GROUND-WATER QUALITY IN GEORGIA FOR 1993

John C. Donahue

and

Neal D. Hunt

GEORGIA DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA GEOLOGIC SURVEY

Atlanta
1996

CIRCULAR 12J

GROUND-WATER QUALITY IN GEORGIA FOR 1993

John C. Donahue

and

Neal D. Hunt

The preparation of this report was funded in part through a grant from the U.S. Environmental Protection Agency under the provisions of Section 106 of the Federal Water Pollution Control Act of 1972, as amended.

GEORGIA DEPARTMENT OF NATURAL RESOURCES
LONICE C. BARRETT, COMMISSIONER

ENVIRONMENTAL PROTECTION DIVISION
HAROLD F. REHEIS, DIRECTOR

GEORGIA GEOLOGIC SURVEY
WILLIAM H. McLEMORE, STATE GEOLOGIST

ATLANTA
1996

CIRCULAR 12J

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This report for calendar year 1993 is the tenth in a series of annual summaries discussing the chemical quality of ground water in Georgia. These summaries are among the tools used by the Georgia Environmental Protection Division (EPD) to assess trends in the quality of the State's ground-water resources. EPD is the State organization with regulatory responsibility for maintaining and, where possible, improving ground-water quality and availability. EPD has implemented a comprehensive state-wide ground-water management policy of anti-degradation (EPD, 1991). Five components constitute EPD's ground-water quality assessment program:

1. The Georgia Ground-Water Monitoring Network. This program is maintained by the Geologic Survey Branch of EPD and is designed to evaluate the ambient ground-water quality of ten aquifer systems throughout the State of Georgia. The data presented in this report were provided by this program.

2. Sampling of public drinking water wells as part of the Safe Drinking Water Program (Water Resources Management Branch). This program provides data on the quality of ground water that is being used by the residents of Georgia.

3. Special studies addressing specific water quality issues. A survey of n-itrite/nitrate levels in shallow wells located throughout the State of Georgia (Shellenberger, et al., 1996; Stuart, et al., 1995) and the operation of a Pesticide Monitoring Network (currently conducted jointly by the Geologic Survey Branch and the Georgia Department of Agriculture) (Webb, 1995) are examples of these types of studies.

4. Ground-water sampling at environmental facilities such as municipal solid waste landfills, RCRA facilities, and sludge disposal facilities. The primary agencies responsible for monitoring these facilities are EPD's Land Protection, Water Protection, and Hazardous Waste Management Branches.

5. The development of a wellhead protection program (WHP), which is designed to protect the area surrounding a municipal drinking water well from contaminants. Georgia's WHP Plan was approved by the Environmental Protection Agency (EPA) September 30, 1992, and was amended into the Georgia Safe Drinking Water Rules effective June 30, 1993. The protection of public water supply wells from contaminants is important not only for maintaining ground-water quality but also for helping ensure that public water supplies meet health standards.

Analyses of water samples collected for the Georgia Ground-Water Monitoring Network during calendar year 1993 and from previous years form the data base for this summary. The Georgia Ground-Water Monitoring Network is comprised of 128 wells and springs which are monitored on a biennial, annual, or semi-annual basis (some stations were sampled twice).

Representative water samples were collected from 107 wells and 4 springs in 1993, totaling 128 samples. A review of the 1993 data, and comparison of these data with those for samples collected as early as 1984, indicate that ground-water quality at most of the 128 sampling sites generally has changed little and remains excellent.

1.2 FACTORS AFFECTING CHEMICAL GROUND-WATER QUALITY

The chemical quality of ground water drawn for sampling is the result of complex physical, chemical, and biological processes. Some of the more significant controls are the chemical quality of the water entering the ground-water flow system, the reactions of infiltrating water with the soils and rocks that are encountered, and the effects of the well-and-pump system.

Most water enters the ground-water system in upland recharge areas. Water seeps through interconnected pores and joints in the soils and rocks until it is discharged to a surface-water body (e.g., stream, river, lake, or ocean). The initial water chemistry, the amount of recharging, and the attenuation capacity of soils have a strong influence on the quality of ground water in recharge areas. Chemical interactions between the water and the aquifer host rocks has an increasing significance with longer underground residence times. As a result, ground water from discharge areas tends to be more highly mineralized than ground water in recharge areas.

The well-and-pump system can also have a strong influence on the quality of the well water. Well casings, through compositional breakdown, can contribute metals (e.g., iron from steel casings) and organic compounds (e.g., tetrahydrofuran from PVC pipe cement) to the water. Pumps often aerate the water being discharged. An improperly constructed well can present a conduit that allows local pollutants to enter the ground-water flow system.

1.3 HYDROGEOLOGIC PROVINCES OF GEORGIA

This report defines three hydrogeologic provinces in Georgia by their general geologic and hydrologic characteristics (Figure 1-1). These provinces consist of:

1) the Coastal Plain Province of south Georgia;
2) the Piedmont/Blue Ridge Province, which includes all but the northwest corner of Georgia; and
3) the Valley and Ridge Province of northwest Georgia.

1.3.1 Coastal Plain Province

Georgia's Coastal Plain Province is generally composed of a wedge of loosely consolidated sediments that gently dip and thicken to the south and southeast. Ground water in the Coastal Plain Province flows through interconnected pore space between grains in the host rocks and through solution-enlarged voids. The oldest outcropping sedimentary formations (Cretaceous) are exposed along the Fall Line, which is the northern limit of the Coastal Plain Province. Successively younger formations occur at the surface to the south and southeast.

The Coastal Plain contains Georgia's major confined (artesian) aquifers. Confined

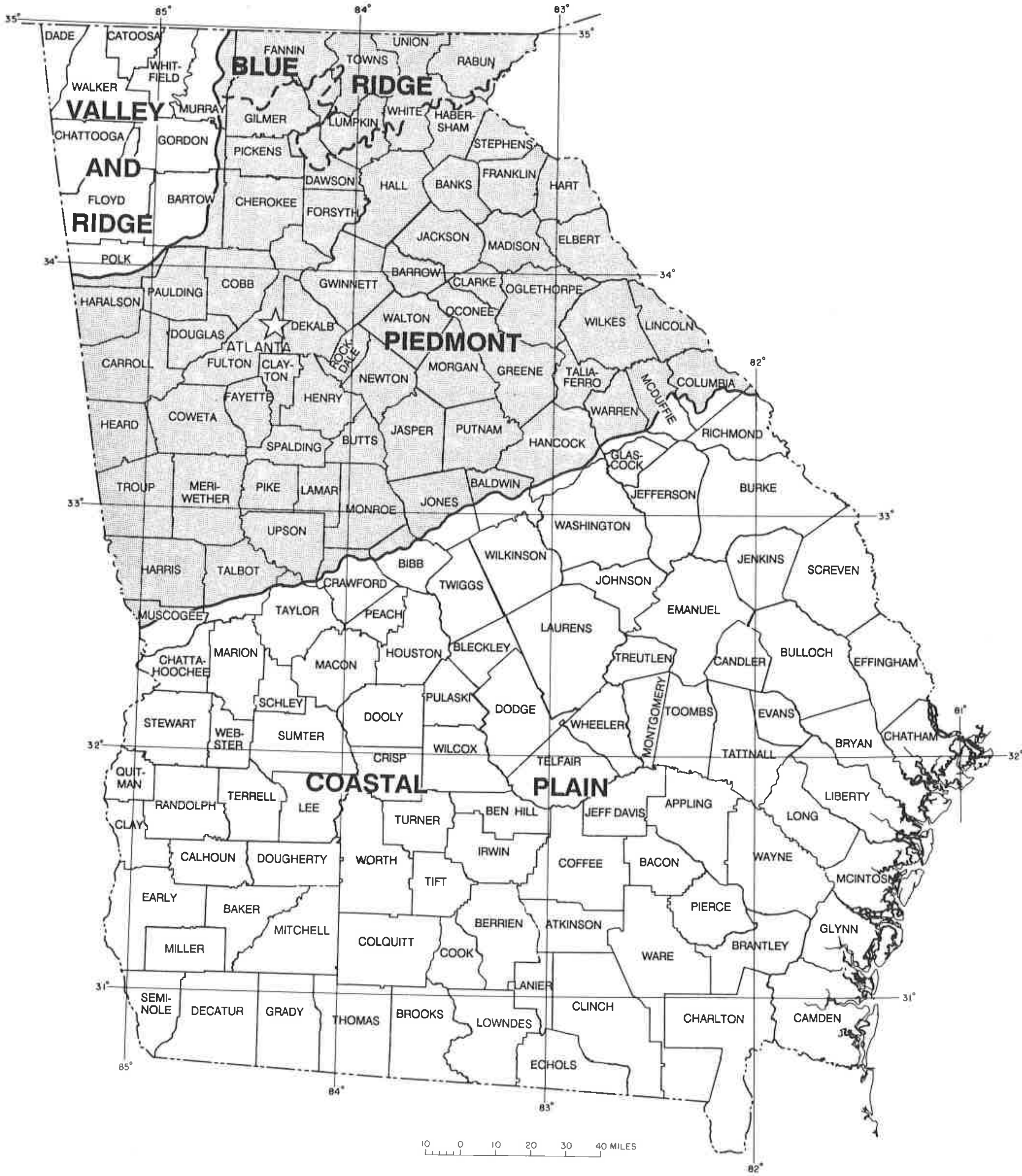


Figure 1-1. - The Hydrogeologic Provinces of Georgia.

aquifers are those in which a layer of impermeable material (e.g. clay or shale) holds the top of the water column at a level below that to which it would normally rise. Water enters the aquifers in their up-dip outcrop areas where the permeable rocks of the aquifer are exposed. Many of the Coastal Plain aquifers are unconfined in their up-dip outcrop areas, but become confined in down-dip areas to the southeast, where they are overlain by successively younger rock formations. Ground-water flow through confined Coastal Plain aquifers is generally to the south and southeast, in the direction of the dip of the rocks.

Rocks forming the seven major confined aquifers in the Coastal Plain range in age from Cretaceous to Miocene. Horizontal and vertical changes in the permeability of the rock units that form these aquifers and the quality of ground water they contain determine the thickness and extent of the aquifers. Several aquifers may be present in a single geographic area, forming a vertical 'stack'.

The Cretaceous and Jacksonian aquifer systems (primarily sands) are a common source of drinking water within a 35-mile wide band that lies adjacent to and south of the Fall Line. Southwestern Georgia relies on four vertically stacked aquifers (sands and carbonates) for drinking-water supplies: the Providence, Clayton, Claiborne and Floridan aquifer systems. A large area of south-central and southeastern Georgia is served by the Floridan aquifer system (primarily carbonates). The Miocene aquifer system (sands and carbonates) is the principal "shallow" unconfined aquifer system occupying much of the broad area underlain by the Floridan aquifer system. It becomes confined in the coastal counties and locally in the Grady, Thomas, Brooks and Lowndes counties area of south Georgia.

1.3.2 Piedmont/Blue Ridge Province

Crystalline rocks of metamorphic and igneous origin (primarily Precambrian and Paleozoic in age) underlie the Piedmont and Blue Ridge provinces. These two provinces differ geologically, but are discussed together here because they share common hydrologic properties. The principal water-bearing features are fractures, compositional layers and other geologic discontinuities in the rock, as well as intergranular porosity in the overlying soil and saprolite horizons. Thick soils and saprolites are often important as the "reservoir" that supplies water to the water-bearing fracture and joint systems. Ground water typically flows from local highlands towards discharge areas along streams. However, during prolonged dry periods or in areas of heavy pumpage, ground water may flow from the streams into the fracture and joint systems.

1.3.3 Valley and Ridge Province

The Valley and Ridge Province is underlain by consolidated Paleozoic sedimentary formations. The permeable features of the Valley and Ridge Province are principally fractures and solution voids; intergranular porosity also is important in some places. Ground-water and surface-water systems are locally closely interconnected. Dolostones and limestones of the Knox Group are the principal aquifers where they occur in the axes of broad valleys. The greater hydraulic conductivities of the thick carbonate sections in this Province, in part due to solution-enlarged joints, permit development of higher yielding wells than in the Piedmont and Blue Ridge Province.

1.4 REGIONAL GROUND-WATER PROBLEMS

Data from ground-water investigations in Georgia, including those from the Ground-Water Monitoring Network, indicate that virtually all of Georgia has shallow ground-water sufficient for domestic supply. Iron, aluminum, and manganese are the only constituents that occur routinely in concentrations exceeding drinking-water standards. These metals are naturally occurring and do not pose a health risk. Iron and manganese can cause reddish-brown stains on objects.

Only a few occurrences of polluted or contaminated ground waters are known from North Georgia (Section 4). Aquifers in the outcrop areas of Cretaceous sediments south of the Fall Line typically yield acidic water that may require treatment. The acidity occurs naturally, and results from the inability of the sandy aquifer sediments to neutralize acidic rainwater and from acid-producing reactions between infiltrating water and soils and sediments. Nitrite/nitrate concentrations in shallow ground water from the farm belt of southeastern Georgia are almost always within drinking-water standards, but are somewhat higher than levels found in other areas of the State.

The Floridan aquifer system contains two areas of naturally occurring reduced ground-water quality in addition to its karstic plain in southwest Georgia. The first is the area of the Gulf Trough, a narrow, linear geological feature extending from southwestern Decatur County through central Bulloch County typically yields water with high total dissolved solids concentrations. Elevated levels of barium, sulfate, and radio nuclides have been reported in ground water from the Gulf Trough. The second is the coastal area of Georgia, where the lower section of the Floridan aquifer system contains water with high dissolved-solid contents. Ground-water withdrawals have allowed up-coning of such water from deeper parts of the aquifer in the Brunswick area.

2.0 GEORGIA GROUND-WATER MONITORING NETWORK

2.1 MONITORING STATIONS

Stations of the 1993 Ground-Water Monitoring Network are situated in the seven major aquifers and aquifer systems of the Coastal Plain Province and in the unconfined ground-water systems of the Piedmont and Blue Ridge Provinces and of the Valley and Ridge Province (Table 2-1). Monitoring stations are located in three critical settings:

a. areas of surface recharge;
b. areas of potential pollution related to regional activities (e.g. agricultural and industrial areas); and
c. areas of significant ground-water use.

The majority of monitoring stations are municipal, industrial, and domestic wells that have reliable well-construction data. Some of the monitoring stations that are located in recharge areas are sampled more than once a year in order to monitor more closely changes in ground-water quality. The Monitoring Network also includes monitoring wells in specific areas where the State's aquifers are recognized to be susceptible to contamination or pollution (e.g. the Dougherty Plain of southwestern Georgia and the State's coastal area). These monitoring wells are maintained jointly by the Geologic Survey Branch and the United States Geological Survey.

2.2 USES AND LIMITATIONS

Regular sampling of wells and springs of the Ground-Water Monitoring Network permits analysis of ground-water quality with respect to location (spatial trends) and with respect to the time of sample collection (temporal trends). Spatial trends are useful for assessing the effects of the geologic framework of the aquifer and regional land-use activities on ground-water quality. Temporal trends permit an assessment of the effects of rainfall and drought periods on ground-water quantity and quality. Both trends are useful for the detection of non-point source pollution. Non-point source pollution arises from broad-scale phenomena such as acid rain deposition and application of agricultural chemicals on crop lands.

It should be noted that the data of the Ground-Water Monitoring Network represent water quality in only limited areas of Georgia. Monitoring water quality at 128 sites located throughout Georgia provides an indication of ground-water quality at the localities sampled and at depths corresponding to the screened interval in the well or to the head of the spring at each station in the Monitoring Network. Caution should be exercised in drawing strict conclusions and applying any results reported in this study to ground waters that are not being monitored.

Stations of the Ground-Water Monitoring Network are intentionally located away from known point sources of pollution. The wells provide baseline data on ambient water quality in Georgia. EPD requires other forms of ground-water monitoring for activities that may result in point source pollution (e.g., landfills, hazardous waste facilities and land application sites) through its environmental facilities permit programs.

Ground-water quality changes gradually and predictably in the areally extensive aquifers of the Coastal Plain Province. The Monitoring Network allows for some definition of the chemical processes occurring in large confined aquifers. Unconfined aquifers in northern Georgia and the surface recharge areas of southern Georgia are of comparatively small areal extent and more open to interactions with land-use activities. The wider spacing of monitoring stations does not permit equal characterization of water-quality processes in all of these settings. The quality of water from monitoring wells completed in unconfined north Georgia aquifers represents only the general nature of ground water in the vicinity of the monitoring wells. In contrast, ground water from monitoring wells located in surface recharge areas of Georgia Coastal Plain aquifers may more closely reflect the general quality of water that has entered these aquifers. Ground water in the recharge areas of the Coastal Plain aquifers is the future drinking-water resource for down-flow areas. Monitoring wells in these recharge areas, in effect, constitute an early warning system for potential future water quality problems in confined portions of the Coastal Plain aquifers.

2.3 ANALYSES

Analyses are available for 128 water samples collected during 1993 from 107 wells and 4 springs. In 1984, the first year of the Ground-Water Monitoring Network, hydrogeologists sampled water from 39 wells located in the Piedmont/Blue Ridge and Coastal Plain Provinces. Nine of these wells have been sampled each year since 1984. Since 1984, the Ground-Water Monitoring Network has been expanded through addition of further wells and springs to cover all three hydrogeologic provinces, with the majority of the monitoring done in the Coastal Plain.

Ground water from all monitoring stations is tested for the basic water quality parameters included in the Monitoring Network's standard analysis. The standard parameters include pH, specific conductivity, chloride, fluoride, sulfate, nitrite/nitrate, and thirty metals (Appendix, Table A-1). Where regional land-use activities have the potential to affect ground-water quality in the vicinity of a monitoring station, additional parameters such as chlorinated pesticides (Organics Screen #2), and phenoxy herbicides (Organics Screen #4) are tested. These and additional chemical screens are listed in the Appendix (Tables A-1, A-2, A-3, and A-4). Tables 2-2 (cations) and 2-3 (anions) summarize the significance of the common major constituents of a water-quality analysis.

The Drinking Water Program of the EPD's Water Resources Management Branch has established Maximum Contaminant Levels (MCL's) for some of the parameters that are included in the analyses performed on Ground-Water Monitoring Network samples. Primary MCL's are established for parameters that may have adverse effects on the public health when their values are exceeded. Secondary MCL's are established for parameters that may give drinking water an objectionable odor or color and consequently cause persons served by public water systems to discontinue its use. The Primary and Secondary MCL's for Ground Water Monitoring Network parameters are given in the Appendix.

In-place pumps are used whenever possible to purge wells and collect water samples. Using these pumps minimizes the potential for cross-contamination of wells. Some wells that are included in the Ground-Water Monitoring Network are continuous water-level monitoring stations and do not have dedicated pumps. A two horse-power, trailer-mounted four-inch electric submersible pump and a three-inch, truck-mounted submersible pump are the principal portable purge-and-sampling devices used. A battery-powered, portable Fultz sampling pump and a PVC hand pump are occasionally used at stations that cannot be sampled using the principal sampling pumps. As sampling these continuous water level monitoring wells made heavy demands on staff and time, all but one of these wells were dropped from the Ground-Water Monitoring Network during 1993.

Sampling procedures are adapted from techniques used by the U.S. Geological Survey and the U.S. Environmental Protection Agency. Hydrogeologists purge the wells (3 to 5 volumes of the well column) prior to the collection of a sample to minimize the influence of the well, pump and distribution system on water quality. Municipal, industrial, and domestic wells typically require approximately 45 minutes of purging prior to sample collection. Wells without dedicated pumps often require much longer periods of purging.

Hydrogeologists monitor water quality parameters prior to sample collection. Measurements of pH, dissolved oxygen content, specific conductivity, and temperature are observed using field instruments. The instruments are mounted in a manifold that captures flow at the pump system discharge point before the water is exposed to atmospheric conditions. Typical trends include a lowering of pH, dissolved oxygen content, and specific conductivity, and a transition toward the mean annual air temperature with increased purging time. Both the hydraulic flow characteristics of unconfined aquifers and the pump effects may alter these trends.

Samples are collected once the parameters being monitored in the field stabilize or otherwise indicate that the effects of the well have been minimized. Files at the Geologic Survey Branch contain records of the field measurements. The sample bottles are filled and then promptly placed in an ice water bath to preserve the water quality. After several hours, the bottles are transferred to a dry cooler refrigerated with an ice tray. The hydrogeologists then transport the samples to the laboratories for analysis on or before the Friday of the week in which they were collected.

During 1993, the EPD laboratories performed the following standard water quality tests on all regular samples: pH, specific conductance, an ICP/AAS metals screen, nitrate/nitrite (reported as ppm nitrogen), and an ion chromatography screen (chloride, fluoride, sulfate). The EPD laboratories also performed the following optional tests on various samples: mercury, organic screen #7 (EDB), organic screens #8 and #9 (semivolatile organic compounds), and organic screen #10 (volatile organic compounds). (Organic screen #7 is performed simultaneously with organic screen #10.) Georgia Department of Agriculture (GDA) laboratories and the Cooperative Extension Service laboratories at the University of Georgia (UGA) performed analyses for organic screens #1, #2, #3, #4, and #5 (pesticides and PCB's). Beginning in December, 1992, pesticide analyses were transferred from UGA to GDA as GDA continued to install the apparatus necessary to perform the analyses. The transfer was completed in December, 1993.

Table 2-1. Georgia Ground-Water Monitoring Network, 1993

AQUIFER SYSTEM	NUMBER OF MONITORING STATIONS & SAMPLES TAKEN IN 1993	PRIMARY STRATIGRAPHIC EQUIVALENTS	AGE OF AQUIFER FORMATIONS
Cretaceous	15 stations (21 samples taken in 1993)	Ripley Formation, Cusseta Sand, Blufftown Formation, Eutaw Formation, Tuscaloosa Formation, and Gaillard Formation	Late Cretaceous
Providence	3 stations (3 samples taken in 1993)	Providence Sand	Late Cretaceous
Clayton	4 stations (4 samples taken in 1993)	Clayton Formation	Paleocene
Claiborne	4 stations (4 samples taken in 1993)	Tallahatta Formation	Middle Eocene
Jacksonian	7 stations (7 samples taken in 1993)	Barnwell Group	Late Eocene
Floridan	40 stations (51 samples taken in 1993)	Predominantly Suwannee Limestone and Ocala Group	Predominantly Middle Eocene to Oligocene
Miocene	12 stations (12 samples taken in 1993)	Predominantly Altamaha Formation and Hawthorne Group	Miocene-Recent
Piedmont	14 stations (14 samples taken in 1993)	Various igneous and metamorphic complexes	Predominately Paleozoic and Precambrian
Blue Ridge	3 stations (3 samples taken in 1993)	Various metamorphic complexes	Predominately Paleozoic and Precambrian
Valley and Ridge	9 stations (9 samples taken in 1993)	Shady Dolomite, Knox Group, and Chickamauga Group	Paleozoic, mostly Cambrian and Ordovician

Table 2-2. The Significance of Parameters of a Basic Water Quality Analysis, Cations (after Wait, 1960).

PARAMETER(S)	SIGNIFICANCE
pH (Hydrogen ion concentration)	pH is a measure of the concentration of the hydrogen ion. Values of pH less than 7.0 denote acidity and values greater than 7.0 indicate alkalinity. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline waters may also attack metals. A pH range between 6.0 and 8.5 is considered acceptable.
Calcium and magnesium *	Calcium and magnesium cause most of the hardness of water. Hard water consumes soap before a lather will form and deposits scale in boilers, water heaters, and pipes. Hardness is reported in terms of equivalent calcium carbonate. The hardness of a water can be estimated by the sum of multiplying the ppm of calcium by 2.5 and that of magnesium by 4.1.

Water Class	Hardness (parts per million)
Soft	Less than 60
Moderately Hard	60 to 120
Hard	121 to 180
Very Hard	More than 180

PARAMETER(S)	SIGNIFICANCE
Sodium and potassium *	Sodium and potassium have little effect on the use of water for most domestic purposes. Large amounts give a salty taste when combined with chloride. A high sodium content may limit the use of water for irrigation.
Iron and manganese	More than 300 ppb of iron stains objects red or reddish brown and more than 50 parts per billion of manganese stains objects black. Larger quantities cause unpleasant taste and favor growth of iron bacteria but do not endanger health.

**Major metallic ions present in most ground waters.*

Table 2-3. The Significance of Parameters of a Basic Water Quality Analysis, Anions (after Wait, 1960).

PARAMETER(S)	SIGNIFICANCE
Chloride	Chloride salts in excess of 100 ppm give a salty taste to water. Large quantities make the water corrosive. Water that contains excessive amounts of chloride is not suitable for irrigation. It is recommended that chloride content should not exceed 250 ppm.
Nitrate/Nitrite	Concentrations much greater than the local average may suggest pollution. Excessive amounts of nitrate/nitrite in drinking or formula water of infants may cause a type of methemoglobinemia ("blue babies"). Nitrate/nitrite in concentrations greater than 10 ppm (as nitrogen) is considered to be a health hazard.
Sulfate	Sulfate in hard water increases the formation of scale in boilers. In large amounts, sulfate in combination with other ions imparts a bitter taste to water. Concentrations above 250 ppm have a laxative effect but 500 ppm is considered safe.

3.0 GROUND-WATER QUALITY IN GEORGIA

3.1 OVERVIEW

Georgia's ten major aquifers and aquifer systems are grouped into three hydrogeologic provinces for the purposes of this report.

The Coastal Plain Province is comprised of seven major aquifers that are restricted to specific regions and depths within the province because of their geometry (Figure 3-1). These major aquifer systems, in many cases, incorporate smaller aquifers that are locally confined. Monitoring wells in the Coastal Plain aquifers are generally located in three settings:

1. Recharge (or outcrop) areas, which are located in regions that are geologically up-dip and generally to the north of confined portions of these aquifers.

2. Up-dip, confined areas, which are located in regions that are proximal to the recharge areas, yet are confined by overlying geologic formations. These areas are generally south to southeast of the recharge areas.

3. Down-dip, confined areas, located to the south and southeast in the deeper, confined portions of the aquifers distal to the recharge areas.

The two hydrogeologic provinces of north Georgia, the Piedmont/Blue Ridge Province and the Valley and Ridge Province, are characterized by small-scale, localized ground-water flow patterns. Deep regional flow systems are unknown in northern Georgia. Ground-water flow in the Piedmont/Blue Ridge Province is generally controlled by geologic discontinuities (such as fractures) and compositional changes within the aquifer. Local topographic features, such as hills and valleys, influence ground-water flow patterns. Many of the factors controlling ground-water flow in the Piedmont/Blue Ridge Province are also present in the Valley and Ridge Province. Furthermore, widespread development of karst features may significantly enhance porosity and permeability in localized areas and exert a strong influence on local ground-water flow patterns.

