GROUND-WATER QUALITY IN GEORGIA FOR 1994

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GEORGIA DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA GEOLOGIC SURVEY

ATLANTA
1997

CIRCULAR 12K

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

This report for calendar year 1994 is the eleventh 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 statewide 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. The Geologic Survey Branch of EPD maintains this program, which is designed to evaluate the ambient ground-water quality of ten aquifer systems throughout the State of Georgia. The data collected from sampling on the Ground-Water Monitoring Network form the basis for this report.

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 the residents of Georgia are using.

3. Special studies addressing specific water quality issues. A survey of nitrite /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 (GDA), (Webb, 1995) are examples of these types of studies. The special studies undertaken also included investigations intended to measure the effects that flooding associated with Tropical Storm Alberto had on ground-water quality.

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. The U.S. Environmental Protection Agency (EPA) approved Georgia's WHP Plan on September 30, 1992. The WHP Plan became a part of the Georgia Safe Drinking Water Rules, effective July 1, 1993. The protection of public water supply wells from contaminants is important not only for maintaining ground-water quality but also for ensuring that public water supplies meet health standards.

Analyses of water samples collected for the Georgia Ground-Water Monitoring Network during calendar year 1994 and from previous years form the data base for this summary. The Georgia Ground-Water Monitoring Network comprises 128 wells and springs. Though sampled at various frequencies in the past, all stations on the network switched to an annual sampling frequency during 1994. In 1994, EPD personnel collected 97 samples from 85 wells and 4 springs. Preliminary scheduling for 1995 includes stations not visited in 1994; data from these visits will be presented in the 1995 report. A review of the 1994 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. Among 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 discharged to a surface-water body (e.g., stream, river, lake, or ocean). The initial water chemistry, the amount of recharge, 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 have 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

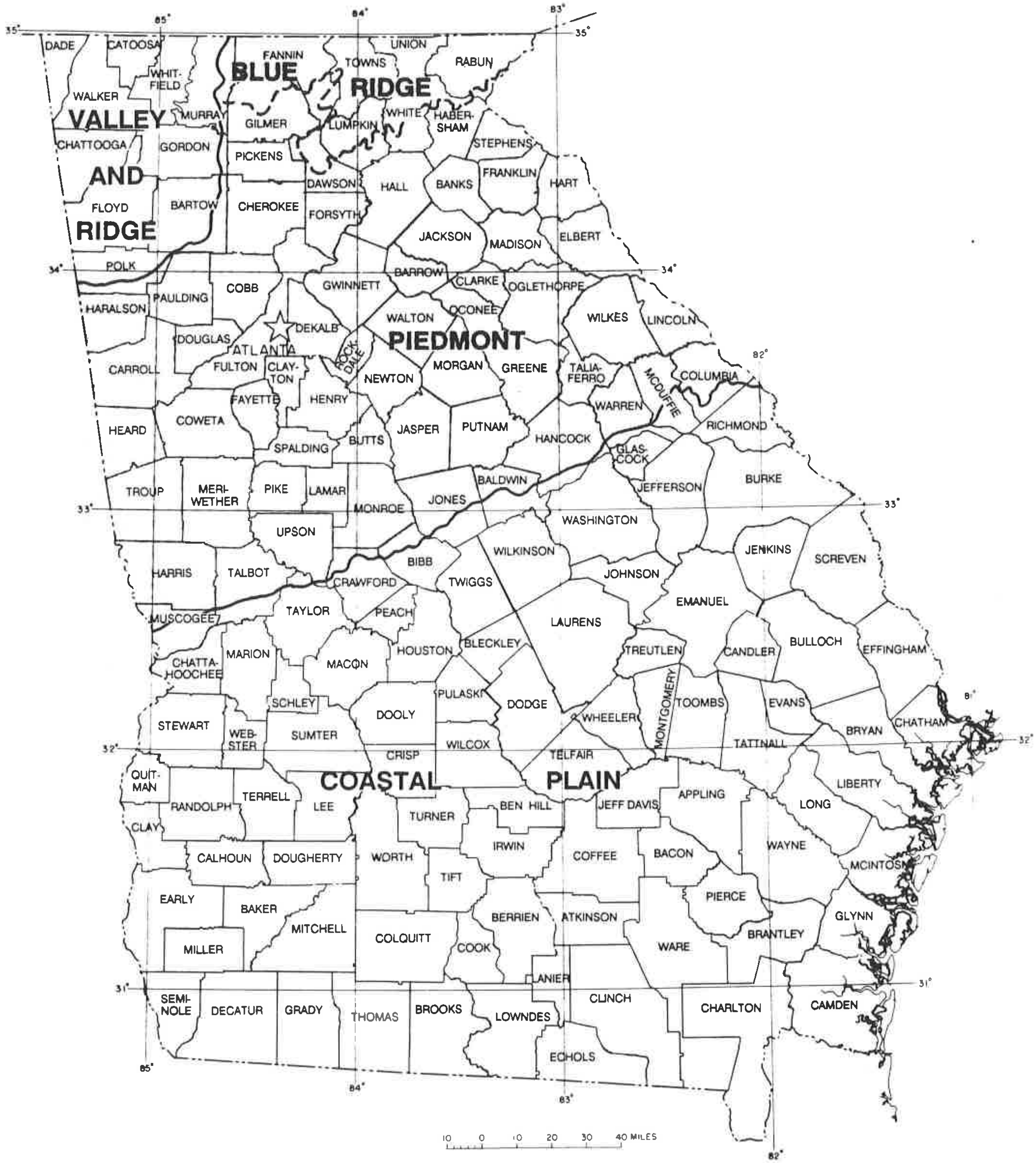


Figure 1-1. - The Hydrogeologic Provinces of Georgia

corner of Georgia; and

3. the Valley and Ridge Province of northwest Georgia.

1.3.1 Coastal Plain Province

Georgia's Coastal Plain Province generally comprises 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 aquifers are those in which a layer of impermeable material (i.e., 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 more permeable sediments of the aquifer tend to be exposed. Many 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.

The sediments 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 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. The Floridan aquifer system (primarily carbonates) serves most of south-central and southeastern Georgia. The Miocene aquifer system (primarily sands) is the principal "shallow" unconfined aquifer system occupying much of the same broad area underlain by the Floridan aquifer system. It becomes confined in the coastal counties and locally in the Grady, Thomas, Brooks and Lowndes County 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 toward 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

Consolidated Paleozoic sedimentary formations characterize the Valley and Ridge Province. The principal permeable features of the Valley and Ridge Province are fractures and solution voids; intergranular porosity also is important in some places. Locally, ground-water and surface-water systems closely interconnect. 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 (see 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 both 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 southern Georgia are usually 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 besides the karst plain area (Dougherty 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. Here, ground water is typically high in total dissolved solids and contains elevated levels of barium, sulfate, and radionuclides. The second is the coastal area of Georgia, where influx of water with high dissolved solids contents presents problems. In the Brunswick area, ground-water withdrawal from the upper Floridan results in up-coning of water with high dissolved solids contents from deeper parts of the aquifer. In the Savannah region, a cone of depression caused by pumping in and around Savannah induces saline ground water to flow down-gradient from the Port Royal Sound area of South Carolina toward Savannah.

1.5 TROPICAL STORM ALBERTO

[*"Tropical Storm Alberto has made landfall, is currently centered over Dothan, Alabama, and is rapidly losing strength."* -- weather announcement televised on the evening of July 3, 1994.]

The above weather announcement gave no hint of what would shortly befall the State. On July 3, 1994, Tropical Storm Alberto, by then officially downgraded to a tropical depression, began moving northeastward into Georgia (Stamey, 1995). Over the next four days, the storm unleashed torrential rainfall over a broad area of western, central, and southwestern Georgia, advancing as far north as the southern and eastern portions of the metro Atlanta area, then retreating into central Alabama. Americus and the surrounding area received the most precipitation, an unprecidented 27.6 inches over the five-day period. The greatest volume of the deluge fell in the Flint and Ocmulgee River basins; over the following two weeks, both basins had the worst flooding on record. The storm and the resultant flooding took 31 lives and caused an estimated $1,000,000,000 in damage. Especially severe harm befell roads, railroads, bridges, dams, public water systems, crop and forest lands, and housing. A number of communities lost water service, and, flooding of major thoroughfares made access to certain areas, notably Macon and Americus, extremely difficult. The flooding contaminated two public water-supply wells on the Ground-Water Monitoring Network, Newton Well #1 (GWN-PA43) with coliform bacteria and Shellman Well #3 (GWN-CL5) with nitrate/nitrite, and forced their eventual abandonment.

In the late summer of 1994, EPD and local health departments sampled and analyzed approximately six thousand wells (McLemore, 1995, letter to Representative Robert Hanner) for coliform bacteria. In the winter of 1995, EPD resampled, or attempted to resample, 153 wells (approximately a 2.5 percent spot check) and test the samples again for such bacteria. In general, EPD concentrated its resampling efforts to those counties that (a) were most severely affected by the Flint River flooding and (b) were sinkhole-prone, as some speculation existed that some flood waters had entered and contaminated the Floridan aquifer via sink holes. Of the 153 wells, fifty-seven percent were wells which, while testing positive for coliform bacteria in the summer of 1994, tested negative in the winter of 1995; twenty percent were wells that remained positive. Thirteen percent were wells that tested negative during both the summer 1994 sampling and the winter 1995 sampling. Bacteria measurements were indeterminate or infeasible for ten percent of the wells. In other words, approximately seventy-four percent of the summer 1994 bacteria-contaminated wells were negative in the winter of 1995, and, no uncontaminated wells became contaminated between summer and winter. Also, wells proximal to the Flint River, that had been contaminated with bacteria appeared to be "cleaning up" similar to wells distal to the river. Although the information base was limited, long-term bacterial contamination appeared to correlate with well construction (i.e., more commonly associated with ungrouted wells). EPD's analysis indicated that the bulk of the Floridan aquifer of the Lower Flint River Basin should be considered free of bacteria contamination. Although no data suggested that they actually occur, some isolated pockets of flood water may have continued to exist within the aquifer.

One special Geologic Survey investigation examined nitrate/nitrite contamination in Shellman Well #3 (GWN-CL5). This examination concluded that unusually heavy precipitation had flushed nitrate fertilizers out of row crop fields and pecan groves in the vicinity of the town, elevating the nitrate content of the well water above the primary MCL (Lineback, 1994, Georgia Geologic Survey internal memorandum).

A study undertaken by the U.S. Geological Survey (Hicks, 1995) examined the effects of the flood on ground-water hydrology in the Upper Floridan in an area along the Flint River in southern Lee, western Worth, Dougherty, northern Baker, and northern Mitchell Counties. The study concluded that (a) in an area north of Albany, the potentiometric surface rose slowly because of the lower hydraulic conductivity of the aquifer in that area; (b) in the general Albany area and south of the city, the potentiometric surface rose rapidly because of higher hydraulic conductivity, but the slope of the potentiometric surface, inclined steeply upward away from the river, would have limited river water intrusion into the aquifer; and (c) in an area around Newton, the rise of the potentiometric surface was also rapid, but the slope of the potentiometric surface, gently upward away from the river, would have allowed river water intrusion into the aquifer. The contamination of Newton Well #1 (GWN-PA43) would be consistent with these findings.

2.0 GEORGIA GROUND-WATER MONITORING NETWORK

2.1 MONITORING STATIONS

Stations of the 1994 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:

1. areas of surface recharge;
2. areas of potential pollution related to regional activities (e.g., agricultural and industrial areas); and
3. areas of significant ground-water use.

Most of the monitoring stations are municipal, industrial, and domestic wells that have reliable well-construction data. The Monitoring Network also includes monitoring wells in specific areas where the State's aquifers are recognized to be especially susceptible to contamination or pollution (e.g., the Dougherty Plain of southwestern Georgia and the State's coastal area).

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 locality sampled and at the horizon 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 intentionally are 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

Table 2-1 Georgia Ground-Water Monitoring Network, 1994

AQUIFER SYSTEM	NUMBER OF MONITORING STATIONS VISITED & SAMPLES TAKEN IN 1994	PRIMARY STRATIGRAPHIC EQUIVALENTS	AGE OF AQUIFER FORMATIONS
Cretaceous	8 stations (8 samples)	Ripley Formation, Cusseta Sand, Blufftown Formation, Eutaw Formation, Tuscaloosa Formation, and Gaillard Formation	Late Cretaceous
Providence	0 stations (0 samples)	Providence Sand	Late Cretaceous
Clayton	0 stations (0 samples)	Clayton Formation	Paleocene
Claiborne	3 stations (3 samples)	Tallahatta Formation	Middle Eocene
Jacksonian	7 stations (7 samples)	Barnwell Group	Late Eocene
Floridan	42 stations (50 samples)	Predominantly Suwannee Limestone and Ocala Group	Predominantly Middle Eocene to Oligocene
Miocene	8 stations (8 samples)	Predominantly Altamaha Formation and Hawthorne Group	Miocene-Recent
Piedmont/Blue Ridge	13 stations (13 samples)	Various igneous and metamorphic complexes	Predominately Paleozoic and Precambrian
Valley and Ridge	8 stations (8 samples)	Shady Dolomite, Knox Group, and Chickamauga Group	Paleozoic, mostly Cambrian and Ordovician

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 wide spacing of monitoring stations does not permit equal characterization of water-quality processes in these settings. The quality of water from monitoring wells completed in unconfined aquifers represents only the general nature of ground water in the vicinity of the monitoring wells. 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 97 water samples collected during 1994 from 85 wells and 4 springs. In 1984, the first year of the Ground-Water Monitoring Network, hydrogeologists sampled water from 39 wells in the Piedmont/Blue Ridge and Coastal Plain Provinces. Three 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 most 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 (Table A-2). The pH measurements are performed in the field, whereas, other parameters are measured in the laboratory. Tables 2-2 (cations) and 2-3 (anions) summarize the significance of the common major constituents found in ground water.

The Drinking Water Program of the EPD's Water Resources Management Branch has established Maximum Contaminant Levels (MCL's) for certain parameters included in the analyses done on Ground-Water Monitoring Network samples. Primary MCL's pertain to parameters that may have adverse effects on human health when their values are exceeded. Secondary MCL's pertain to parameters that may give drinking water objectionable, though not health-threatening, properties that may cause persons served by public water systems to cease its use. Foul odor and unpleasant taste are examples of such properties. MCL's apply

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 corrode 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 promote 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 the chloride content should not exceed 250 ppm.
Nitrate/Nitrite	Excessive amounts of nitrate/nitrite in drinking water or formula water for 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 concentrations up to 500 ppm are not considered unhealthful.

only to treated water offered for public consumption, nevertheless, they are useful guidelines for evaluating the quality of untreated (raw) water. Tables A-1 and A-2 in the Appendix list the Primary and Secondary MCL's for Ground Water Monitoring Network parameters.

Most of the wells originally on the Monitoring Network had in-place pumps. Using such pumps to purge the wells and collect samples reduces the potential for cross-contamination of wells. For those wells that lacked in-place pumps, EPD personnel used portable pumps for purging and sampling. In recent years, however, all wells that lacked in-place pumps were dropped from the Monitoring Network, except for a flowing well tapping the lower Floridan, GWN-PA9C (see Appendix, Table A-6).

Sampling procedures are adapted from techniques used by the USGS and the EPA. Hydrogeologists purge the wells (three to five times the volume of the water column in the well) before 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 30 to 45 minutes of purging before sample collection.

EPD personnel monitor certain water quality parameters prior to sample collection. The personnel observe and record pH, dissolved oxygen content, specific conductivity, and temperature using field instruments. A manifold captures flow at the pump system discharge point before the water is exposed to the atmosphere and conducts it past the instrument probes. With increased purging time, typical trends include a lowering of pH, dissolved oxygen content, and specific conductivity, and a transition toward the mean annual air temperature. The hydraulic flow characteristics of unconfined aquifers, the depth of withdrawal, and 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 the records of the field measurements taken during sampling (i.e., pH, dissolved oxygen content, specific conductivity, and temperature). EPD personnel fill the sample bottles and then promptly place them on ice to preserve the water quality. The personnel next transport the samples to the laboratories for analysis on or before the Friday of the week in which they were collected.

During 1994, various laboratories performed the chemical analyses of water samples for the Ground-Water Monitoring Network. Before tropical storm Alberto, EPD laboratories did the following standard water quality tests on all regular samples: specific conductance, an ICP/AAS metals screen, a nitrate/nitrite test (results reported as ppm nitrogen), and an ion chromatography screen (chloride, fluoride, and sulfate). EPD laboratories also did 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. The Georgia Department of Agriculture laboratory performed analyses for screens #1, #2, #3, #4, and #5 (pesticides and PCB's) during this same period. Following the Alberto flooding, EPD laboratories became the main agency responsible for testing drinking water supplies in the flooded areas and had only limited capacity to analyze Monitoring Network water samples. Samples, which EPD laboratories could not test, were forwarded to the Cooperative Extension Service laboratories at the University of Georgia for the standard water quality tests.

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 comprises seven major aquifers or aquifer systems that are restricted to specific regions and depths within the province (Figure 3-1). These major aquifer systems, in many cases, incorporate smaller aquifers that are locally confined. Ground-Water Monitoring Network wells in the Coastal Plain aquifers are generally located in three settings:

1. Recharge (or outcrop) areas that 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 that 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.

Small-scale, localized ground-water flow patterns characterize the two hydrogeologic provinces of north Georgia, the Piedmont/Blue Ridge Province and the Valley and Ridge Province. Deep regional flow systems are unknown in northern Georgia. Geologic discontinuities (such as fractures) and compositional changes within the aquifer generally control ground-water flow in the Piedmont/Blue Ridge Province. 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 also apply in the Valley and Ridge Province. The Valley and Ridge Province additionally possesses widespread karst features, which significantly enhance porosity and permeability in localized areas and exert a strong influence on local ground-water flow patterns.

