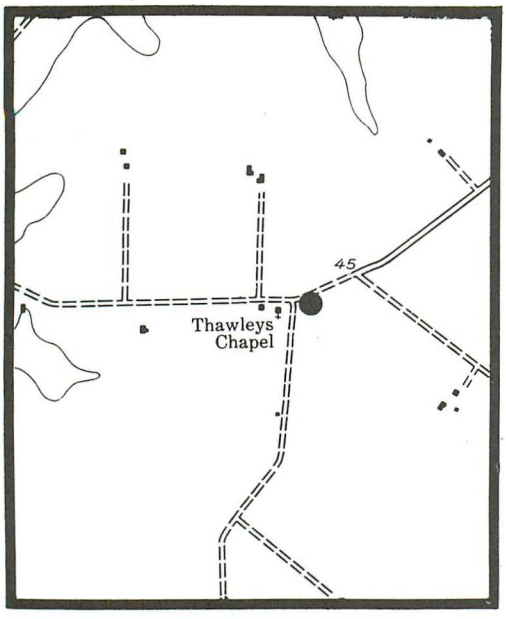


Well PG Bc 37.
Washington East quadrangle.

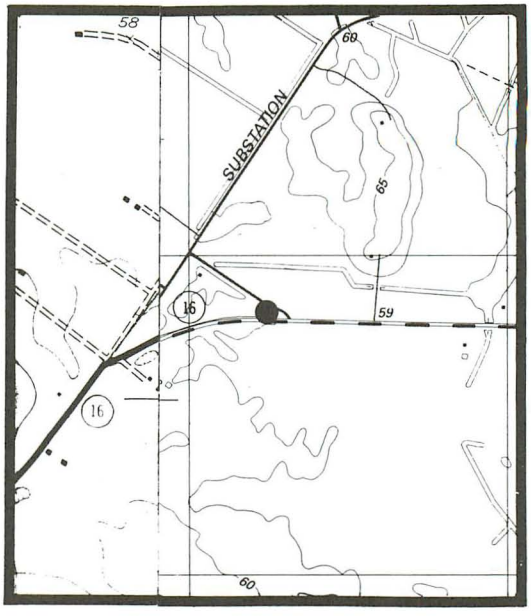


Well SM Ef 80.
St. Marys City quadrangle.

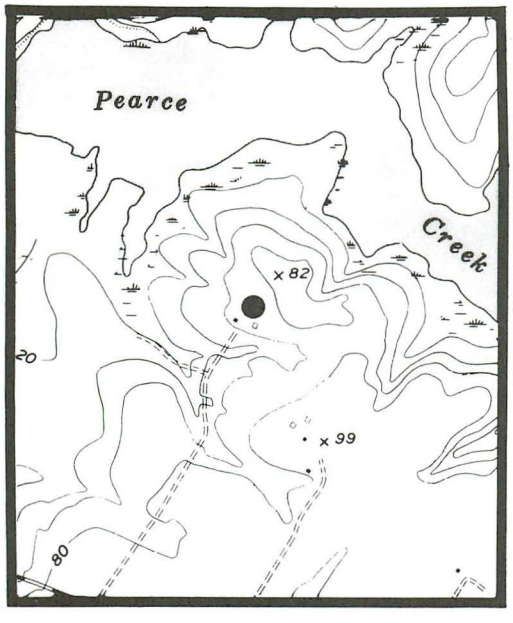
Segment IV: Eastern Shore Coastal Plain



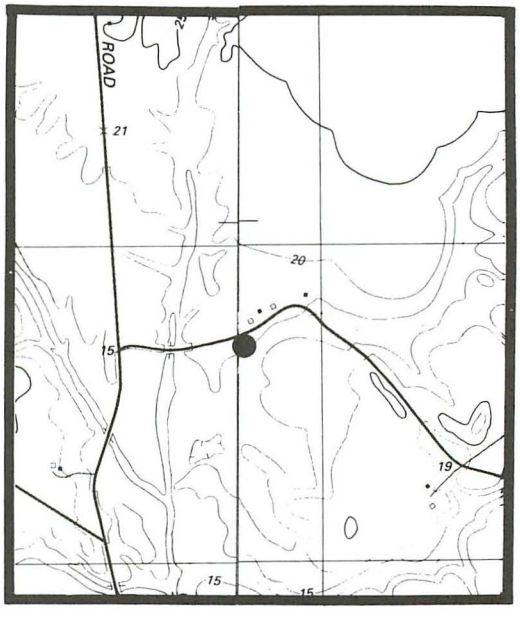
Well CO Dc 146.
Ridgely quadrangle.