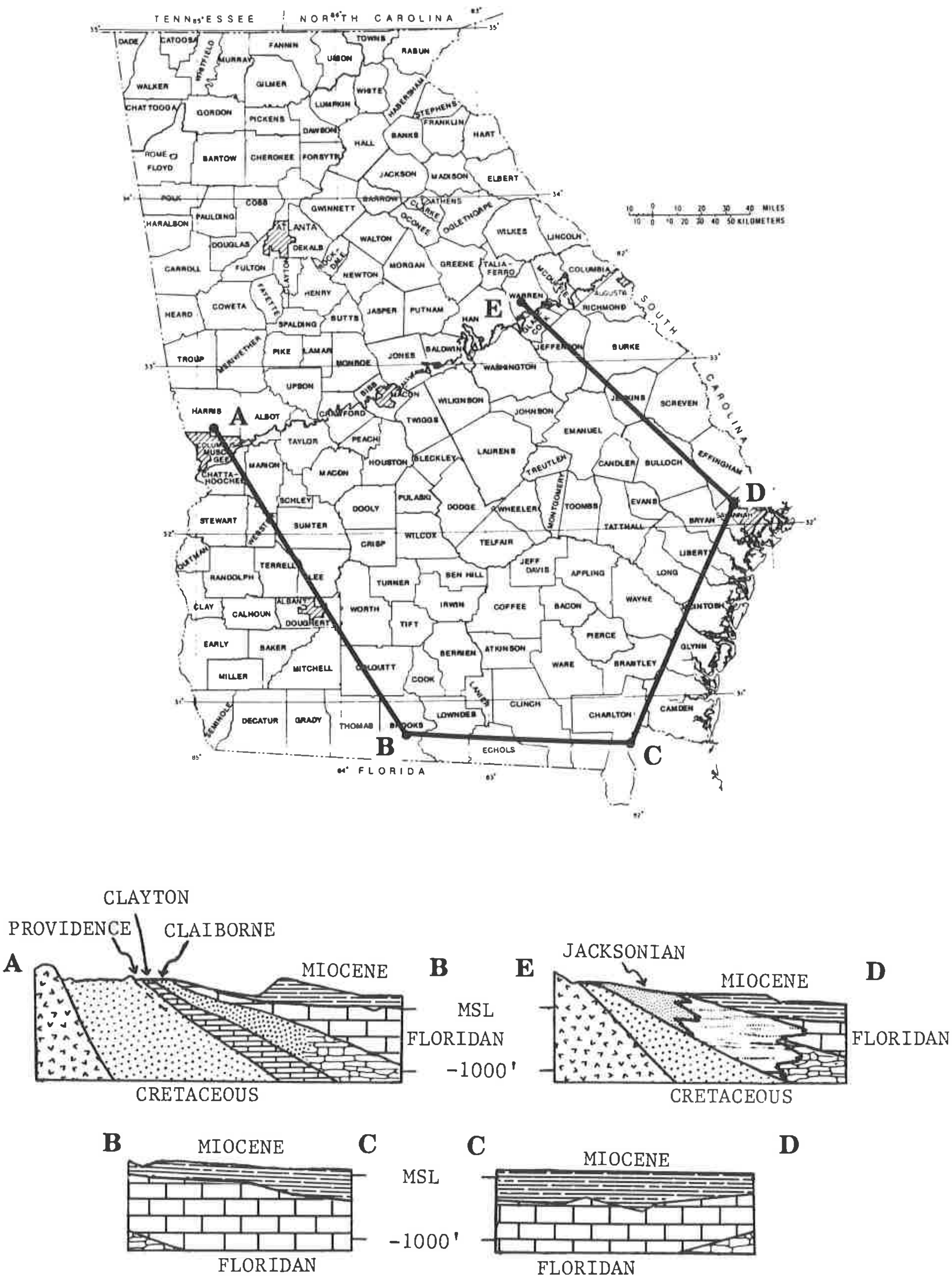


Figure 3-1. - The Seven Major Aquifers and Aquifer Systems of the Coastal Plain Province.

3.2 CRETACEOUS AQUIFER SYSTEM

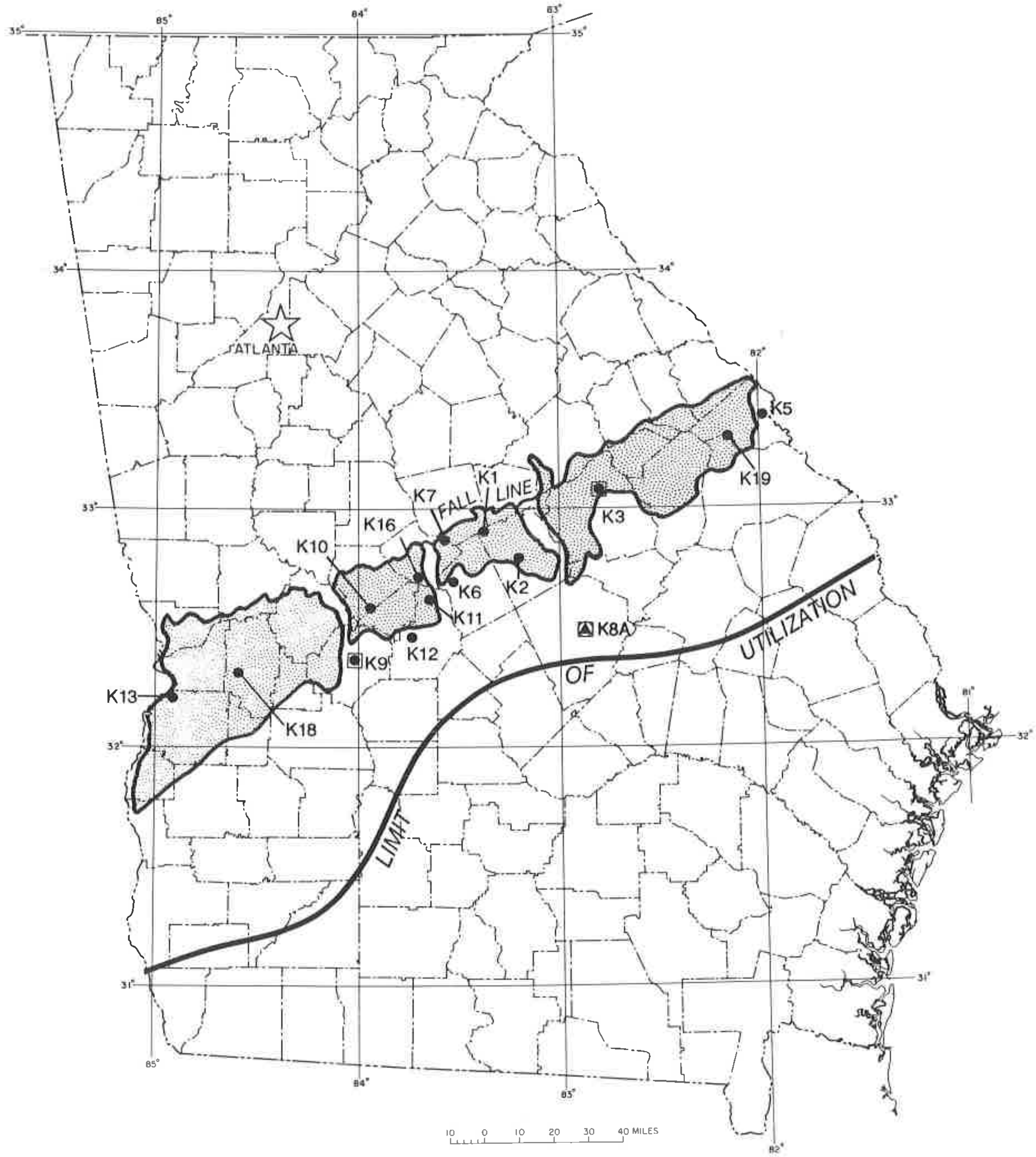
The Cretaceous aquifer system is a complexly interconnected group of aquifer subsystems developed in the Late Cretaceous sands of the Coastal Plain Province. These sands crop out in an extensive recharge area immediately south of the Fall Line in west and central Georgia (Figure 3-2). Overlying sediments restrict Cretaceous outcrops to valley bottoms in parts of the northeastern Coastal Plain. Five distinct subsystems of the Cretaceous aquifer system, including the Providence aquifer system, are recognized west of the Ocmulgee River (Pollard and Vorhis, 1980). These merge into three subsystems to the east (Clarke, et al., 1985). Aquifer sands thicken southward from the Fall Line, where they pinch out against crystalline Piedmont rocks, to a sequence of sand and clay approximately 2,000 feet thick at the southern limits of the main aquifer-use area. Leakage from adjacent members of the aquifer system provides significant recharge in down-dip areas.

Water quality of the Cretaceous aquifer system, excluding the Providence aquifer system (discussed separately in this report), was monitored in 15 wells. Two of these wells (GWN-K8 and GWN-K12) are located away from the recharge area. The remainder are located in up-dip areas in or adjacent to outcrop and surface recharge areas for the Cretaceous aquifer system. Water from the wells was soft and, in the up-dip area wells, acidic, while water from GWN-K13, a down-dip well, was basic.

Iron concentrations exceeded the State secondary MCL of 300 parts per billion (ppb) in only three wells: GWN-K3 in Washington County yielded 720 ppb, GWN-K8A in Laurens County yielded 4,100 ppb, and GWN-K9 in Macon County yielded 1,200 ppb. Manganese at a concentration equal to the MCL was found in a sample from GWN-K8A. Figure 3-3 shows trends in iron concentrations for selected wells in the Cretaceous aquifer.

Aluminum concentrations exceeded the secondary MCL of 200 ppb in three wells: GWN-K1 (630 ppb), GWN-K9 (470 ppb), and GWN-K12 (420 ppb). Concentrations of major alkali and alkaline earth metals (potassium, sodium, calcium, and magnesium) were generally either low or below detection limits. Other trace metals (copper, barium, strontium, and lead) were present in low concentrations in samples from various wells.

Water samples from ten wells contained detectable levels of nitrite/nitrate. The highest value, 1.8 ppb, was measured from well GWN-K10. Similar values have been measured for this well over the past several years. Figure 3-4 shows trends in levels of combined nitrite/nitrate (reported as parts per million [ppm] nitrogen) for selected wells that have historically yielded water with detectable and non-detectable nitrite/nitrate levels. Detectable chloride was present in all the samples and detectable sulfate and fluoride were present in the majority of the samples. A case of pollution by synthetic organic compounds found in a sample from well GWN-K5 is thought to be spurious, as tests on a follow-up sample found no such substances. Analytical results for samples collected from the Cretaceous aquifer system are given in the Appendix.



General recharge area (from Davis, et al., 1988)

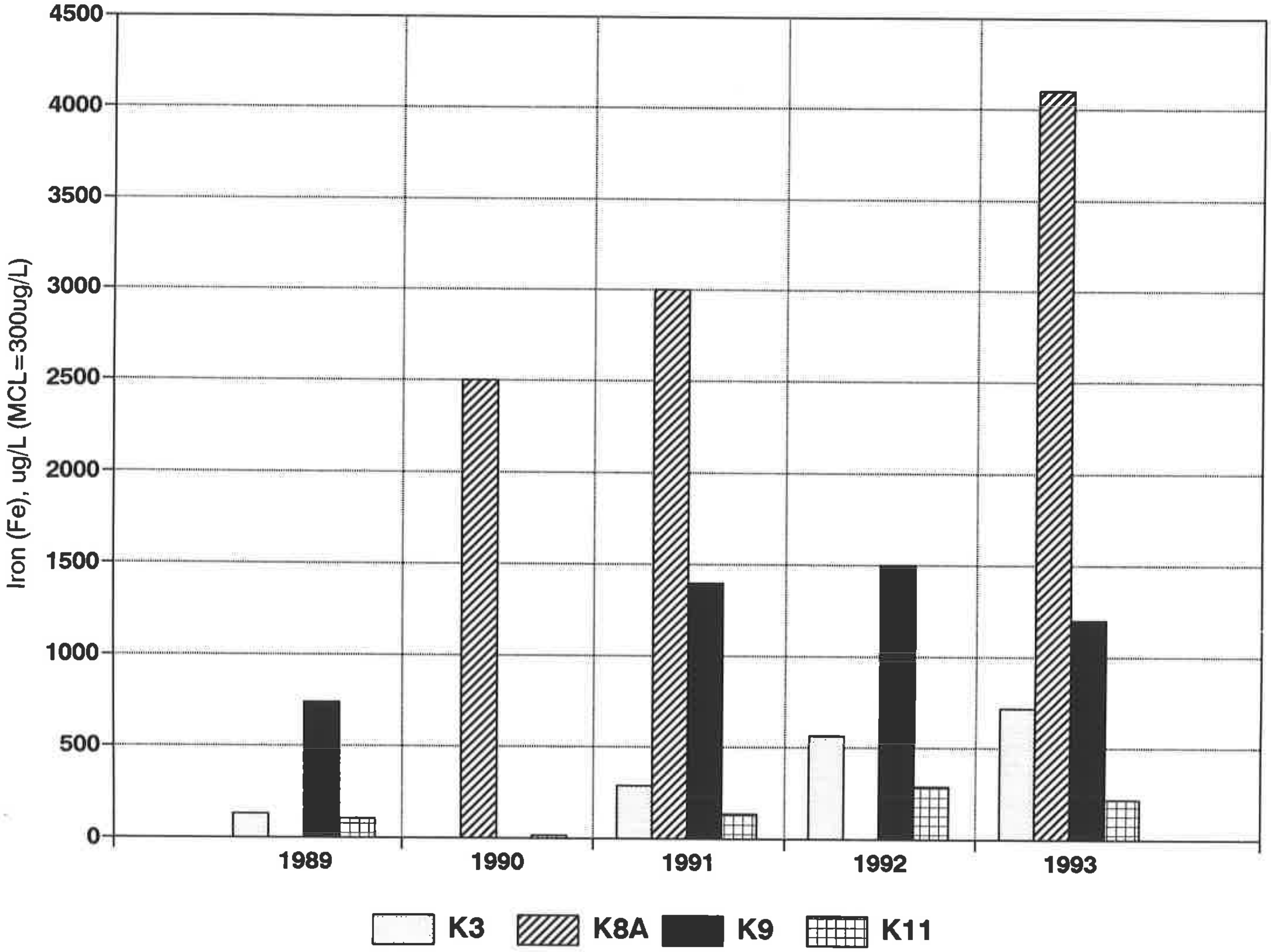
● Soft water

▲ Moderately hard water

○ Manganese exceeds MCL

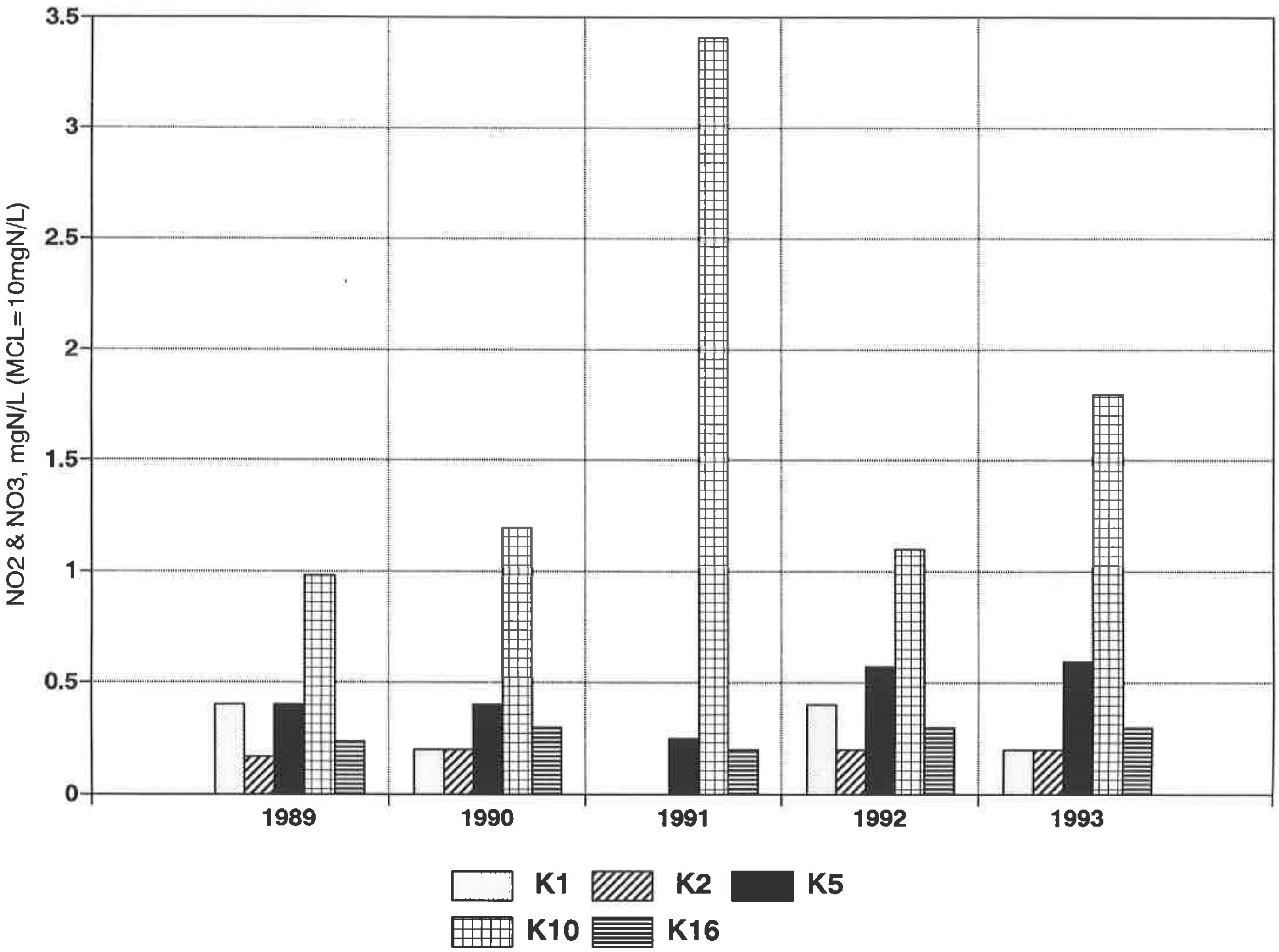
□ Iron exceeds MCL

Figure 3-2. - Water Quality of the Cretaceous Aquifer System.



*Iron levels detected below the MDL are represented as 20 ppb. An absent column of data indicates that the well was not sampled during that particular year.

Figure 3-3. - Iron Concentrations for Selected Wells in the Cretaceous Aquifer System.



*Nitrate/nitrite levels detected below the MDL are represented as 0.1 ppm. An absent column of data indicates that the well was not sampled during that particular year or that no nitrate/nitrite data are available.

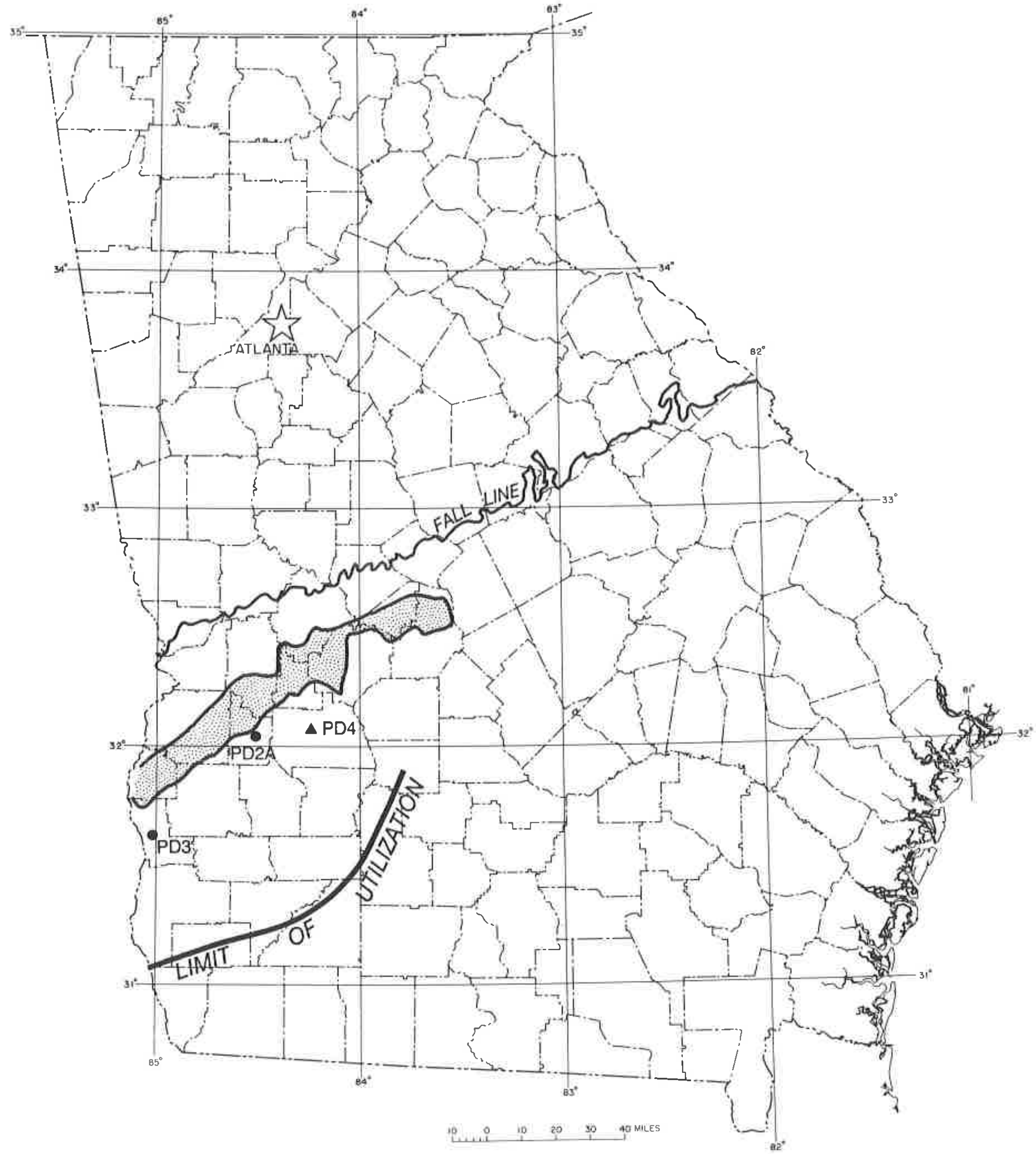
Figure 3-4. - Nitrate/Nitrite Concentrations for Selected Wells in the Cretaceous Aquifer System.

3.3 PROVIDENCE AQUIFER SYSTEM

Sand and coquinoid limestones of the Late Cretaceous Providence Formation comprise the Providence aquifer system of southwestern Georgia. Outcrops of the aquifer system extend from northern Clay and Quitman Counties through eastern Houston County. In its up-dip extent, the aquifer system thickens both to the east and to the west of a broad area adjacent to the Flint River. Areas where the thickness of the Providence exceeds 300 feet are known in Pulaski County, and similar thicknesses have been projected in the vicinity of Baker, Calhoun and Early counties (Clarke, et al., 1983).

The permeable Providence Formation-Clayton Formation interval forms a single aquifer east of the Flint River (Clarke, et al., 1983). This same interval is recognized as the Dublin aquifer system to the east of the Ocmulgee River (Clarke, et al., 1985). Outcrop areas and adjacent covered areas to the east of the Flint River, where the aquifer is overlain by permeable sand units, are surface recharge areas. The Chattahoochee River forms the western discharge boundary for this flow system in Georgia.

Water samples were taken from three wells in the Providence aquifer system in 1993 (Figure 3-5). The pH of two samples was slightly basic and one, acidic. Concentrations of metals were generally low or below detection limits. Sodium, calcium, chloride, strontium, and sulfate were present in low concentrations and were most abundant in the down-dip samples. The only well to yield a sample with detectable nitrate/nitrite, 0.7 ppm nitrogen, was the up-dip well GWN-PD2A. Other inorganic ions detected consisted of barium, magnesium, manganese, fluoride, and aluminum. None of these anions or metals exceeded MCL's. No synthetic organic compounds were detected in samples derived from the Providence aquifer. Trends in iron and nitrate/nitrite concentrations for the three Providence wells are shown in Figures 3-6 and 3-7. Analytic results for the samples collected from the Providence Aquifer System wells are summarized in the Appendix.

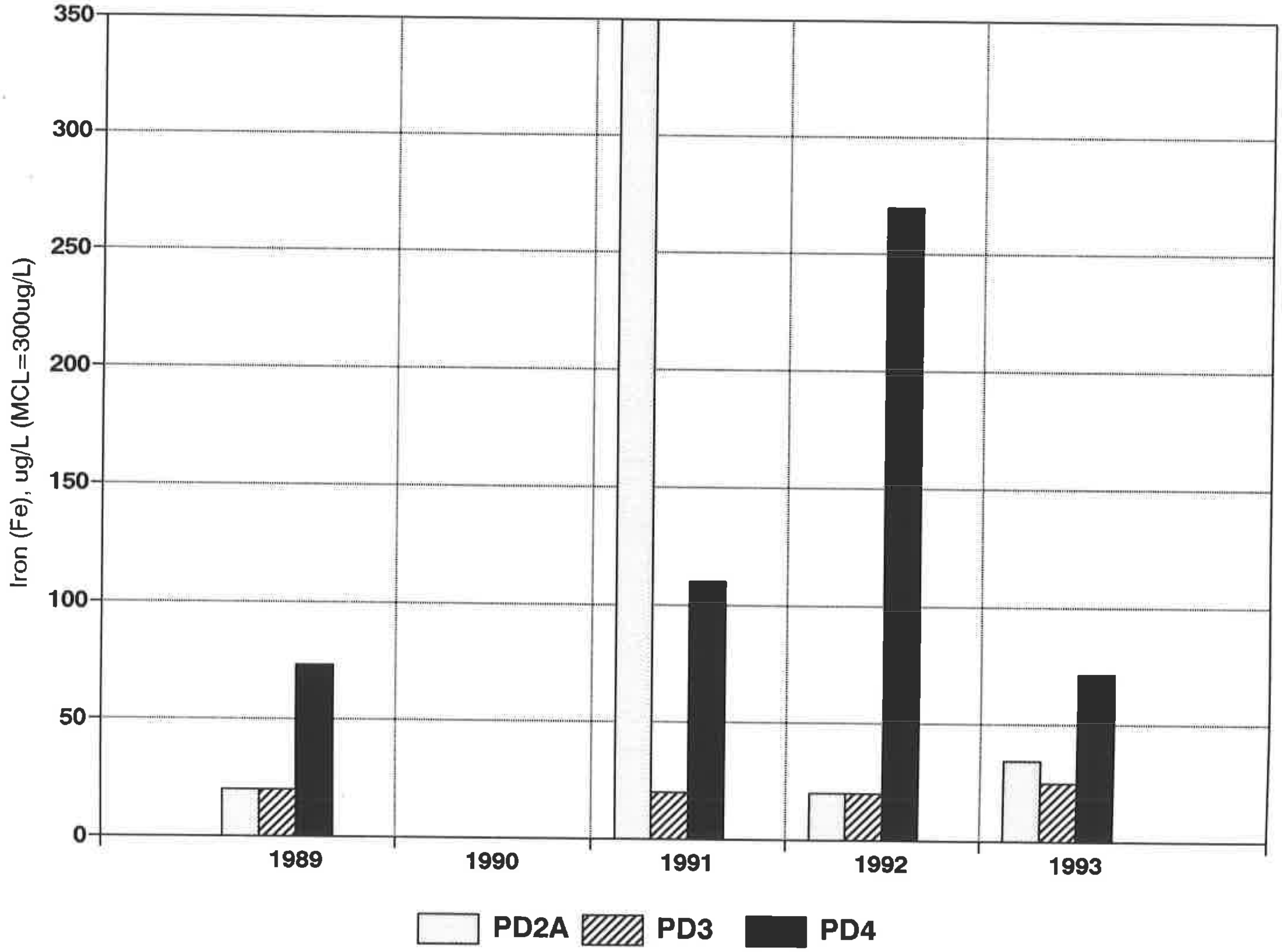


General recharge area (from Davis, et al., 1988)

● Soft water

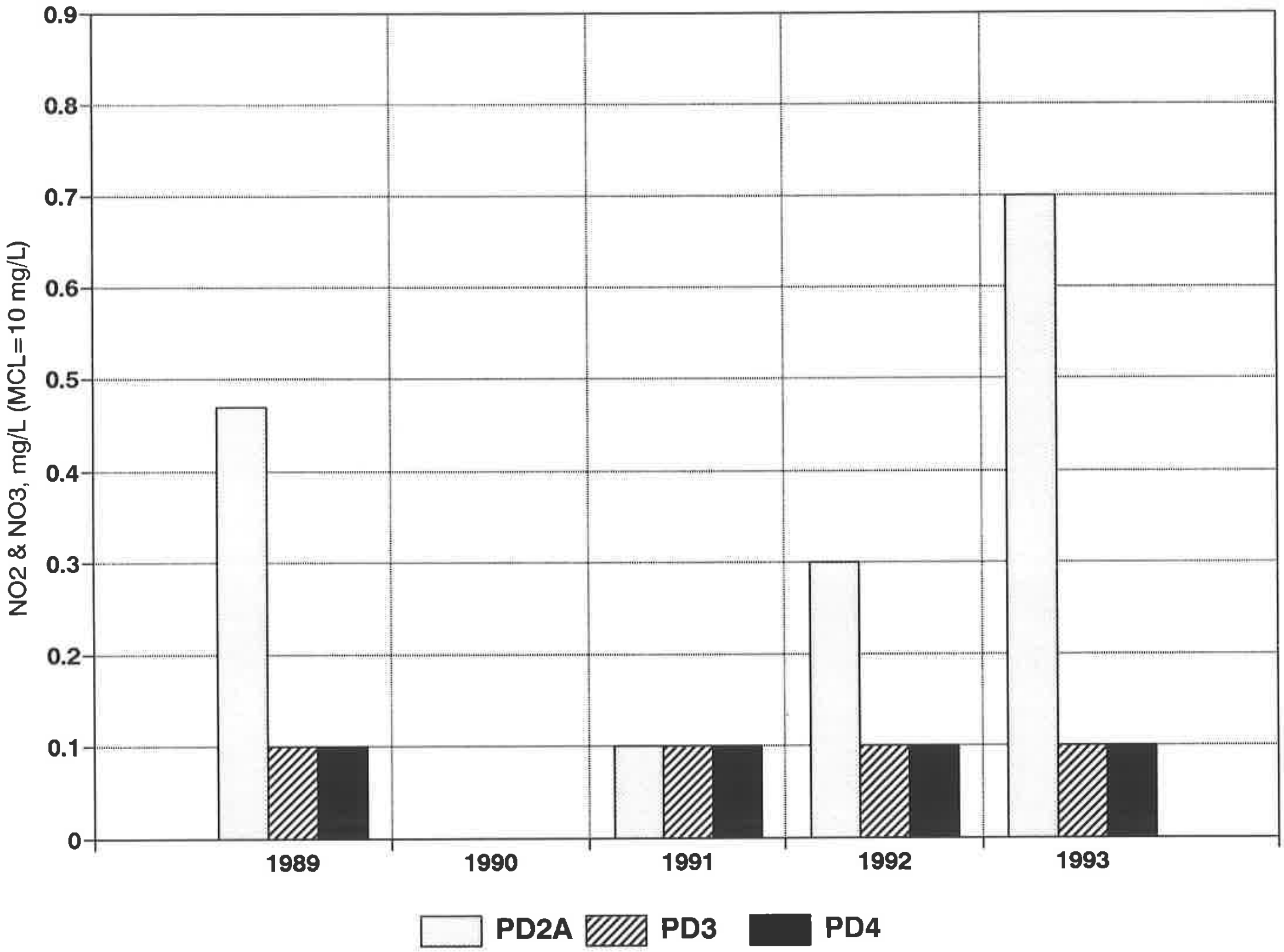
▲ Moderately hard water

Figure 3-5. - Water Quality of the Providence Aquifer System.