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 Tertiary 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

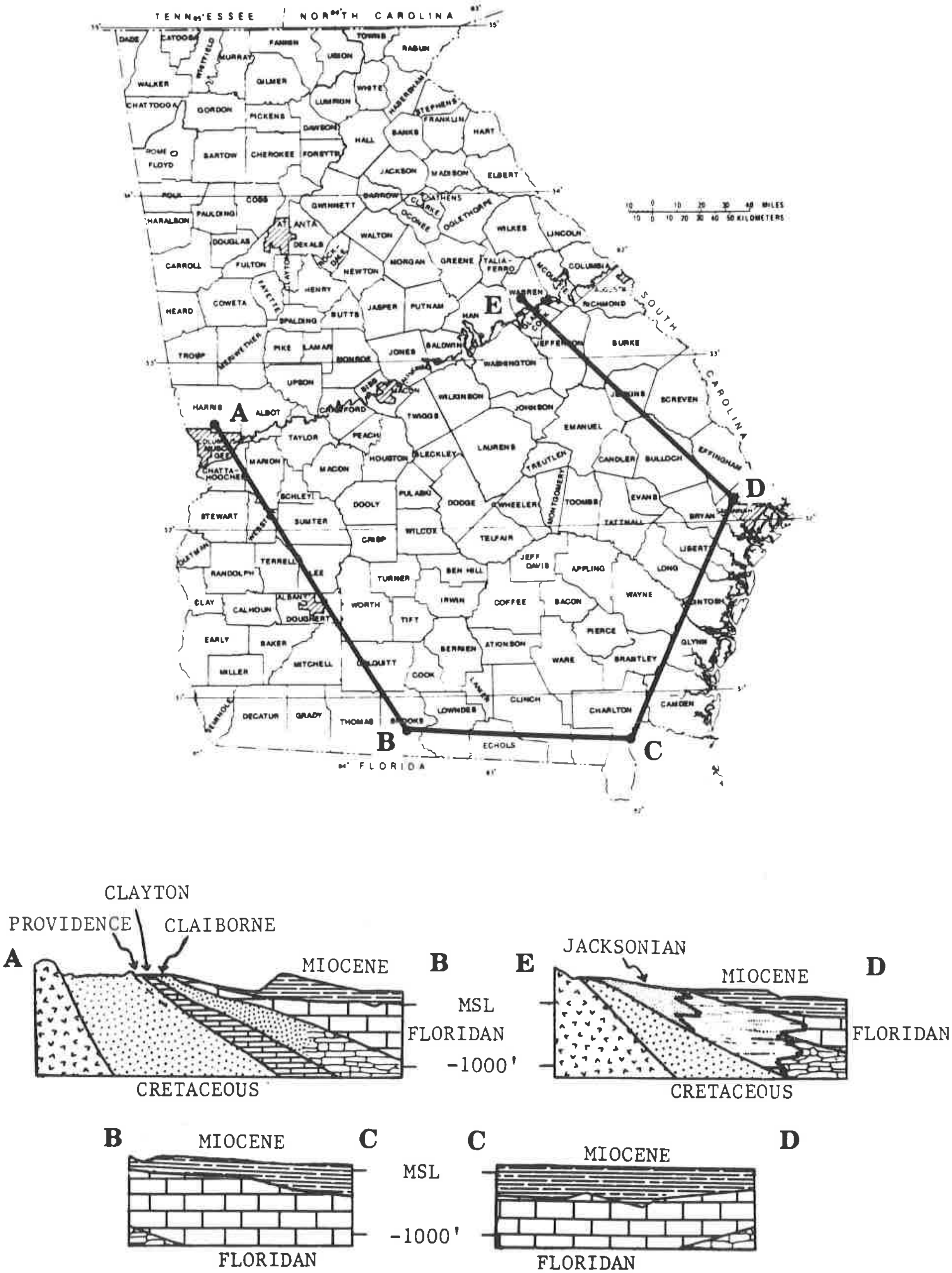
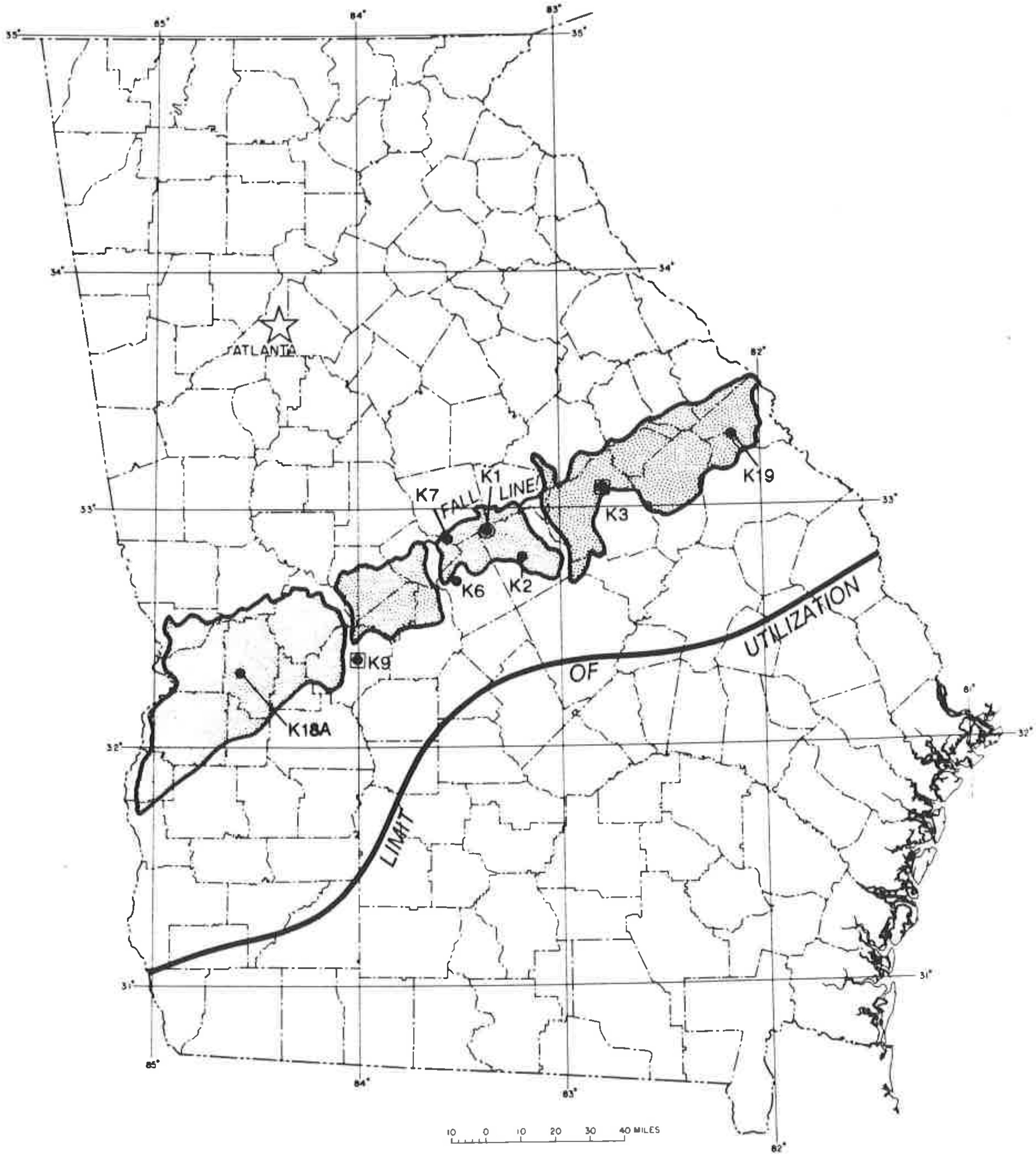


Figure 3-1. - The Seven Major Aquifer Systems of the Coastal Plain Province



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

● Soft water

○ Manganese exceeds MCL

□ Iron exceeds MCL

Figure 3-2. Water Quality of Selected Wells in the Cretaceous Aquifer System east (Clarke, et al., 1985). Aquifer sands thicken southward from the Fall Line, from 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 (limit of utilization, Figure 3-2). Vertical leakage from overlying members of the aquifer system provides significant recharge in down-dip areas.

EPD sampled 8 wells in 1994 to monitor the water quality of the Cretaceous aquifer system, exclusive of the Providence aquifer system. All the sampled wells are located in up-dip areas in or adjacent to outcrop and surface recharge areas for the Cretaceous aquifer system. All wells yielded soft, acidic water.

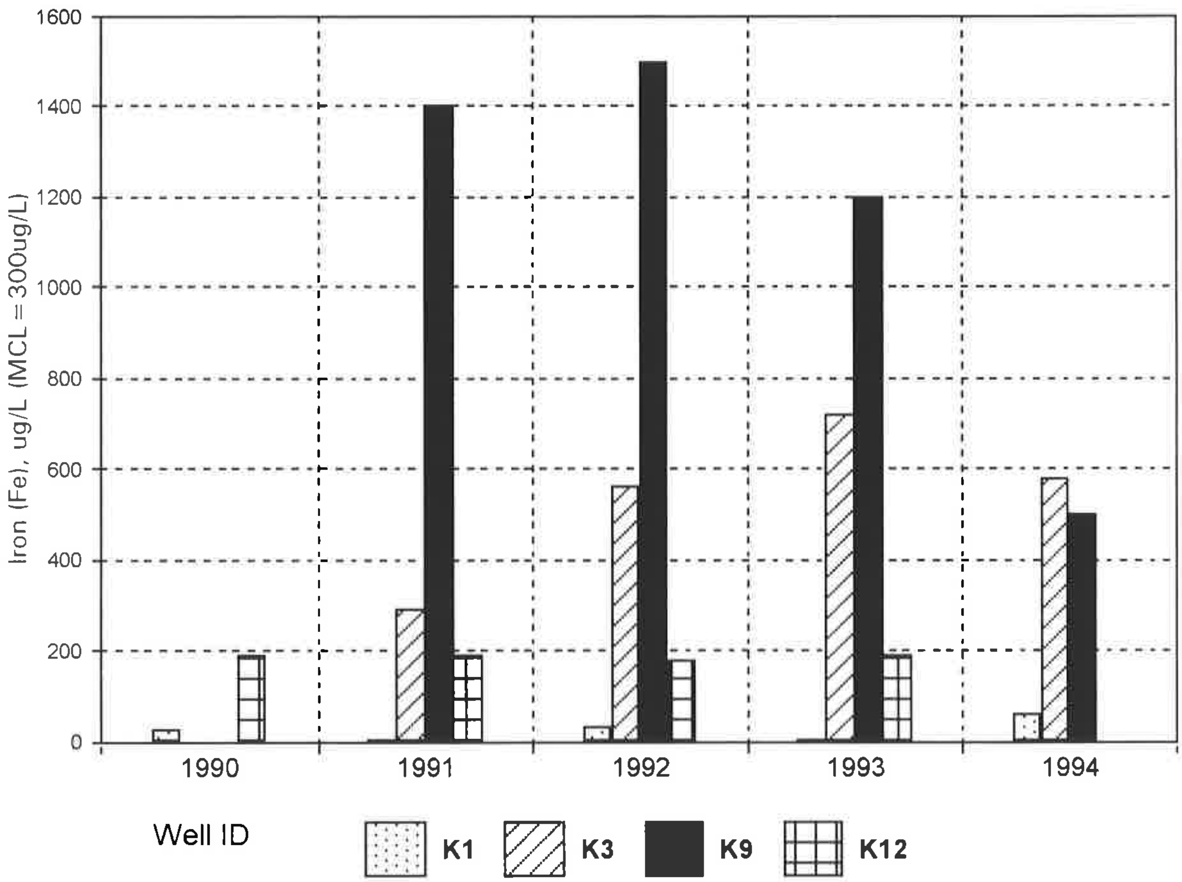
Iron concentrations exceeded the State secondary MCL of 300 parts per billion (ppb) in only two wells: GWN-K3 in Washington County (580 ppb) and GWN-K9 in Macon County (500 ppb). Well GWN-K1 yielded a sample with a manganese concentration of 60 ppb, which exceeds the applicable secondary MCL of 50 ppb. Figure 3-3 shows trends in iron concentrations for selected wells in the Cretaceous aquifer system.

Aluminum concentrations exceeded the secondary MCL of 200 ppb in samples from two wells: GWN-K1 (2600 ppb) and GWN-K9 (440 ppb). All samples contained low or undetectable levels of major alkali and alkaline earth metals (potassium, sodium, calcium, and magnesium). Water samples from various wells also had detectable levels of the following trace elements: copper, barium, strontium, molybdenum, vanadium, zinc, lead, and selenium.

Water samples from six wells contained detectable levels of nitrite/nitrate, with the highest concentration, 0.71 ppm as nitrogen, occurring in a sample from well GWN-K1. Figure 3-4 shows trends in levels of nitrite/nitrate (reported as parts per million [ppm] nitrogen) for selected wells. All of the samples contained detectable chloride; the majority of the samples also had measurable sulfate. None of the samples contained quantifiable synthetic organic compounds. Table A-3 in the Appendix lists the analytical results for samples collected from the Cretaceous aquifer system.

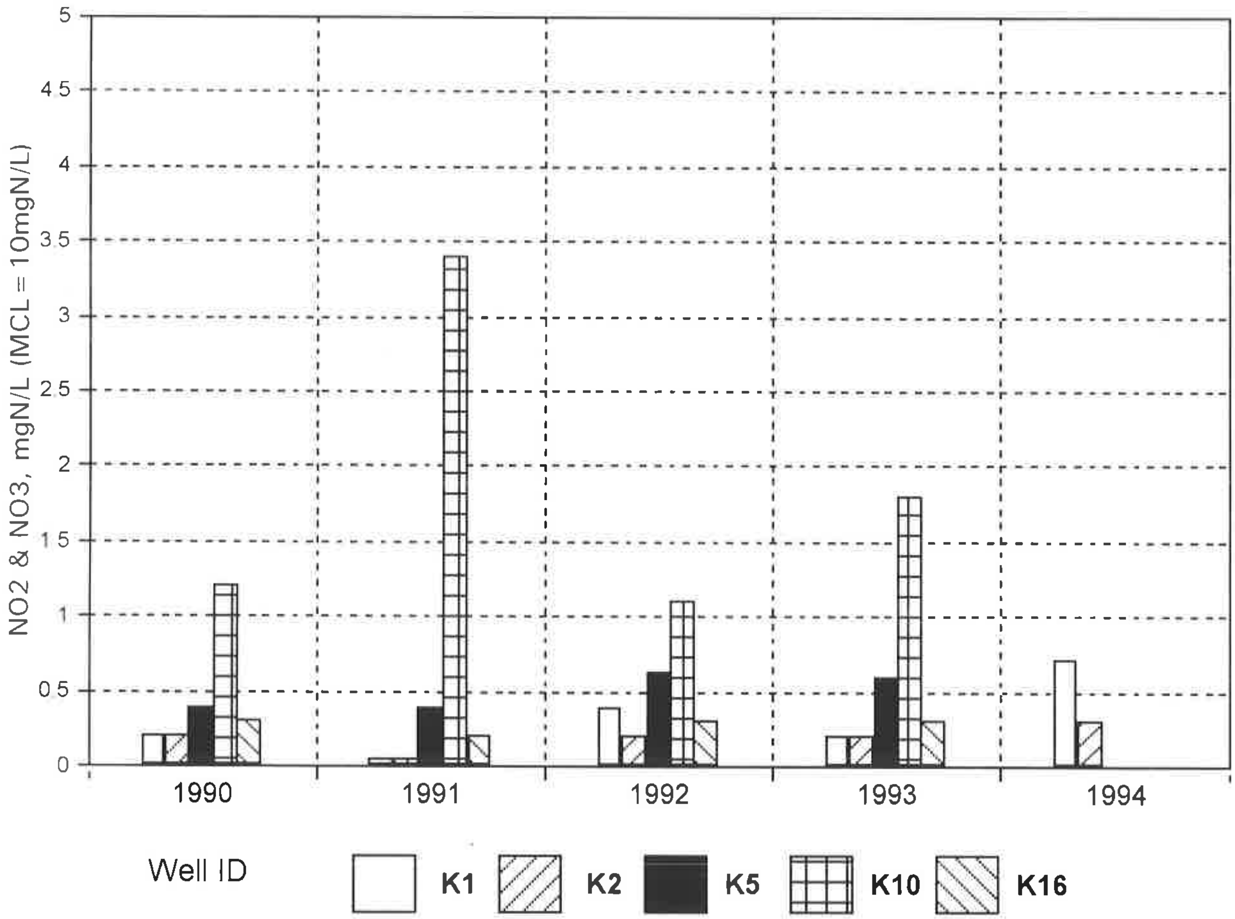
3.3 PROVIDENCE AQUIFER SYSTEM

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 (Figure 3-5). At 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. The aquifer system also generally thickens downdip, with an area where the thickness exceeds 300 feet existing in Pulaski County and an area of similar thickness indicated in the Baker/Calhoun/Early county region (Clarke, et al., 1983). Figure 3-5 also shows the down-dip limit of the area in which the aquifer system is utilized.



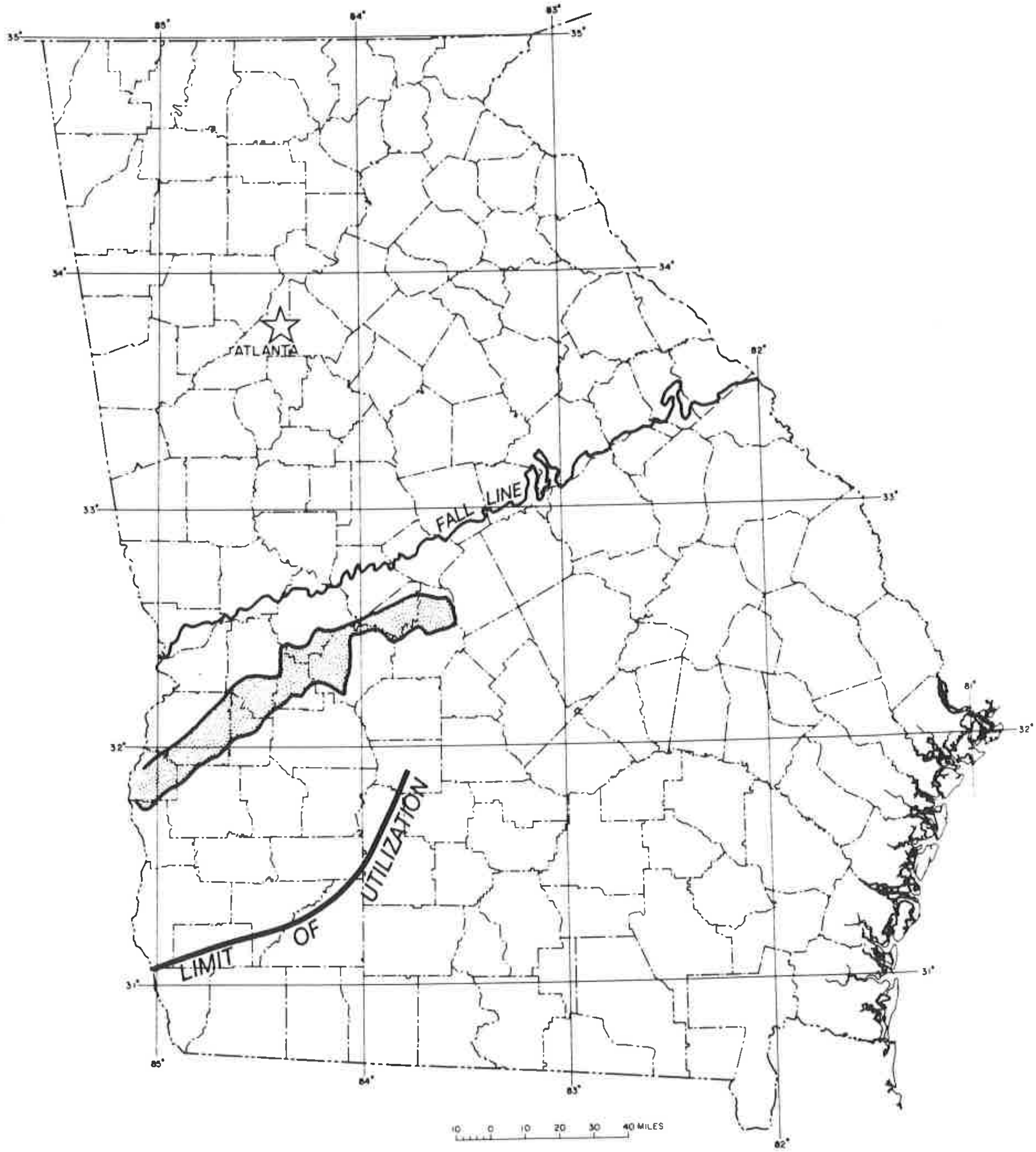
Iron levels below the detection limit are assigned a value of 5.1 ppb. A missing bar indicates that data are not available for that year.