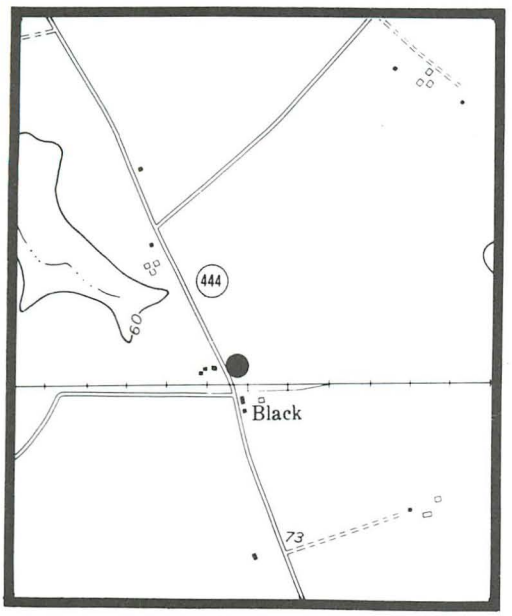
Well CO De 16.
Hickman and Hobbs quadrangles.



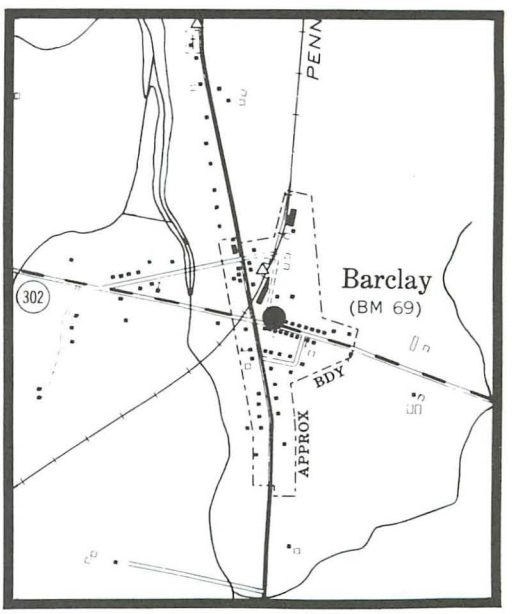
Well CE Dd 102.
Earleville quadrangle.



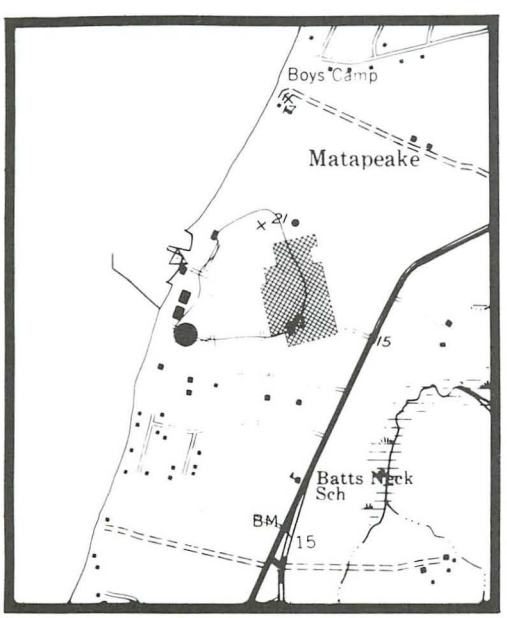
Well DO Cg 46. Rhodesdale and
East New Market quadrangles.