*Iron levels detected below the MDL are represented as 20 ppb. An absent column of data indicates that the well was not sampled during that particular year.

Figure 3-6. - Iron Concentrations for Selected Wells in the Providence Aquifer System.



*Nitrate/nitrite levels detected below the MDL are represented as 0.1 ppm. An absent column of data indicates that the well was not sampled during that particular year or that no nitrate/nitrite data are available.

Figure 3-7. - Nitrate/Nitrite Concentrations for Selected Wells in the Providence Aquifer System.

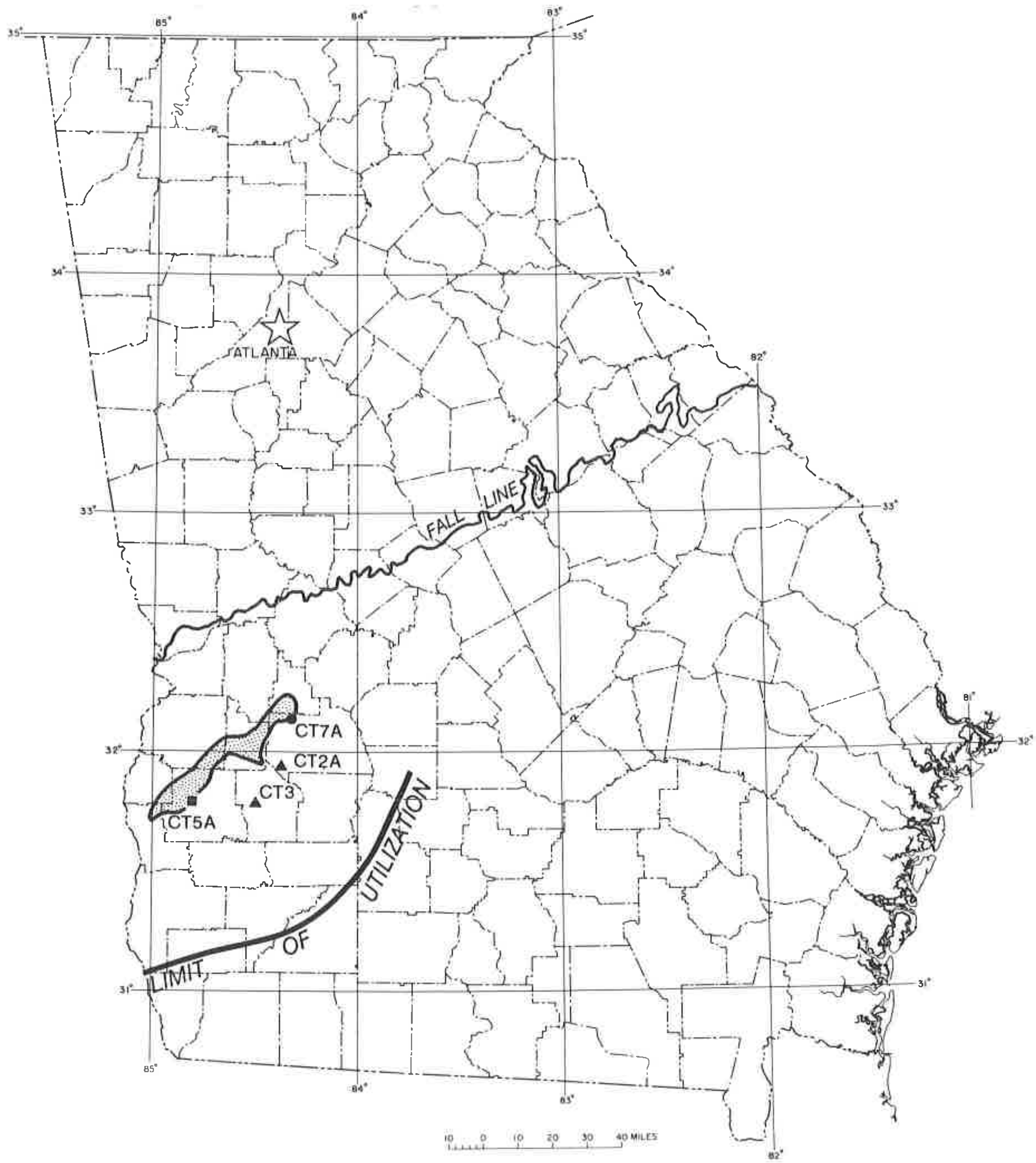
3.4 CLAYTON AQUIFER SYSTEM

The Clayton aquifer system of southwestern Georgia is developed mainly in the middle limestone unit of the Paleocene Clayton Formation. Limestones and calcareous sands of the Clayton aquifer system crop out in a narrow belt extending from northeastern Clay County to southwestern Schley County (Figure 3-8). Aquifer thickness varies, ranging from 50 feet near outcrop areas to 265 feet in southeastern Mitchell County (Clarke, et al., 1984). Both the Flint River, to the east, and the Chattahoochee River, to the west, are areas of discharge for the aquifer system in its up-dip extent. Leakage from the underlying Providence aquifer system and the overlying Wilcox confining zone is significant in down-dip areas (Clarke, et al., 1984). The Clayton Formation and Providence Formation merge to form a single aquifer unit in up-dip areas (Long, 1989). In areas east of the Ocmulgee River, the combination of these two aquifers is referred to as the Dublin aquifer system (Clarke, et al., 1985).

Four wells in the Clayton aquifer system were used to monitor water quality in 1993. Wells GWN-CT5A and GWN-CT7A are located in or near the recharge area. The pH levels were alkaline in three wells, as expected for limestone aquifers and was acidic in a sample from an up-dip sand well. Iron concentrations range from 24 ppb in well GWN-CT3 to 250 ppb in GWN-CT5A and GWN-CT7A. Barium, sodium, calcium, magnesium, chloride, fluoride, tin, titanium, strontium, and zinc were also detected.

Chloride contents were low in the down-dip wells, at less than 2 ppm. However, up-dip well GWN-CT7A had a somewhat elevated chloride content of 14 ppm. Aluminum was detected at a level of 510 ppb from well GWN-CT7A, in excess of the secondary MCL.

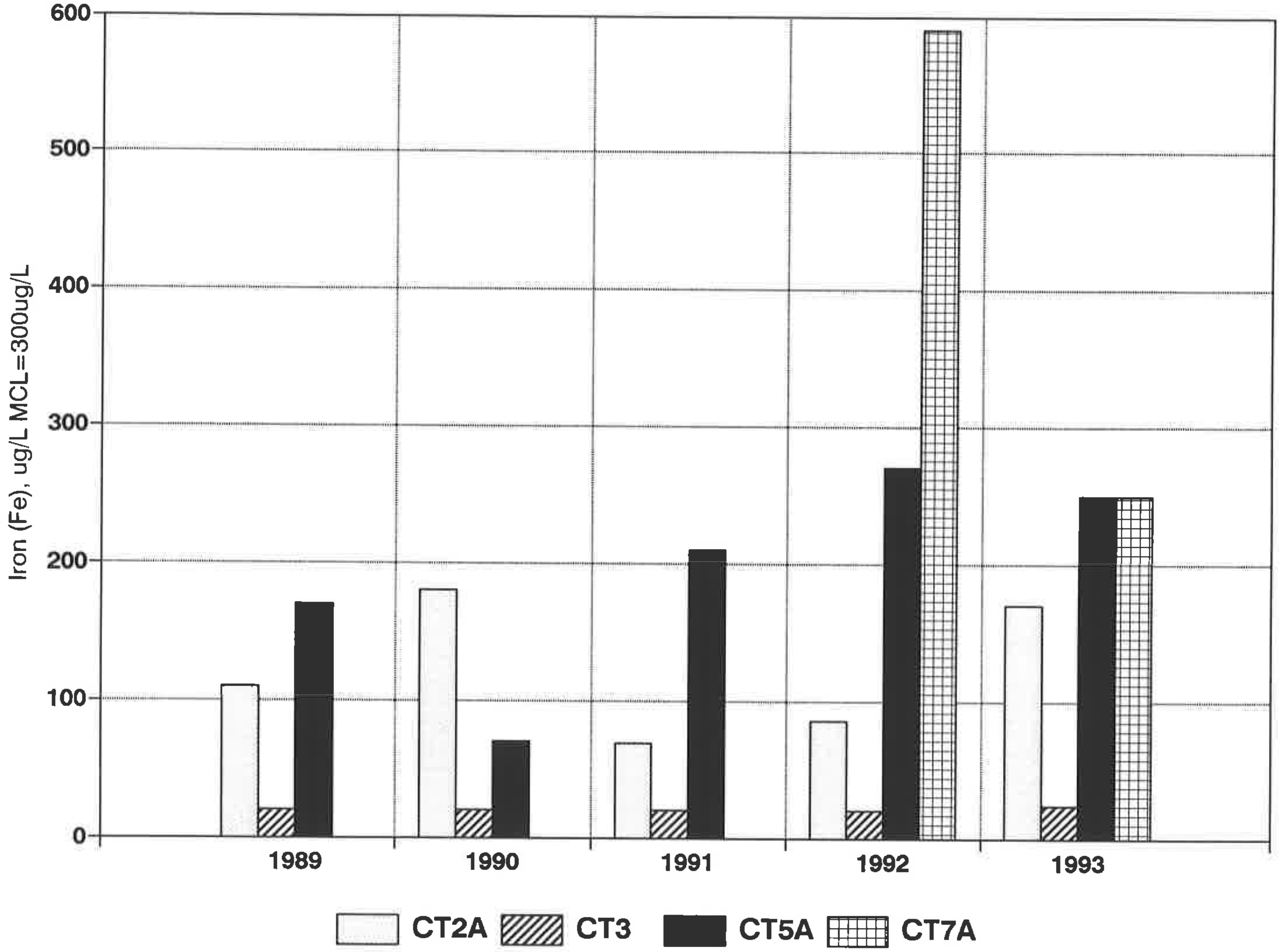
Nitrate/nitrite concentration levels were below detectable limits in down-dip wells, but higher in GWN-CT7A (9.2 ppm nitrogen). Sulfate was limited to the three down-dip wells with a range of 12.4- 19.0 ppm. No synthetic organic chemicals were found. Trends of iron and nitrite/nitrate concentrations in Clayton aquifer wells are shown in Figures 3-9 and 3-10. Analytical results for samples collected from the Clayton aquifer system wells are provided in the Appendix.



General recharge area (after Davis, et al., 1988)

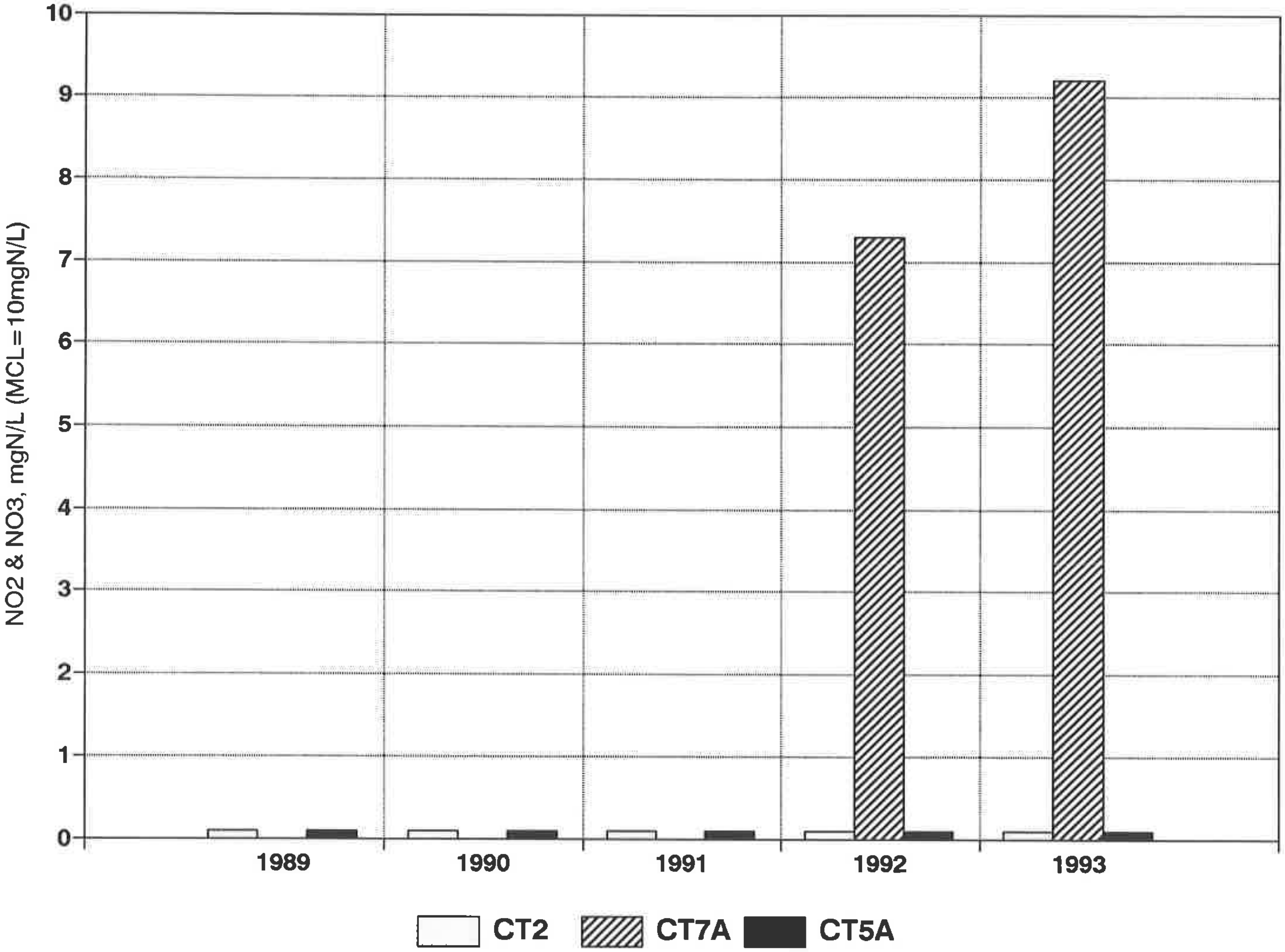
- ● Soft water
- ▲ Moderately hard water
- ■ Hard water

Figure 3-8. - Water Quality of the Clayton Aquifer System.



*Iron levels detected below the MDL are represented as 20 ppb. An absent column of data indicates that the well was not sampled during that particular year.

Figure 3-9. - Iron Concentrations for Selected Wells in the Clayton Aquifer System.



*Nitrate/nitrite levels detected below the MDL are represented as 0.1 ppm. An absent column of data indicates that the well was not sampled during that particular year or that no nitrate/nitrite data are available.

Figure 3-10. - Nitrate/Nitrite Concentrations for Selected Wells in the Clayton Aquifer System.

3.5 CLAIBORNE AQUIFER SYSTEM

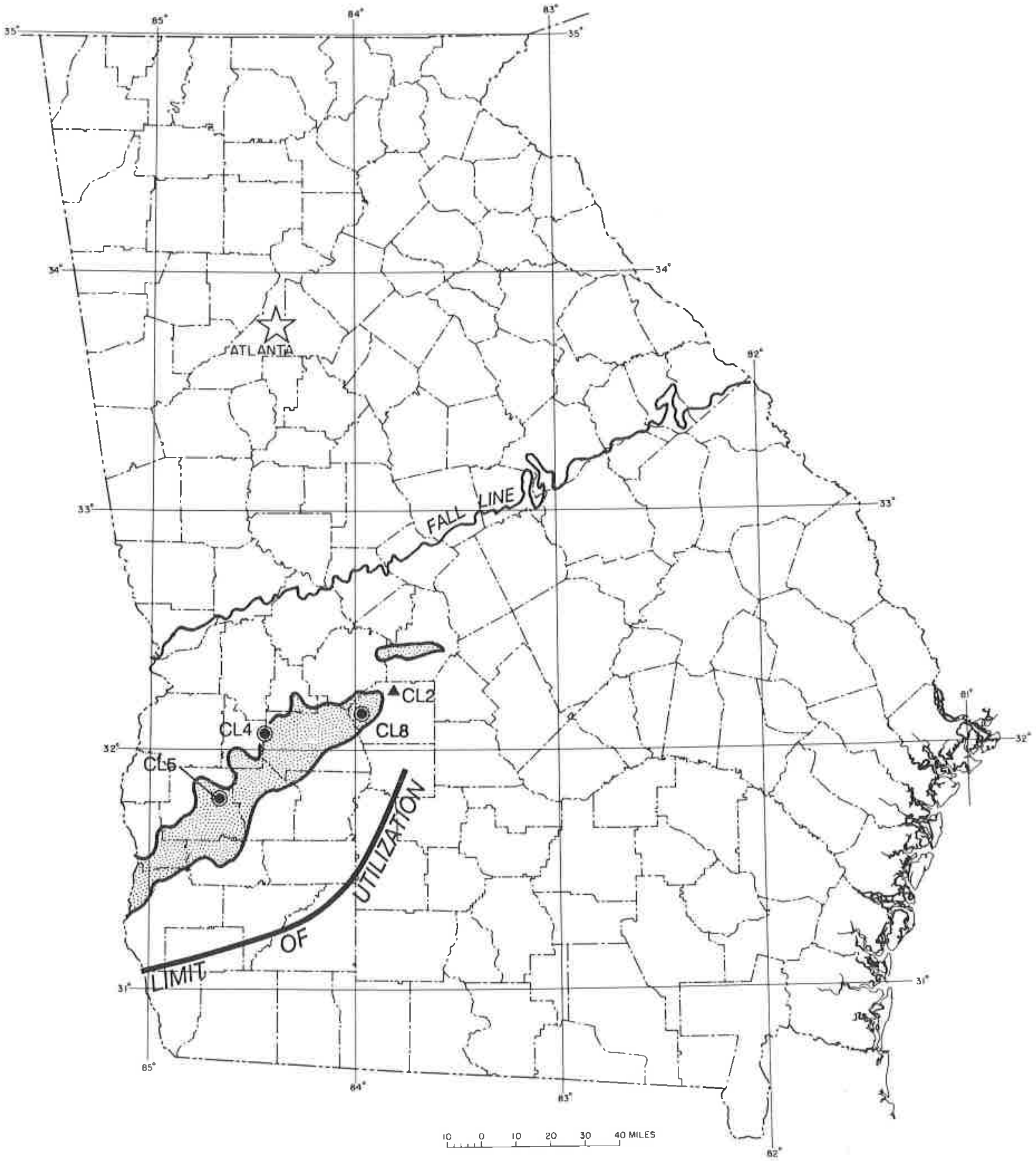
Sands of the Middle Eocene Claiborne Group are the primary members of the Claiborne aquifer system of southwestern Georgia (Figure 3-11). Claiborne Group sands crop out in a belt extending from northern Early County through western Dooly County. Limited recharge may be derived down-dip in the vicinity of Albany in Dougherty County by leakage from the overlying Floridan aquifer system (Hicks, et al., 1981). Discharge boundaries of the aquifer system are the Ocmulgee River, to the east, and the Chattahoochee River, to the west.

The aquifer generally thickens from the outcrop area towards the southeast, attaining a maximum of almost 300 feet in eastern Dougherty County. In down-dip areas where the Claiborne Group can be divided into the Lisbon Formation above and the Tallahatta Formation below, the Claiborne aquifer system is generally restricted to the Tallahatta Formation, and the Lisbon Formation acts as a confining unit that separates the Claiborne aquifer from the overlying Floridan aquifer (McFadden and Perriello, 1983; Long, 1989). The permeable Tallahatta unit is included in the Gordon aquifer system east of the Ocmulgee River (Brooks, et al., 1985).

During 1993 four wells were used to monitor the water quality of the Claiborne aquifer. The pH of the water samples ranged from acidic in the up-dip area (4.27 for well GWN-CL5 at Shellman in Randolph County) to slightly basic in the down-dip area (7.2 for GWN-CL2 in Dooly County). Manganese levels in samples from wells GWN-CL4, GWN-CL5 and GWN-CL8 and the aluminum level from well GWN-CL5 exceeded the secondary MCL's for these elements.

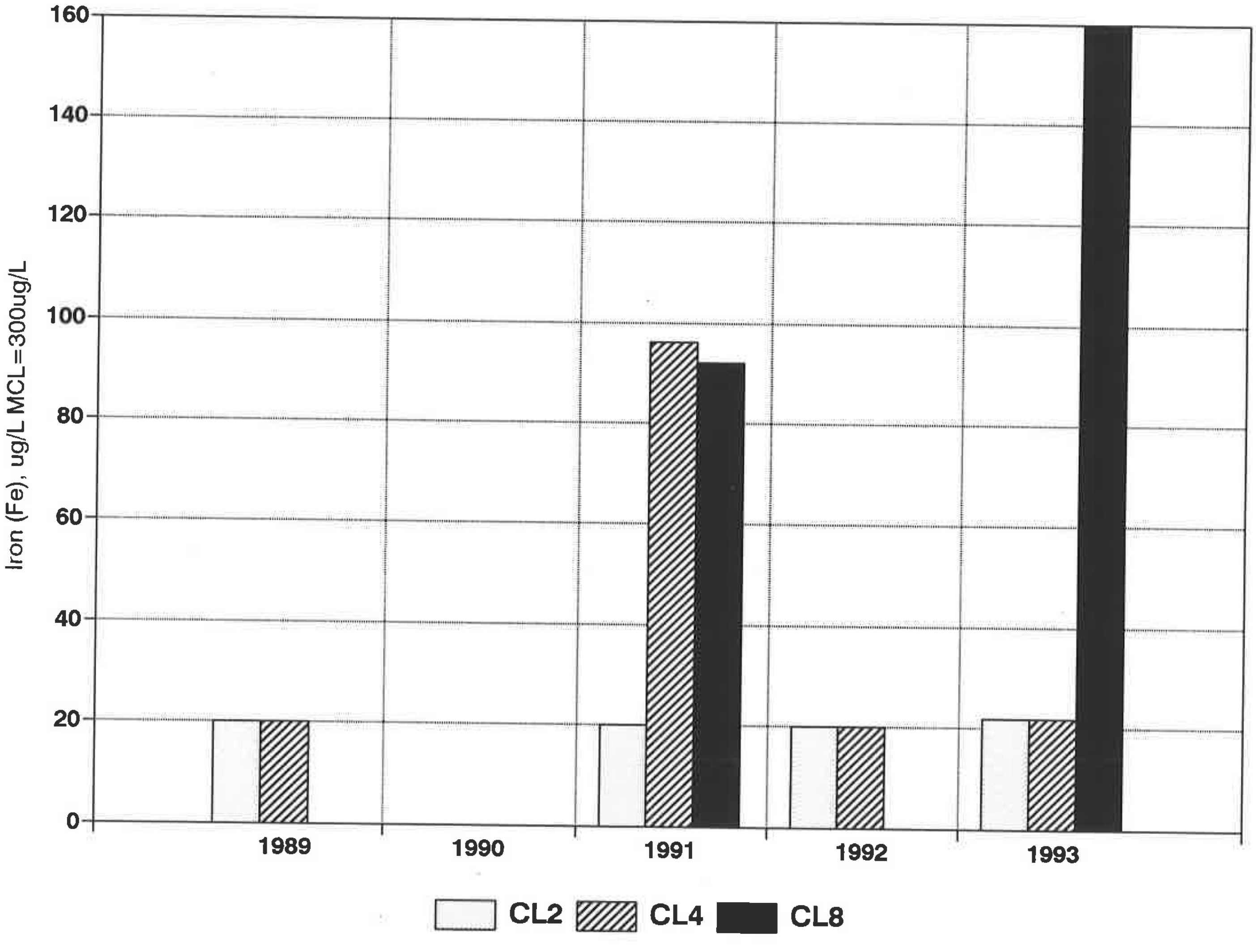
Calcium and sodium concentrations were greatest in the sample from the down-dip well. The calcium concentration in the down-dip well is consistent with ground waters derived from limestone. Other metals detected included iron, barium, strontium, zinc, copper, yttrium, and cobalt. Lead was detected at 37 ppb from well GWN-CL5. Figure 3-12 shows trends in iron concentrations in three wells.

Samples from three of the wells (GWN-CL4, GWN-CL5, and GWN-CL8), all in the recharge area, contained detectable levels of nitrite/nitrate, with the sample from GWN-CL5 containing 9.84 parts per million (as nitrogen). Water samples from this well have historically had high nitrate/nitrite (and manganese) levels. Figure 3-13 shows nitrite/nitrate concentrations for selected wells. Chloride was detected in samples from all wells, with a maximum of 10.4 ppm in well GWN-CL5. Sulfate was detected only in GWN-CL2 at a concentration of 7.3 ppm. The recharge area wells contained no detectable sulfate. Traces of fluoride were also found in samples from two wells. No synthetic organic compounds were detected in any of the samples collected. See the Appendix for analytical results of all collected samples.



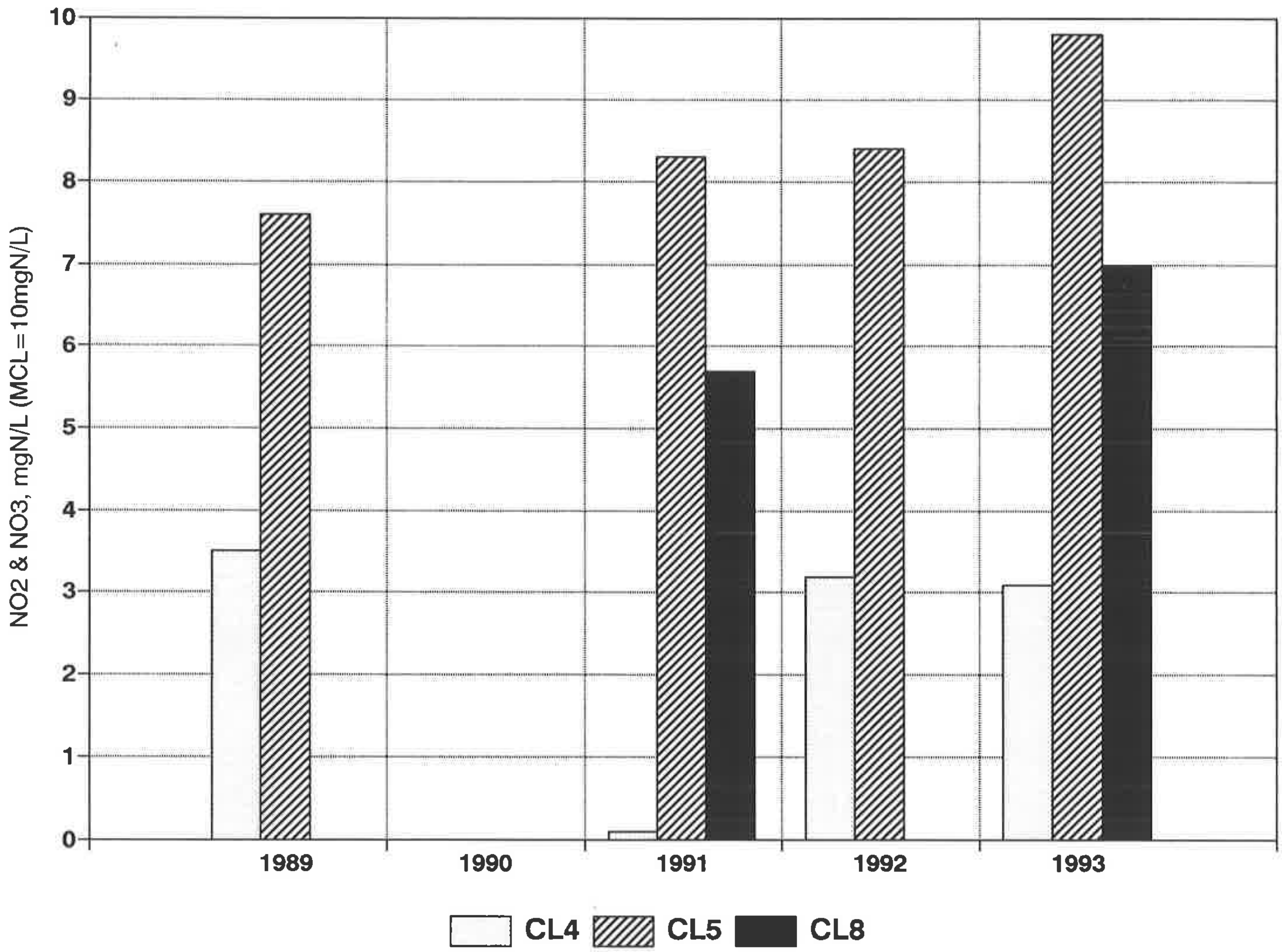
General recharge area (from Davis, et al., 1988)
● Soft water
▲ Hard water
○ Manganese exceeds MCL

Figure 3-11. - Water Quality of the Claiborne Aquifer System.