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



Nitrate/nitrite levels below the detection limit are assigned a value of 0.05 ppm. A missing bar indicates data are not available for that year.

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



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

Figure 3-5 - Recharge Area and Limit of Utilization of the Providence Aquifer System

The permeable Providence Formation-Clayton Formation interval forms a single aquifer in the up-dip areas (Long, 1989) and to the 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. EPD did not collect any samples from Providence aquifer wells in 1994.

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 3-6). 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 from permeable units in the overlying Wilcox confining zone provides significant recharge 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) as well as east of the Flint River (Clarke, et al., 1983). 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). Figure 3-6 also shows the down-dip limit of the area in which the aquifer system is utilized. EPD did not sample any Clayton wells in 1994.

3.5 CLAIBORNE AQUIFER SYSTEM

Sands of the Middle Eocene Claiborne Group are the primary units of the Claiborne aquifer system of southwestern Georgia (Figure 3-7). Claiborne Group sands crop out in a belt extending from northern Early County through western Dooly County. Recharge to the aquifer system occurs both as direct infiltration of precipitation in the recharge area and as leakage from the overlying Floridan aquifer system (Hicks, et al., 1981; Gorday, et al., 1997). Discharge boundaries of the aquifer system are the Ocmulgee River, to the east, and the Chattahoochee River, to the west. Figure 3-7 shows the down-dip limit of utilization.

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 generally lies within 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).

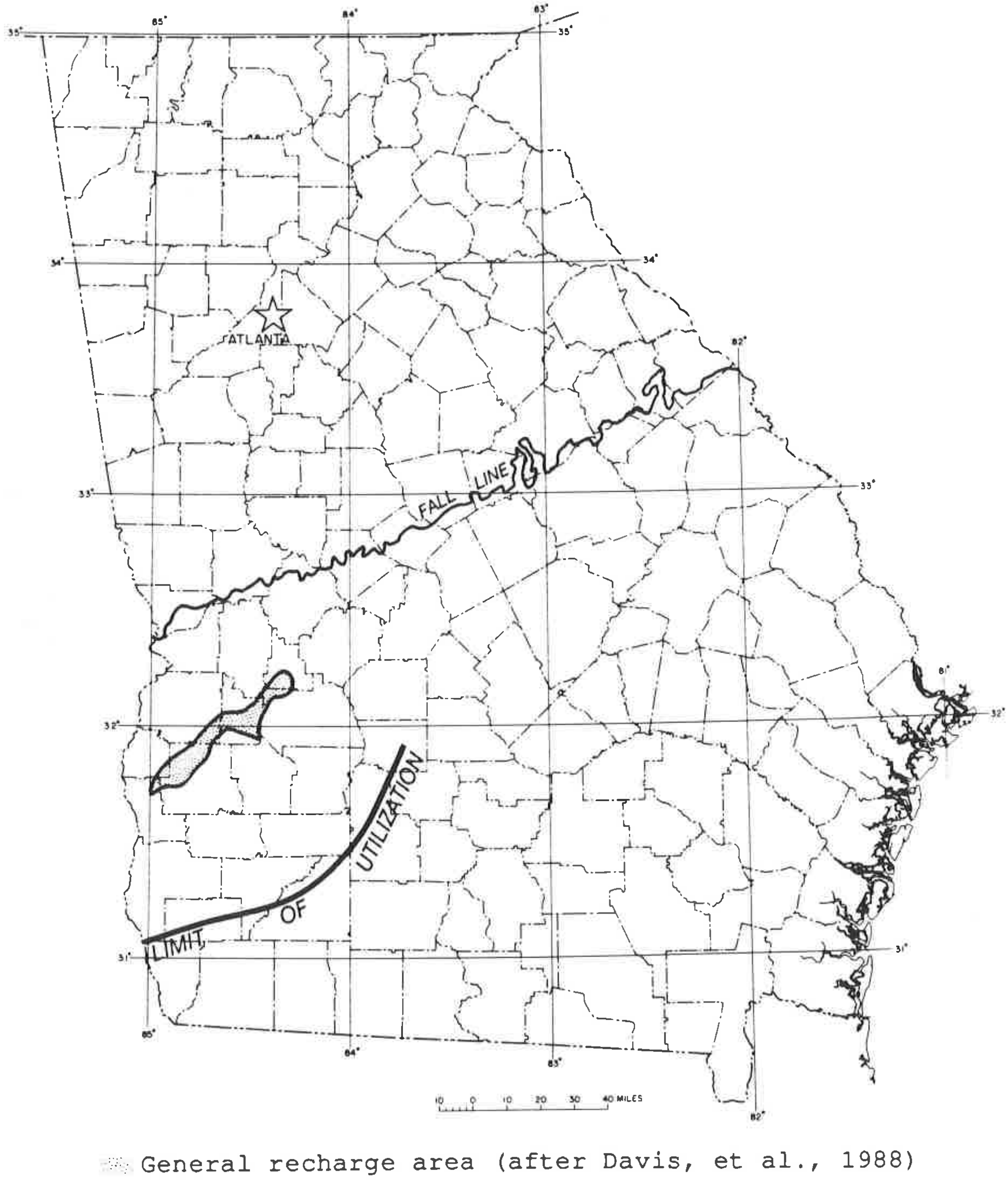
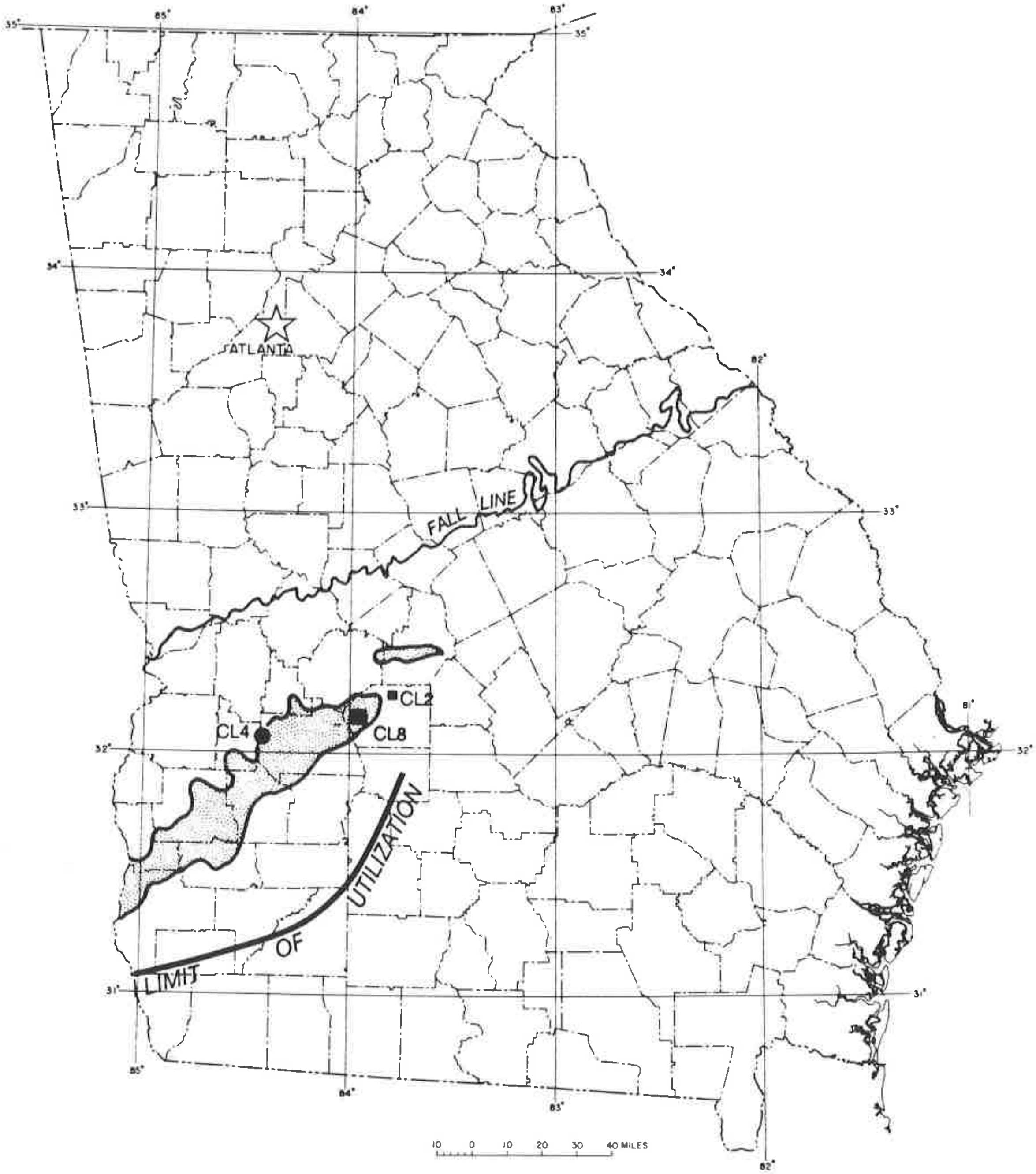


Figure 3-6. - Recharge Area and Limit of Utilization of the Clayton Aquifer System



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

Figure 3-7. - Water Quality of Selected Wells in the Claiborne Aquifer System

During 1994, EPD personnel used three wells to monitor the water quality of the Claiborne aquifer system. The pH of the water samples from the up-dip area (wells GWN-CL4 and GWN-CL8) fell below 7.00, while the pH of the sample from the down-dip area (well GWN-CL2) slightly exceeded 7.00. The two up-dip wells yielded soft water, while well GWN-CL2 yielded hard water. Manganese levels in samples from wells GWN-CL4 and GWN-CL8 and iron in the sample from well GWN-CL8 equaled or exceeded the secondary MCL's for these elements.

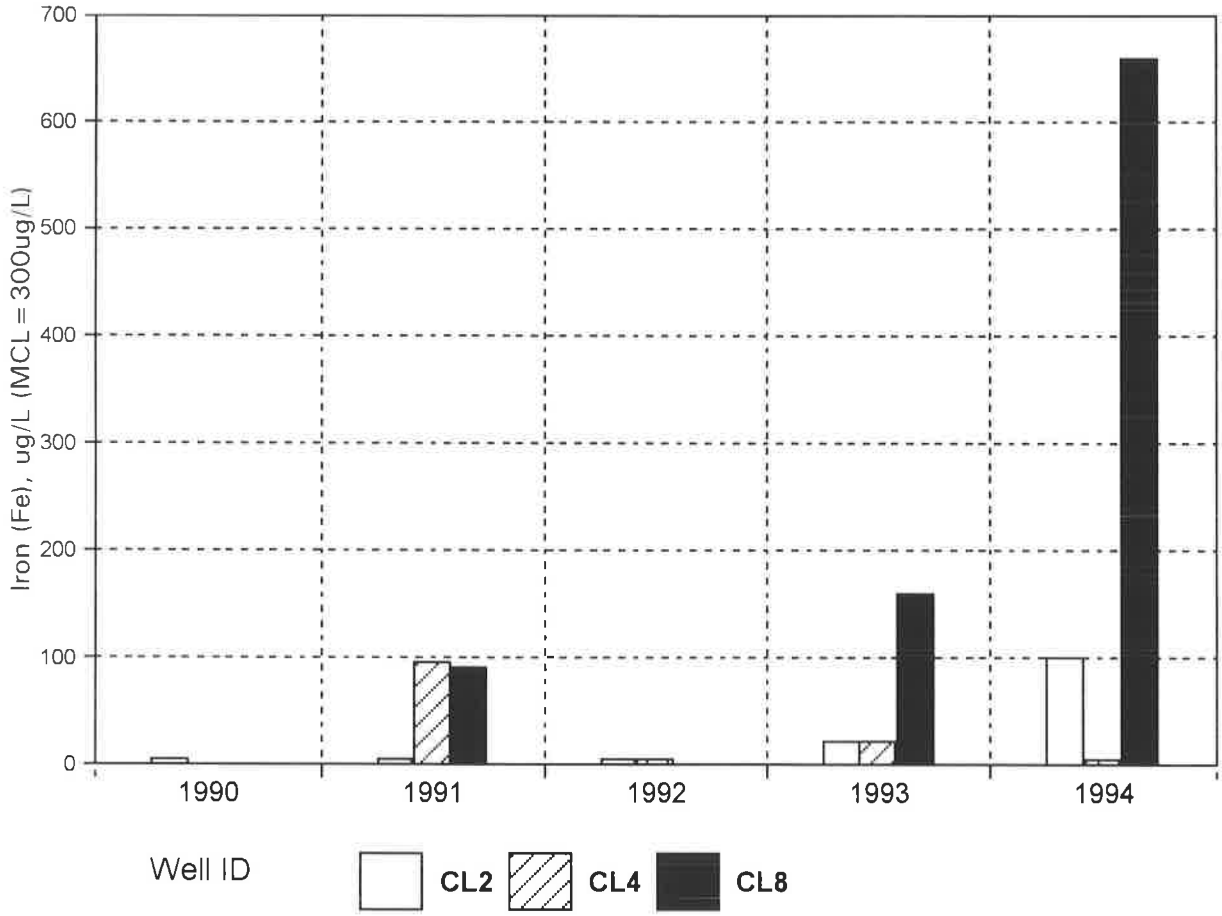
The sample from the down-dip well GWN-CL2 had the highest calcium concentration. The down-dip well GWN-CL6 yielded the sample with the highest sodium concentration. The calcium concentration in the down-dip sample is consistent with ground waters derived from limestone. Other metals and semimetals detected included barium, strontium, aluminum, zinc, copper, silver, arsenic, vanadium, molybdenum, and lead. Figure 3-8 shows trends in iron concentrations in three wells.

Samples from all three wells (GWN-CL2, GWN-CL4, and GWN-CL8) contained detectable levels of nitrite/nitrate, with the sample from GWN-CL4 having the highest concentration. In the aftermath of tropical storm Alberto, routine samples of treated water from well GWN-CL5 (Shellman Well #3, Randolph County), collected for EPD's Drinking Water Program, began showing nitrite/nitrate levels in excess of the primary MCL (Lineback, 1994). The well collapsed in November of 1994, before the yearly Monitoring Network sample could be collected. Lineback (1994) reported the increase in nitrite/nitrate concentration in water from well GWN-CL5 to be due to leaching of fertilized row crop fields and pecan groves north and west of the town by storm precipitation. Figure 3-9 shows nitrite/nitrate concentrations for selected wells.

Samples from all three wells contained measurable chloride, with a maximum of 6.2 ppm in the sample from well GWN-CL4. Samples from wells GWN-CL2 and GWN-CL8 contained detectable sulfate. Well GWN-CL2 yielded a sample containing fluoride at a concentration of 5.0 ppm, which exceeded the primary MCL of 4 ppm. Previous testing has shown the fluoride levels to be low or undetectable in samples from this well, and, the 5.0 ppm value is thought to be spurious. The sample from well GWN-CL4 contained benzene (10 ppb) in excess of the primary MCL of 5 ppb and a non-quantifiable trace of xylenes. Table A-4 in the Appendix gives the analytical results for the samples from Claiborne wells.

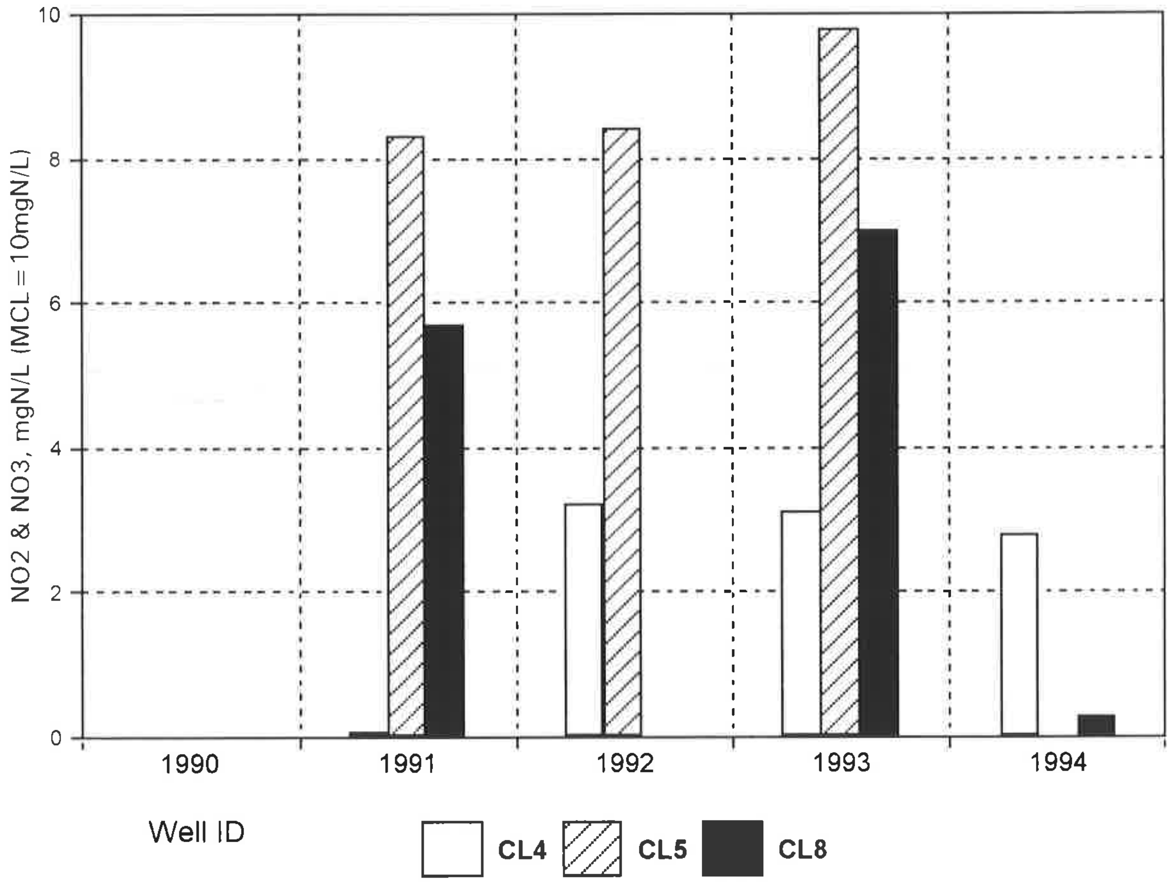
3.6 JACKSONIAN AQUIFER SYSTEM

The Jacksonian aquifer system of central and east-central Georgia comprises predominantly sands of the Eocene Barnwell Group, though, locally, isolated limestone bodies are important. Barnwell Group outcrops extend from Macon and Peach Counties eastward to Burke and Richmond Counties (Figure 3-10). Aquifer sands form a northern clastic facies of the Barnwell Group; the sands 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