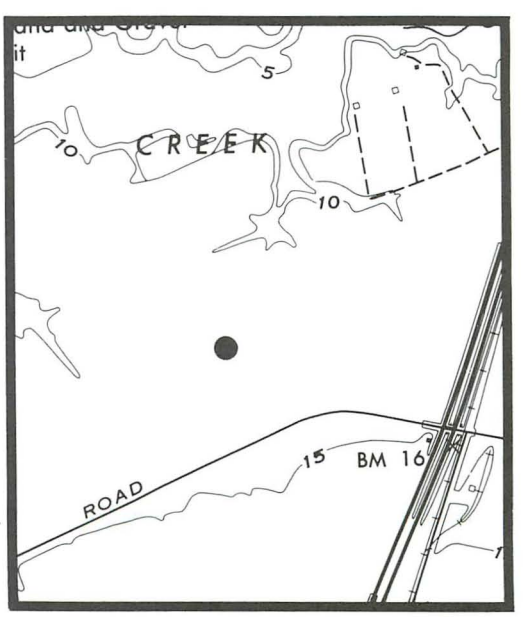
Well KE Be 47.
Galena quadrangle.



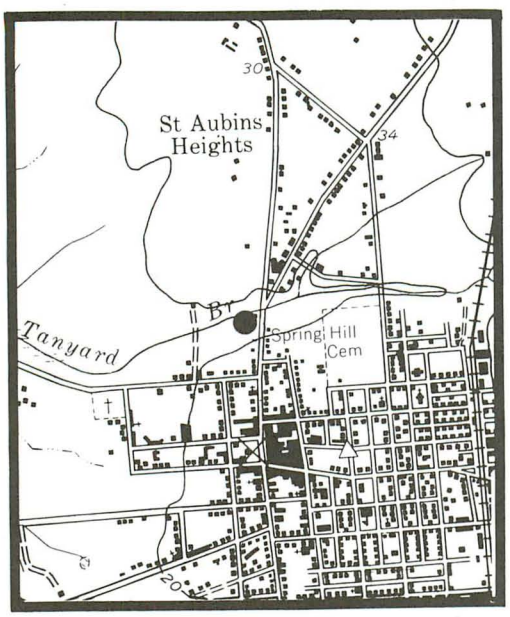
Well QA Cg 1.
Sudlersville quadrangle.



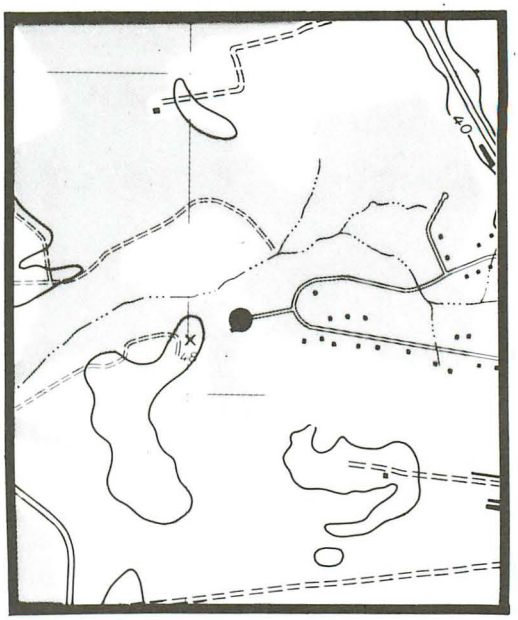
Well QA Ea 78.
Kent Island quadrangle.



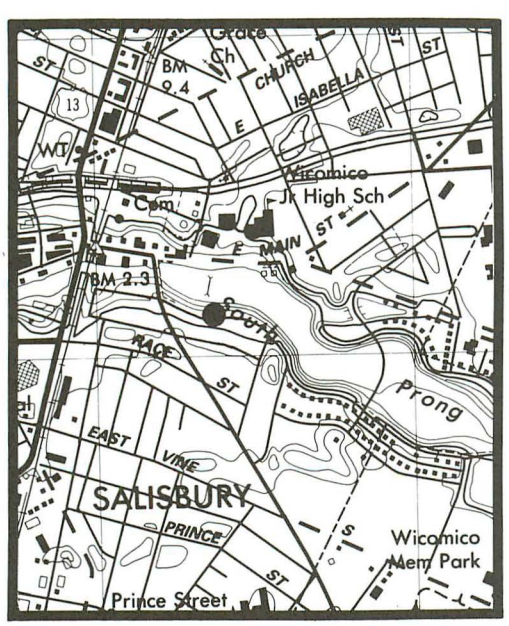
Well SO Ce 98.
Princess Anne quadrangle.