*Iron levels detected below the MDL are represented as 20 ppb. An absent column of data indicates that the well was not sampled during that particular year.

Figure 3-12. - Iron Concentrations for Selected Wells in the Claiborne Aquifer System.



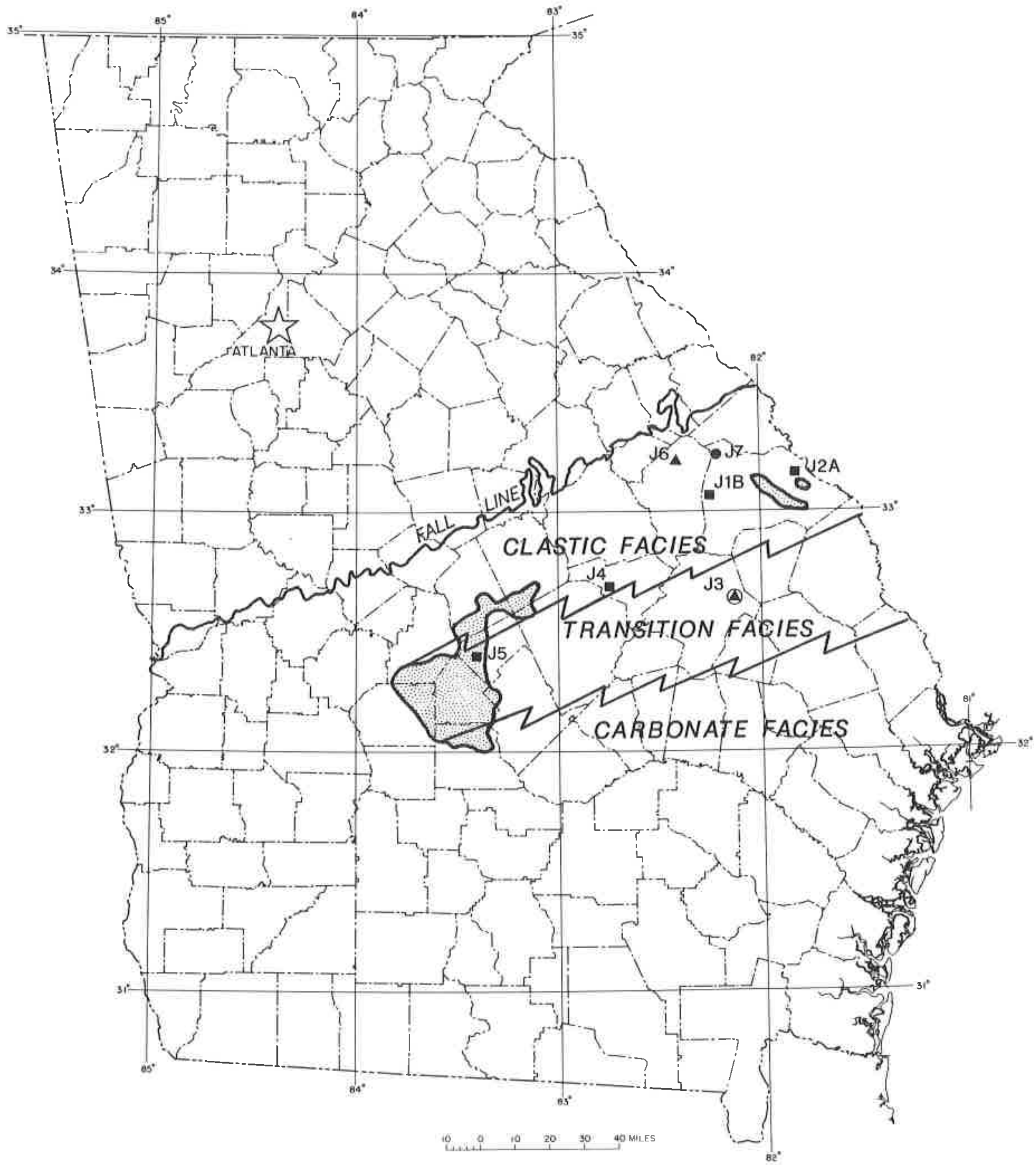
*Nitrate/nitrite levels detected below the MDL are represented as 0.1 ppm. An absent column of data indicates that the well was not sampled during that particular year or that no nitrate/nitrite data are available.

Figure 3-13. - Nitrate/Nitrite Concentrations for Selected Wells in the Claiborne Aquifer System.

3.6 JACKSONIAN AQUIFER SYSTEM

The Jacksonian aquifer system of central and east-central Georgia is developed predominantly in sands of the Eocene Barnwell Group, though, locally, isolated bodies may be important. Barnwell Group outcrops extend from Macon and Peach counties eastward to Burke and Richmond counties (Figure 3-14). Aquifer sands form a northern clastic facies of the Barnwell Group and grade southward into less permeable silts and clays of a transition facies (Vincent, 1982). The water-bearing sands are relatively thin, ranging from ten to fifty feet in thickness. Limestones equivalent to the Barnwell Group form a southern carbonate facies and are included in the Floridan aquifer system. The Savannah River and Ocmulgee River are eastern and western discharge boundaries respectively for the up-dip flow system of the Jacksonian aquifer system.

Seven Jacksonian aquifer wells were monitored during 1993, five wells in the clastic facies and two wells in the transition facies (one, GWN-J2A, in an isolated limestone body). The pH measurements were, for the most part, near-neutral to slightly basic, ranging from 6.70-7.81. An exception was up-dip well GWN-J7, which yielded water of a pH of 4.82. Iron, aluminum, and manganese concentrations in the samples were below the secondary MCL's for drinking water with the exception of manganese in well GWN-J3 (100 ppb). Sodium concentrations were generally low, with the highest occurring in a sample from the transition well GWN-J3. Calcium concentrations were moderate in samples from six of the wells, but were low in a sample from the up-dip well GWN-J7. Magnesium was detected in four of the wells, with the highest level of 6.0 ppm occurring in the sample from transition well GWN-J3. Other metals detected included barium, strontium, zinc, and copper. Nitrite/nitrate was more abundant in samples from the up-dip wells. Neither fluoride, chloride, nor sulfate exceeded their respective MCL's. See Figures 3-15 and 3-16 for trends in iron and nitrite/nitrate concentrations in selected wells. Well GWN-J2A gave water with traces of hydrocarbons and chloroform, both below primary MCL's. The Appendix contains the analytical results for all the wells sampled.



General recharge area (from Davis, et al., 1988)

Facies boundary (from Vincent, 1982)

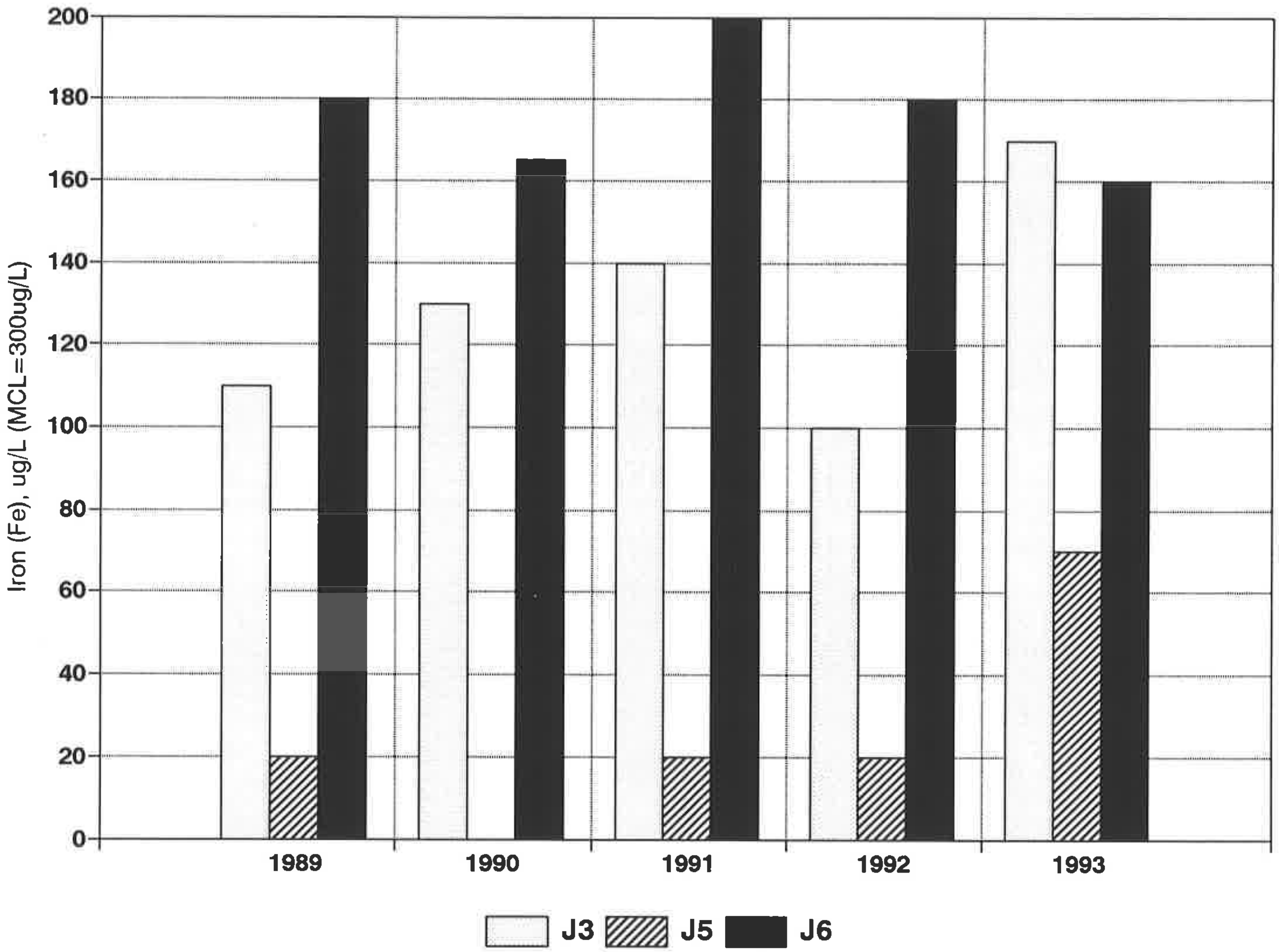
● Soft water

▲ Moderately hard water

○ Manganese exceeds MCL

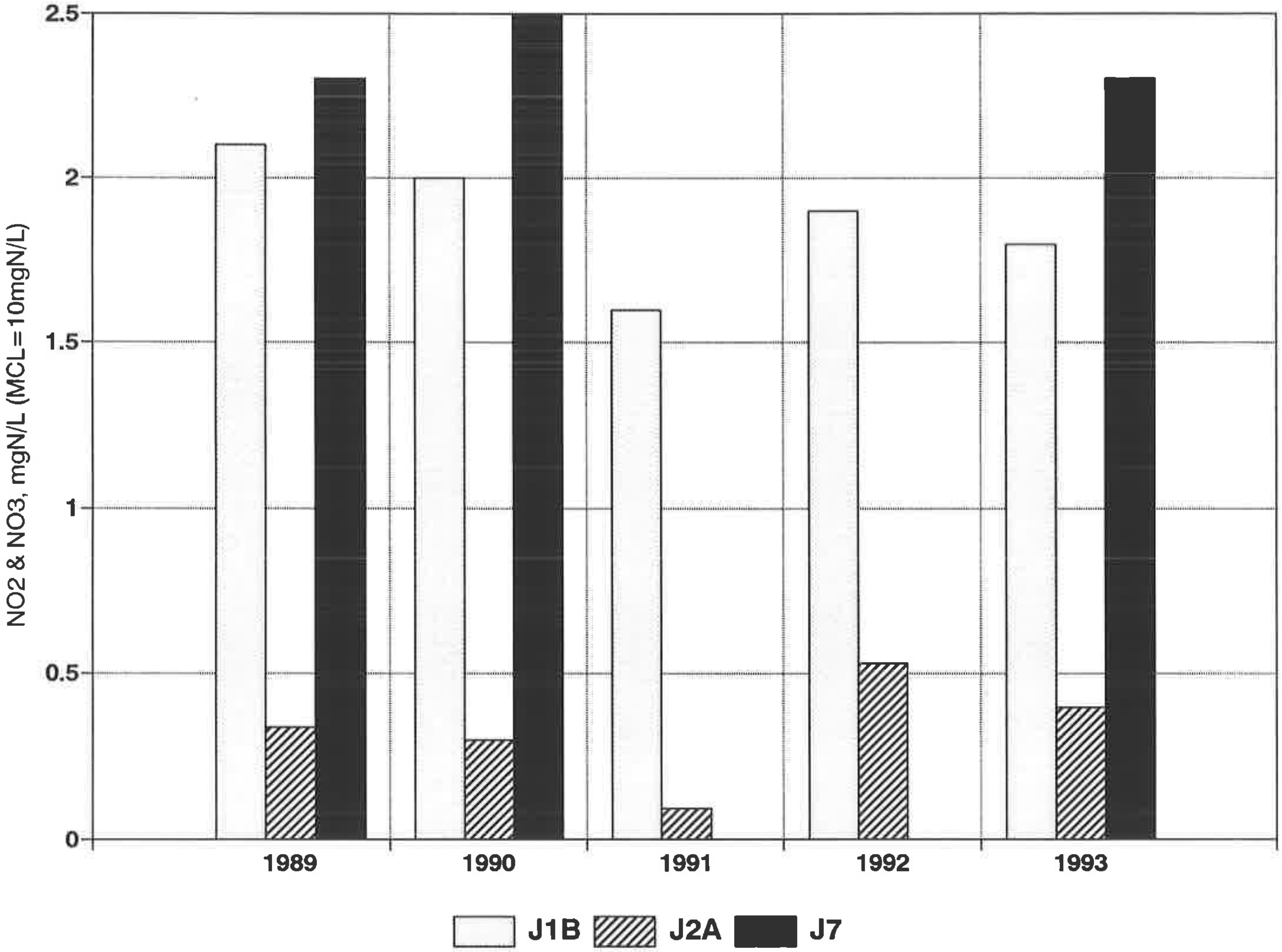
■ Hard water

Figure 3-14. - Water Quality of the Jacksonian Aquifer System.



*Iron levels detected below the MDL are represented as 20 ppb. An absent column of data indicates that the well was not sampled during that particular year.

Figure 3-15. - Iron Concentrations for Selected Wells in the Jacksonian Aquifer System.



*Nitrate/nitrite levels detected below the MDL are represented as 0.1 ppm. An absent column of data indicates that the well was not sampled during that particular year or that no nitrate/nitrite data are available.

Figure 3-16. - Nitrate/Nitrite Concentrations for Selected Wells in the Jacksonian Aquifer System.

3.7 FLORIDAN AQUIFER SYSTEM

The Floridan aquifer system (formerly known in Georgia as the Principal Artesian aquifer system) consists predominantly of Eocene and Oligocene limestones and dolostones that underlie most of the Coastal Plain Province. Other units are included locally in the aquifer. The aquifer is a major source of ground water for much of its outcrop area and throughout its down-dip extent to the south and east.

The upper water-bearing units of the Floridan are the Eocene Ocala Group and the Oligocene Suwanee Limestone (Crews and Huddlestun, 1984). These limestones crop out in the Dougherty Plain (a karstic area in southwestern Georgia) and in adjacent areas along a strike to the northeast. In Camden and Wayne counties the Oligocene unit is absent, and the upper part of the Floridan is restricted to units of Eocene age (Clarke, et al., 1990). The lower portion of the Floridan consists mainly of dolomitic limestone of middle and early Eocene age and pelletal, vuggy, dolomitic limestone of Paleocene age but extends into the late Cretaceous in Glynn County. The lower Floridan is deeply buried and not widely used, except in several municipal and industrial wells in the Savannah area (Clarke, et al., 1990). From its up-dip limit, defined in the east by clays of the Barnwell Group, the aquifer thickens to well over 700 feet in coastal Georgia. A dense limestone facies along the trend of the Gulf Trough locally limits ground-water quality and availability (Kellam and Gorday, 1990). The Gulf Trough is a linear depositional feature in the Ocala Group that extends from southwestern Decatur County through central Bulloch County.

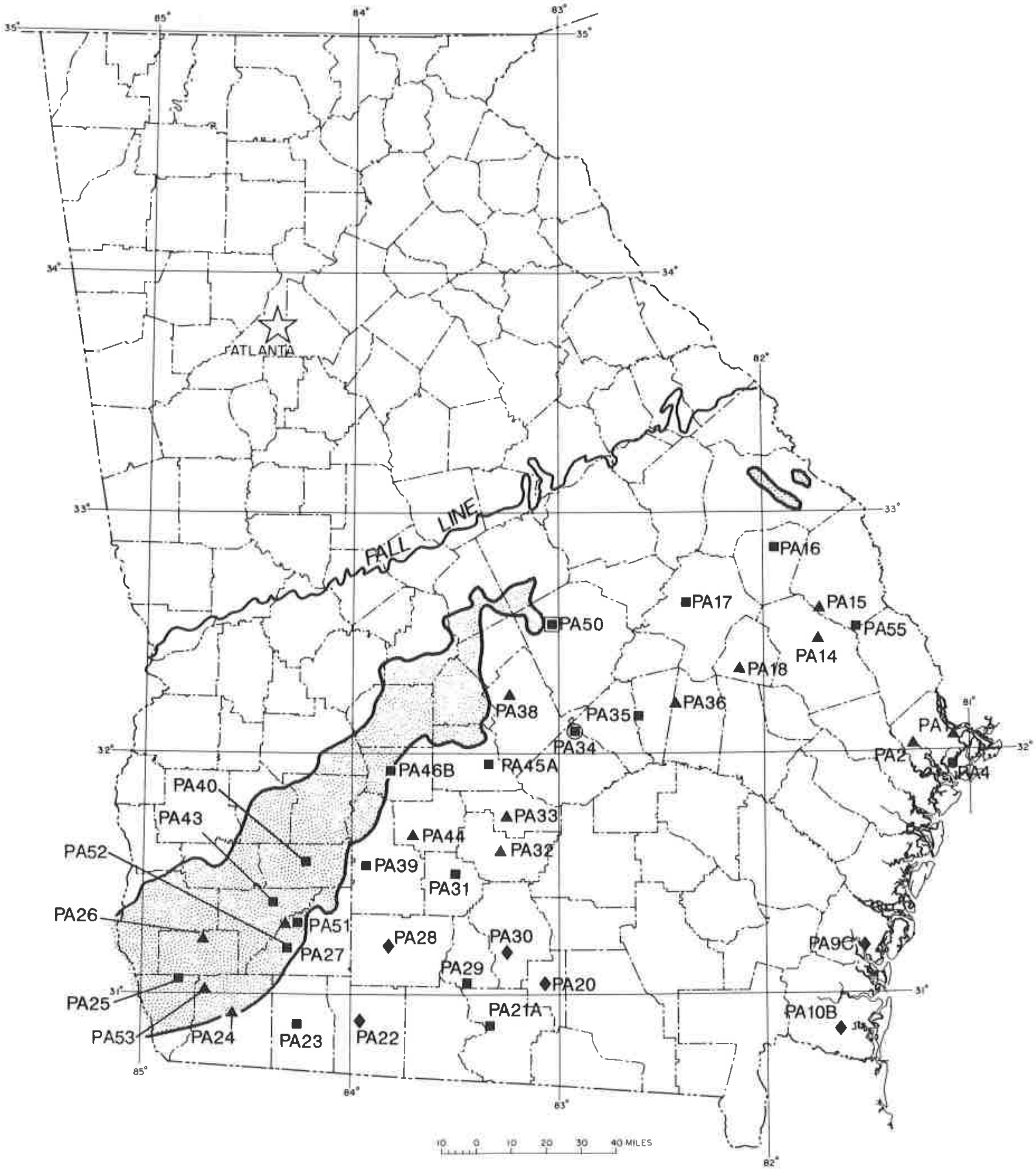
A ground-water divide separates a southwestward flow system in the Floridan aquifer in the Dougherty Plain from the Floridan aquifer system's major southeastward flow system in the remainder of Georgia. Rainfall infiltration in outcrop areas and leakage from extensive surficial aquifers provides recharge to the Dougherty Plain flow system (Hayes, et al., 1983). The main body of the Floridan aquifer system, to the east, is recharged by leakage from the Jacksonian aquifer system and by rainfall infiltration in outcrop areas and in areas where overlying strata are thin. Significant recharge also occurs in the area of Brooks, Echols and Lowndes counties where the Withlacoochee River and numerous sinkholes breach upper confining beds (Krause, 1979).

In 1993, ground-water samples were collected from 40 wells in the Floridan aquifer system (Figure 3-17). The pH levels for all water samples taken were slightly basic. Iron exceeded the secondary MCL in samples from two wells, GWN-PA9C (370 ppb) in Glynn County and GWN-PA50 (480 ppb) in Laurens County. Trends in iron levels from selected wells in the Floridan aquifer are shown on Figure 3-18. Aluminum exceeded the secondary MCL in samples from two wells, with concentrations of 210 ppb and 330 ppb. Most wells yielding water with detectable manganese levels are located in the Gulf Trough area (wells GWN-PA18, GWN-PA29, and GWN-PA32 through GWN-PA36). Manganese concentrations in excess of the secondary MCL were detected in two wells: GWN-PA18 (62 ppb), and GWN-PA34 (100 ppb).

Sodium concentrations ranged from 1.6 to 690 parts per million, and magnesium ranged from undetected to 94 ppm. Both elements are most abundant in samples from wells in the coastal area, with the highest concentrations of these elements occurring in a sample from well GWN-PA9C in Brunswick. Calcium ranged from 24 ppm in a sample from well GWN-PA2A in Savannah to 170 ppm in well GWN-PA9C. The barium concentration from well GWN-PA33 in the Gulf Trough area was 2200 ppb which exceeds the primary MCL. Other metals and semimetals detected include potassium, zirconium, vanadium, molybdenum, selenium, strontium, iron, and zinc. None of these substances exceeded applicable MCL's.

The water samples were also analyzed for the anions chloride, sulfate, fluoride, and nitrate/nitrite. Chloride levels ranged from below the detection limit to 844.9 ppm. The 844.9 ppm level occurred in well GWN-PA9C in the coastal area and was the only value to exceed the secondary MCL for chloride. Sulfate ranged from undetected to 231.8 ppm. The concentrations of fluoride ranged from undetected to 0.6 ppm. Certain samples were analyzed for synthetic organic chemicals; none were detected.

Most of the samples collected from the confined portions of the Floridan aquifer contained no detectable nitrite/nitrate, whereas most samples in the unconfined portion contained detectable concentrations of nitrite/nitrate. The highest level, 4.8 ppm nitrogen, was collected from well GWN-PA53. Trends in nitrate levels from selected wells in the Floridan Aquifer are presented in Figure 3-19. The Appendix gives the analytical results for samples from the Floridan aquifer system.



General recharge area (from Davis, et al., 1988)

▲ Moderately hard water

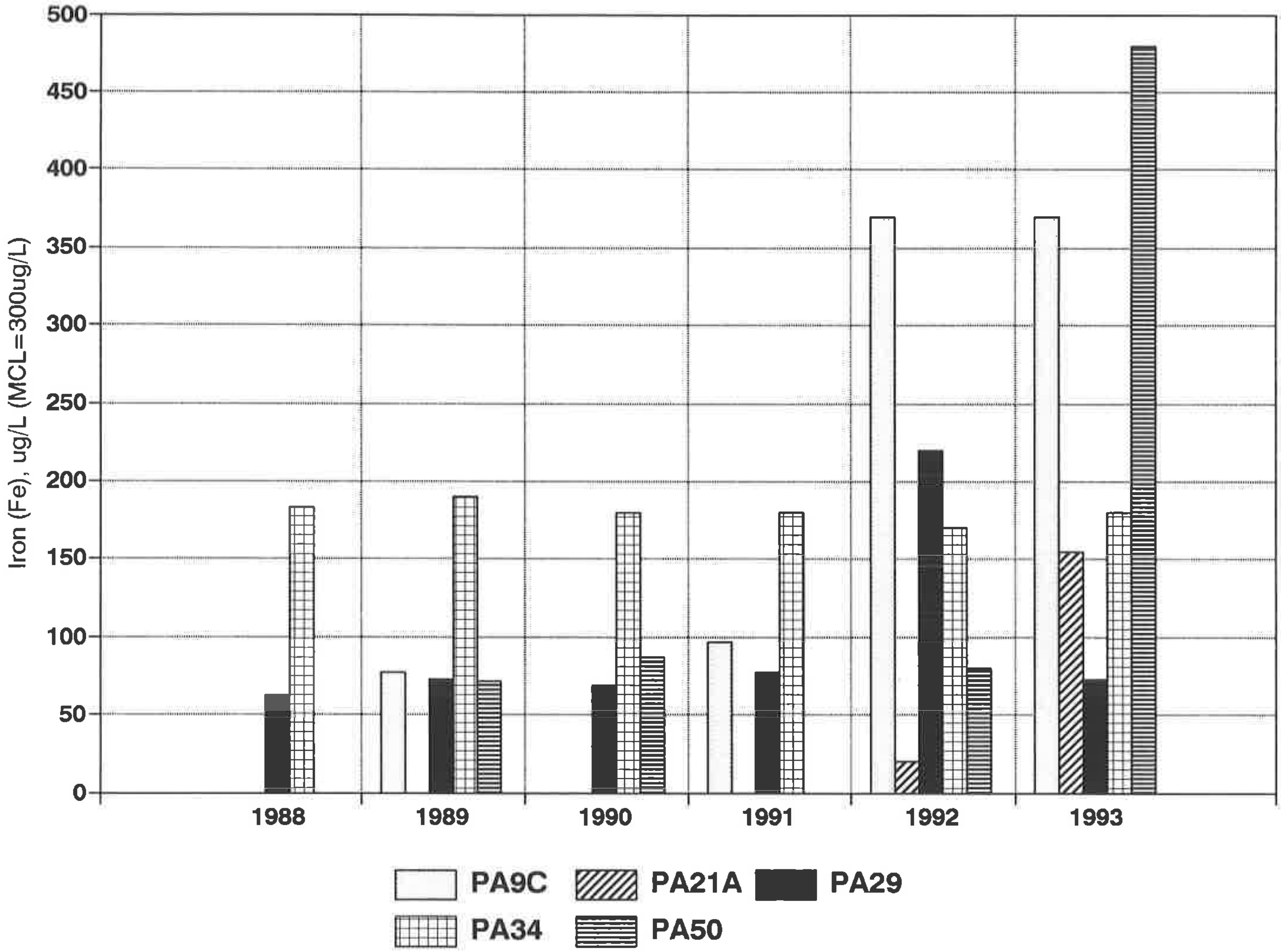
■ Hard water

◆ Very hard water

□ Iron exceeds MCL

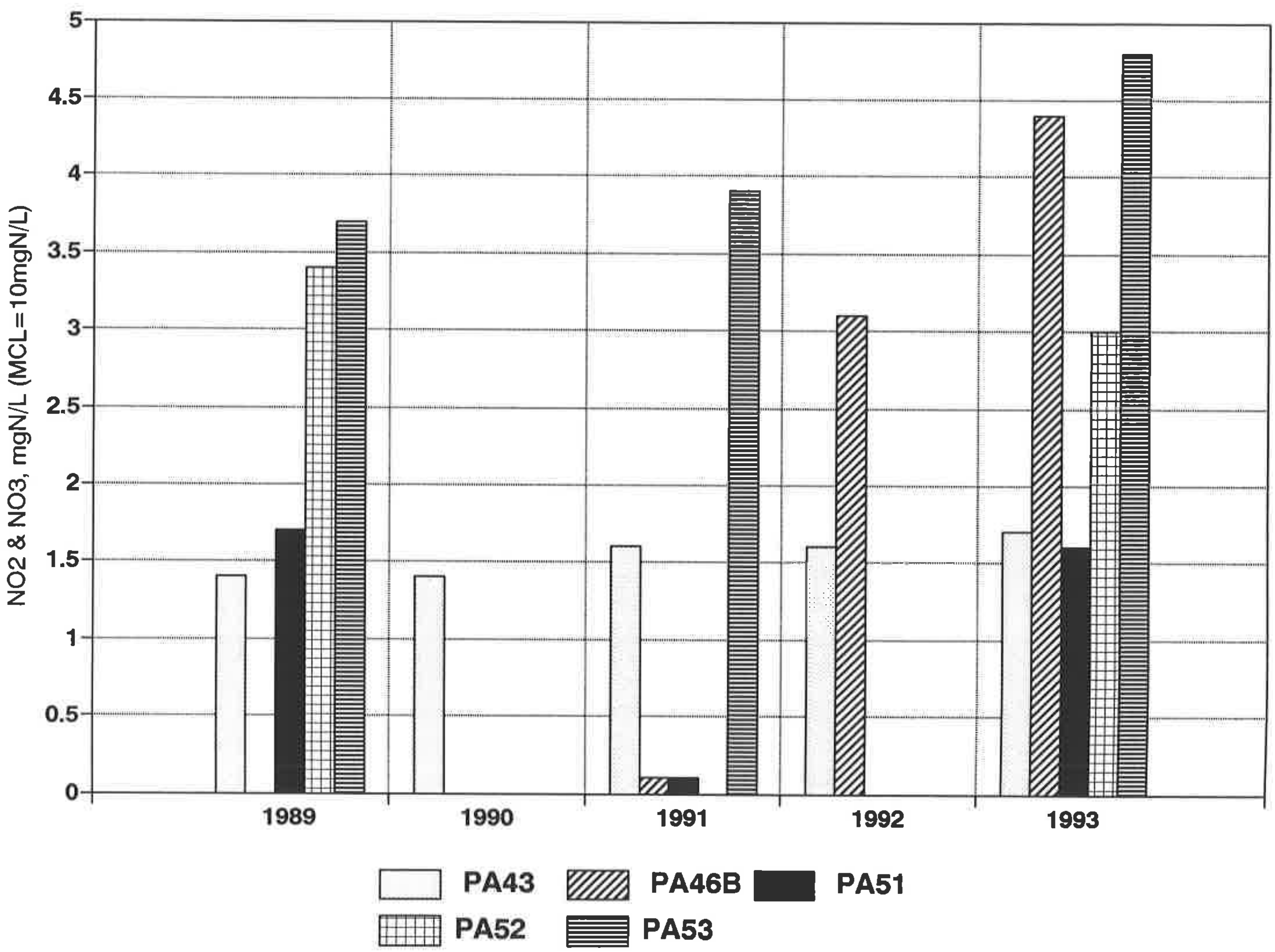
○ Manganese exceeds MCL

Figure 3-17. - Water Quality of the Floridan Aquifer System.