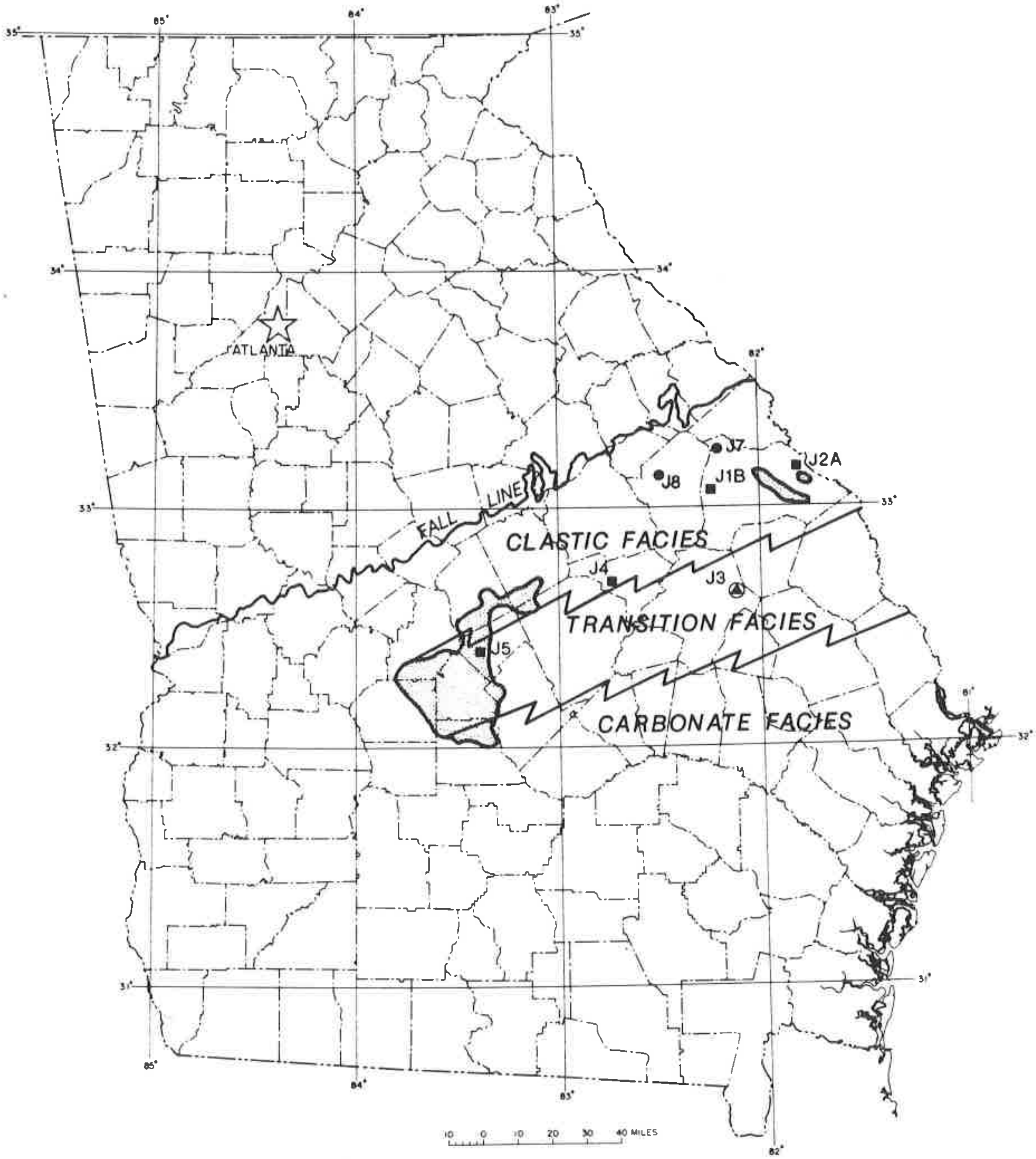
Iron levels below the detection limit are assigned a value of 5.1 ppb. A missing bar indicates data are not available for that year.

Figure 3-8. - Iron Concentrations for Selected Wells in the Claiborne Aquifer System.



Nitrate/nitrite levels below the detection limit are assigned a value of 0.05 ppm. A missing bar indicates data arenot available for that year.

Figure 3-9. - Nitrate/Nitrite Concentrations for Selected Wells in the Claiborne Aquifer System.



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

Facies boundary (from Vincent, 1982)

● Soft water

▲ Moderately hard water   O Manganese exceeds MCL

■ Hard water

Figure 3-10. - Water Quality of Selected Wells in the Jacksonian Aquifer System.

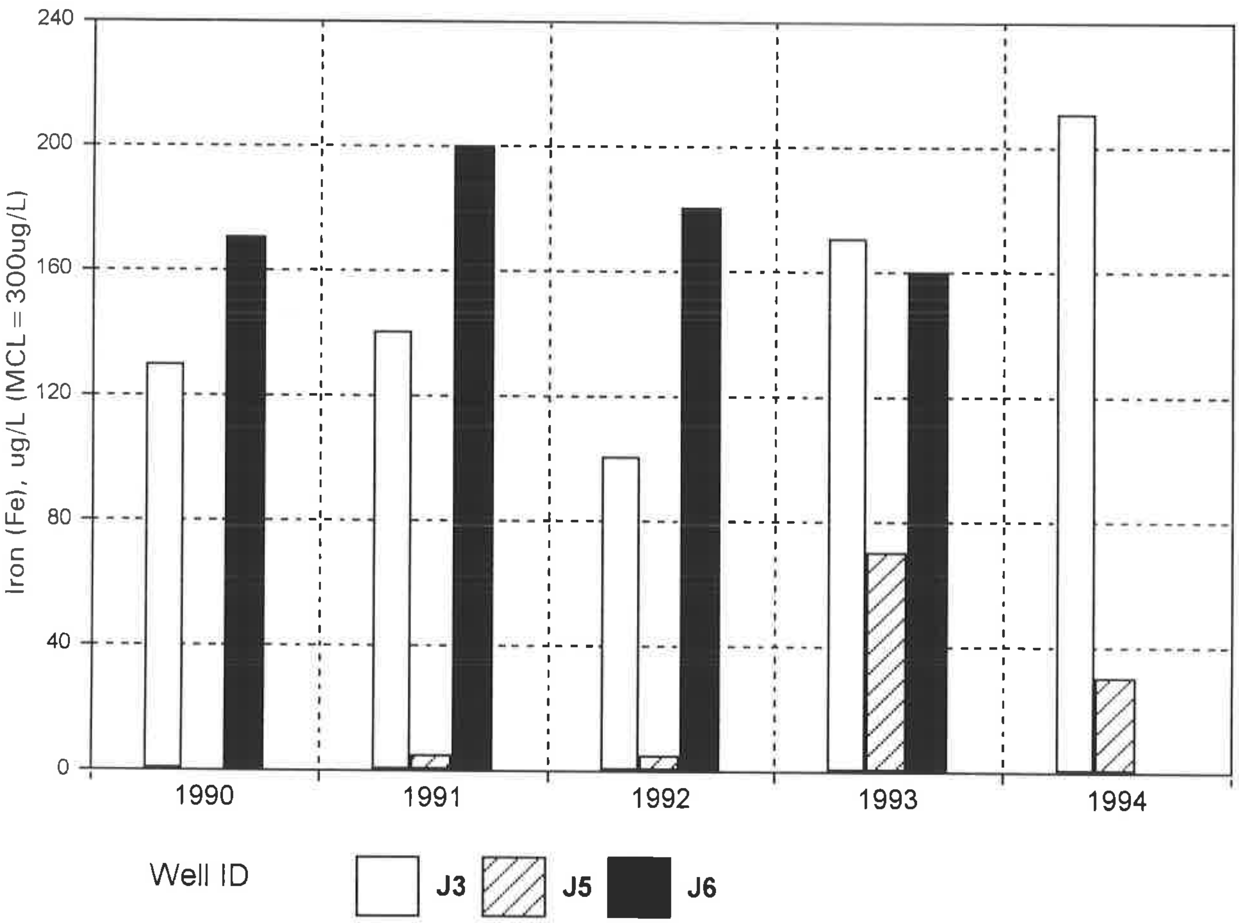
carbonate facies and are included in the Floridan aquifer system. The Savannah River and Ocmulgee River are eastern and western discharge boundaries respectively for the up-dip flow system of the Jacksonian aquifer system.

EPD monitored water quality in the Jacksonian aquifer system in 1994 by sampling seven wells. Five wells are in the clastic facies (one,GWN-J2A, drawing from an isolated limestone body), and, two wells are in the transition facies. Except for two up-dip wells, GWN-J7 and GWN-J8, which yielded very acidic water, the pH of the water samples ranged from 6.68 to 7.72. Water hardness ranged from soft (up-dip wells GWN-J7 and GWN-J8) to hard. Concentrations of iron, aluminum, and manganese in the water samples fell below the secondary MCL's for drinking water, except for wells GWN-J3 and GWN-J8, which yielded samples with excessive manganese (130 ppb and 70 ppb, respectively). The samples tested generally low in sodium, with the highest concentration occurring in a sample from the transition well GWN-J3. Calcium concentrations ranged from 37 ppm to 65 ppm in in samples from five of the wells, but fell below 10 ppm in samples from the up-dip wells GWN-J7 and GWN-J8. Samples from five of the wells contained magnesium, with the highest level of 6.4 ppm occurring in the sample from transition well GWN-J3. Other detected metals and semimetals included barium, strontium, copper, lead, zinc, vanadium, beryllium, and arsenic. Higher nitrite/nitrate concentrations occurred in samples from the up-dip wells, with the concentration in a sample from well GWN-J8 exceeding the primary MCL of 10 ppm as nitrogen. In no samples did fluoride, chloride, or sulfate exceed their respective MCL's. Likewise, none of the samples contained any quantifiable synthetic organic chemicals. Figures 3-11 and 3-12 depict trends in iron and nitrite/nitrate concentrations for selected wells. Table A-5 in the Appendix lists the analytical results for all the wells sampled.

3.7 FLORIDAN AQUIFER SYSTEM

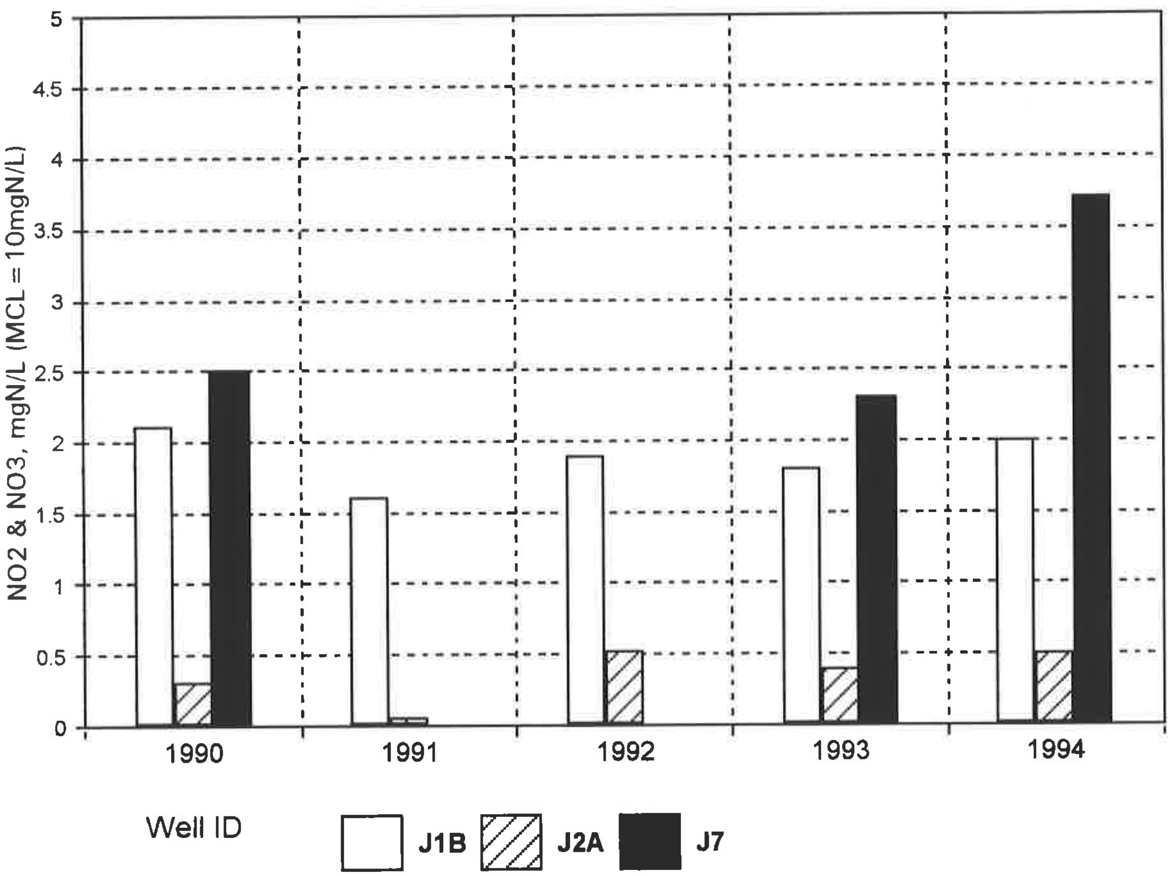
The Floridan aquifer system consists predominantly of Eocene and Oligocene limestones and dolostones that underlie most of the Coastal Plain Province. The aquifer is a major source of ground water for much of its outcrop area and throughout its down-dip extent to the south and east.

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



Iron levels below the detection limit are assigned a value of 5.1 ppb. A missing bar indicates data arenot available for that year.

Figure 3-11. - Iron Concentrations for Selected Wells in the Jacksonian Aquifer System.



Nitrate/nitrite levels below the detection limit are assigned a value of 0.05 ppm. A missing bar indicates data arenot available for that year.

Figure 3-12. - Nitrate/Nitrite Concentrations for Selected Wells in the Jacksonian Aquifer System.

Gulf Trough is a linear depositional feature in the Coastal Plain that extends from southwestern Decatur County through central Bulloch County.

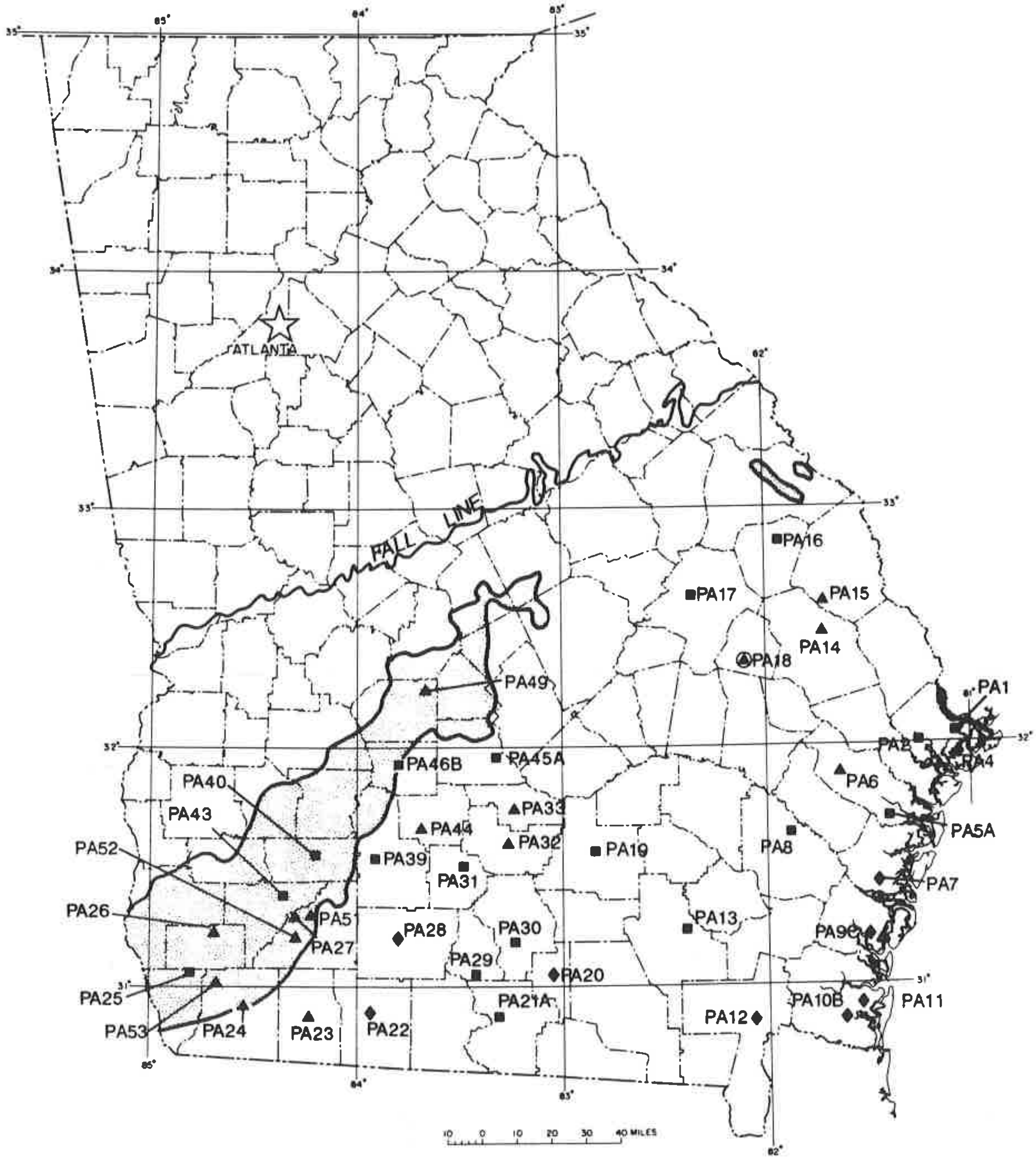
A ground-water divide separates a smaller southwestwardly flow regime in the Floridan aquifer system in the Dougherty Plain from the larger southeastwardly flow regime in the remainder of Georgia. Rainfall infiltration in outcrop areas and downward leakage from extensive surficial residuum provides recharge 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 1994, EPD collected 50 samples from 42 wells in the Floridan aquifer system (Figure 3-13). The pH levels in all samples were basic, and, water hardness ranged from moderately hard to very hard. Iron and aluminum concentrations fell below the secondary MCL's in all samples. Trends in iron levels from selected wells in the Floridan aquifer are shown on Figure 3-14. Most wells yielding water with detectable manganese levels fall within the Gulf Trough area (wells GWN-PA18, GWN-PA19, GWN-PA29, GWN-PA30, GWN-PA32, and GWN-PA33). The manganese concentration in a sample from well GWN-PA18 exceeded the secondary MCL of 50 ppb.

Sodium concentrations ranged from 1.9 to 800 parts per million (ppm), and, magnesium ranged from undetected to 110 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 samples from wells GWN-PA2A and GWN-PA33 to 160 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 of 2000 ppb. Other metals detected in measurable concentrations included potassium, molybdenum, strontium, copper, and zinc. None of these substances exceeded applicable MCL's.