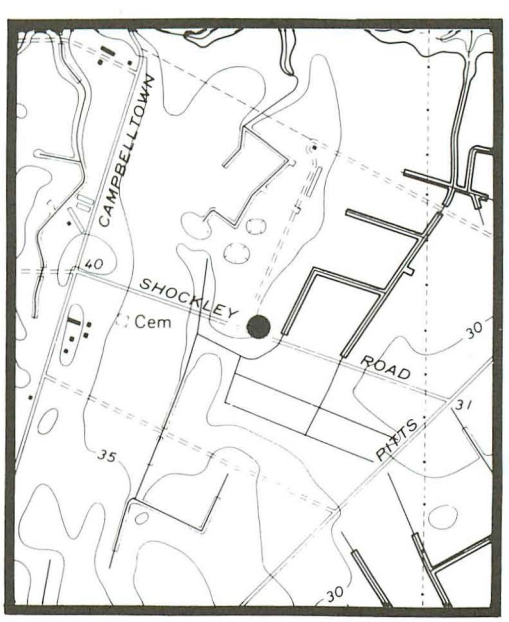
Well TA Ce 7.
Easton quadrangle.



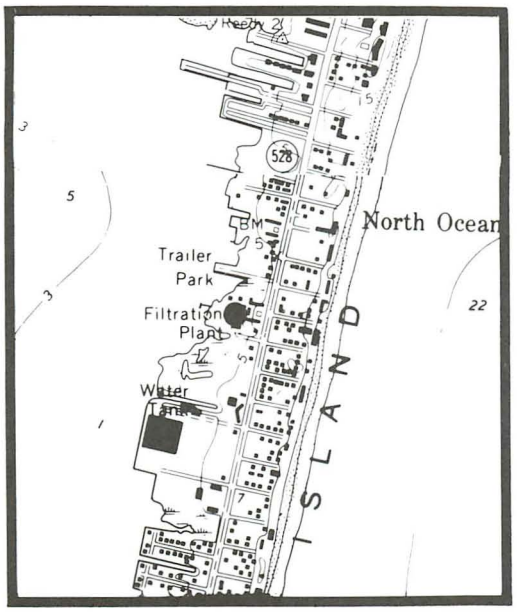
Well WI Cd 71.
Hebron quadrangle.



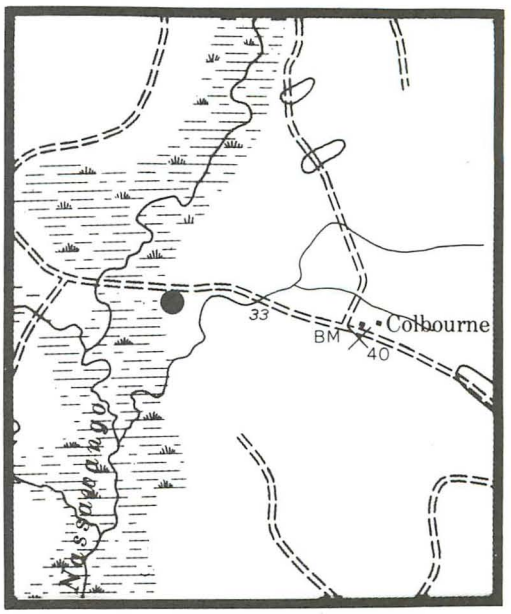
Well WI Ce 13.
Salisbury quadrangle.



Well WO Bf 87.
Selbyville quadrangle.



Well WO Bh 84. Ocean City and
Assawoman Bay quadrangles.



Well WO Cc 3.
Wango quadrangle.