*Iron levels detected below the MDL are represented as 20 ppb. An absent column of data indicates that the well was not sampled during that particular year.

Figure 3-18. - Iron Concentrations for Selected Wells in the Floridan Aquifer System.



*Nitrate/nitrite levels detected below the MDL are represented as 0.1 ppm. An absent column of data indicates that the well was not sampled during that particular year or that no nitrate/nitrite data are available.

Figure 3-19. - Nitrate/Nitrite Concentrations for Selected Wells in the Floridan Aquifer System.

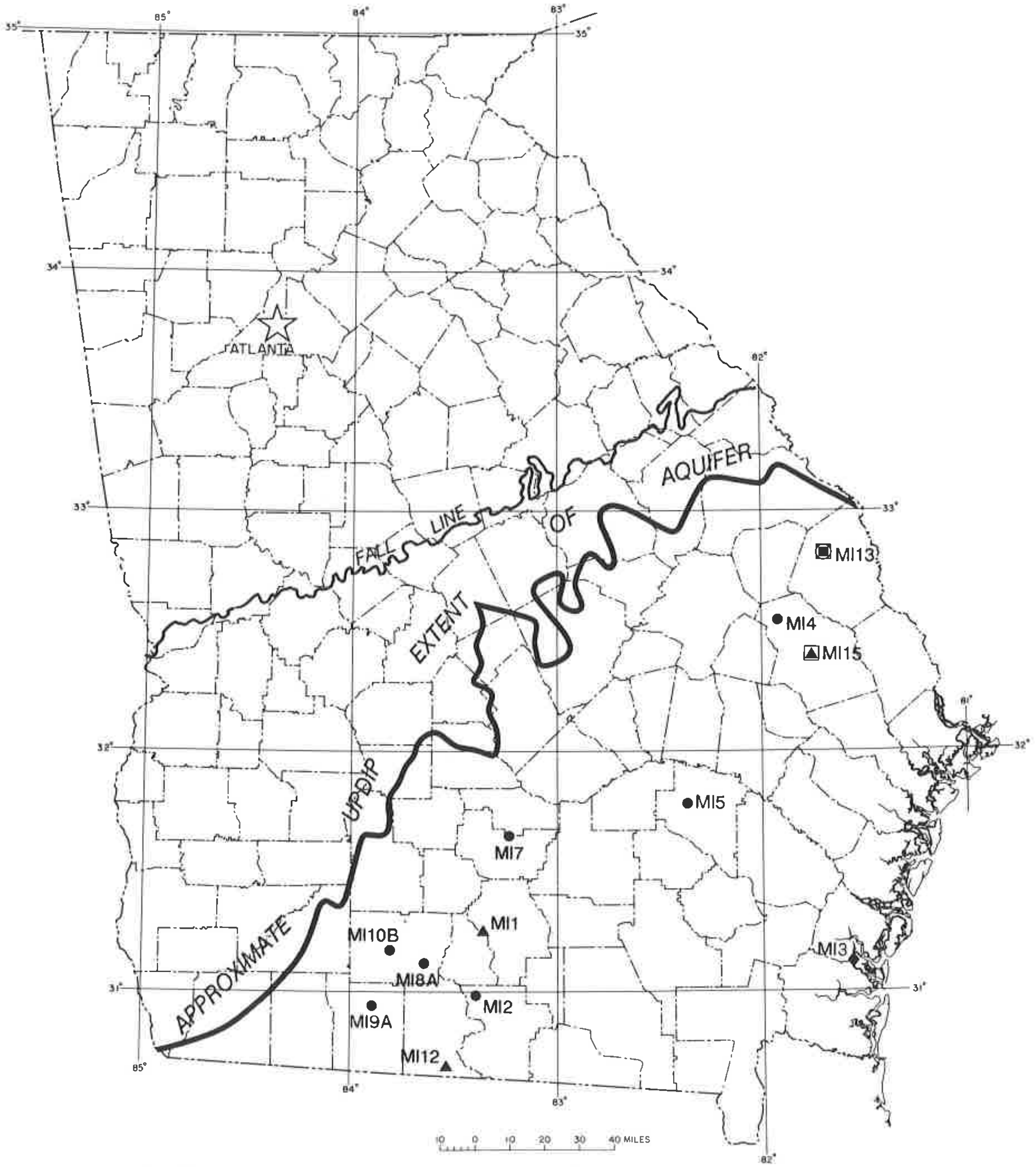
3.8 MIOCENE AQUIFER SYSTEM

Much of south-central and southeastern Georgia lies within outcrop areas of the Miocene Altamaha Formation and Hawthorne Group. Discontinuous lens-shaped bodies of sand, 50 to 80 feet thick, are the main permeable units. Miocene clays and sandy clays are thickest, more than 500 feet, in Wayne County (Watson, 1982).

Areas of confinement exist along the coastal counties. Leakage from overlying surface aquifers into the Miocene aquifer system and, in some areas, from the underlying Floridan aquifer system is significant in the coastal counties (Watson, 1982). Two principal aquifer units are present in the coastal area (Joiner, et al., 1988). Clarke (et. al, 1990) use the names upper and lower Brunswick aquifers to refer to these two sandy aquifer units.

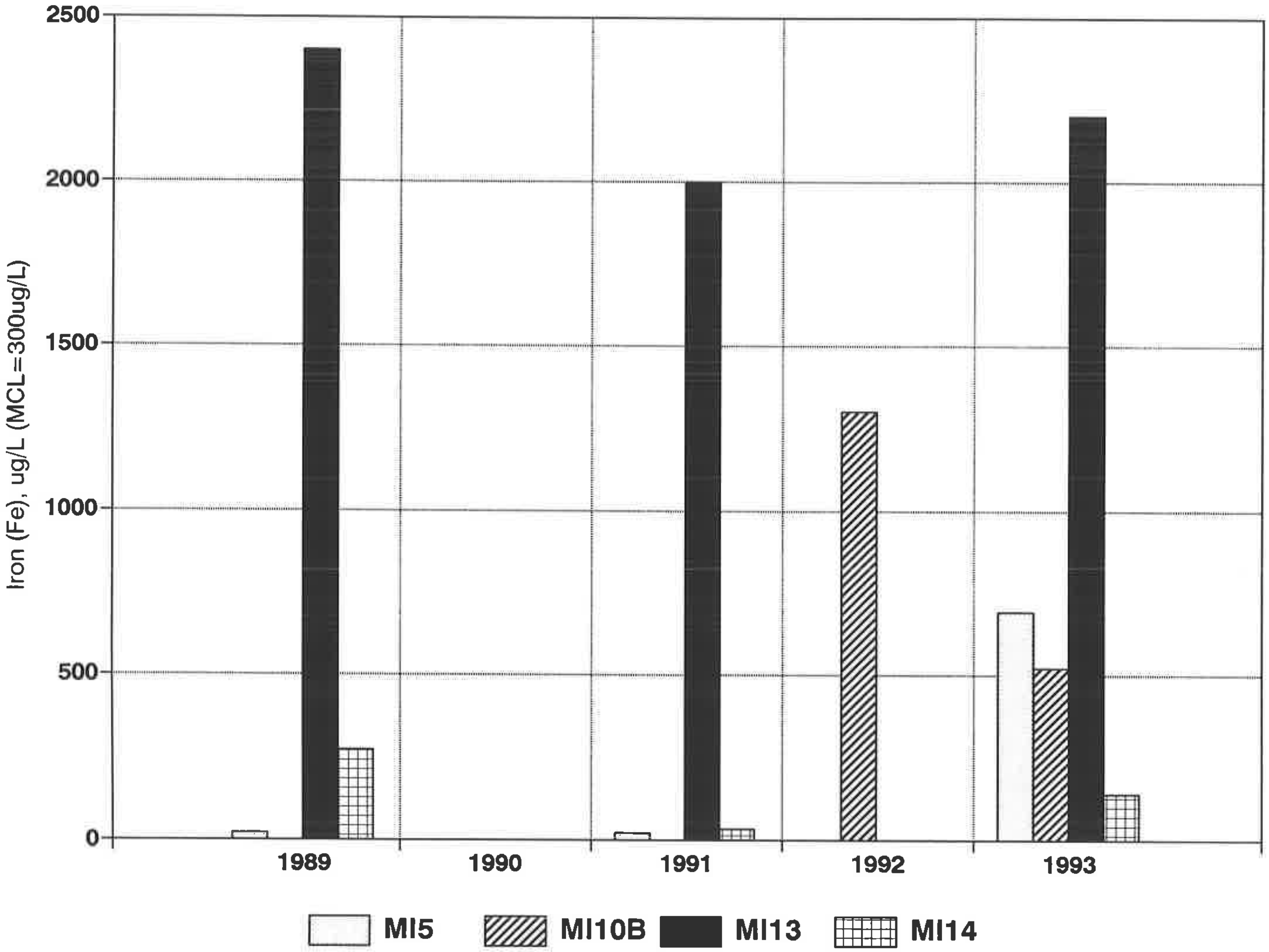
Water quality of the Miocene aquifer system was monitored in twelve wells (Figure 3-20). The pH of the samples ranged from 4.25 to 8.04. Iron and manganese levels ranged from undetected to 2200 and 210 ppb, respectively. Water samples from four wells, GWN-MI5, GWN-MI10B, GWN-MI13, and GWN-MI15, contained iron in excess of the secondary MCL. Water samples from two wells, GWN-MI10B and GWN-MI13, exceeded the secondary MCL for manganese. Figure 3-21 shows trends in iron concentrations in selected wells. Aluminum exceeded the secondary MCL in three samples ranging from 600 to 3400 ppb. Sodium ranged from 1.9 to 24 ppm while calcium ranged from below the detection limit to 71 ppm. Other metals and semimetals detected were potassium, magnesium, barium, strontium, zinc, copper, titanium, arsenic, and zirconium. None of these are present in excess of applicable MCL's.

Chloride ranged from undetected to 38.3 ppm, sulfate levels ranged from undetected to 49.6 parts per million. Both of these anions were highest in samples from the coastal well GWN-MI3. Chloride concentrations were lowest in the deeper domestic wells (GWN-MI1, GWN-MI2, GWN-MI10B, and GWN-MI13). Fluoride was also detected in samples from 8 wells. Detectable levels of nitrite/nitrate, ranging from 1.4 to 18.4 ppm, were found in samples from five wells (GWN-MI5, GWN-MI7, GWN-MI8A, GWN-MI9A, and GWN-MI15). Wells GWN-MI7, GWN-MI8A, and GWN-MI15 exceeded the primary MCL for nitrate. Concentrations of nitrate/nitrite for selected wells are illustrated in Figure 3-22. No synthetic organic chemicals were found. Analytical data for samples drawn from the Miocene aquifer system are given in the Appendix.



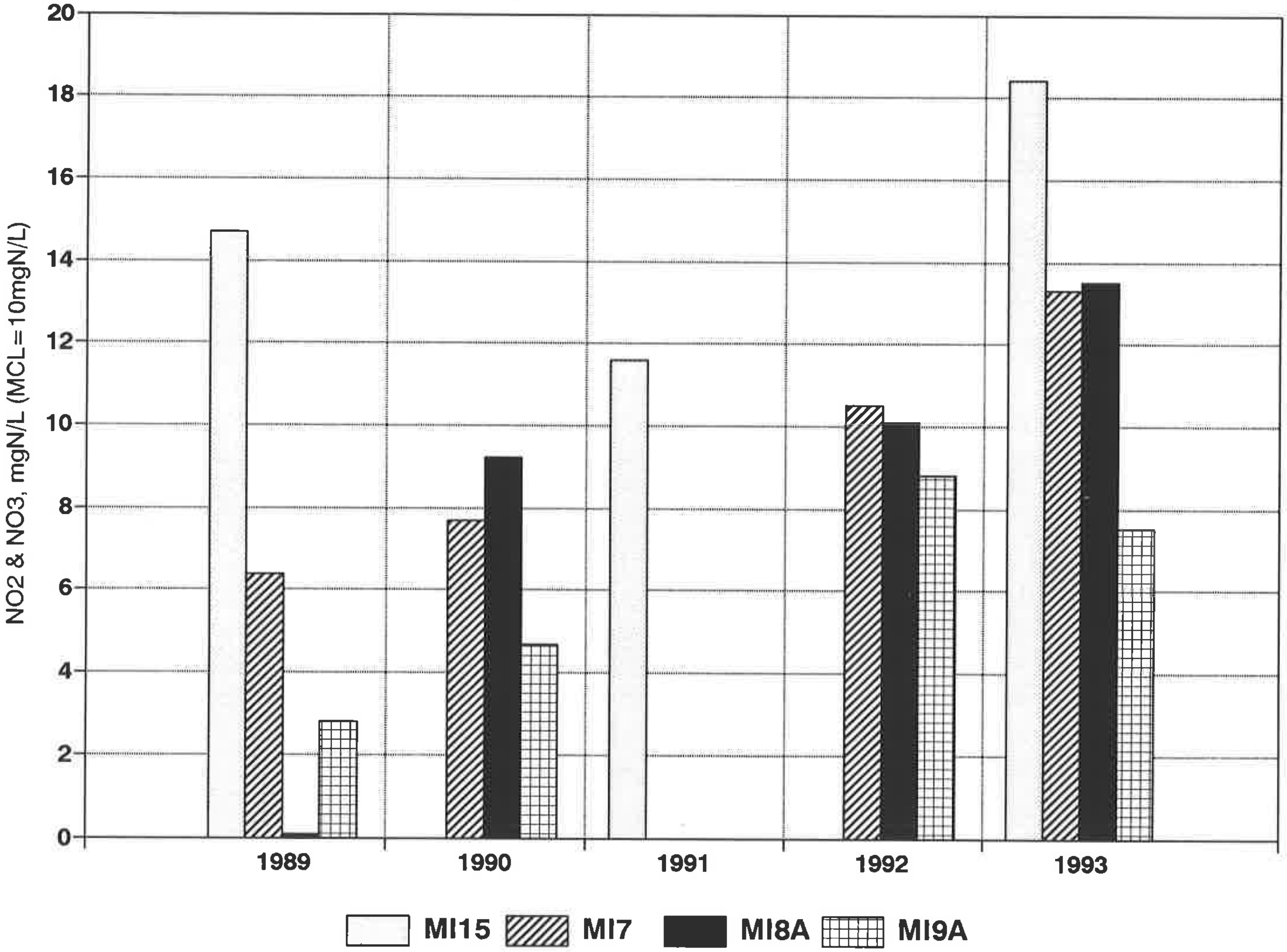
● Soft water
▲ Moderately hard water
■ Hard water
♦ Very hard water
□ Iron exceeds MCL
○ Manganese exceeds MCL

Figure 3-20. - Water Quality of the Miocene Aquifer System.



*Iron levels detected below the MDL are represented as 20 ppb. An absent column of data indicates that the well was not sampled during that particular year.

Figure 3-21. - Iron Concentrations for Selected Wells in the Miocene Aquifer System.



*Nitrate/nitrite levels detected below the MDL are represented as 0.1 ppm. An absent column of data indicates that the well was not sampled during that particular year or that no nitrate/nitrite data are available.

Figure 3-22. - Nitrate/Nitrite Concentrations for Selected Wells in the Miocene Aquifer System.

3.9 PIEDMONT/BLUE RIDGE UNCONFINED AQUIFERS

Georgia's Piedmont and Blue Ridge Physiographic Provinces are developed on metamorphic and igneous rocks that are predominantly Precambrian and Paleozoic in age. Soil and saprolite horizons, compositional layers, and openings along fractures and joints in the rocks are the major water-bearing features. Fracture density and interconnection provide the primary controls on the rate of water flow into wells completed in crystalline rocks. The permeability and thickness of soils and shallow saprolite horizons determine the amount of discharge that can be sustained.

Ground-water samples were collected from sixteen wells and two springs in the Piedmont and Blue Ridge Provinces. Figure 3-23 shows locations of the monitoring stations. Water from wells and springs in the crystalline-rock aquifers was acidic, the exception being water from well GWN-P6B, with a pH of 7.61. Iron and manganese ranged from undetected to 13,000 (GWN-P10A) and 180 ppb (GWN-P9), respectively. Iron exceeded the secondary MCL in water samples from five of the sampling stations. Figure 3-24 shows trends in iron concentrations for selected wells in the Piedmont sector. Figure 3-25 illustrates iron concentrations for selected wells in the Blue Ridge sector. Manganese exceeded the secondary MCL in samples from six stations. Aluminum exceeded the secondary MCL in a sample from well GWN-P10A (1100 ppb). Sodium was detected at relatively low concentrations in samples from all stations. Calcium and magnesium were detected in samples from all stations except well GWN-P14. Potassium, barium, strontium, molybdenum, vanadium, zinc, and beryllium were other metals detected at concentrations below any applicable MCL.

Chloride and sulfate concentrations in the water samples ranged from undetected to 12.6 and 69.0 ppm, respectively. Sulfate levels were below 15 ppm in all but three wells, GWN-P1B, GWN-P9, and GWN-P10A. Fluoride was detected in samples from 8 wells. Nitrite/nitrate was present in water from ten stations, all at levels well below the MCL. Figures 3-26 and 3-27 show nitrite/nitrate concentrations in selected wells from the Piedmont and Blue Ridge aquifers, respectively. No synthetic organic chemicals were detected. An analysis summary for Piedmont/Blue Ridge wells and springs is found in the Appendix.

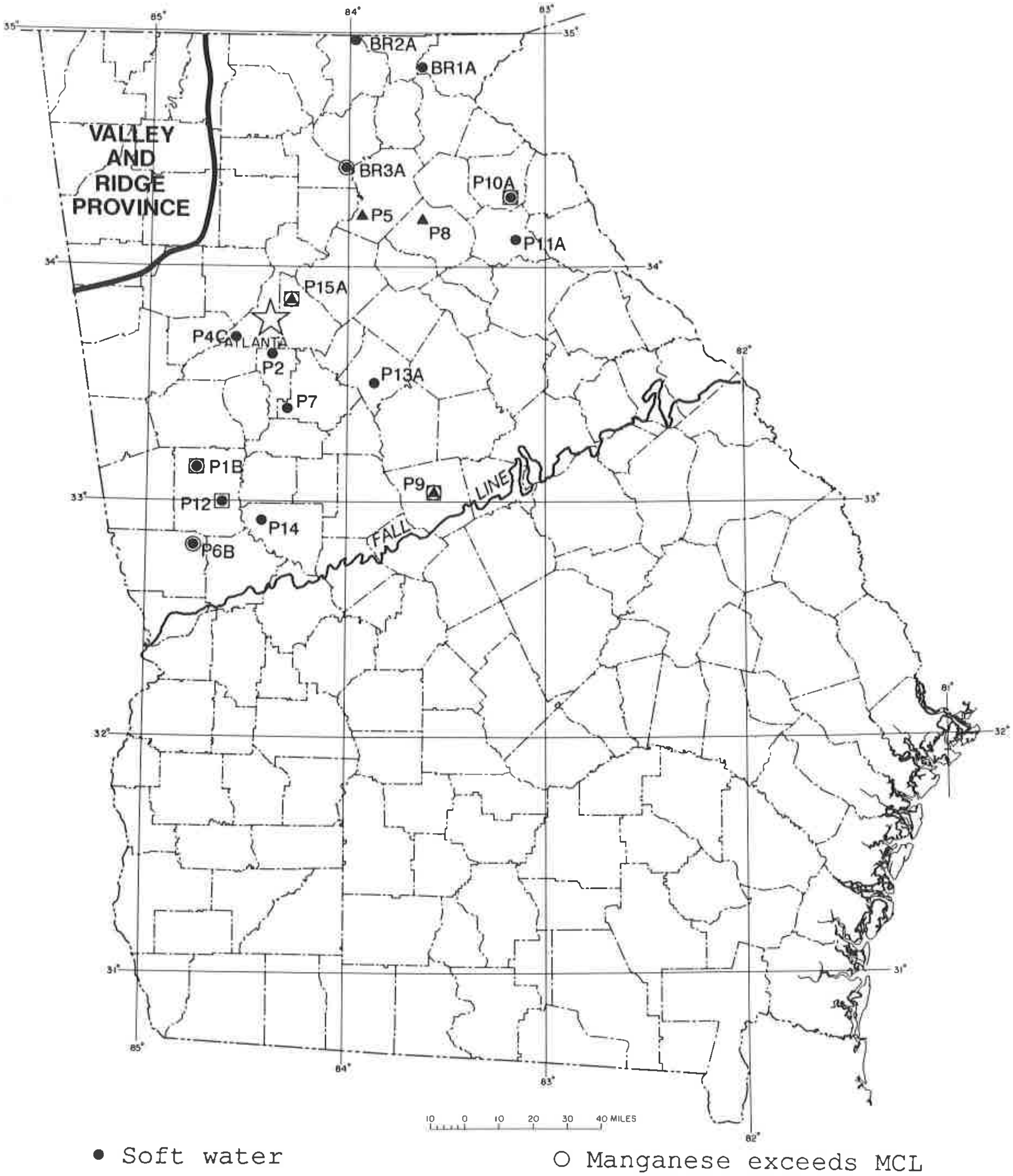
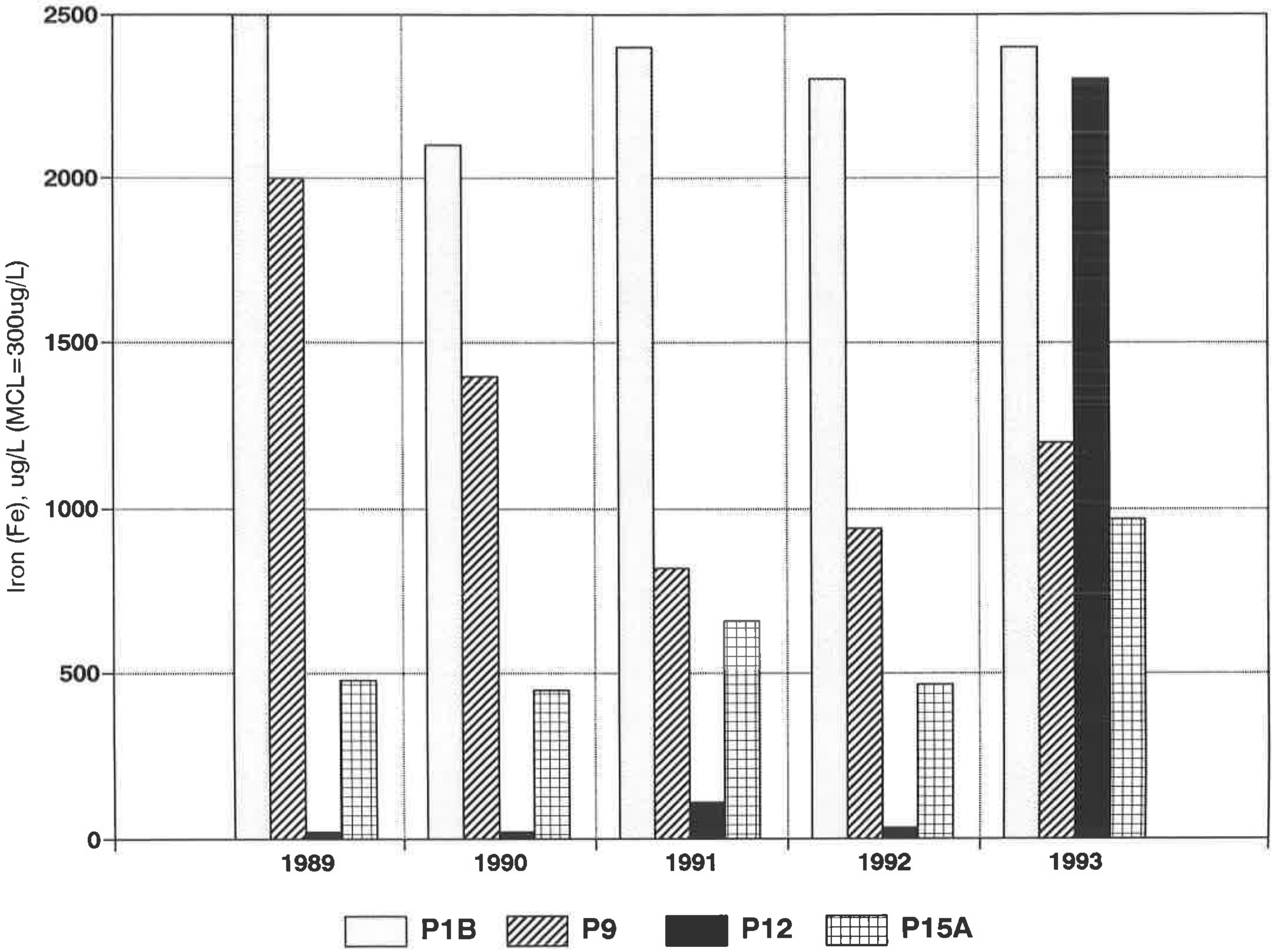
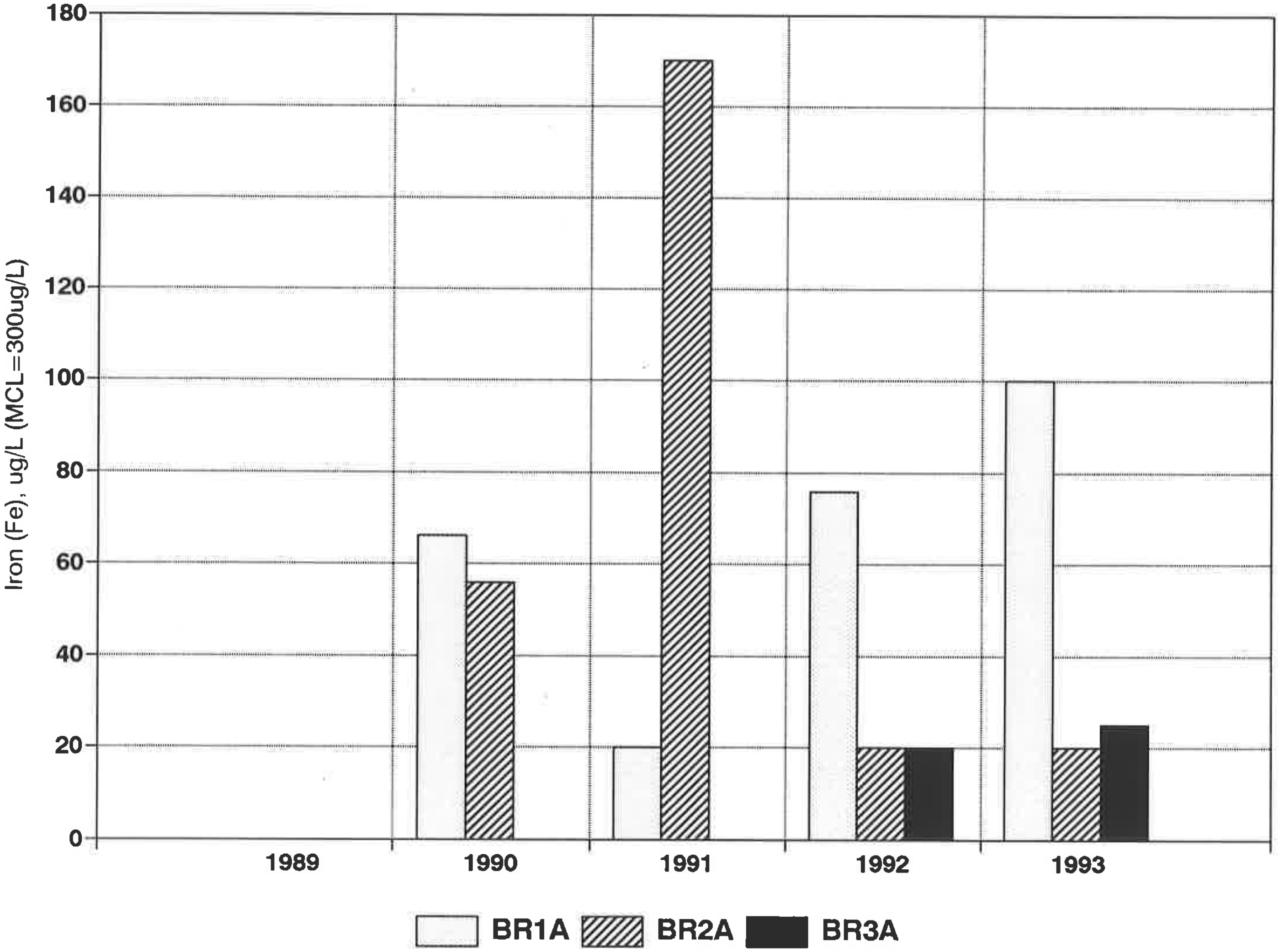


Figure 3-23. - Water Quality of the Piedmont/Blue Ridge Unconfined Aquifers.