All water samples underwent tests for the anions: chloride, sulfate, fluoride, and nitrate/nitrite. A few samples also recieved tests for phosphorus. Chloride levels ranged from 1.9 ppm to 1770 ppm. The 1770 ppm level occurred in well GWN-PA9C in the coastal area and was the only value to exceed the secondary MCL (250 ppm) for chloride. Sulfate ranged from undetected to 398 ppm. This high sulfate level occurred in the sample from well GWN-PA9C and exceeds the secondary MCL (250 ppm). The concentrations of fluoride ranged from undetected to 0.9 ppm. The sample collected from well GWN-PA39 was the only sample to have a synthetic organic compound, a non-quantifiable trace of chloroform.

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, 4.08 ppm as nitrogen, was in a sample collected from well GWN-PA53 in the Dougherty Plain. Trends in nitrate



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

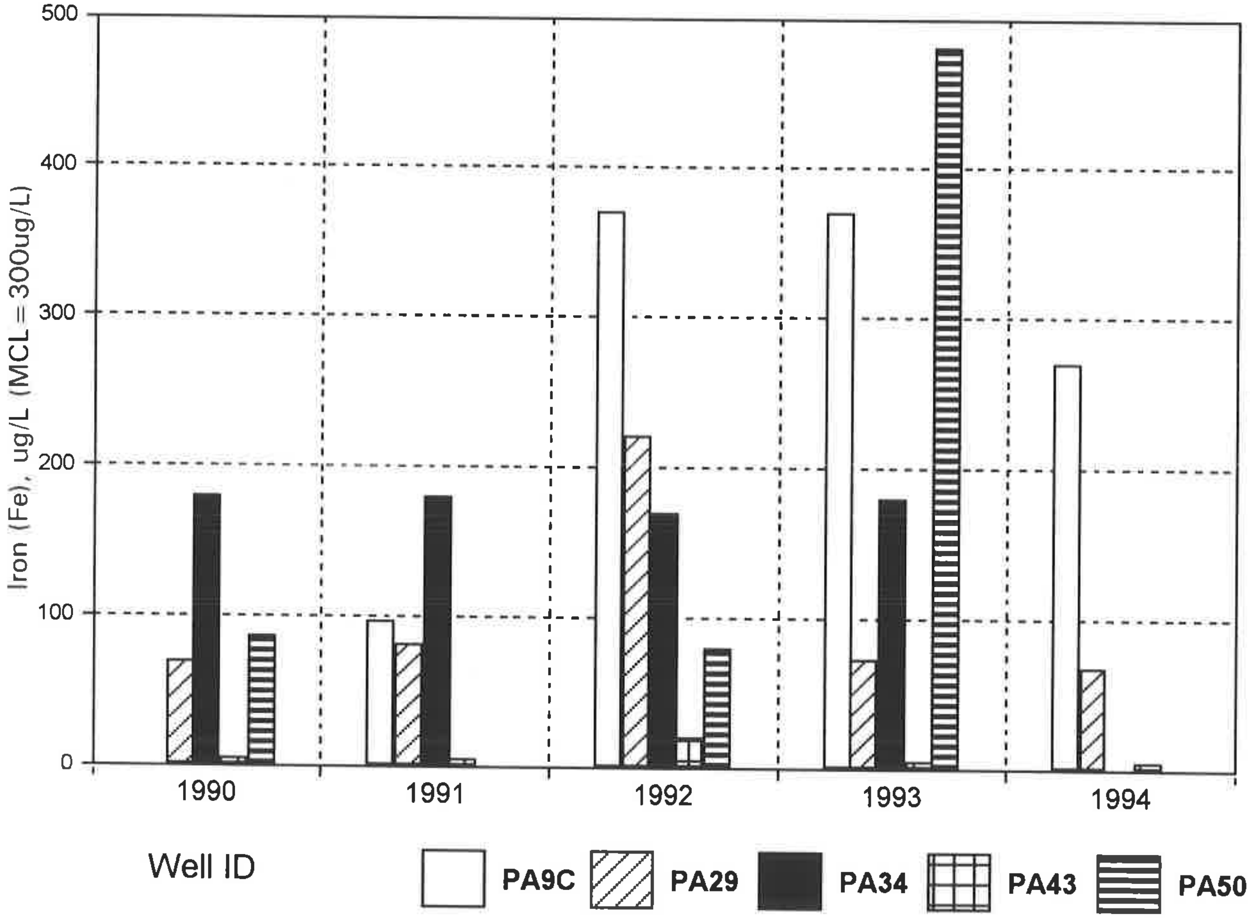
▲ Moderately hard water

■ Hard water

♦ Very hard water

○ Manganese exceeds MCL

Figure 3-13. - Water Quality of Selected Wells in the Floridan Aquifer System



Iron levels below the detection limit are assigned a value of 5.1 ppb. A missing bar indicates data are not available for that year.

Figure 3-14. - Iron Concentrations for Selected Wells in the Floridan Aquifer System.

levels from selected wells in the Floridan Aquifer are presented in Figure 3-15. The Appendix (Table A-6) gives the analytical results for samples from 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).

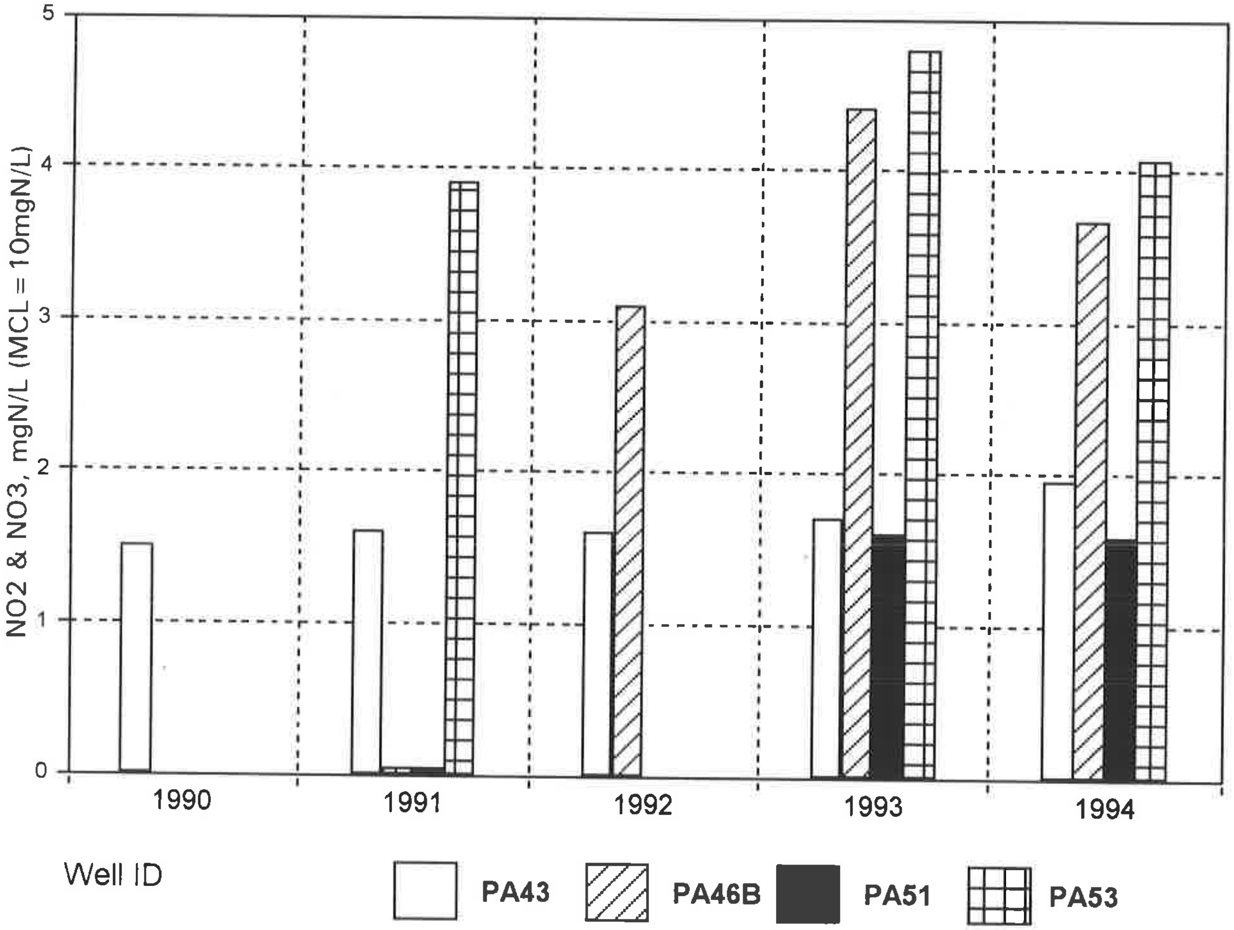
Areas of confinement exist in the coastal counties. Leakage from overlying surface aquifers into the Miocene aquifer system and, in some areas, from the underlying Floridan aquifer system is significant in the coastal counties (Watson, 1982). Here, two principal aquifer units are present (Joiner, et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

EPD collected water samples from eight wells to monitor the water quality in the Miocene aquifer system (Figure 3-16). The pH of the samples ranged from 4.05 to 7.65 and hardness from soft to hard. Iron and manganese levels ranged from undetected to 2200 and 210 ppb, respectively. The water sample from well GWN-MI13 contained iron in excess of the secondary MCL (300 ppb). Water samples from four wells, GWN-MI5, GWN-MI8A, GWN-MI10B and GWN-MI13, exceeded the secondary MCL (50 ppb) for manganese. Figure 3-17 shows trends in iron concentrations in selected wells. Samples from three wells contained aluminum in excess of the secondary MCL, at levels of 430 ppb, 730 ppb, and 740 ppb. Sodium ranged from 1.7 ppm to 7.7 ppm , and, calcium ranged from 5.8 ppm to 54 ppm. Other metals detected were potassium, magnesium, barium, strontium, and zinc. None of these exceed applicable MCL's.

Chloride concentrations ranged from 2.1 ppm to 40.1 ppm, and, sulfate levels ranged from undetected to 3.4 parts per million. The deeper domestic wells (GWN-MI1, GWN-MI2, GWN-MI10B, and GWN-MI13) yielded samples with the lowest chloride concentrations. Samples from four wells contained quantifiable concentrations of fluoride. Detectable levels of nitrite/nitrate, ranging from 0.1ppm to 14.1 ppm, occurred in samples from four wells (GWN-MI2, GWN-MI5, GWN-MI8A, and GWN-MI15). Nitrate/nitrite concentrations in wells GWN-MI8A and GWN-MI15 exceeded the primary MCL (10 ppm as N). Concentrations of nitrate/nitrite for selected wells are illustrated in Figure 3-18. None of the samples contained synthetic organic chemicals. Table A-7 in the Appendix gives analytical data for samples drawn from Miocene aquifer system wells.

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.



Nitrate/nitrite levels below the detection limit are assigned a value of 0.05 ppm. A missing bar indicates data arenot available for that year.

Figure 3-15. - Nitrate/Nitrite Concentrations for Selected Wells in the Floridan Aquifer System.

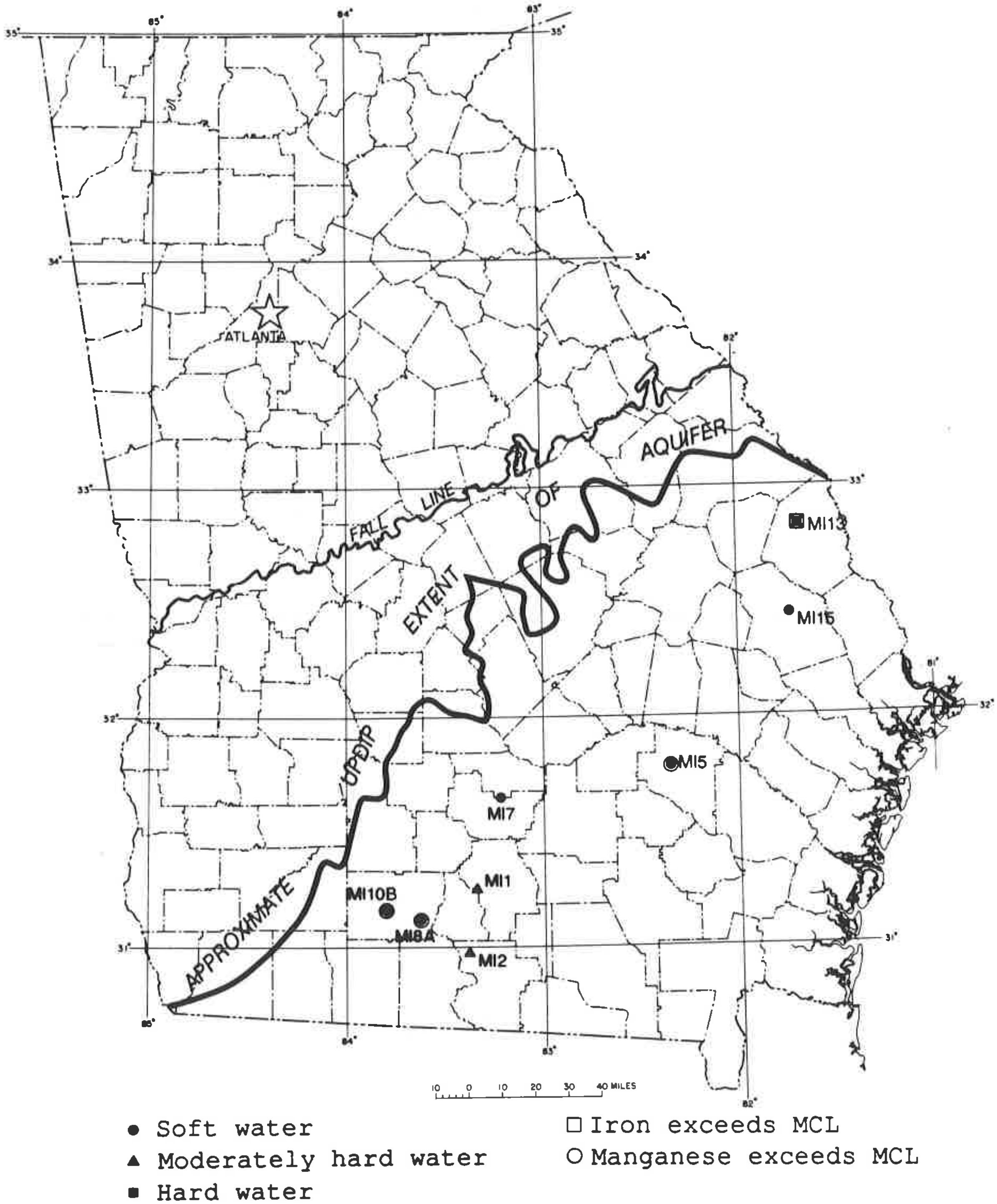
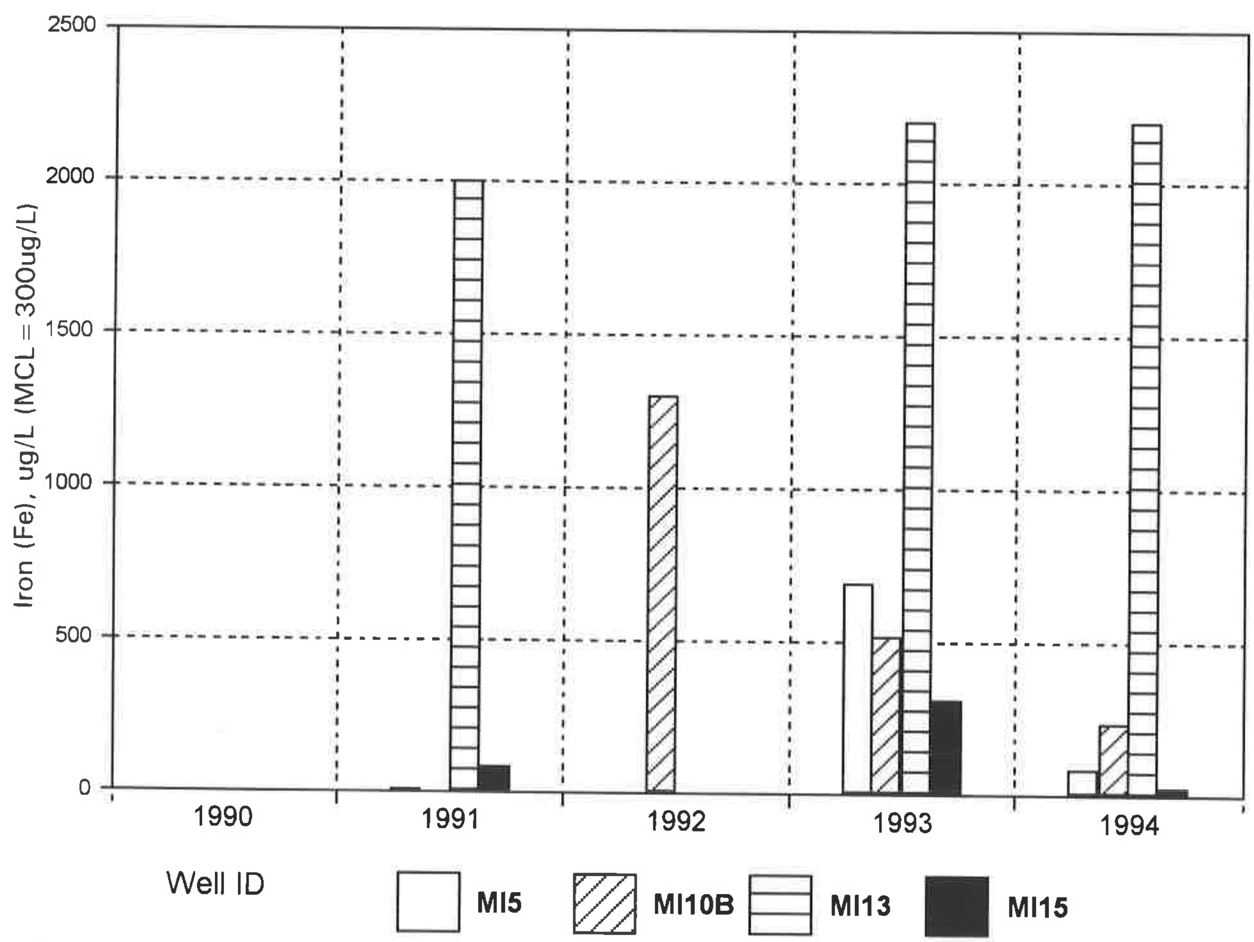
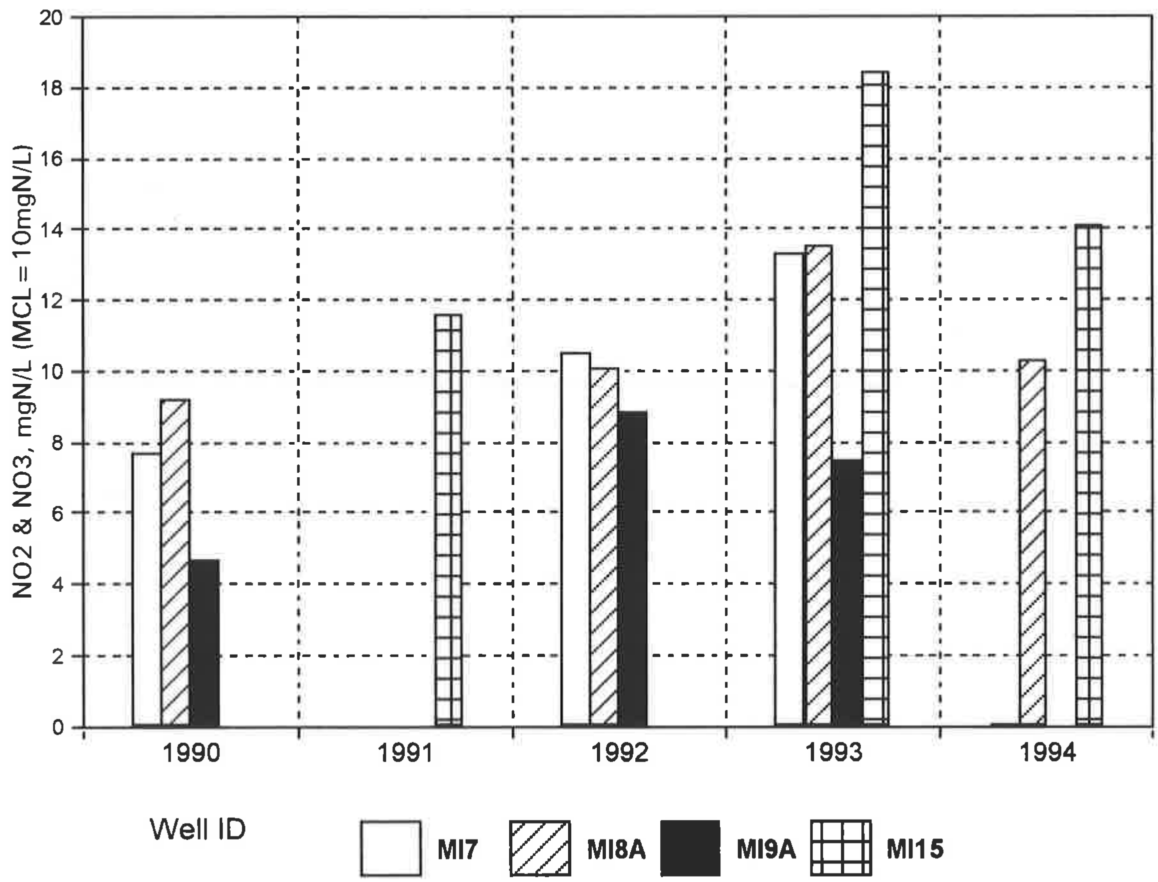


Figure 3-16. - Water Quality of Selected Wells in the Miocene Aquifer System.