APPENDIX D.
CUMULATIVE-PERCENTAGE PLOTS FOR SELECTED ANALYTES

Cumulative-percentage plots for selected analytes were constructed using the median analyte value at each site. For some analytes, detection levels changed during the project sampling period. For other analytes, some sites with only two analyses had one sample above detection level and the other below detection level. Thus there were some difficulties in plotting these data near the detection levels.

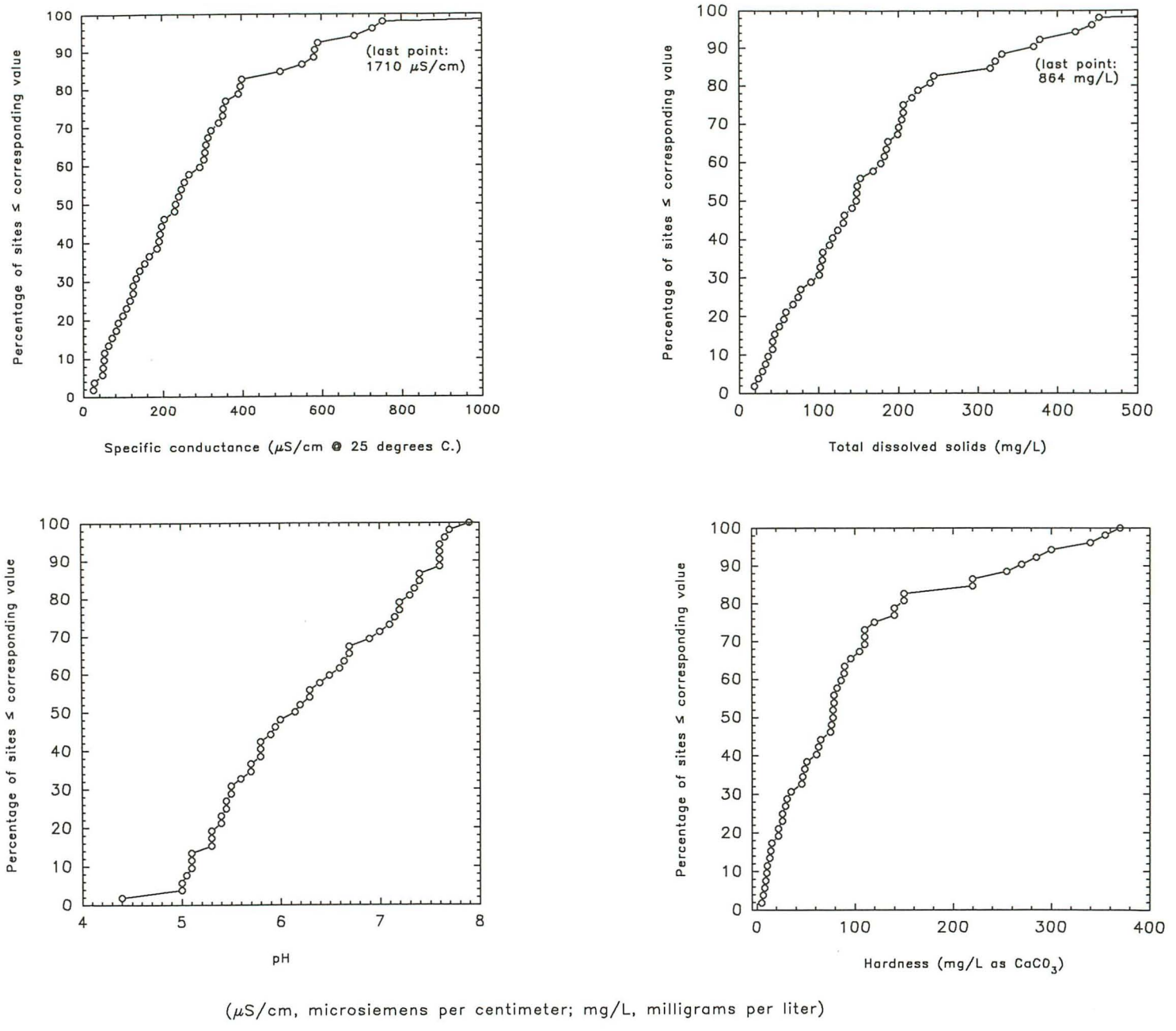


Figure D1.—Cumulative-percentage plots of median specific conductance, total-dissolved-solids, pH, and hardness values.