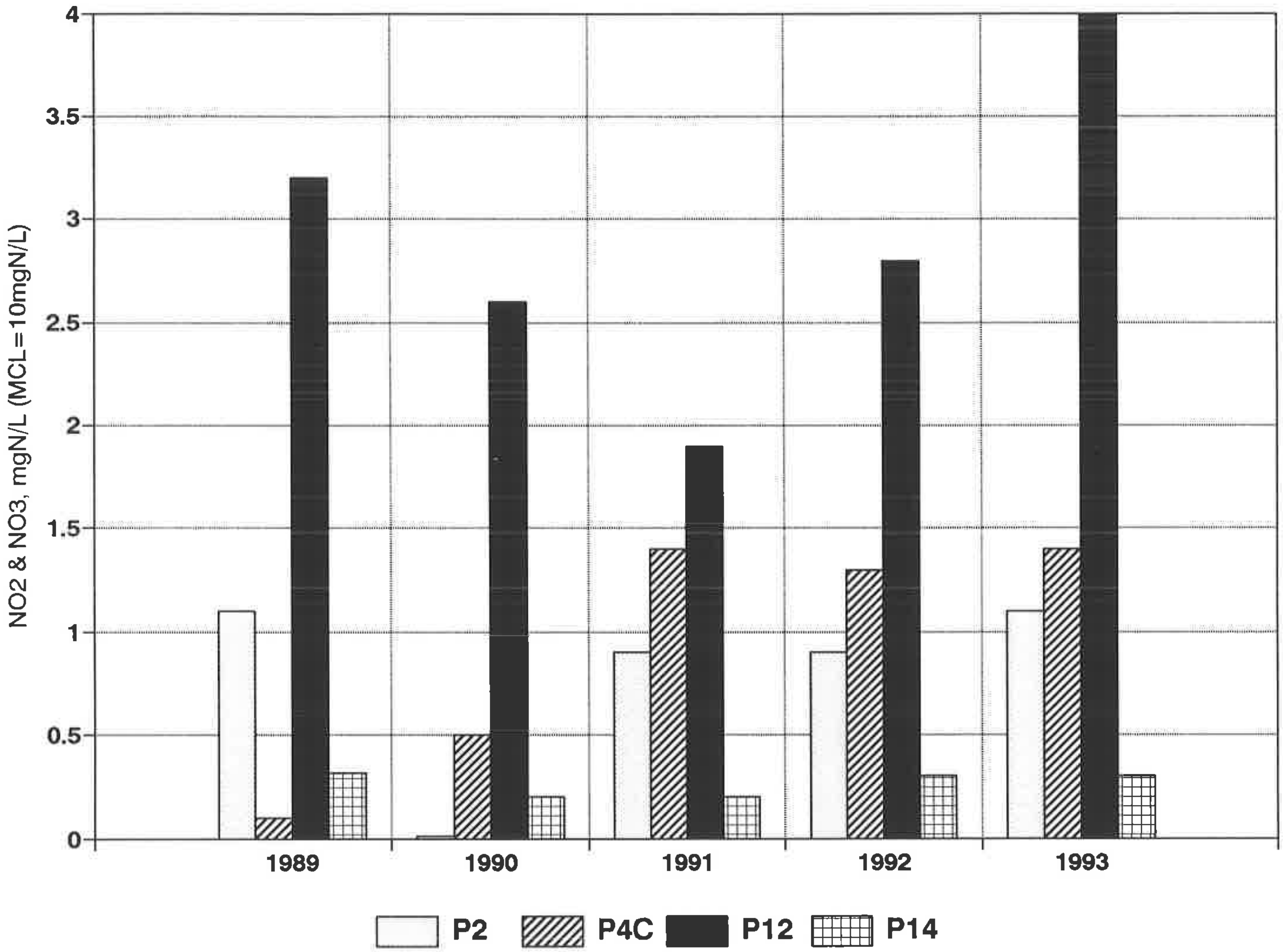
*Iron levels detected below the MDL are represented as 20 ppb. An absent column of data indicates that the well was not sampled during that particular year.

Figure 3-24. - Iron Concentrations for Selected Wells in the Piedmont/Blue Ridge Unconfined Aquifer System: Piedmont Sector.



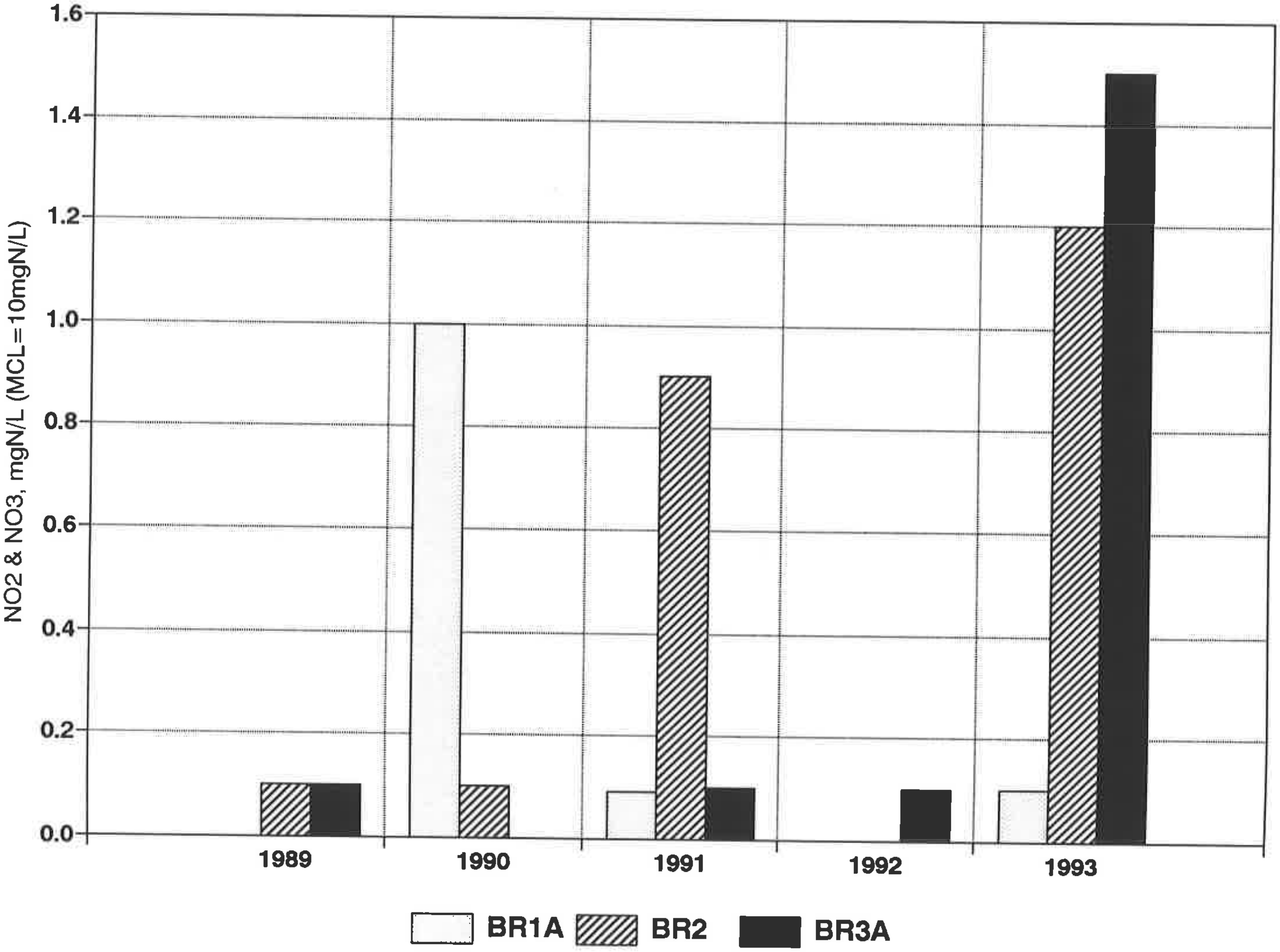
*Iron levels detected below the MDL are represented as 20 ppb. An absent column of data indicates that the well was not sampled during that particular year.

Figure 3-25. - Iron Concentrations for Selected Wells in the Piedmont/Blue Ridge Unconfined Aquifer System: Blue Ridge Sector.



*Nitrate/nitrite levels detected below the MDL are represented as 0.1 ppm. An absent column of data indicates that the well was not sampled during that particular year or that no nitrate/nitrite data are available.

Figure 3-26. - Nitrate/Nitrite Concentrations for Selected Wells in the Piedmont/Blue Ridge Unconfined Aquifer System: Piedmont Sector.



*Nitrate/nitrite levels detected below the MDL are represented as 0.1 ppm. An absent column of data indicates that the well was not sampled during that particular year or that no nitrate/nitrite data are available.

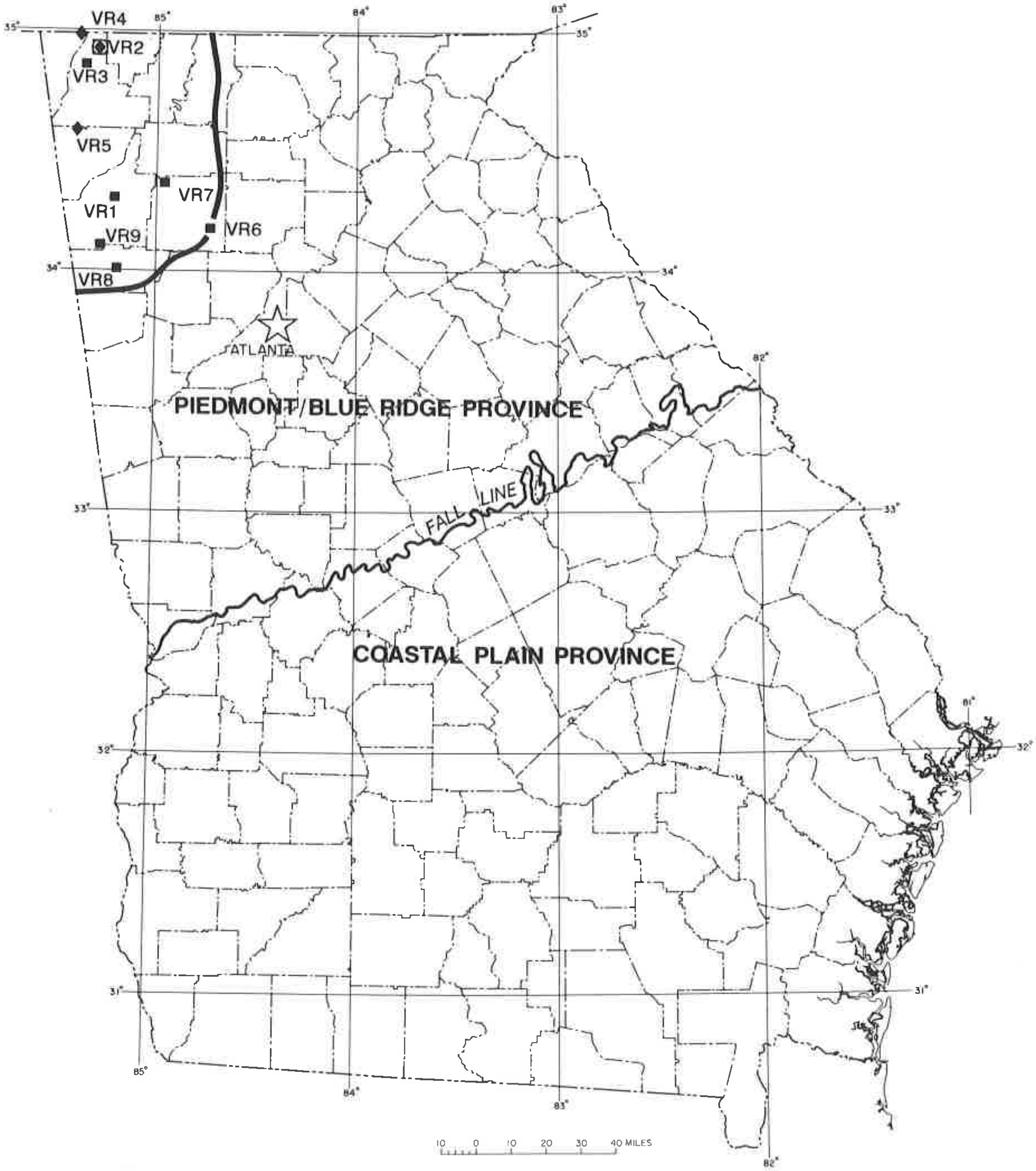
Figure 3-27. - Nitrate/Nitrite Concentrations for Selected Wells in the Piedmont/Blue Ridge Unconfined Aquifer System: Blue Ridge Sector.

3.10 VALLEY AND RIDGE UNCONFINED AQUIFERS

Soil and residuum form low-yield unconfined aquifers across most of the Valley and Ridge Province of northwestern Georgia. Valley bottoms underlain by dolostones and limestones of the Cambro-Ordovician Knox Group are the locations of most higher-yielding wells and springs that are suitable for municipal supplies.

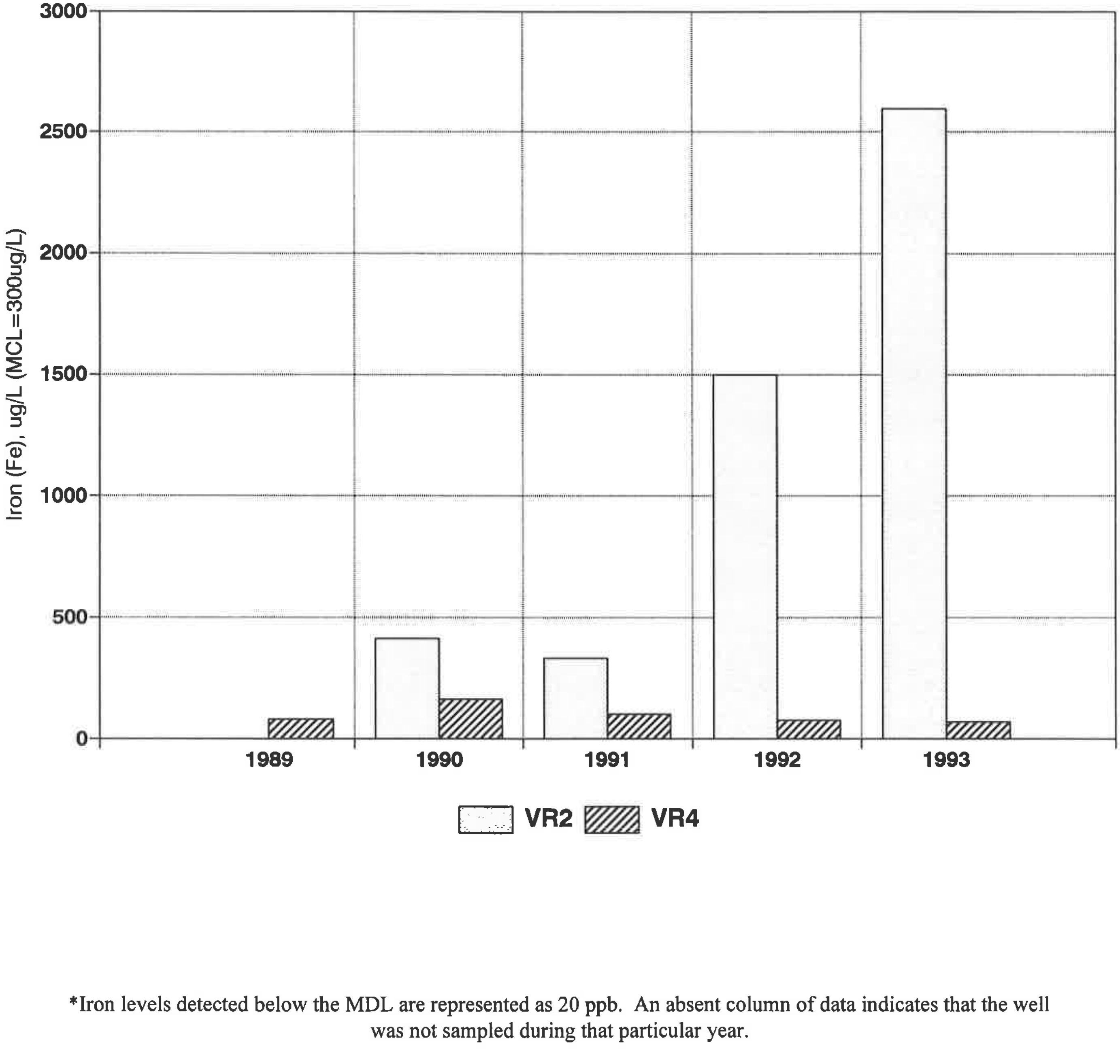
Water quality in the Valley and Ridge unconfined aquifers was monitored in six wells and three springs (Figure 3-28). Three of these wells and all three springs produced water from Knox Group carbonates. The other wells were used to sample water in the Ordovician Chickamauga Group in Walker County and the Cambrian Shady Dolomite in Bartow County. Water from the Valley and Ridge monitoring stations was typically basic, with pH ranges of 6.8 to 7.9. Iron and manganese concentrations were below detection limits for seven of the stations sampled and exceeded secondary MCL's in only one of the wells sampled (GWN-VR2). Calcium ranged from 29 to 83 parts per million and manganese was detected in samples from all stations. Barium and strontium were commonly detected trace metals. The highest barium concentration, 590 ppb, was detected in a sample from well GWN-VR6. This particular well draws water from the Shady Dolomite Group which contains an abundance of barite ($BaSO_4$) deposits. Chloride ranged in concentration from 1.1 to 21.7 ppm, while sulfate ranged from undetectable to 47.1 ppm. Detectable fluoride was found in samples from 2 wells. Detectable nitrite/nitrate was present in samples from all wells and springs except GWN-VR2, and GWN-VR4. The highest nitrate/nitrite concentration occurred in a sample from well GWN-VR5 with a level of 3.0 ppm as nitrogen. Figures 3-29 and 3-30 show iron and nitrite/nitrate levels, respectively, for selected wells in the Valley and Ridge aquifers.

Volatile organic compounds were detected in samples from three wells (GWN-VR2, GWN-VR4, and GWN-VR6), all located in urban or industrial settings. The sample from well VR2 contained motor fuel constituents. The benzene concentration in the sample exceeded the primary MCL of 5 ppb (Section 4). The major ground-water bearing strata in the Valley and Ridge Physiographic Province are commonly associated with Karst development. Therefore, due to the susceptibility of karst to surface pollution, testing for volatile organic compounds has been instituted for all sampling stations in this Province.



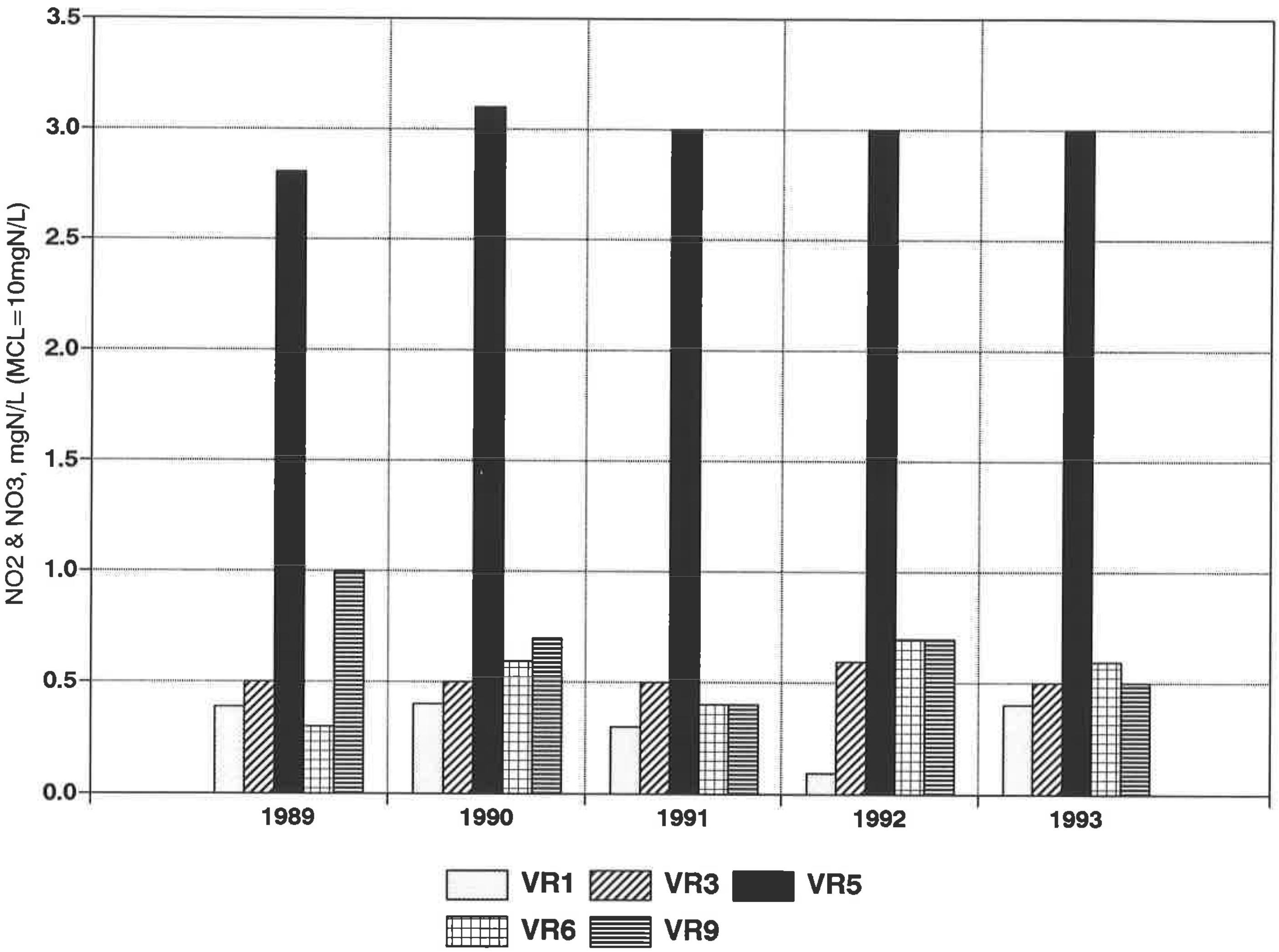
■ Hard water
♦ Very hard water
○ Manganese exceeds MCL
□ Iron exceeds MCL

Figure 3-28. - Water Quality of the Valley and Ridge Unconfined Aquifers.



*Iron levels detected below the MDL are represented as 20 ppb. An absent column of data indicates that the well was not sampled during that particular year.

Figure 3-29. - Iron Concentrations for Selected Wells in the Valley and Ridge Aquifer System.



*Nitrate/nitrite levels detected below the MDL are represented as 0.1 ppm. An absent column of data indicates that the well was not sampled during that particular year or that no nitrate/nitrite data are available.

Figure 3-30. - Nitrate/Nitrite Concentrations for Selected Wells in the Valley and Ridge Aquifer System.

4.0 SUMMARY AND CONCLUSIONS

One hundred and twenty-eight raw water samples were collected for analysis from 107 wells and 4 springs for the Ground-Water Monitoring Network in 1993. These wells and springs are used to sample ten aquifer systems in Georgia:

- Cretaceous aquifer system
- Providence aquifer system
- Clayton aquifer system
- Claiborne aquifer system
- Jacksonian aquifer system
- Floridan aquifer system
- Miocene aquifer system
- Piedmont/Blue Ridge unconfined aquifers
- Valley and Ridge unconfined aquifers

Analyses of water samples collected in 1993 were compared with analyses for the Ground-Water Monitoring Network dating back to 1984, permitting the recognition of temporal trends. Table 4-1 lists the major contaminants and pollutants that were detected at the stations of the Ground-Water Monitoring Network during 1993. New MCL's that became effective in 1993 are also noted. Although isolated water quality problems were documented during 1993 at specific localities, the quality of water from the majority of the Ground-Water Monitoring Network stations remains excellent.

Nitrate/nitrite are the most common substances present in ground water in Georgia that can have adverse health effects. Three wells, all shallow domestic wells tapping the Miocene aquifer system (MI7 and MI8A, and MI15) yielded water samples in 1993 with nitrite/nitrate concentrations exceeding the primary MCL of 10 ppm as nitrogen (Table 4-1).