Iron levels below the detection limit are assigned a value of 5.1 ppb. A missing bar indicates data are not available for that year.

Figure 3-17. - Iron Concentrations for Selected Wells in the Miocene Aquifer System.



Nitrate/nitrite levels below the detection limit are assigned a value of 0.05 ppm. A missing bar indicates data are not available for that year.

Figure 3-18. - Nitrate/Nitrite Concentrations for Selected Wells in the Miocene Aquifer System.

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 saprolite horizons determine the amount of well yield that can be sustained.

EPD collected 13 ground-water samples from twelve wells and one spring in the Piedmont/Blue Ridge Province. Figure 3-19 shows locations of the monitoring stations. Hardness ranged from soft to moderately hard. The pH of the water fell below 7.00 at eleven of the sampling stations and was greater than 7.00 at two others. Iron and manganese ranged from undetected to 1600 ppb (GWN-P9) and 230 ppb (GWN-P16C), respectively. Iron exceeded the secondary MCL (300 ppb) in water samples taken at three stations, and, manganese exceeded the secondary MCL (50 ppb) at five stations. None of the samples contained detectable aluminum. Figures 3-20 and 3-21, respectively, show trends in iron concentrations for selected stations in the Piedmont and Blue Ridge sectors of the province.

Samples from all stations contained sodium, with concentrations ranging from 1.4 ppm to 15.0 ppm. All well samples (except GWN-P14) contained calcium and magnesium (except GWN-P14 and GWN-BR1A). Testing also detected potassium, barium, strontium, and zinc, at concentrations below applicable MCL's.

Chloride and sulfate concentrations in the water samples ranged from undetected to 11.0 ppm and 55.9 ppm, respectively. Samples from four out of thirteen stations contained quantifiable fluoride. Concentrations of nitrite/nitrate, present in water samples from ten stations, were below the primary MCL (10 ppm as N). Figures 3-22 and 3-23 show nitrite/nitrate concentrations in selected stations from the Piedmont and Blue Ridge sectors, respectively. A non-quantifiable trace of naphthalene occurred in a sample from well GWN-P2, which is located in an urban setting. An analytical summary for the Piedmont/Blue Ridge sampling stations is in Appendix Table A-8.

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.

EPD collected water samples from five wells and three springs to monitor the water quality in the Valley and Ridge unconfined aquifers (Figure 3-24). Three of these wells and all three springs produced water from Knox Group carbonates. The other wells are representative of water from the Ordovician Chickamauga Group in Walker County and the Cambrian Shady Dolomite in Bartow County. Water from the Valley and Ridge monitoring stations ranged in pH from 7.08 to 7.91 and in hardness from moderately hard to very hard. Only one station (GWN-VR4) yielded a sample containing detectable iron and manganese.

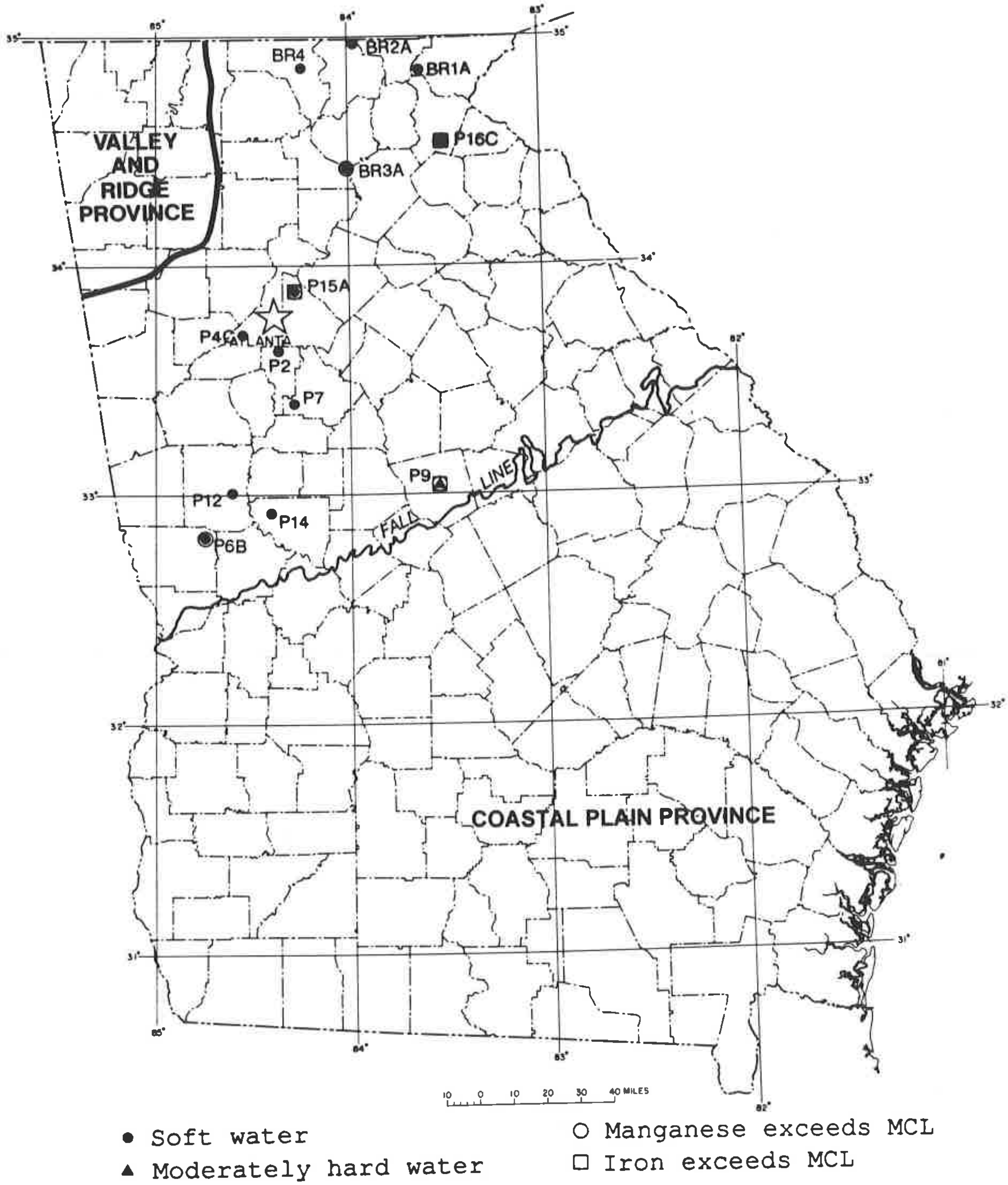
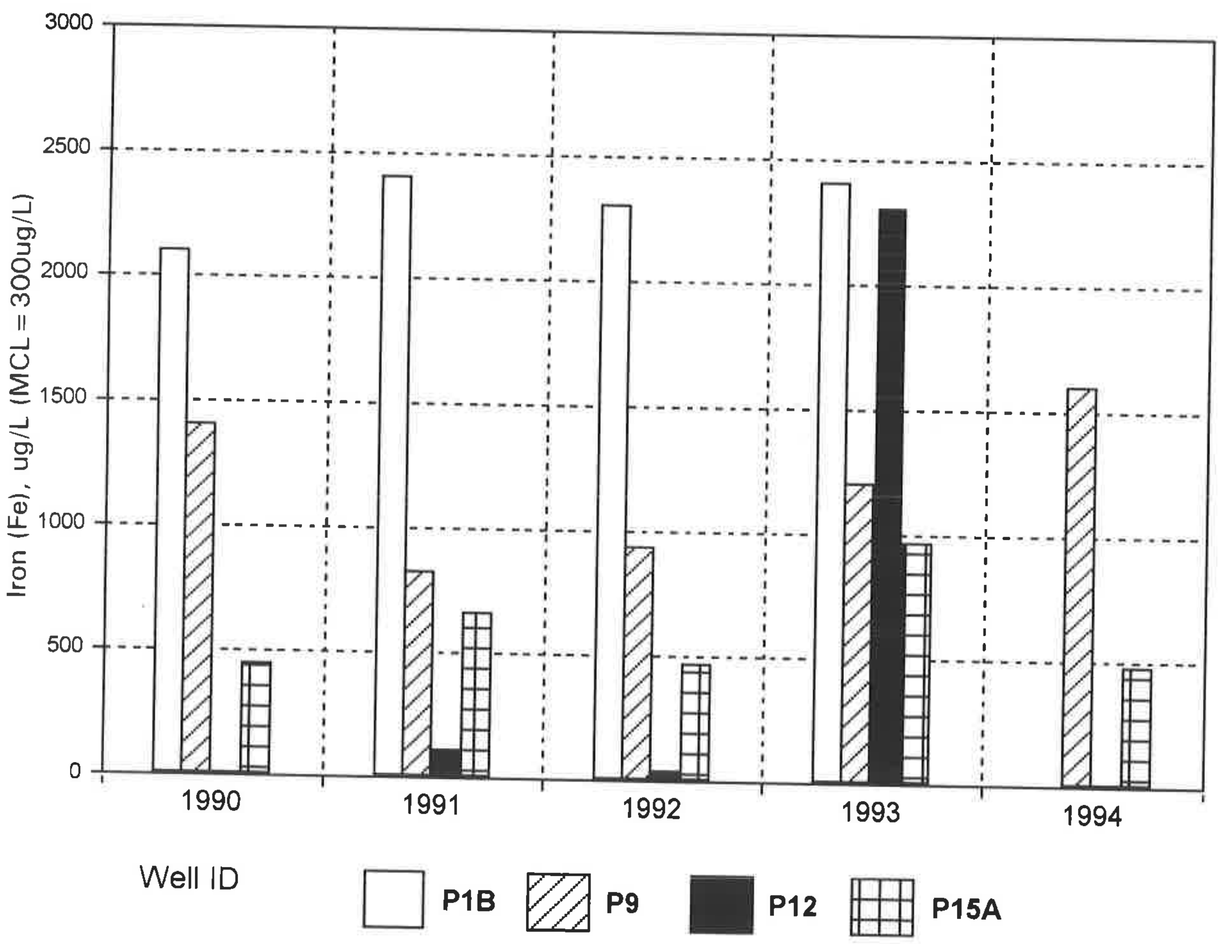
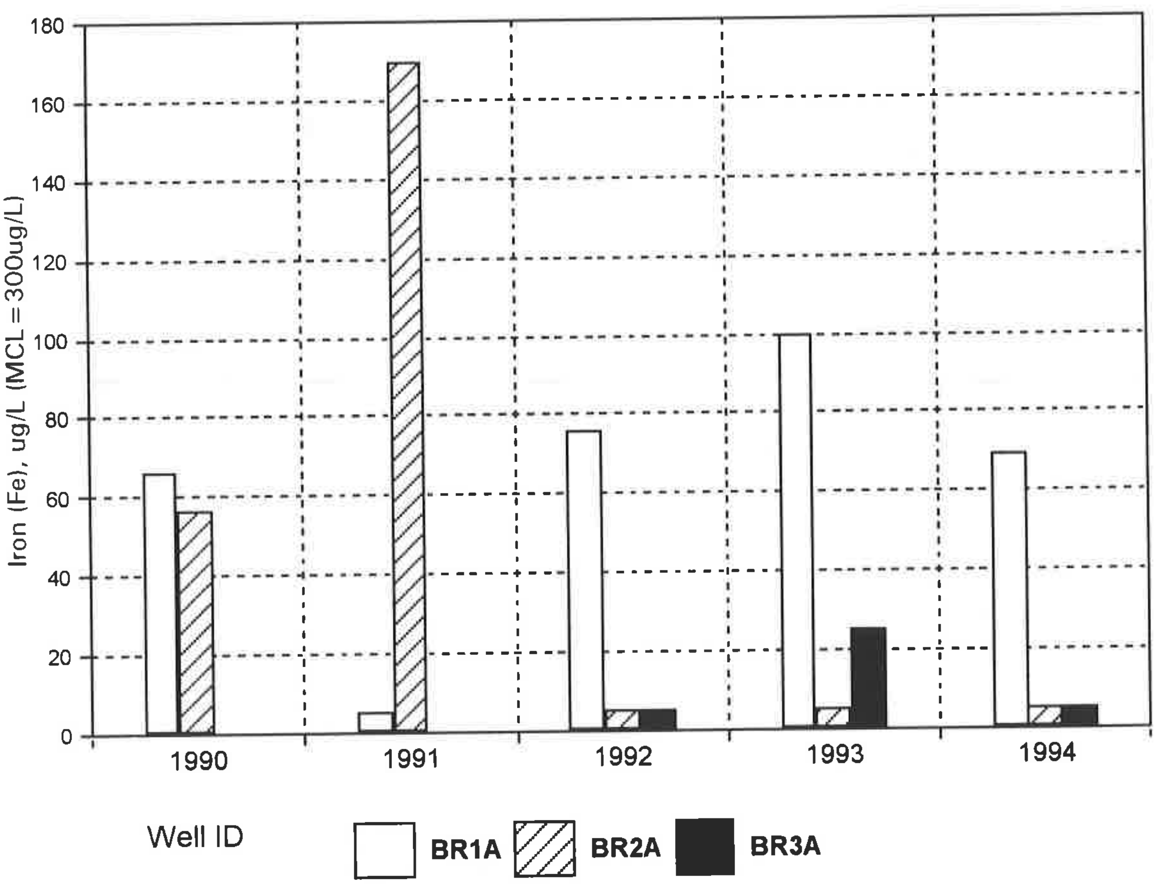


Figure 3-19. - Water Quality of Selected Wells in the Piedmont/Blue Ridge Unconfined Aquifers



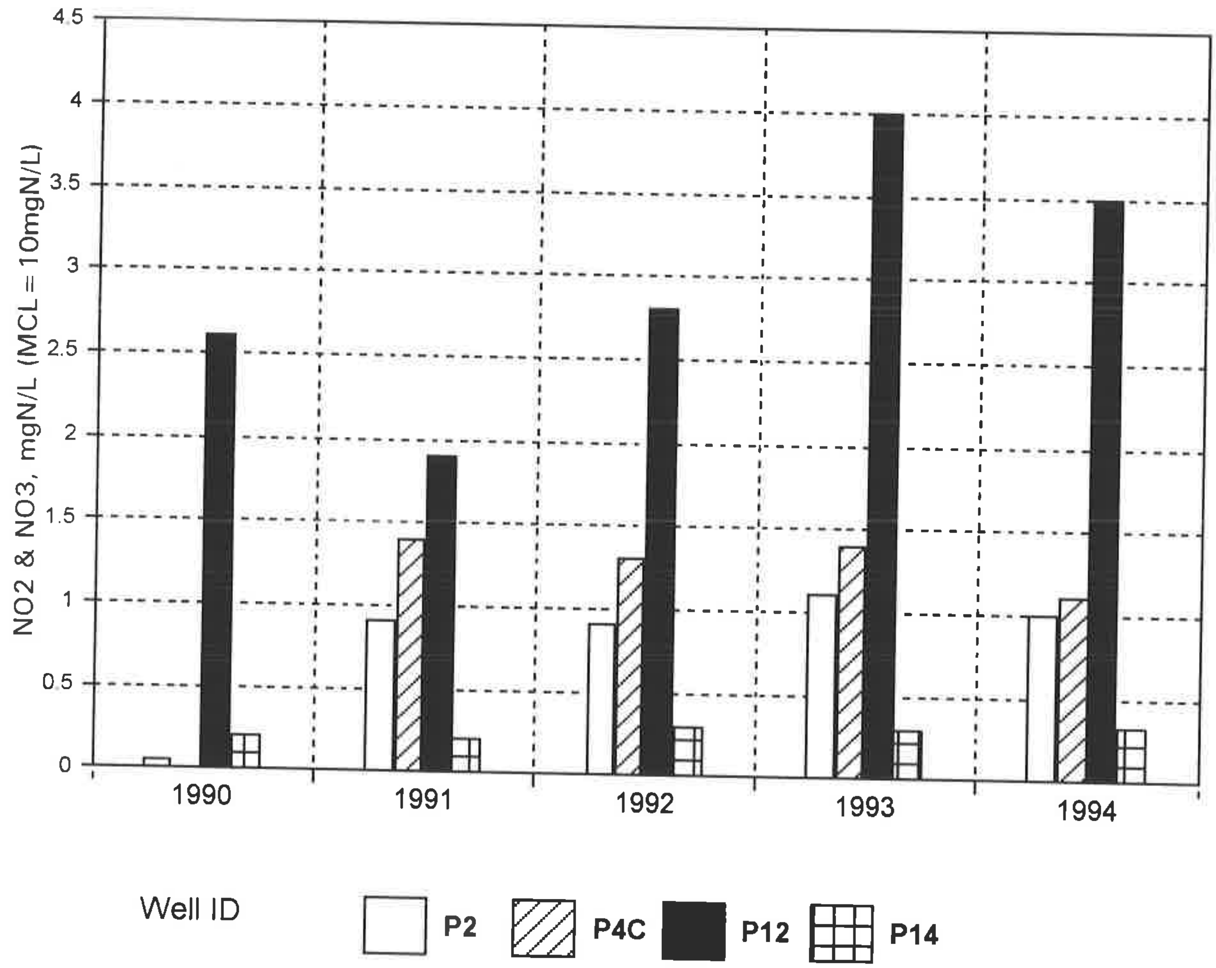
*Iron levels below the detection limit are assigned a value of 12.1 ppb. A missing bar indicates data are not available for that year.