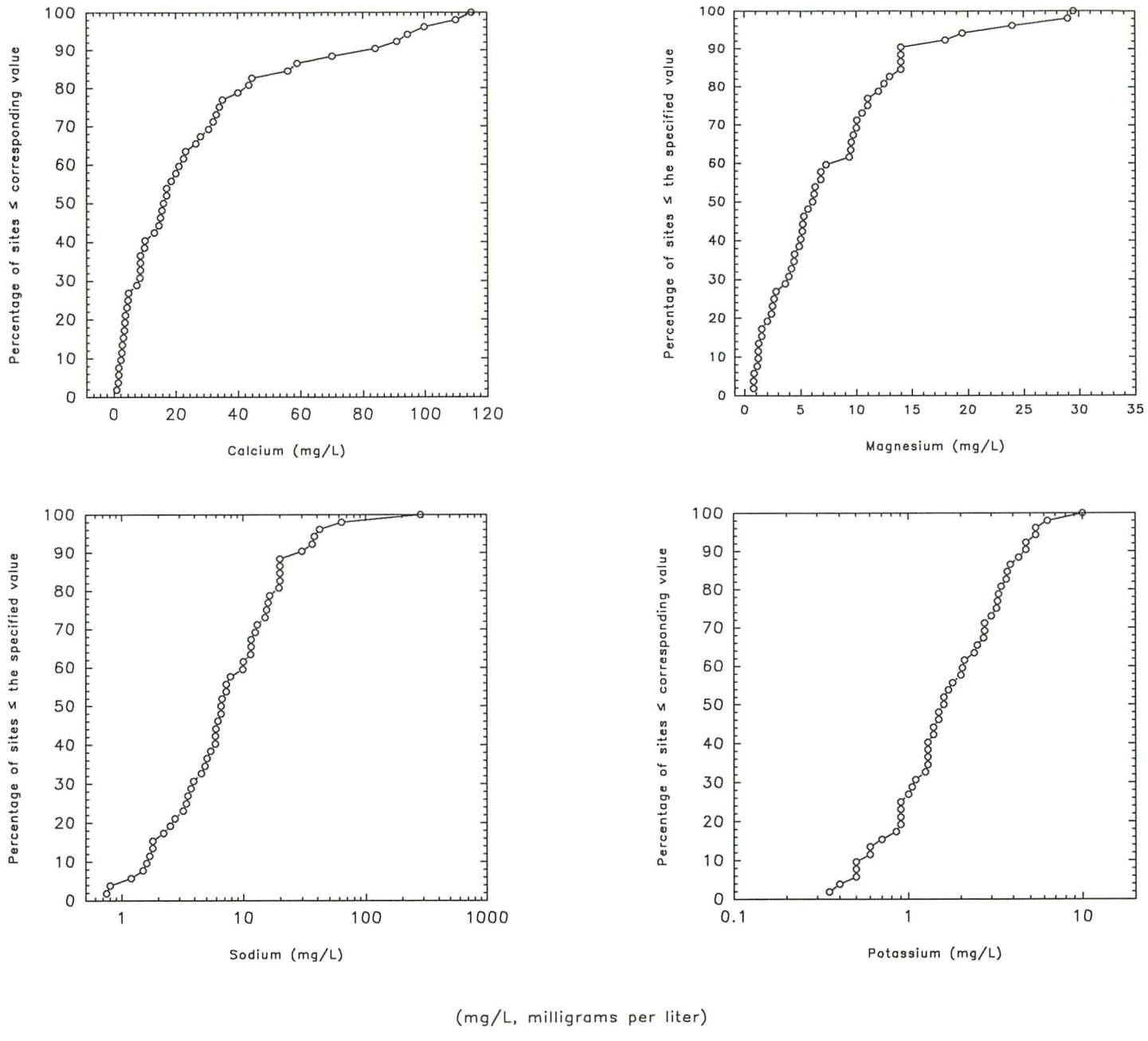


Figure D2.—Cumulative-percentage plots of median calcium, magnesium, sodium, and potassium concentrations.