Spatial and temporal limitations of the Ground-Water Monitoring Network preclude the identification of the exact sources of the increasing levels of nitrogen compounds in some of Georgia's ground water. Nitrite/nitrate originates in ground water from direct sources and through oxidation of other forms of dissolved nitrogen, deriving from both natural and man-made sources. The most common sources of man-made dissolved nitrogen in Georgia usually are derived from septic systems, agricultural wastes, and storage or application of fertilizers (Robertson, et. al, 1993). Dissolved nitrogen is also present in rainwater, derived form terrestrial vegetation and volatilization of fertilizers (Drever, 1988). The conversion of other nitrogen species to nitrate occurs in aerobic environments such as recharge areas. Anaerobic conditions in ground water, as are commonly developed along the flow path of ground water, foster the denitrification process. However, this process may be inhibited by the lack of denitrifying bacteria in ground water (Freeze and Cherry, 1979).

Iron, manganese, and aluminum are the three naturally occurring substances responsible for the greatest incidence of ground-water quality problems in Georgia (Table 4-1). Although minor increases or decreases in iron, manganese, and aluminum were noted for some stations, no long-term trends in concentrations of these metals were documented for the majority of the wells and springs sampled.

The presence of synthetic organic compounds was again documented in water from a few of the wells sampled in the Valley and Ridge. Because of the sporadic nature of the occurrence of such compounds in most of these wells, spatial and temporal trends in levels of organic pollution cannot be defined at this time.

Table 4-1. Pollution and contamination incidents, 1993.

Station	Contaminant/ Pollutant**	Primary MCL	Secondary MCL
GWN-K1	Al=630ppb		Al=200ppb
GWN-K3	Fe=720ppb		Fe=300ppb
GWN-K8A	Fe=4100ppb Mn=50ppb		Fe=300ppb Mn=50ppb
GWN-K9	Fe=1200ppb Al=470ppb		Fe=300ppb Al=200ppb
GWN-K12	Al=420ppb		Al=200ppb
GWN-CT7A	Al=510ppb		Al=200ppb
GWN-CL4	Mn=56ppb		Mn=50ppb
GWN-CL5	Mn=680ppb Al=440ppb		Mn=50ppb Al=200ppb
GWN-CL8	Mn=120ppb		Mn=50ppb
GWN-J2A	$CHCl_3$=tr C_xH_x=tr	$CHCl_3$=100ppb MCL varies with compound	
GWN-J3	Mn=100ppb		Mn=50ppb
GWN-PA9C	Fe=370ppb Al=330ppb Cl=844ppm		Fe=300ppb Al=200ppb Cl=250ppm
GWN-PA10B	Al=210ppb		Al=200ppb
GWN-PA18	Mn=62ppb		Mn=50ppb
GWN-PA33	Ba=2200ppb	Ba=2000ppb	
GWN-PA34	Mn=100ppb		Mn=50ppb
GWN-PA50	Fe=480ppb		Fe=300ppb
GWN-MI5	Fe=690ppb Al=3400ppb		Fe=300ppb Al=200ppb
GWN-MI7	NOx=13.3ppm as N Al=840pb	NOx=10ppm as N	Al=200ppb

Table 4-1. (continued)

Station	Contaminant/ Pollutant**	Primary MCL	Secondary MCL
GWN-MI8A	NOx=13.5ppm as N Al=1300ppb	NOx= 10ppm as N	Al=200ppb
GWN-MI10B	Fe=520ppb Mn=150ppb		Fe=300ppb Mn=50ppb
GWN-MI13	Fe=2200ppb Mn=210ppb		Fe=300ppb Mn=50ppb
GWN-MI15	Fe=310ppb Nox=18.4ppm as N Al=600ppm	NOx= 10ppm as N	Fe=300ppb Al=200ppb
GWN-BR3A	Mn=83ppb		Mn=50ppb
GWN-P1B	Fe=2400ppb Mn=63ppb		Fe=300ppb Mn=50ppb
GWN-P6B	Mn=93ppb		Mn=50ppb
GWN-P9	Fe=1200ppb Mn=180ppb		Fe=300ppb Mn=50ppb
GWN-P10A	Fe=13000ppb Mn=120ppb Al=1100ppb		Fe=300ppb Mn=50ppb Al=200ppb
GWN-P12	Fe=2300ppb		Fe=300ppb
GWN-P15A	Fe=970ppb Mn=140ppb		Fe=300ppb Mn=50ppb
GWN-VR2	Fe=2600ppb Mn=2000ppb benzene=350ppb toluene=610ppb xylenes=480ppb ethlybenzene=160ppb	benzene=5ppb toluene=1000ppb xylenes=10000ppb ethlybenzene=700ppb	Fe=300ppb Mn=50ppb
GWN-VR4	1,1,1-trichloroethane=trace	1,1,1-trichloroethane=200ppb	
GWN-VR6	tetrachloroethylene= trace	tetrachloroethylene= 5ppb*	

*effective July 30, 1992

**highest value reported if multiple samples taken

5.0 LIST OF REFERENCES

Brooks, R., Clarke, J.S., and Faye, R.E., 1985, Hydrology of the Gordon Aquifer System of East-Central Georgia: Georgia Geologic Survey Information Circular 75, 41 p., 2 pl.

Clarke, J.S., Brooks, R., and Faye, R.E., 1985, Hydrogeology of the Dublin and Midville Aquifer Systems of East Central Georgia: Georgia Geologic Survey Information Circular 74, 62 p., 2 pl.

Clarke, J.S., Faye, R.E., and Brooks, R., 1983, Hydrogeology of the Providence Aquifer of Southwest Georgia: Georgia Geologic Survey Hydrologic Atlas 11, 5 pl.

Clarke, J.S., Faye, R.E., and Brooks, R., 1984, Hydrogeology of the Clayton Aquifer of Southwest Georgia: Georgia Geologic Survey Hydrologic Atlas 13, 6 pl.

Clarke, J.S., Hacke, C.M., and Peck, M.F., 1990, Geology and Ground-Water Resources of the Coastal Area of Georgia: Georgia Geologic Survey Bulletin 113, 116 p., 12 pl.

Crews, P.A., and Huddlestun, P.F., 1984, Geologic Sections of the Principal Artesian Aquifer System, in Hydrogeologic Evaluation for Underground Injection Control in the Coastal Plain of Georgia, R. Arora, ed., Georgia Geologic Survey Hydrologic Atlas 10, 5 p., 41pl.

Drever, J. I., 1988, The Geochemistry of Natural Waters: Prentice-Hall, Englewood Cliffs, New Jersey, 437 p.

EPD, 1991, A Ground-Water Management Plan for Georgia: Georgia Geologic Survey Circular 11, 100 p.

EPD, 1992, Rules for Safe Drinking Water, Section 391-3-5, Rules of the Georgia Department of Natural Resources Environmental Protection Division, p. 601-730.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Prentice-Hall, Englewood Cliffs, New Jersey, 604 p.

Hayes, L.R., Maslia, M.L., and Meeks, W.C., 1983, Hydrology and Model Evaluation of the Principal Artesian Aquifer, Dougherty Plain, Southwest Georgia: Georgia Geologic Survey Bulletin 97, 93 p.

Hicks, D.W., Krause, R.E., and Clarke, J.S., 1981, Geohydrology of the Albany Area, Georgia: Georgia Geologic Survey Information Circular 57, 31 p.

Joiner, C.N., Reynolds, M.S., Stayton, W.L., and Boucher, F.G., 1988, Ground-Water Data for Georgia, 1987: United States Geological Survey Open-File Report 88-323, 172 p.

Kellam, M.F., and Gorday, L.L., 1990, Hydrogeology of the Gulf Trough-Apalachicola Embayment Area, Georgia: Georgia Geologic Survey Bulletin 94, 74 p., 15 pl.

Krause, R.E., 1979, Geohydrology of Brooks, Lowndes, and Western Echols Counties, Georgia: United States Geological Survey Water-Resources Investigations 78-117, 48 p., 8 pl.

Long, A.F., 1989, Hydrogeology of the Clayton and Claiborne Aquifer Systems: Georgia Geologic Survey Hydrologic Atlas 19, 6 pl.

McFadden, S.S., and Perriello, P.D., 1983, Hydrogeology of the Clayton and Claiborne Aquifers in Southwestern Georgia: Georgia Geologic Survey Information Circular 55, 59p., 2 pl.

Pollard, L.D., and Vorhis, R.C., 1980, The Geohydrology of the Cretaceous Aquifer System in Georgia: Georgia Geologic Survey Hydrologic Atlas 3, 5 pl.

Robertson, S.J., Shellenberger, D.L., York, G.M., Clark, M.G., Eppihimer, R.M., Lineback, J.A., 1993, Sampling for Nitrate Concentrations in North Georgia's Ground Water: 1993 Georgia Water Resources Conference 364-365, 1 p.

Shellenberger, D.L., Barget, R.G., Lineback, J.A., and Shapiro, E.A., 1996, Nitrate in Georgia's Ground Water: Georgia Geologic Survey Project Report 25.

Stuart, M.A., Rich, F.J., and Bishop, G.A., 1995, Survey of Nitrate Contamination in Shallow Domestic Drinking Water Wells in the Inner Coastal Plain of Georgia: Ground Water, Vol. 33, No. 2, p. 284-290.

Vincent, R.H., 1982, Geohydrology of the Jacksonian Aquifer in Central and East Central Georgia: Georgia Geologic Survey Hydrologic Atlas 8, 3 pl.

Wait, R.L., 1960, Source and Quality of Ground Water in Southwestern Georgia: Georgia Geologic Survey Information Circular 18, 74p.

Watson, T., 1982, Aquifer Potential of the Shallow Sediments of the Coastal Area of Georgia: Proceedings, Second Symposium on the Geology of the Southeastern Coastal Plain, Arden, D.D., Beck, B.F., Morrow, E., eds., Georgia Geologic Survey Information Circular 53, p. 183-194.

Webb, G.L., 1995, Pesticide Monitoring Network 1993-1994: Georgia Geologic Survey Project Report 22.

APPENDIX

ANALYSES OF SAMPLES COLLECTED DURING 1993 FOR THE GEORGIA GROUND-WATER MONITORING NETWORK

All water quality samples that are collected for the Georgia Ground-Water Monitoring Network are subjected to a Standard Analysis which includes tests for pH, specific conductance, certain common inorganic anions, and thirty metals. Analyses for additional parameters may be included for samples that are collected from areas where the possibility of ground-water pollution exists due to regional activities. These optional tests or screens include tests for agricultural chemicals, coal-tar creosote, phenols and anilines and volatile organic compounds (Tables A-1 and A-2). Because parameters other than the two physical parameters, three of the major anions, and eight of the metals of the Standard Analysis were detected less commonly or rarely, other parameters are listed in the following analytical results table only if they were detected.

For this appendix, the following abbreviations are used:

SU	= standard units
mg/L	= milligrams per liter (parts per million)
mgN/L	= milligrams per liter (parts per million), as nitrogen
ug/L	= micrograms per liter (parts per billion)
umho/cm	= micromhos per centimeter
U	= less than (below detection limit). Where this abbreviation is used for a figure that is a calculated average, the average is below the typical detection limit for the parameter

(Note: detection limits may change due to temporarily improved instrument performance or to use of different analytical methods by different laboratories)

Table A-1. Standard Water Quality Analysis: Physical Parameters, Major Anions, Minerals and ICP/AAS Metals Screen.

Parameter	Typical Detection Limit	Max. Contaminant Level
METALS		
Silver (Ag)	30 ug/L	100 ug/L $_2$
Aluminum (Al)	50 ug/L	200 ug/L $_2$
Arsenic* (As)	25 ug/L	50 ug/L$_1$
Gold (Au)	10 ug/L	NA
Barium (Ba)	10 ug/L	2000 ug/L$_1$
Beryllium** (Be)	2 ug/L*$_1$	NA
Bismuth (Bi)	25 ug/L	NA
Cobalt (Co)	10 ug/L	NA
Chromium (Cr)	10 ug/L	100 ug/L$_1$
Cadmium** (Cd)	2.5 ug/L	5.0 ug/L$_1$
Copper (Cu)	20 ug/L	1000 ug/L$_2$
Iron (Fe)	20 ug/L	300 ug/L$_2$
Manganese (Mn)	10 ug/L	50 ug/L $_2$
Molybdenum (Mo)	10 ug/L	NA
Nickel (Ni)	20 ug/L	NA
Lead (Pb)	30 ug/L	NA
Antimony** (Sb)	3 ug/L	NA
Selenium* (Se)	25 ug/L	50 ug/L$_1$
Tin (Sn)	110 ug/L	NA
Strontium (Sr)	10 ug/L	NA
Titanium (Ti)	10 ug/L	NA
Thallium** (Tl)	1 mg/L	NA
Vanadium (V)	10 ug/L	NA
Yttrium (Y)	10 ug/L	NA

Table A-1 (continued):

Parameter	Typical Detection Limit	Max. Contaminant Level
Zinc (Zn)	20 ug/L	5000 ug/L $_2$
Zirconium (Zr)	10 ug/L	NA
Mercury*** (Hg)	0.2 ug/L	2.0 ug/L$_1$
ANIONS		
Chloride (Cl^-)	0.1 mg/L	250 mg/L $_2$
Sulfate ($SO_4^=$)	2.0 mg/L	250 mg/L$_2$
Nitrate/Nitrite (NO_x^-)	0.1 mg/L	10.0 mg/L as N$_1$
Fluoride (Fl^-)	0.1 mg/L	4.0 mg/L$_1$, 2.0 mg/L $_2$
MINERALS		
Calcium (Ca)	1.0 mg/L	NA
Potassium (K)	5.0 mg/L	NA
Magnesium (Mg)	1.0 mg/L	NA
Sodium (Na)	1.0 mg/L	NA
OTHER PARAMETERS		
pH	±0.01 SU	NA
Conductivity	1.0 mho/cm	NA

*Analyzed by atomic absorption spectrophotometry (AAS) using graphite furnace.
**Analyzed by AAS beginning sometime in 1993.
***Analyzed by manual cold vapor.
$_1$=Primary Maximum Contaminant Level (MCL).
$_2$=Secondary MCL.
NA=No MCL established.

MCL's from Georgia Rules for Safe Drinking Water, July, 1993, (EPD, 1993).

Table A-2. Additional Water Quality Analyses: Organic Screens #1, #2, #3, #4, #5, #7, #8, #9, and #10.

ORGANIC SCREEN #1 *(organophosphates/herbicides)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Alachlor	1.0 ug/L	2.0 ug/L
Atrazine	0.3 ug/L	3.0 ug/L
Azodrin	1.0 ug/L	NA
Chloropyrifos	0.8 ug/L	NA
Cyanazine	1.0 ug/L	NA
DCPA	0.01 ug/L	NA
Dasanit	0.6 ug/L	NA
Demeton	1.0 ug/L	NA
Diazinon	1.0 ug/L	NA
Dimethoate	0.5 ug/L	NA
Disyston	1.0 ug/L	NA
Eptam	0.5 ug/L	NA
Ethoprop	0.5 ug/L	NA
Fonophos	0.5 ug/L	NA
Guthion	2.0 ug/L	NA
Isopropalin	1.0 ug/L	NA
Malathion	1.4 ug/L	NA
Metolachlor	1.0 ug/L	NA
Metribuzin	1.25 ug/L	NA
Mevinphos	1.4 ug/L	NA
Parathion (E)	0.08 ug/L	NA
Parathion (M)	0.1 ug/L	NA

ORGANIC SCREEN #1 (continued) *(organophosphates/herbicides)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Pebulate	0.6 ug/L	NA
Pendimethalin	0.8 ug/L	NA
Phorate	1.0 ug/L	NA
Profluralin	0.9 ug/L	NA
Simazine	0.9 ug/L	NA
Sutan	0.7 ug/L	NA
Terbufos	3.0 ug/L	NA
Trifluralin	1.0 ug/L	NA
Vernam	0.5 ug/L	NA

ORGANIC SCREEN #2 *(organochlorine pesticides/PCB's)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Dicofol	0.1 ug/L	NA
Endrin	0.03 ug/L	0.2 ug/L
Methoxychlor	0.3 ug/L	40.0 ug/L
gamma-HCH (lindane)	0.008 ug/L	0.2 ug/L
PCB's	0.6 ug/L	0.5 ug/L
Permethrin	0.3 ug/L	NA
Toxaphene	1.2 ug/L	3.0 ug/L

ORGANIC SCREENS #3 AND #4 *(dinoseb/phenoxy herbicides)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
2,4-D	5.2 ug/L	70.0 ug/L
Acifluorfen	1.0 ug/L	NA
Chloramben	0.2 ug/L	NA
Dinoseb	0.1 ug/L	NA
Silvex	O.1 ug/L	50.0 ug/L
Trichlorofon	2.0 ug/L	NA

ORGANIC SCREEN #5 *(carbamate pesticides)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Carbaryl	2.0 ug/L	NA
Carbofuran	1.0 ug/L	40.0 ug/L
Diuron	1.0 ug/L	NA
Fluometron	1.0 ug/L	NA
Linuron	1.0 ug/L	NA
Methomyl	1.0 ug/L	NA
Monuron	1.0 ug/L	NA

ORGANIC SCREEN #7* *(volatile organic compound)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
EDB	5.0 ug/L	0.05 ug/L

**currently analyzed along with Organic Screen #10.*

ORGANIC SCREENS #8 AND #9 *(semivolatile organic compounds)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
1,2-Dichlorobenzene (o)	10.0 ug/L	600.0 ug/L
1.3-Dichlorobenzene (m)	10.0 ug/L	NA
1,4-Dichlorobenzene (p)	10.0 ug/L	75.0 ug/L
Bis(2-Chloroethyl) Ether	10.0 ug/L	NA
Hexachloroethane	10.0 ug/L	NA
N-Nitrosodi-N-Propylamine	10.0 ug/L	NA
Nitrobenzene	10.0 ug/L	NA
Hexachlorobutadiene	10.0 ug/L	NA
1,2,4-Trichlorobenzene	10.0 ug/L	NA
Napthalene	10.0 ug/L	NA
Bis(2-Chloroethoxy) Methane	10.0 ug/L	NA
Isophorone	10.0 ug/L	NA
Hexachlorocyclopentadiene	10.0 ug/L	NA
2-Chloronaphthalene	10.0 ug/L	NA
Acenaphthylene	10.0 ug/L	NA
Acenaphthene	10.0 ug/L	NA

ORGANIC SCREENS #8 AND #9 (continued) *(semivolatile organic compounds)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Dimethyl Phthalate	10.0 ug/L	NA
2,4-Dinitrotoluene	10.0 ug/L	NA
2,6-Dinitrotoluene	10.0 ug/L	NA
4-Chlorophenyl Phenyl Ether	10.0 ug/L	NA
Fluorene	10.0 ug/L	NA
Diethyl Phthalate	10.0 ug/L	NA
N-Nitrosodimethylamine	10.0 ug/L	NA
N-Nitrosodiphenylamine	10.0 ug/L	NA
Hexachlorobenzene	10.0 ug/L	NA
4-Bromophenyl Phenyl Ether	10.0 ug/L	NA
Phenanthrene	10.0 ug/L	NA
Anthracene	10.0 ug/L	NA
Di-N-Butyl Phthalate	10.0 ug/L	NA
2-Methyl Naphthalene	10.0 ug/L	NA
Dibenzofuran	10.0 ug/L	NA
Bis(2-Chloroisopropyl)Ether	10.0 ug/L	NA
2,4,5-Trichlorophenol	10.0 ug/L	NA
Fluoranthene	10.0 ug/L	NA
Pyrene	10.0 ug/L	NA
N-Butyl Benzyl Phthalate	10.0 ug/L	NA
Bis(2-Ethylhexyl)Phthalate	10.0 ug/L	NA
Chrysene	10.0 ug/L	NA
Benzo (a) Anthracene	10.0 ug/L	NA

ORGANIC SCREENS #8 AND #9 (continued) *(semivolatile organic compounds)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Di-N-Octyl Phthalate	10.0 ug/L	NA
Benzo-(B)Fluoranthene	10.0 ug/L	NA
Benzo-(K)Fluoranthene	10.0 ug/L	NA
Benzo-A-Pyrene	10.0 ug/L	NA
Indeno(1,2,3-CD)Pyrene	10.0 ug/L	NA
1,2,5,6-Dibenzanthracene	10.0 ug/L	NA
Benzo(GHI)Perylene	10.0 ug/L	NA
2-Chlorophenol	10.0 ug/L	NA
2-Nitrophenol	10.0 ug/L	NA
Phenol (GC/MS)	10.0 ug/L	NA
2,4-Dimethylphenol	10.0 ug/L	NA
2,4-Dichlorophenol	10.0 ug/L	NA
2,4,6-Trichlorophenol	10.0 ug/L	NA
4-Chloro-3-methylphenol	200.0 ug/L	NA
2,4-Dinitrophenol	50.0 ug/L	NA
4,6-Dinitro-2-methylphenol	50.0 ug/L	NA
Pentachlorophenol	50.0 ug/L	1.0 ug/L
4-Nitrophenol	50.0 ug/L	NA
Benzidine	80.0 ug/L	NA
3,3-Dichlorobenzidine	20.0 ug/L	NA
2-Methylphenol	10.0 ug/L	NA
4-Methylphenol	10.0 ug/L	NA

ORGANIC SCREEN #10 *(volatile organic compounds)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Methylene Chloride	5.0 ug/L	NA
Trichlorofluoromethane	5.0 ug/L	NA
1,1-Dichloroethylene	5.0 ug/L	7.0 ug/L
1,1-Dichloroethane	5.0 ug/L	NA
Trans 1,2-Dichloroethylene	5.0 ug/L	100.0 ug/L
Chloroform	5.0 ug/L	100.0 ug/L*
1,2-Dichloroethane	5.0 ug/L	5.0 ug/L
1,1,1-Trichloroethane	5.0 ug/L	200.0 ug/L
Carbon Tetrachloride	5.0 ug/L	5.0 ug/L
Dichlorobromomethane	5.0 ug/L	100.0 ug/L*
1,2-Dichloropropane	5.0 ug/L	5.0 ug/L
Trans-1,3-Dichloropropene	5.0 ug/L	NA
Trichloroethylene	5.0 ug/L	5.0 ug/L
Benzene	5.0 ug/L	5.0 ug/L
Chlorodibromomethane	5.0 ug/L	100.0 ug/L*
1,1,2-Trichloroethane	5.0 ug/L	NA
Cis-1,3-Dichloropropene	5.0 ug/L	NA
Bromoform	5.0 ug/L	100.0 ug/L*
1,1,2,2,-Tetrachloroethane	5.0 ug/L	NA
Tetrachloroethylene	5.0 ug/L	5.0 ug/L
Toluene	5.0 ug/L	1000.0 ug/L
Chlorobenzene	5.0 ug/L	100.0 ug/L
Ethylbenzene	5.0 ug/L	700.0 ug/L

ORGANIC SCREEN #10 (continued) *(volatile organic compounds)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Acetone	100.0 ug/L	NA
Methyl Ethyl Ketone	100.0 ug/L	NA
Carbon Disulfide	5.0 ug/L	NA
Vinyl Chloride	10.0 ug/L	2.0 ug/L
2-Hexanone	50.0 ug/L	NA
Methyl Isobutyl Ketone	50.0 ug/L	NA
Styrene	5.0 ug/L	100.0 ug/L
Xylenes (total)	5.0 ug/L	10,000.0 ug/L
Chloroethane	10.0 ug/L	NA
1,2-Dibromoethane	5.0 ug/L	NA
Vinyl Acetate	50.0 ug/L	NA
Chloromethane	10.0 ug/L	NA
Bromomethane	10.0 ug/L	NA

NA *indicates that a Maximum Contaminant Level has not yet been established.*
* *indicates a trihalomethane compound. The primary MCL for total trihalomethanes is 100 ug/L.*

1993 Ground-Water Quality Analyses of the Cretaceous Aquifer System

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-K1		4.68	1.4	5U	1.3	1U	10U	10U	20U	17	630	1.9	0.2	7.3	0.2	33		2,4
	Well Name:		Englehard Kaolin Company #2															
	County:		Wilkinson															
	Date Sampled:		1993/04/13															
GWN-K2		4.67	1.4	5U	1.4	1U	10U	10U	48	10U	45U	1.9	0.1	3.7	0.2	26		2,4,10
	Well Name:		Irwinton #2															
	County:		Wilkinson															
	Date Sampled:		1993/04/13															
GWN-K3		6.11	1.9	5U	18	1.4	63	22	720	32	45U	2.3	0.1	7.8	0.1U	97		2,4,10
	Well Name:		Sandersville #7B															
	County:		Washington															
	Date Sampled:		1993/04/12															
GWN-K5		4.97	1.4	5U	1U	1U	10U	10U	20U	10U	45U	1.4	0.1U	2U	0.6	18	bis-2-ethylhexyl-phthalate=110? fatty acids=310?	2,4,8,9,Hg
	Well Name:		Richmond County #101															
	County:		Richmond															
	Date Sampled:		1993/06/24															
GWN-K5		4.88	(special follow-up)														bis-2-ethylhexyl-phthalate=U fatty acids=U	8,9 only
	Well Name:		Richmond County #101															
	County:		Richmond															
	Date Sampled:		1993/09/23															
GWN-K5		5.24	2.1	5U	1U	1U	10U	10U	20U	10U	50U	1.5	0.1U	2U	0.6	18		2,4,8,9,Hg
	Well Name:		Richmond County #101															
	County:		Richmond															
	Date Sampled:		1993/12/30															
GWN-K6		5.64	3.5	5U	4.5	1U	59	16	20U	10U	45U	2.6	0.1	4.4	0.1U	42		10
	Well Name:		J.M. Huber #6															
	County:		Twiggs															
	Date Sampled:		1993/04/14															
GWN-K7		5.23	1.7	5U	2.1	1U	14	15	20U	10U	45U	2.5	0.1	2U	0.1U	21		2,4
	Well Name:		Jones County #4															
	County:		Jones															
	Date Sampled:		1993/04/13															

1993 Ground-Water Quality Analyses of the Cretaceous Aquifer System (Continued)

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-K8A		6.88	2.0	5U	28	1.2	120	81	4100	50	52	2.0	0.1	12	0.1U	157		10
	Well Name:	Mohawk Carpet #4																
	County:	Laurens																
	Date Sampled:	1993/11/29																
GWN-K9		4.1	1.2	5U	1U	1U	10U	10U	1200	10U	470	1.4	1.0	9.2	0.1U	47		
	Well Name:	Marshallville #1																
	County:	Macon																
	Date Sampled:	1993/04/26																
GWN-K10		4.9	4.8	5U	1.7	1U	10U	10U	20U	10U	45U	4.8	0.1U	2U	1.8	39		10
	Well Name:	Fort. Valley #1																
	County:	Peach																
	Date Sampled:	1993/04/26																
GWN-K10		5.01	3.0	5U	1.3	1U	10U	10U	20U	10U	51	3.3	0.1U	2U	1.2	32		2,4,10
	Well Name:	Fort. Valley #1																
	County:	Peach																
	Date Sampled:	1993/11/30																
GWN-K11		5.0	1.4	5U	1U	1U	10U	10U	230	10U	45U	1.1	0.1U	2U	0.2	16		10
	Well Name:	Warner Robins #1A																
	County:	Houston																
	Date Sampled:	1993/04/26																
GWN-K11		5.00	1.1	5U	1U	1U	10U	10U	210	10U	50U	1.1	0.1U	2U	0.2	16		2,4,10
	Well Name:	Warner Robins #1A																
	County:	Houston																
	Date Sampled:	1993/11/30																
GWN-K12		4.1	1.4	5U	1U	1U	10U	10U	190	12	420	4.8	0.1U	8.0	0.1U	44		5,10
	Well Name:	Perry/Holiday Inn Well																
	County:	Houston																
	Date Sampled:	1993/04/27																
GWN-K12		4.22	1.1	5U	1U	1U	10U	10U	190	13	400	1.4	0.1U	8.1	0.1U	48		1,2,3,4,5,10
	Well Name:	Perry/Holiday Inn Well																
	County:	Houston																
	Date Sampled:	1993/11/30																

1993 Ground-Water Quality Analyses of the Cretaceous Aquifer System (Continued)

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-K13		9.04	46	5U	2.2	1U	40	10U	20U	10U	45U	9.4	0.3	8.0	0.1U	171		Hg
	Well Name:	Omaha #1																
	County:	Stewart																
	Date Sampled:	1993/04/28																
GWN-K16		5.4	5.4	5U	1U	1U	10U	10U	20U	10U	45U	2.1	0.1U	6.4	0.3	27		10
	Well Name:	Packaging Corp. Amer. North Well																
	County:	Bibb																
	Date Sampled:	1993/04/28																
GWN-K16		5.41	4.9	5U	1U	1U	10U	10U	20U	10U	50U	2.2	0.1U	2.4	0.3	29	Pb=32	2,3,4,10
	Well Name:	Packaging Corp. Amer. North Well																
	County:	Bibb																
	Date Sampled:	1993/11/30																
GWN-K18		4.53	1.4	5U	1.6	1U	10U	10U	160	10U	66	3.1	0.1U	4.5	0.1U	27	Cu=23	2,3,4,10,Hg
	Well Name:	Buena Vista #6																
	County:	Marion																
	Date Sampled:	1993/04/28																
GWN-K19		4.90	2.0	5U	1U	1U	10U	10U	20U	10U	45U	1.5	0.1	2U	0.1U	17		2,3,4,10,Hg
	Well Name:	Hephzibah Murphy St. Well																
	County:	Richmond																
	Date Sampled:	1993/06/24																