Figure 3-20. - Iron Concentrations for Selected Wells in the Piedmont/Blue Ridge Unconfined Aquifer System: Piedmont sector.



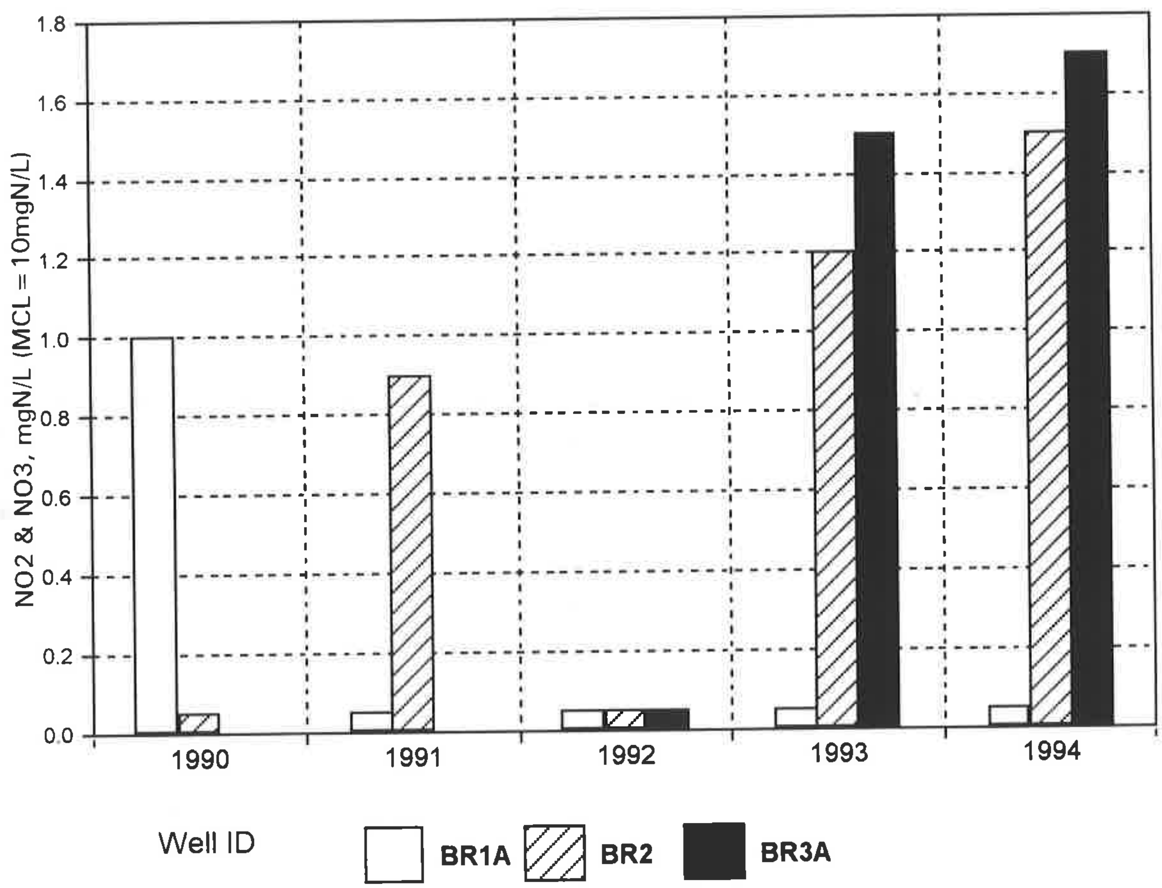
Iron levels below the detection limit are assigned a value of 5.1 ppb. A missing bar indicates data are not available for that year.

Figure 3-21. - Iron Concentrations for Selected Wells in the Piedmont/Blue Ridge Unconfined Aquifer System: Blue Ridge Sector.



Nitrate/nitrite levels below the detection limit are assigned a value of 0.05 ppm. A missing bar indicates data are not available for that year.

Figure 3-22. - Nitrate/Nitrite Concentrations for Selected Wells in the Piedmont/Blue Ridge UnconfinedAquifer System: Piedmont Sector.



Nitrate/nitrite levels below the detection limit are assigned a value of 0.05 ppm. A missing bar indicates data are not available for that year.

Figure 3-23. - Nitrate/Nitrite Concentrations for Selected Wells in the Piedmont/Blue Ridge Unconfined Aquifer System: Blue Ridge Sector.

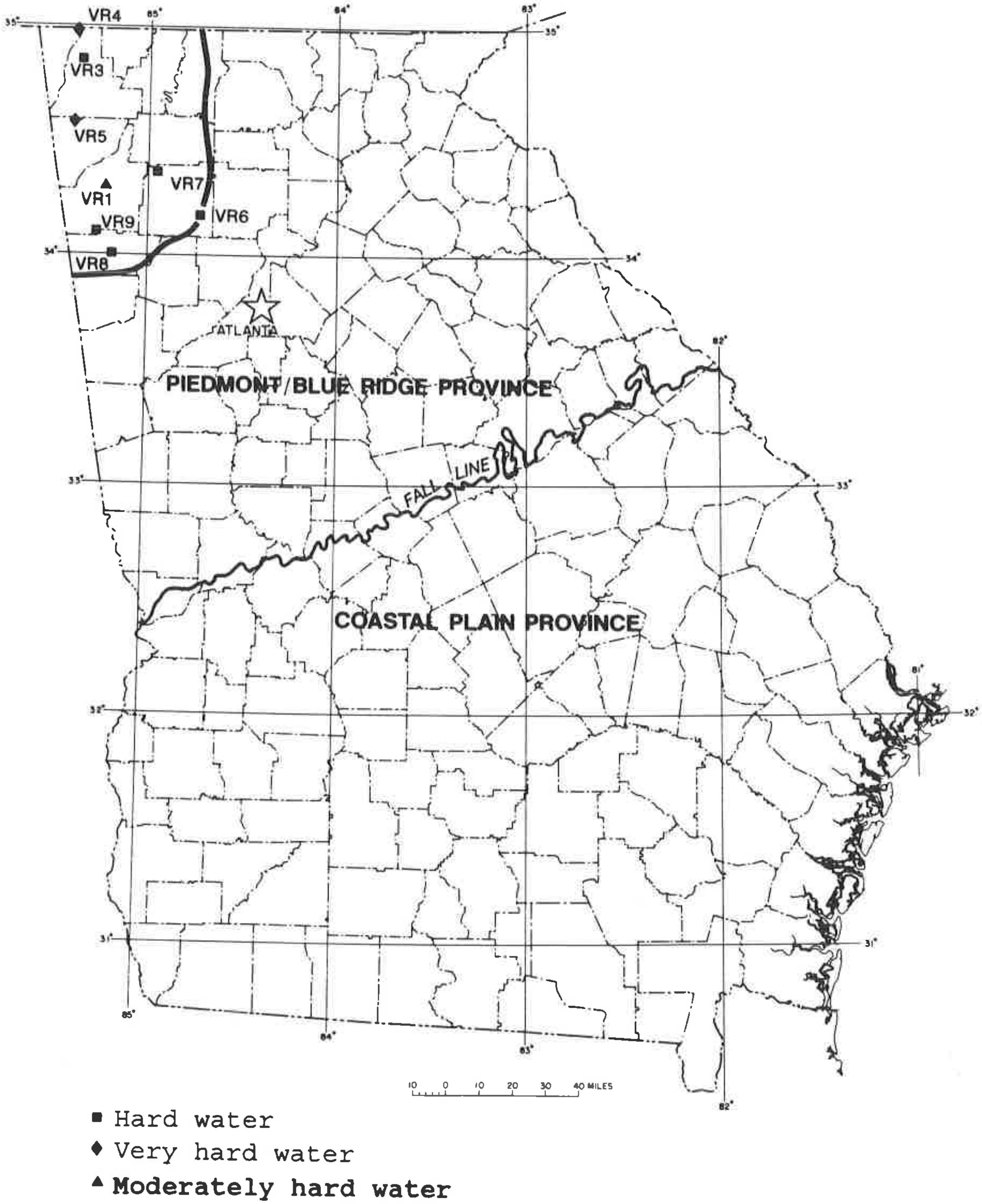
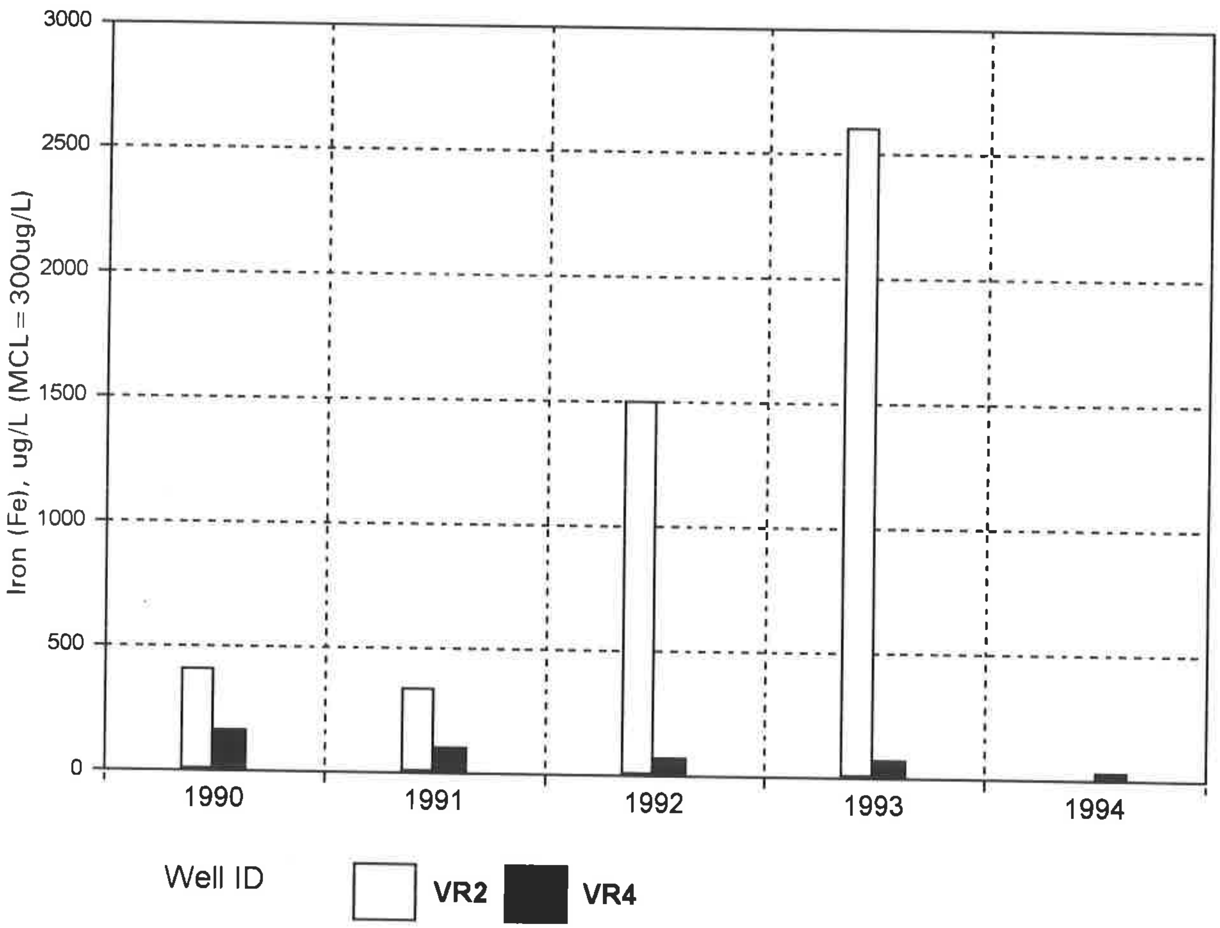


Figure 3-24. - Water Quality of Selected Wells in the Valley and Ridge Unconfined Aquifers.

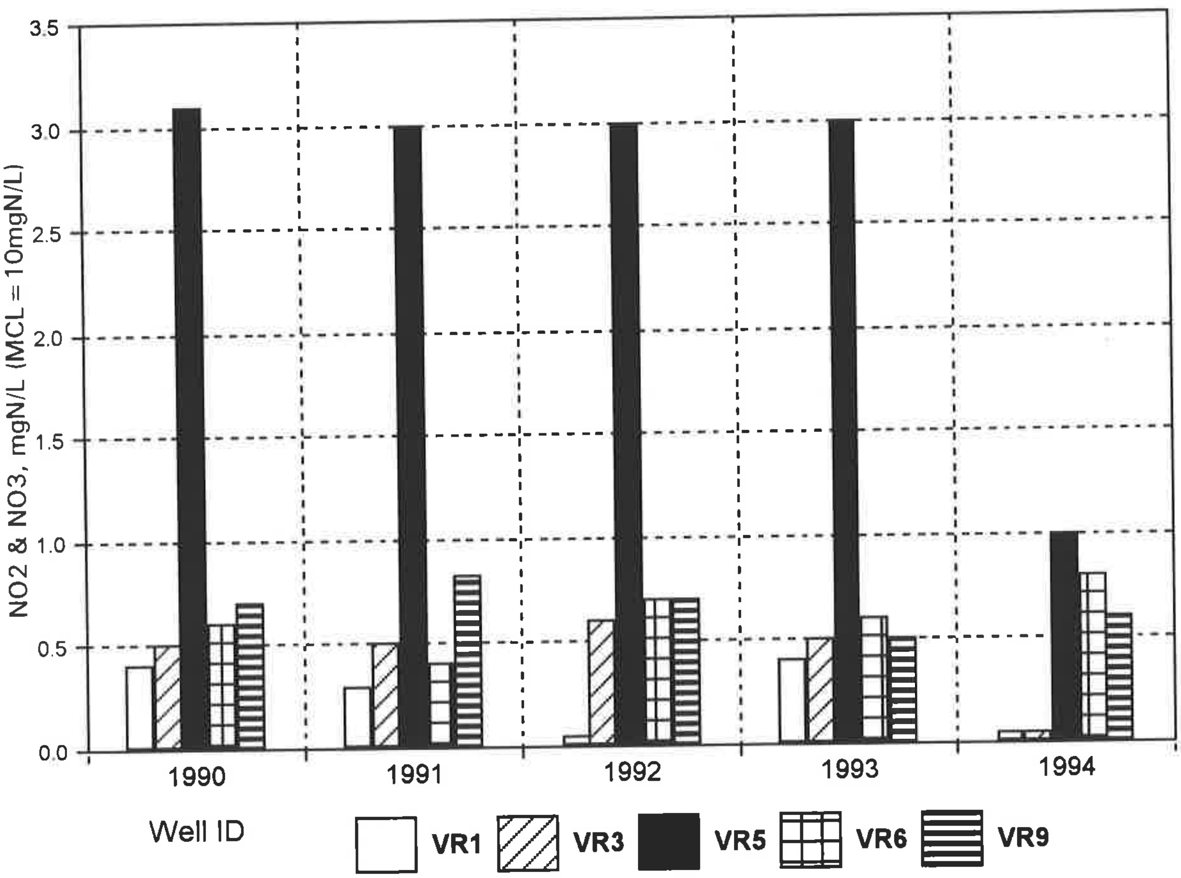
Concentrations fell below applicable MCL's. Samples from all eight stations contained calcium and magnesium. The commonly detected trace metals consisted of barium and strontium. The highest barium concentration, 600 ppb, occurred in a sample from well GWN-VR6. This particular well draws water from the Shady Dolomite Group which contains an abundance of barite ($BaSO_4$) deposits. Chloride concentrations ranged from 1.1 ppm to 11.7 ppm, and sulfate ranged from undetectable to 42.3 ppm. Spring GWN-VR3 yielded the only sample with detectable fluoride. Except for stations GWN-VR1 and GWN-VR3, samples from all wells and springs contained nitrate/nitrite. The highest nitrate/nitrite concentration (2.8 ppm as N) occurred in a sample from well GWN-VR4. Figures 3-25 and 3-26 show iron and nitrite/nitrate levels, respectively, for selected sampling stations in the Valley and Ridge aquifers.

The sample from well GWN-VR6, which is located in an industrial setting, contained a non-quantifiable concentration of tetrachloroethylene. Also, methyl-tert-butyl ether occurred at a level of 23 ppb in well GWN-VR5, which is located in a rural setting. There is no MCL for the compound. Appendix Table A-9 presents the analytical summary for the wells and springs located in the Valley and Ridge unconfined aquifers.



A missing bar indicates that data are not available for that year.

Figure 3-25. - Iron Concentrations for Selected Wells in the Valley and Ridge UnconfinedAquifers.



Nitrate/nitrite levels below the detection limit are assigned a value of 0.05 ppm. A missing bar indicates data are not available for that year.

Figure 3-26. - Nitrate/Nitrite Concentrations for Selected Wells in the Valley and Ridge UnconfinedAquifers.

4.0 SUMMARY AND CONCLUSIONS

EPD personnel collected 97 raw water samples from 85 wells and 4 springs on the Ground-Water Monitoring Network in 1994 for inorganic and organic analysis. These wells and springs monitor the water quality of seven aquifer systems in Georgia:

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

Comparisons of analyses of water samples collected in 1994 were made 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 detected at the stations of the Ground-Water Monitoring Network during 1994. Although isolated water quality problems existed during 1994 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 and the up-dip Jacksonian aquifer systems (J8, MI8A and MI15) yielded water samples in 1994 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 consist of septic systems, agricultural wastes, and storage or application of fertilizers (Robertson, et. al, 1993). Dissolved nitrogen also is present in rainwater and can be 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, which commonly develop 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 occurred at 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 again became apparent in water from a few of the wells sampled in the Valley and Ridge. The sporadic nature of the occurrence of such

Table 4-1. Pollution and Contamination Incidents, 1994.