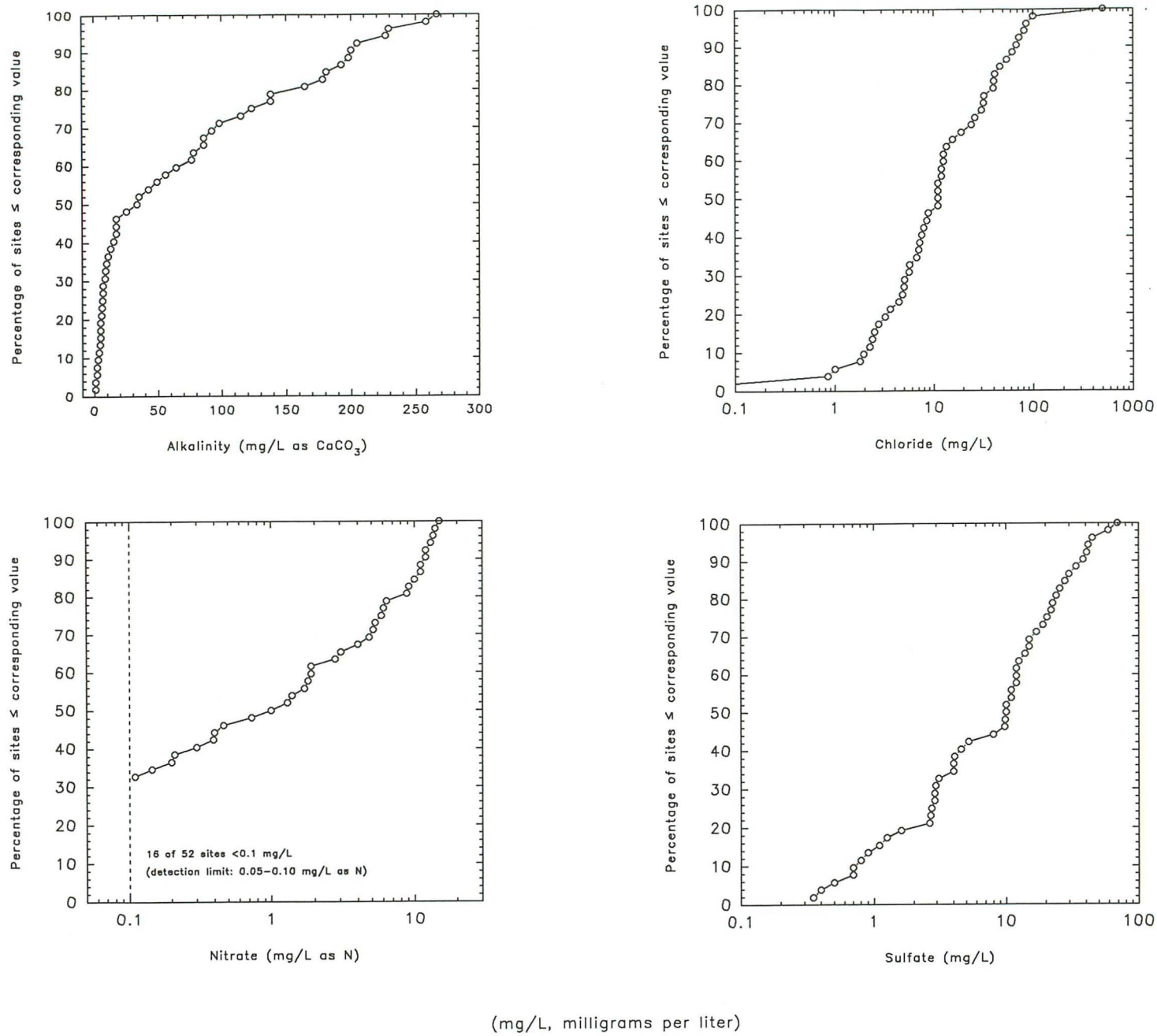
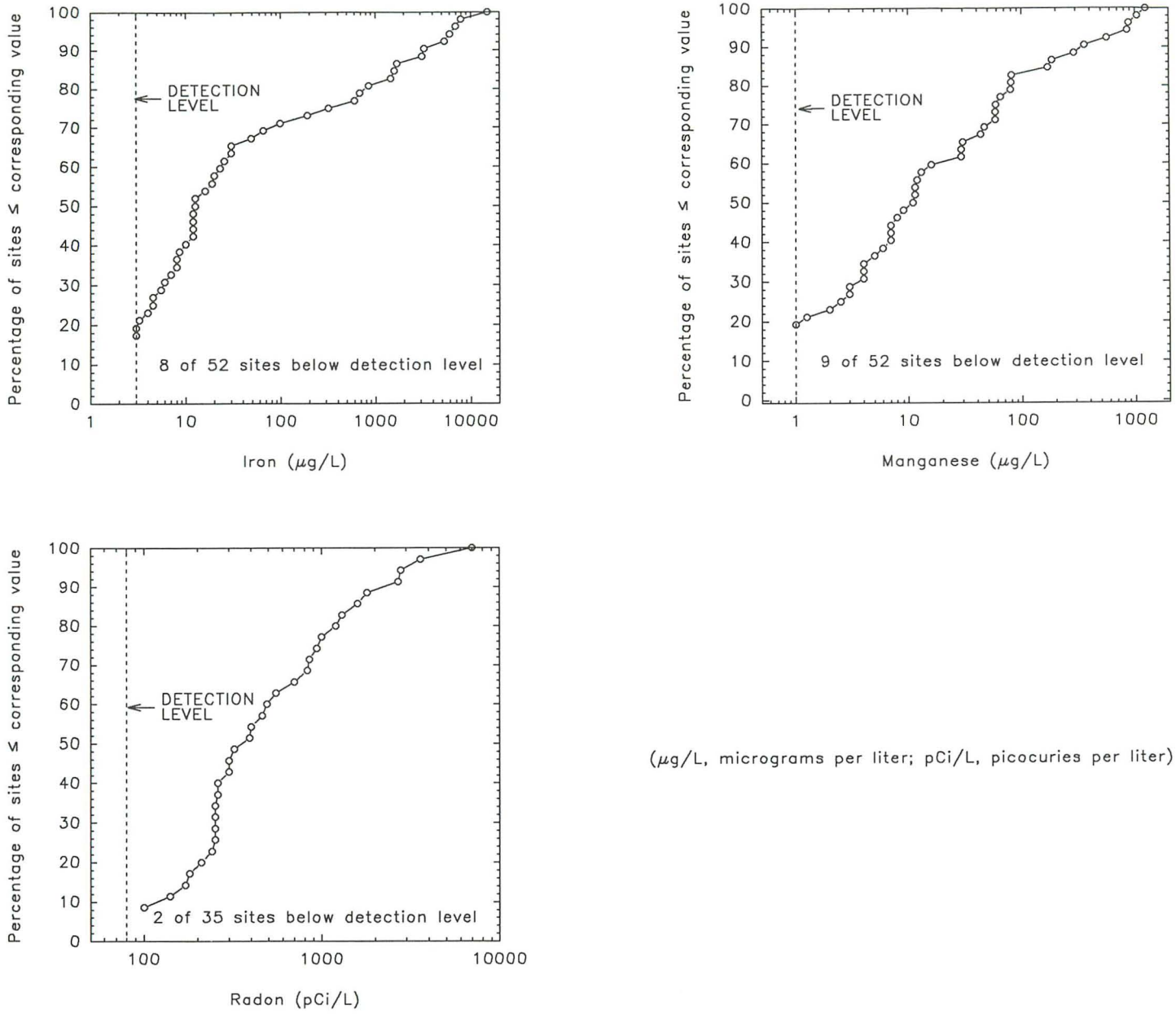


Figure D3.—Cumulative-percentage plots of median alkalinity, chloride, nitrate, and sulfate concentrations.



(μg/L, micrograms per liter; pCi/L, picocuries per liter)

Figure D4.—Cumulative-percentage plots of median iron, manganese, and radon concentrations.