1993 Ground-Water Quality Analyses of the Providence Aquifer System

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-PD2A		5.57	1.7	5U	3.8	1U	10U	13	34	10U	53	1.8	0.5	3.3	0.7	40	Pb=38	10
	Well Name:	Preston #2																
	County:	Webster																
	Date Sampled:	1993/08/25																
GWN-PD3		8.44	81	5U	6.4	1	100	10U	25	10U	50U	10.2	0.7	9.9	0.1U	263		
	Well Name:	Ft. Gaines #2																
	County:	Clay																
	Date Sampled:	1993/09/09																
GWN-PD4		7.50	2.4	5U	34	2	170	10U	71	14	45U	1.3	0.1U	11.9	0.1U	193	Pb=32 Zn=22	10
	Well Name:	Americus #3																
	County:	Sumter																
	Date Sampled:	1993/08/25																

1993 Ground-Water Quality Analyses of the Clayton Aquifer System

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-CT2A		7.76	6.1	5U	42	2.9	270	10U	170	10U	50U	1.3	0.1	19.0	0.1U	227	Zn=29	1,2,3,4,5
	Well Name:	Burton Thomas Residence Well																
	County:	Sumter																
	Date Sampled:	1993/10/27																
GWN-CT3		7.88	7.4	5U	40	4.1	410	10U	24	10U	50U	1.8	0.1	13.8	0.1U	237		10
	Well Name:	Dawson Crawford St. Well																
	County:	Terrell																
	Date Sampled:	1993/04/13																
GWN-CT5A		7.92	2.3	5U	45	3.8	150	16	250	33	50U	1.8	0.1U	12.4	0.1U	226	Sn=105	1,2,3,4,5
	Well Name:	Cuthbert #3																
	County:	Randolph																
	Date Sampled:	1993/10/27																
GWN-CT7A		4.67	2.0	5U	5.0	6.0	77	29	250	14	510	14	0.1U	2U	9.2	115	Ti=14	1,2,3,4,5,10
	Well Name:	St. John Farm Well																
	County:	Sumter																
	Date Sampled:	1993/10/27																

1993 Ground-Water Quality Analyses of the Claiborne Aquifer System

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-CL2		7.47	1.4	5U	44	1U	100	12	22	10U	45U	1.4	0.2	7.3	0.1U	197		3,4
	Well Name:	Unadilla #3																
	County:	Dooly																
	Date Sampled:	1993/08/27																
GWN-CL4		4.93	4.2	5U	2.1	1.2	14	16	22	56	85	6.5	0.1U	2U	3.1	56	Cu=47 Zn=49	1,2,3,4,5,10
	Well Name:	Plains #3																
	County:	Sumter																
	Date Sampled:	1993/08/25																
GWN-CL5		4.27	3.1	5U	6.6	2.6	39	63	20U	680	440	10.4	0.1	2U	9.8	124	Co=28 Pb=37 Y=77 Zn=33	2,4,10
	Well Name:	Shellman #2																
	County:	Randolph																
	Date Sampled:	1993/10/05																
GWN-CL8		4.86	2.6	5U	5.9	3.1	51	110	160	120	140	5.98	0.1U	2U	7.0	87	Y=14	1,2,3,4,5
	Well Name:	Flint River Nursery office well																
	County:	Dooly																
	Date Sampled:	1993/08/25																

1993 Ground-Water Quality Analyses of the Jacksonian Aquifer System

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-J1B		7.27	3.4	5U	59	1U	25	19	20U	10U	45U	8.1	0.1	2U	1.8	265		1,2,3,4,5
	Well Name:	Hudlow house well																
	County:	Burke																
	Date Sampled:	1993/06/23																
GWN-J2A		7.46	1.3	5U	53	1U	57	56	36	10U	45U	1.7	0.1U	2U	0.4	229	Zn=22ppb CHCl3=tr. CxHx=tr.	1,2,3,4,5,10
	Well Name:	Oakwood Village Mobile Home Park #2																
	County:	Burke																
	Date Sampled:	1993/06/23																
GWN-J3		7.81	11	5U	36	6.0	290	670	170	100	45U	7.3	0.1	2U	0.1U	237		1,2,3,4,5,10
	Well Name:	Black house well																
	County:	Emanuel																
	Date Sampled:	1993/06/21																
GWN-J4		7.70	4.0	5U	49	2.3	180	10U	20U	10U	45U	2.4	0.1U	6.5	0.1U	248		1,2,3,4,5,10
	Well Name:	Wrightsville #4																
	County:	Johnson																
	Date Sampled:	1993/06/21																
GWN-J5		7.43	3.3	5U	68	2.4	220	10U	70	35	45U	2.3	0.1	11.9	0.1U	344		1,2,3,4,5,10
	Well Name:	Cochran #3																
	County:	Bleckley																
	Date Sampled:	1993/06/21																
GWN-J6		6.70	1.5	5U	30	1U	36	12	160	13	45U	1.5	0.1	7.6	0.1U	139		1,2,3,4,5,10, Hg
	Well Name:	Wrens #3																
	County:	Jefferson																
	Date Sampled:	1993/06/23																
	Note: In previous editions of Circular 12, this well has been incorrectly labeled Well #4.																	
GWN-J7		4.82	3.3	5U	2.7	1.4	16	22	70	21	45U	6.4	0.1	2U	2.3	50	Cu=27 Zn=160	1,2,3,4,5
	Well Name:	Templeton livestock well																
	County:	Burke																
	Date Sampled:	1993/06/24																

1993 Ground-Water Quality Analyses of the Floridan Aquifer System

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-PA1		7.99	31	5U	28	11	380	10U	20U	10U	45U	56.4	0.4	9.5	0.1U	360		
	Well Name:		Thunderbolt #1															
	County:		Chatham															
	Date Sampled:		1993/06/22															
GWN-PA2		8.02	11	5U	24	7.9	290	11	25	10U	45U	3.9	0.3	5.2	0.1U	212		
	Well Name:		Savannah #6															
	County:		Chatham															
	Date Sampled:		1993/06/22															
GWN-PA4		7.98	50	5U	33	23	1200	10U	20U	10U	35U	48.1	0.6	146.8	0.1U	543		
	Well Name:		Tybee Island #1															
	County:		Chatham															
	Date Sampled:		1993/06/22															
GWN-PA9C		7.6	690	14	170	94	2700	67	370	10U	330	844.9	0.6	2U	0.1U	4960	V=19	10
	Well Name:		Miller Ball Park TW25															
	County:		Glynn															
	Date Sampled:		1993/01/19															
GWN-PA10B		7.3	67	5U	78	39	820	38	29	10U	210	0.1U	0.5	231.8	0.1U	872		
	Well Name:		Gilman Paper #11															
	County:		Camden															
	Date Sampled:		1993/01/20															
GWN-PA14		8.00	6.9	5U	36	5.2	230	30	20U	10U	78	2.7	0.3	5.5	0.1U	207		10
	Well Name:		Statesboro #7															
	County:		Bulloch															
	Date Sampled:		1993/04/12															
GWN-PA15		7.9	9.1	5U	29	8.8	440	10U	43	10U	75	2.3	0.2	7.3	0.1U	221		10
	Well Name:		King Finishing Co. fire well															
	County:		Screven															
	Date Sampled:		1993/01/06															
GWN-PA16		7.6	5.6	5U	49	3.2	210	10U	32	37	130	6.2	0.1U	8.7	0.1U	256		10
	Well Name:		Millen #1															
	County:		Jenkins															
	Date Sampled:		1993/01/06															

1993 Ground-Water Quality Analyses of the Floridan Aquifer System (Continued)

PARAMETER / Well ID#	UNITS	pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
		SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-PA24		7.98	2.1	5U	41	3.5	42	10U	20U	10U	83	2.8	0.1U	2U	1.4	219		2,3,4,10
	Well Name:		Bainbridge #1															
	County:		Decatur															
	Date Sampled:		1993/03/23															
GWN-PA24		7.78	2.3	5U	39	3.3	35	10U	20U	10U	50U	3.0	0.1	2U	1.2	197		1,2,3,4,5,10
	Well Name:		Bainbridge #1															
	County:		Decatur															
	Date Sampled:		1993/09/08															
GWN-PA25		7.86	4.1	5U	60	1U	28	10U	20U	10U	120	4.3	0.1U	2U	1.3	268		2,3,4,10
	Well Name:		Donalsonville 7th Street Well															
	County:		Seminole															
	Date Sampled:		1993/03/23															
GWN-PA25		7.53	4.2	5U	57	1U	25	10U	20U	10U	50U	4.6	0.1U	2U	1.3	253		1,2,3,4,5,10
	Well Name:		Donalsonville 7th Street Well															
	County:		Seminole															
	Date Sampled:		1993/09/09															
GWN-PA26		7.75	2.8	5U	48	1U	21	10U	20U	10U	120	2.8	0.1U	2U	1.4	217		2,3,4,10
	Well Name:		Colquitt #3															
	County:		Miller															
	Date Sampled:		1993/03/23															
GWN-PA26		7.68	2.6	5U	46	1U	19	10U	20U	10U	62	3.3	0.1U	2U	1.8	203		1,2,3,4,5,10
	Well Name:		Colquitt #3															
	County:		Miller															
	Date Sampled:		1993/09/09															
GWN-PA27		7.82	1.6	5U	47	1.2	43	10	20U	10U	89	2.1	0.1U	2U	0.2	220		2,3,4,8,9,10
	Well Name:		Camilla New Well															
	County:		Mitchell															
	Date Sampled:		1993/03/23															
GWN-PA27		7.68	2.2	5U	45	1.2	36	10U	20U	10U	<50	2.3	0.1U	2U	0.1U	2U		1,2,3,4,5,8,9,10
	Well Name:		Camilla New Well															
	County:		Mitchell															
	Date Sampled:		1993/09/08															

1993 Ground-Water Quality Analyses of the Floridan Aquifer System (Continued)

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-PA28		7.8	29	5U	41	22	250	95	20U	10U	100	10.4	0.6	141	0.1U	443		10
	Well Name:		Moultrie #1															
	County:		Colquitt															
	Date Sampled:		1993/02/17															
GWN-PA29		7.81	3.7	5U	46	15	310	15	73	37	120	3.1	0.3	53	0.1U	317	Zr=15	
	Well Name:		Adel #6															
	County:		Cook															
	Date Sampled:		1993/03/23															
GWN-PA29		8.02	4.5	5U	44	14	260	15	65	31	45U	2.9	0.2	46	0.1U	300	Zn=630	
	Well Name:		Adel #6															
	County:		Cook															
	Date Sampled:		1993/08/26															
GWN-PA30		7.8	5.5	5U	45	17	28	57	20U	24	110	0.1U	0.3	2U	0.1	334	Zr=10	
	Well Name:		Amoco/Nashville Mills #2															
	County:		Berrien															
	Date Sampled:		1993/02/18															
GWN-PA30		7.84	4.5	5U	43	15	220	49	20U	10U	45U	4.2	0.3	55.6	0.1U	328		
	Well Name:		Amoco/Nashville Mills #2															
	County:		Berrien															
	Date Sampled:		1993/08/26															
GWN-PA31		7.6	2.6	5U	47	8.5	31	67	20U	10U	100	2.0	0.4	2U	0.1U	260		
	Well Name:		Tifton #6															
	County:		Tift															
	Date Sampled:		1993/02/17															
GWN-PA32		7.7	2.5	5U	37	5.1	18	81	130	27	87	2.1	0.1	2U	0.1U	197		
	Well Name:		Ocilla #3															
	County:		Irwin															
	Date Sampled:		1993/02/17															
GWN-PA33		8.0	3.3	5U	24	8.7	31	2200	20U	14	61	2.1	0.2	2U	0.1U	171		10
	Well Name:		Fitzgerald Well C															
	County:		Ben Hill															
	Date Sampled:		1993/02/17															

1993 Ground-Water Quality Analyses of the Floridan Aquifer System (Continued)

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-PA34		7.39	4.9	5U	48	10	740	260	180	100	50U	5.2	0.1	3.2	0.1U	309		10
	Well Name:	McRae Telfair Ave. Well																
	County:	Telfair																
	Date Sampled:	1993/12/29																
GWN-PA35		7.85	6.6	5U	29	13	490	95	57	31	50U	3.2	0.3	6.8	0.1U	254		
	Well Name:	Mt. Vernon New Well																
	County:	Montgomery																
	Date Sampled:	1993/12/29																
GWN-PA36		7.98	11	5U	28	5.3	370	150	23	37	50U	3.6	0.3	3.1	0.1U	214		
	Well Name:	Vidalia #1																
	County:	Toombs																
	Date Sampled:	1993/12/29																
GWN-PA38		7.56	2.1	5U	43	1.4	96	120	20U	10U	50U	2.0	0.1U	2U	0.1U	217		10
	Well Name:	Eastman #4																
	County:	Dodge																
	Date Sampled:	1993/12/29																
GWN-PA39		7.50	3.7	5U	52	7.3	430	190	20U	10U	110	2.5	0.3	2U	0.1U	278	V=10 Zn=56 Zr=15	10
	Well Name:	Sylvester #1																
	County:	Worth																
	Date Sampled:	1993/03/22																
GWN-PA39		7.51	3.4	5U	48	7.7	364	175	20U	10U	50U	2.2	0.2	2U	0.1U	265		10
	Well Name:	Sylvester #1																
	County:	Worth																
	Date Sampled:	1993/09/08																
GWN-PA40		7.56	2.7	5U	64	1.2	59	17	20U	10U	140	3.1	0.16	2U	1.5	271	Zn=28	10
	Well Name:	Merck and Co. #8																
	County:	Worth																
	Date Sampled:	1993/03/22																
GWN-PA40		7.45	2.9	5U	59	1.1	51	16	20U	10U	50U	3.4	0.1U	2U	1.5	263		10
	Well Name:	Merck and Co. #8																
	County:	Worth																
	Date Sampled:	1993/09/08																

1993 Ground-Water Quality Analyses of the Floridan Aquifer System (Continued)

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-PA43		7.76	2.9	5U	49	1U	45	10U	20U	10U	99	3.1	0.1U	2U	1.7	229		2,3,4,10
	Well Name:		Newton #1															
	County:		Baker															
	Date Sampled:		1993/03/23															
GWN-PA43		7.59	3.5	5U	47	1.0	43	5U	20U	10U	50U	3.2	0.1U	2U	1.7	215		1,2,3,4,5,10
	Well Name:		Newton #1															
	County:		Baker															
	Date Sampled:		1993/09/08															
GWN-PA44		7.8	2.4	5U	33	4.3	33	150	20U	10U	85	1.6	0.2	2U	0.1	180		10
	Well Name:		Sycamore #2															
	County:		Turner															
	Date Sampled:		1993/02/17															
GWN-PA45A		7.5	1.8	5U	57	1.1	10U	70	20U	10U	140	2.1	0.1U	2U	0.2	250		
	Well Name:		Abbeville #1															
	County:		Wilcox															
	Date Sampled:		1993/02/16															
GWN-PA46B		7.7	2.9	5U	48	1.0	10U	40	20U	10U	110	6.0	0.1	2U	4.4	226		1,2,3,4,5,10
	Well Name:		Wenona Mobile Home Park well															
	County:		Crisp															
	Date Sampled:		1993/02/16															
GWN-PA49		7.8	1.8	5U	42	1U	10U	20	20U	10U	94	2.1	0.1	2U	1.1	194	Zn=34	1,2,3,4,5
	Well Name:		Harmony Church well															
	County:		Dooly															
	Date Sampled:		1993/2/2															
GWN-PA50		7.36	3.4	5U	57	1.4	170	43	480	19	50U	4.0	0.1U	4.5	1.1	281		1,2,3,4,5
	Well Name:		Reynolds house well															
	County:		Laurens															
	Date Sampled:		1993/12/28															
GWN-PA51		7.75	3.0	5U	49	1U	26	10U	20U	10U	100	3.6	0.1	2U	1.6	228	Zn=31	2,3,4,5
	Well Name:		J.L. Adams house well															
	County:		Mitchell															
	Date Sampled:		1993/03/23															

1993 Ground-Water Quality Analyses of the Floridan Aquifer System (Continued)

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-PA52		7.92	2.3	5U	42	1U	28	10U	20U	10U	90	3.6	0.1	2U	3.0	201	Se=7.2 Zn=27	2,3,4,5
	Well Name:	J. Simmons house well																
	County:	Mitchell																
	Date Sampled:	1993/03/23																
GWN-PA53		7.82	3.0	5U	39	1U	24	11	20U	10U	50U	5.6	0.1U	2U	4.8	197	Zn=50	1,2,3,4
	Well Name:	L. Cato house well																
	County:	Decatur																
	Date Sampled:	1993/10/28																
GWN-PA55		7.74	3.1	5U	52	2.3	220	150	48	10U	45U	2.1	0.2	4.5	0.1U	243		1,2,3,4,5
	Well Name:	W. Holland house well																
	County:	Burke																
	Date Sampled:	1993/06/23																

1993 Ground-Water Quality Analyses of the Miocene Aquifer System

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-MI1		8.04	7.3	5U	24	13	120	20	110	28	69	2.9	0.5	4.2	0.1U	223	Zn=190, Zr=11	1,3,4,5,10, Hg
	Well Name:	McMillan house well																
	County:	Cook																
	Date Sampled:	1993/04/27																
GWN-MI2		6.06	2.5	5U	3.2	1.0	10U	10U	20U	10U	45U	2.7	0.5	2U	0.1U	40		1,3,4,5,8,9, 10,Hg
	Well Name:	Boutwell house well																
	County:	Lowndes																
	Date Sampled:	1993/04/27																
GWN-MI3		7.5	24	5U	71	11	480	11	230	18	180	38.3	0.3	49.6	0.1U	475		2,3,4,10
	Well Name:	Coffin Park TW 3																
	County:	Glynn																
	Date Sampled:	1993/01/20																
GWN-MI5		6.0	4.5	5U	9.4	1.3	40	47	690	37	3400	6.7	0.1	3.7	1.4	88	Ti=140	1,2,3,4
	Well Name:	Carter house well																
	County:	Appling																
	Date Sampled:	1993/02/01																
GWN-MI7		4.27	5.3	5U	6	5.2	58	93	28	17	840	16.3	0.2	2U	13.3	153	Zn=33	1,2,3,4
	Well Name:	Chaudoin house well																
	County:	Irwin																
	Date Sampled:	1993/10/25																
GWN-MI8A		4.25	4.2	5.4	6.9	5.2	61	140	44	48	1300	15.9	0.1	2U	13.5	162	Zn=42	1,2,3,4,5
	Well Name:	Barry house well																
	County:	Colquitt																
	Date Sampled:	1993/10/26																
GWN-MI9A		5.35	4.8	5U	4.7	3.1	31	34	140	35	170	7.7	0.1U	2U	7.5	84	Cu=25 Zn=48	1,2,3,4
	Well Name:	Murphy garden well																
	County:	Thomas																
	Date Sampled:	1993/10/26																
GWN-MI10B		6.57	7.1	5.1U	9.5	6.2	89	210	520	150	50U	2.8	0.4	2U	0.1U	122	Zn=120	1,2,3,4,5
	Well Name:	Calhoun house well																
	County:	Colquitt																
	Date Sampled:	1993/10/26																

1993 Ground-Water Quality Analyses of the Miocene Aquifer System (Continued)

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-MI12		7.61	2.3	5U	46	1.2	36	11	270	17	<50	4.2	0.1	2U	0.1U	231	Zn=34	1,2,3,4,5
	Well Name:	Herzog nursery well																
	County:	Brooks																
	Date Sampled:	1993/10/26																
GWN-MI13		7.5	2.5	5U	54	1U	52	24	2200	210	140	3.0	0.1U	2U	0.1U	232	As=17.4	1,2,3,4
	Well Name:	Meeks rental house well																
	County:	Screven																
	Date Sampled:	1993/01/06																
GWN-MI14		4.7	8.2	5U	1U	1U	11	12	140	<10	170	8.8	0.1U	2U	0.1U	74	Zn=20	1,2,3,4,5
	Well Name:	Thomas rental house well																
	County:	Bulloch																
	Date Sampled:	1993/01/06																
GWN-MI15		5.0	1.9	5U	11	8.7	110	61	310	19	600	10.4	0.1U	2U	18.4	156	Ti=12 Zn=61	1,2,3,4,5
	Well Name:	Aldrich house well																
	County:	Bulloch																
	Date Sampled:	1993/01/06																

1993 Ground-Water Quality Analyses of the Piedmont/Blue Ridge Unconfined Aquifers

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-BR1A		6.65	2.4	5U	17	1U	94	16	100	13	45U	1U	0.1U	3.7	0.1U	98	Zn=93	
	Well Name:	Hiawassee #7																
	County:	Towns																
	Date Sampled:	1993/07/20																
GWN-BR2A		5.62	3.4	5U	3.6	1.4	38	43	20U	10U	45U	3.1	0.1U	2U	1.2	51		10
	Well Name:	Notla Water Auth. #3																
	County:	Union																
	Date Sampled:	1993/07/20																
GWN-BR3A		5.79	4.5	5U	3.3	1.5	24	26	25	83	93	5.2	0.1U	2U	1.5	72	Zn=29	
	Well Name:	Dawsonville City Spring																
	County:	Dawson																
	Date Sampled:	1993/07/20																
GWN-P1B		6.47	10	5.6	8.3	2.6	100	11	2400	63	45U	5.7	0.1U	19.2	0.1U	111	V=10 Zn=34	
	Well Name:	Luthersville New Well																
	County:	Meriwether																
	Date Sampled:	1993/04/29																
GWN-P2		6.70	11	5.0	15	1.5	83	24	58	16	50	2.5	0.2	2U	1.1	118	Mo=12 V=17 Zn=26	10,Hg
	Well Name:	Riverdale Delta Drive Well																
	County:	Clayton																
	Date Sampled:	1993/05/20																
GWN-P4C		6.11	7.8	5U	6.8	1.1	69	21	20U	10U	45U	1.4	0.4	2U	1.4	81	V=10	
	Well Name:	Barton Brands #3																
	County:	Fulton																
	Date Sampled:	1993/05/20																
GWN-P5		6.94	1.6	5U	22	3.7	84	28	20U	10U	50U	1.4	0.1U	2U	0.4	143		10
	Well Name:	Flowery Branch #1																
	County:	Hall																
	Date Sampled:	1993/11/23																
GWN-P6B		7.61	8.4	5U	17	2.5	45	10U	76	93	69	2.1	0.3	5.8	0.1U	137		Hg
	Well Name:	Shiloh #1																
	County:	Harris																
	Date Sampled:	1993/04/29																

1993 Ground-Water Quality Analyses of the Piedmont/Blue Ridge Unconfined Aquifers (Continued)

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-P7		6.52	9.0	5.5	13	5.0	75	54	20U	10U	54	2.3	0.1U	4.3	0.2	124	Mo=13 V=26	10,Hg
	Well Name:		Hampton #6															
	County:		Henry															
	Date Sampled:		1993/05/20															
GWN-P8		6.80	8.3	5U	27	8.3	74	10U	21	25	50U	12.6	0.2	6.1	0.1U	222		8,9,10
	Well Name:		Wayne Poultry #4															
	County:		Jackson															
	Date Sampled:		1993/11/23															
GWN-P9		6.25	17	5U	23	10	180	49	1200	180	56	8.7	0.2	69.0	0.1U	252		
	Well Name:		Gray #4															
	County:		Jones															
	Date Sampled:		1993/04/13															
GWN-P10A		6.26	7.8	5U	6.8	3.9	83	17	13000	120	1100	4.2	0.1	33.3	0.1U	114	Be=2.2 Zn=94	10
	Well Name:		Franklin Springs #4															
	County:		Franklin															
	Date Sampled:		1993/11/23															
GWN-P11A		6.59	7.1	5U	11	5.0	32	10	110	21	50U	2.6	0.2	6.1	0.2	120	Zn=150	
	Well Name:		Danielsville #3															
	County:		Madison															
	Date Sampled:		1993/11/23															
GWN-P12		6.33	13	5U	9.0	2.2	70	41	2300	10	45U	11.4	0.1U	3.5	4.0	132	Zn=93	Hg
	Well Name:		Specialty Brands #1															
	County:		Meriwether															
	Date Sampled:		1993/04/29															
GWN-P13A		5.81	7.0	5.4	4.8	1.2	40	29	20U	10U	45U	8.7	0.1U	2U	0.7	71	Mo=13 V=18	10
	Well Name:		Covington Academy Spring															
	County:		Newton															
	Date Sampled:		1993/05/20															
GWN-P14		5.12	1.8	5U	1U	1U	10U	29	20U	10U	45U	1.5	0.1U	2U	0.3	23		Hg
	Well Name:		Upson County Sunset Village well															
	County:		Upson															
	Date Sampled:		1993/04/28															

1993 Ground-Water Quality Analyses of the Piedmont/Blue Ridge Unconfined Aquifers (Continued)

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-P15A		7.24	8.8	6.7	22	4.8	100	65	970	140	61	8.0	0.2	6.5	0.1U	176	V=11 Zn=270	10

Well Name: Bolton garden well
County: DeKalb
Date Sampled: 1993/05/20

1993 Ground-Water Quality Analyses of the Valley and Ridge Unconfined Aquifers

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-VR1		7.85	1.3	5U	29	14	16	10U	20U	10U	45U	1.7	0.1U	2U	0.4	229		10
	Well Name:	Floyd County Kingston Rd, Well																
	County:	Floyd																
	Date Sampled:	1993/07/14																
GWN-VR2		6.8	15	5U	65	22	10U	36	2600	2000	170	21.7	0.1U	14.1	0.1U	469	Cu=31 Zn=51 benzene=350 toluene=610 ethylbenzene=160 trimethylbenzene=980 xylenes=480	10
	Well Name:	Hucheson Medical Center cooling well																
	County:	Catoosa																
	Date Sampled:	1993/02/09																
GWN-VR3		7.53	1.1	5U	33	13	25	72	20U	10U	45U	1.4	0.1U	2U	0.5	245		10
	Well Name:	Chickamauga Crawfish Spring																
	County:	Walker																
	Date Sampled:	1993/07/13																
GWN-VR4		7.28	14	5U	83	18	680	110	69	20	45U	11.9	0.2	47.1	0.1U	542	111-trichloroethane=t	10
	Well Name:	Coats-American #3																
	County:	Walker																
	Date Sampled:	1993/07/13																
GWN-VR5		7.17	53	5U	79	3.6	170	96	20U	10U	35U	8.2	0.1U	3.3	3.0	404		
	Well Name:	Chattooga County #4																
	County:	Chattooga																
	Date Sampled:	1993/08/04																
GWN-VR6		7.80	5.4	5U	31	16	240	590	20U	10U	45U	4.6	0.1U	4.6	0.6	278	tetrachloroethylene=tr	10
	Well Name:	Chemical Products Corp. East Well																
	County:	Bartow																
	Date Sampled:	1993/07/14																
GWN-VR7		7.94	1.1	5U	32	14	23	29	20U	10U	45U	1.1	0.1U	2U	0.3	238		10
	Well Name:	Adairsville Lewis Spring																
	County:	Bartow																
	Date Sampled:	1993/07/13																

1993 Ground-Water Quality Analyses of the Valley and Ridge Unconfined Aquifers (Continued)

PARAMETER		pH	Na	K	Ca	Mg	Sr	Ba	Fe	Mn	Al	Cl	F	SO4	Nitrate/ Nitrite	Spec. Cond.	Other Parameters Detected	Other Screens Tested
Well ID#	UNITS	SU	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	mgN/L	mho/cm	ug/L	
GWN-VR8		7.67	1.5	5U	35	14	20	11	20U	10U	45U	1.6	0.2	2U	0.4	250		10
	Well Name:		Cedartown Spring															
	County:		Polk															
	Date Sampled:		1993/07/14															
GWN-VR9		7.61	1.2	5U	40	12.0	24	10U	20U	10U	45U	1.9	0.1U	2U	0.5	257		10
	Well Name:		Polk County #2															
	County:		Polk															
	Date Sampled:		1993/07/14															

Editor and Cartographer: Donald L. Shellenberger