Station	Contaminant/ Pollutant	Primary MCL	Secondary MCL
GWN-K1	Al=2600ppb		Al=200ppb
GWN-K3	Fe=580ppb		Fe=300ppb
GWN-K9	Fe=500ppb Al=440ppb		Fe=300ppb Al=200ppb
GWN-CL2	F=5.0ppm*	F=4.0ppm	
GWN-CL4	C_6H_6=10ppb O-xylene=tr Mn=62ppb	C_6H_6=5.0ppb xylenes=10,000ppb	Mn=50ppb
GWN-CL8	Fe=660ppb Mn=50ppb		Fe=300ppb Mn=50ppb
GWN-J3	Mn=130ppb		Mn=50ppb
GWN-J8	NO_X=10.7ppm as N Mn=70ppb	NO_X=10ppm as N	Mn=50ppb
GWN-PA9C	SO_4=398ppm Cl=1770ppm		SO_4=250ppm Cl=250ppm
GWN-PA18	Mn=52ppb		Mn=50ppb
GWN-PA33	Ba=2.2ppm	Ba=2.0ppm	
GWN-PA39	$CHCl_3$=tr	trihalomethanes=100ppb	
GWN-MI5	Mn=110ppb Al=430ppb		Mn=50ppb Al=200ppb
GWN-MI7	Al=730ppb		Al=200ppb
GWN-MI8A	NO_X=10.3ppm as N Al=740ppb Mn=74ppb	NO_X=10ppm as N	Al=200ppb Mn=50ppb
GWN-MI10B	Mn=160ppb		Mn=50ppb
GWN-MI13	Fe=2200ppb Mn=210ppb		Fe=300ppb Mn=50ppb
GWN-MI15	NO_X=14.1ppm as N Al=220ppm	NO_X=10ppm as N	Al=200ppb

*belioeved to be questionable

Table 4-1 (continued). Pollution and Contamination Incidents, 1994.

Station	Contaminant/ Pollutant	Primary MCL	Secondary MCL
GWN-BR3A	Mn=72ppb		Mn=50ppb
GWN-P2	naphthalene=tr	(no MCL)	(no MCL)
GWN-P6B	Mn=85ppb		Mn=50ppb
GWN-P9	Fe=1600ppb Mn=170ppb		Fe=300ppb Mn=50ppb
GWN-P15A	Fe=480ppb Mn=81ppb		Fe=300ppb Mn=50ppb
GWN-P16C	Fe=900ppb Mn=230ppb		Fe=300ppb Mn=50ppb
GWN-VR5	methyl-tert-butyl ether=23ppb	(no MCL)	(no MCL)
GWN-VR6	tetrachloroethylene=trace	tetrachloroethylene=5ppb	

compounds in most of these wells makes defining spatial and temporal trends in levels of organic pollutants impossible at this time.

Tropical Storm Alberto apparently was only responsible for localized chemical ground-water quality degradation but caused widespread bacterial contamination. The storm is believed to have been instrumental in causing excess nitrate/nitrite to enter well water at Shellman and bacterial contamination of numerous domestic wells. A reconnaissance sampling of Ground-Water Monitoring Network wells in the Dougherty Plain found that the overall chemical quality of Floridan ground water was only minimally affected. Sampling of inundated wells in the Flint River area, however, showed that many of these wells suffered flood-related bacterial contamination.

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ANALYSES OF SAMPLES COLLECTED DURING 1994 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 mercury, 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)
mg/L as N	= 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	None
Barium (Ba)	10 ug/L	2000 ug/L_1
Beryllium* (Be)	2 ug/L	4 ug/L_1
Bismuth (Bi)	25 ug/L	None
Cobalt (Co)	10 ug/L	None
Chromium (Cr)	10 ug/L	100 ug/L_1
Cadmium* (Cd)	2.5 ug/L	5 ug/L_1
Copper (Cu)	20 ug/L	1000 ug/L_2
Iron (Fe)	20 ug/L	300 ug/L_2
Manganese (Mn)	20 ug/L	50 ug/L_2
Molybdenum (Mo)	10 ug/L	None
Nickel (Ni)	20 ug/L	100 ug/L_1
Lead (Pb)	50 ug/L	None
Antimony* (Sb)	3 ug/L	6 ug/L_1
Selenium* (Se)	25 ug/L	50 ug/L_1
Tin (Sn)	90 ug/L	None
Strontium (Sr)	10 ug/L	None
Titanium (Ti)	10 ug/L	None
Thallium* (Tl)	1 ug/L	2 ug/L_1
Vanadium (V)	10 ug/L	None
Yttrium (Y)	10 ug/L	None

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	None
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 as N	10 mg/L as N_1
Fluoride (F^-)	0.1 mg/L	4.0 mg/L_1, 2.0 mg/L_2
MINERALS		
Calcium (Ca)	1.0 mg/L	None
Potassium (K)	5.0 mg/L	None
Magnesium (Mg)	1.0 mg/L	None
Sodium (Na)	1.0 mg/L	None
OTHER PARAMETERS		
pH	0.01 SU	None
Conductivity	1.0 mho/cm	None

*Analyzed by atomic absorbtion spectrophotometry (AAS), using graphite furnace.
$_1$=Primary Maximum Contaminant Level (MCL).
$_2$=Secondary MCL.

MCL's from Georgia Rules for Safe Drinking Water, March 1994 edition (EPD, 1994).

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

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	None
Chloropyrifos	0.8 ug/L	None
Cyanazine	1.0 ug/L	None
DCPA	0.01 ug/L	None
Dasanit	0.6 ug/L	None
Demeton	1.0 ug/L	None
Diazinon	1.0 ug/L	None
Dimethoate	0.5 ug/L	None
Disyston	1.0 ug/L	None
Eptam	0.5 ug/L	None
Ethoprop	0.5 ug/L	None
Fonophos	0.5 ug/L	None
Guthion	2.0 ug/L	None
Isopropalin	1.0 ug/L	None
Malathion	1.4 ug/L	None
Metolachlor	1.0 ug/L	None
Metribuzin	1.25 ug/L	None
Mevinphos	1.4 ug/L	None
Parathion (E)	0.08 ug/L	None
Parathion (M)	0.1 ug/L	None

ORGANIC SCREEN #1 (continued) *(organophosphates/herbicides)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Pebulate	0.6 ug/L	None
Pendimethalin	0.8 ug/L	None
Phorate	1.0 ug/L	None
Profluralin	0.9 ug/L	None
Simazine	0.9 ug/L	4.0 ug/L
Sutan	0.7 ug/L	None
Terbufos	3.0 ug/L	None
Trifluralin	1.0 ug/L	None
Vernam	0.5 ug/L	None

ORGANIC SCREEN #2 *(organochlorine pesticides/PCB's)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Chlordane	2.0 ug/L	2.0 ug/L
Dicofol	0.1 ug/L	None
Endrin	0.03 ug/L	2.0 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	None
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	None
Chloramben	0.2 ug/L	None
Dalapon	0.2 ug/L	200 ug/L
Dinoseb	0.1 ug/L	7ug/L
Pichloram	500 ug/L	500 ug/L
Silvex	0.1 ug/L	50.0 ug/L
Trichlorofon	2.0 ug/L	None

ORGANIC SCREEN #5 *(carbamate pesticides)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Carbaryl	2.0 ug/L	None
Carbofuran	1.0 ug/L	40.0 ug/L
Diuron	1.0 ug/L	None
Fluometron	1.0 ug/L	None
Linuron	1.0 ug/L	None
Methomyl	1.0 ug/L	None
Monuron	1.0 ug/L	None
Oxamyl	2.0 ug/L	200 ug/L

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**
N-Nitrosodimethyl-amine	10.0 ug/L	None
2-Picoline	10.0 ug/L	None
Methylmethanesul-fonate	10.0 ug/L	None
Ethylmethanesul-fonate	20.0 ug/L	None
Aniline	10.0 ug/L	None
Phenol	10.0 ug/L	None
Bis(2-Chloroethyl) ether	10.0 ug/L	None
2-Chlorophenol	10.0 ug/L	None
1.3-Dichlorobenzene (m)	10.0 ug/L	None
1,4-Dichlorobenzene (p)	10.0 ug/L	75.0 ug/L
Benzyl Alcohol	20.0 ug/L	None
1,2-Dichlorobenzene (o)	10.0 ug/L	600.0 ug/L
2-Methylphenol	10.0 ug/L	None

ORGANIC SCREENS #8 AND #9 (continued) *(semivolatile organic compounds)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Bis(2-Chloroiso-propyl) Ether	10.0 ug/L	None
Acetophenone	10.0 ug/L	None
4-Methylphenol	10.0 ug/L	None
N-Nitrosodi-N-Propylamine	10.0 ug/L	None
Hexachloroethane	10.0 ug/L	None
Nitrobenzene	10.0 ug/L	None
N-Nitrosopiperidine	20.0 ug/L	None
Isophorone	10.0 ug/L	None
2-Nitrophenol	10.0 ug/L	None
2,4-Dimethylphenol	10.0 ug/L	None
Bis(2-Chloroethoxy) Methane	10.0 ug/L	None
Benzoic Acid	50.0 ug/L	None
2,4-Dichlorophenol	10.0 ug/L	None
1,2,4-Trichlorobenzene	10.0 ug/L	None
A,a-Dimethyl-phenylethylamine	10.0 ug/L	None
Naphthalene	10.0 ug/L	None
4-Chloroaniline	20.0 ug/L	None
2,6-Dichlorophenol	10.0 ug/L	None
Hexachlorobutadi-ene	10.0 ug/L	None
N-Nitroso-Di-N-Butylamine	10.0 ug/L	None

ORGANIC SCREENS #8 AND #9 (continued) *(semivolatile organic compounds)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
4-Chloro-3-methylphenol	20.0 ug/L	None
2-Methyl Naphthalene	10.0 ug/L	None
1,2,4,5-Tetrachlorobenzene	10.0 ug/L	None
Hexachlorocyclo-pentadiene	10.0 ug/L	50 ug/L
2,4,6-Trichlorophenol	10.0 ug/L	None
2-Chloronaphthalene	10.0 ug/L	None
2,4,5-Trichlorophenol	10.0 ug/L	None
1-Chloronaphthalene	10.0 ug/L	None
2-Nitroanaline	50.0 ug/L	None
Dimethylphthalate	10.0 ug/L	None
Acenaphthylene	10.0 ug/L	None
2,6-Dinitrotoluene	10.0 ug/L	None
3-Nitroaniline	50.0 ug/L	None
Acenaphthene	10.0 ug/L	None
2,4-Dinitrophenol	50.0 ug/L	None
4-Nitrophenol	50.0 ug/L	None
Dibenzofuran	10.0 ug/L	None
Pentachlorobenzene	10.0 ug/L	None
2,4-Dinitrotoluene	10.0 ug/L	None
1-Naphthylamine	10.0 ug/L	None
2-Naphthylamine	10.0 ug/L	None

ORGANIC SCREENS #8 AND #9 (continued) *(semivolatile organic compounds)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
2,3,4,6-tetrachlorobenzene	10.0 ug/L	None
Diethylphthalate	10.0 ug/L	None
Fluorene	10.0 ug/L	None
4-Chlorophenyl Phenyl Ether	10.0 ug/L	None
4-Nitroaniline	20.0 ug/L	None
Diphenylamine	10.0 ug/L	None
4,6-Dinitro-2-methylphenol	50.0 ug/L	None
N-Nitroso-diphenylamine	10.0 ug/L	None
1,2-diphenyl-hydrazine	10.0 ug/L	None
4-Bromophenyl-Phenyl Ether	10.0 ug/L	None
Phenacetin	20.0 ug/L	None
Hexachlorobenzene	10.0 ug/L	1 ug/L
4-Aminobiphenyl	20.0 ug/L	None
Pentachlorophenol	50.0 ug/L	1.0 ug/L
Pronamide	10.0 ug/L	None
Pentachloronitro-benzene	20.0 ug/L	None
Phenanthrene	10.0 ug/L	None
Anthracene	10.0 ug/L	None
Di-N-Butyl Phthalate	10.0 ug/L	None
Fluoranthene	10.0 ug/L	None

ORGANIC SCREENS #8 AND #9 (continued) *(semivolatile organic compounds)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Benzidine	80.0 ug/L	None
Pyrene	10.0 ug/L	None
P-Dimethyl-aminoazobenzene	10.0 ug/L	None
N-butylbenzylphthalate	10.0 ug/L	None
Benzo (a) Anthracene	10.0 ug/L	None
3,3-Dichlorobenzidine	20.0 ug/L	None
Chrysene	10.0 ug/L	None
Bis(2-Ethyl-hexyl) Phthalate	10.0 ug/L	6 ug/L
Di-N-Octyl Phthalate	10.0 ug/L	None
Benzo (B)Fluoranthene	10.0 ug/L	None
Benzo (K)Fluoranthene	10.0 ug/L	None
7,12-Dimethylbenz (A)Anthracene	10.0 ug/L	None
Benzo (A)Pyrene	10.0 ug/L	0.2ug/L
3-Methyl-cholanthrene	10.0 ug/L	None
Dibenz(A,J)Acridine	10.0 ug/L	None
Indeno(1,2,3-C-D)Pyrene	10.0 ug/L	None
Dibenz(A.H)Anthra-cene	10.0 ug/L	None

ORGANIC SCREENS #8 AND #9 (continued) *(semivolatile organic compounds)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Benzo(GHI)-Perylene	10.0 ug/L	None
ά-BHC	10.0 ug/L	None
′Y-BHC (Lindane)	10.0 ug/L	0.2 ug/L
δ-BHC	10.0 ug/L	None
β-BHC	10.0 ug/L	None
Heptachlor	10.0 ug/L	0.4 ug/L
Aldrin	10.0 ug/L	None
Heptachlor Epoxide	25.0 ug/L	0.2 ug/L
Endosulfan 1	50.0 ug/L	None
Dieldrin	10.0 ug/L	None
P,P'-DDE	10.0 ug/L	None
Endrin	20.0 ug/L	2.0 ug/L
Endosulfan 2	50.0 ug/L	None
P,P'-DDD	10.0 ug/L	None
Endrin Aldehyde	10.0 ug/L	None
Endosulfan Sulfate	25.0 ug/L	None
P,P'-DDT	10.0 ug/L	None

ORGANIC SCREEN #10 *(volatile organic compounds)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Dichlorodifluoro-methane	5.0 ug/L	None

ORGANIC SCREEN #10 (continued) *(volatile organic compounds)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
Chloromethane	10.0 ug/L	None
Bromomethane	10.0 ug/L	None
Chloroethane	10.0 ug/L	None
Vinyl Chloride	10.0 ug/L	2.0 ug/L
Dichloromethane	5.0 ug/L	5.0 ug/L
Trichlorofluoro-methane	5.0 ug/L	None
Acetone	100 ug/L	None
Dibromomethane	5.0 ug/L	None
Trans-1,2-Dichloroethylene	5.0 ug/L	100 ug/L
Iodomethane	5.0 ug/L	None
Carbon Disulfide	5.0 ug/L	None
1,1-Dichloro-ethylene	5.0 ug/L	7.0 ug/L
1,1-Dichloroethane	5.0 ug/L	None
Cis-1,2-Dichloro-ethylene	5.0 ug/L	70.0 ug/L
2,2-Dichloropropane	5.0 ug/L	None
Bromochloro-methane	5.0 ug/L	None
Chloroform	5.0 ug/L	100 ug/L*
1,1-Dichloro-propylene	5.0 ug/L	None
1,2-Dichloroethane	5.0 ug/L	5.0 ug/L
Methyl Ethyl Ketone	100 ug/L	None

ORGANIC SCREEN #10 (continued) *(volatile organic compounds)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
1,1,1-Trichloro-ethane	5.0 ug/L	200 ug/L
Carbon Tetrachloride	5.0 ug/L	5.0 ug/L
Vinyl Acetate	50 ug/L	None
Bromodichloro-methane	5.0 ug/L	100 ug/L*
1,2-Dichloropropane	5.0 ug/L	5.0 ug/L
Trichloroethylene	5.0 ug/L	5.0 ug/L
Benzene	5.0 ug/L	5.0 ug/L
2-Chloroethyl Vinyl Ether	5.0 ug/L	None
Cis-1,3-Dichloropropylene	5.0 ug/L	None
Trans-1,3-Dichloropropylene	5.0 ug/L	None
Chlorodibromo-methane	5.0 ug/L	100 ug/L*
1,1,2-Trichloroethane	5.0 ug/L	5.0 ug/L
Bromoform	5.0 ug/L	100 ug/L*
1,2,3-Trichloro-propane	5.0 ug/L	None
Methyl Isobutyl Ketone	50 ug/L	None
Methyl N-butyl Ketone	50 ug/L	None
Tetrachloroethylene	5.0 ug/L	5.0 ug/L
1,2-Dichloropropane	5.0 ug/L	5.0 ug/L

ORGANIC SCREEN #10 (continued) *(volatile organic compounds)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
1,1,2,2,-Tetra-chloroethane	5.0 ug/L	None
Toluene	5.0 ug/L	1000 ug/L
1,2-Dibromoethane	5.0 ug/L	None
Ethylene dibromide	5.0 ug/L	0.05 ug/L
Chlorobenzene	5.0 ug/L	100 ug/L
Ethylbenzene	5.0 ug/L	700 ug/L
1,1,1,2-Tetra-chloroethane	5.0 ug/L	None
Styrene	5.0 ug/L	100 ug/L
Xylenes (total)	5.0 ug/L	10,000 ug/L
Isopropylbenzene	5.0 ug/L	None
Bromobenzene	5.0 ug/L	None
N-Propylbenzene	5.0 ug/L	None
2-Chlorotoluene	5.0 ug/L	None
1,3,5-Trimethyl-benzene	5.0 ug/L	None
4-Chlorotoluene	5.0 ug/L	None
Tert-Butylbenzene	5.0 ug/L	None
1,2,4-Trimethyl-benzene	5.0 ug/L	None
Sec-Butylbenzene	5.0 ug/L	None
1,3-Dichlorobenzene (m)	5.0 ug/L	None
1,4-Isopropyltoluene	5.0 ug/L	None
1,4-Dichlorobenzene (p)	5.0 ug/L	75.0 ug/L

ORGANIC SCREEN #10 (continued) *(volatile organic compounds)*		
Parameter	**Minimum Detection Limit**	**Primary Maximum Contaminant Level**
N-Butylbenzene	5.0 ug/L	None
1,2-Dichlorobenzene (o)	5.0 ug/L	600 ug/L
1,2-Dibromo-3-Chloropropane	5.0 ug/L	0.2ug/L
1,2,4-Trichlorobenzene	5.0 ug/L	70.0 ug/L
Hexachlorobutadi-ene	5.0 ug/L	None
Naphthalene	5.0 ug/L	None
1,2,3-Trichlorobenzene	5.0 ug/L	None

* *Indicates a trihalomethane compound. The primary MCL for total trihalomethanes is 100 ug/L.*

MERCURY SCREEN*		
Parameter	**Method Detection Limit**	**Primary Maximum Contaminant Level**
Mercury (Hg)	0.2 ug/L	2.0 ug/L

**Analysis is by manual cold vapor.*

Table A-3. 1994 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		4.60	2.6	0.4U	3.8	1.7	--	13	60	60	2600	2.36	0.5 U	12.5	0.71	102	Cu=9 Mo=20 Pb=60 Se=0.9 V=16 Zn=20	2,3,4
	Well Name:		Englehard Kaolin Company #2															
	County:		Wilkinson															
	Date Sampled:		1994/09/22															
GWN-K2		4.03	1.7	5U	1.2	1U	10U	10U	53	10U	50U	2.0	0.1U	3.9	0.31	29		10
	Well Name:		Irwinton #2															
	County:		Wilkinson															
	Date Sampled:		1994/09/28															
GWN-K3		5.26	2.1	5U	17	1.3	54	23	580	30	50U	2.2	0.1U	7.3	0.1U	102		1,2,3,4,5, 10
	Well Name:		Sandersville #7B															
	County:		Washington															
	Date Sampled:		1994/09/28															
GWN-K6		5.25	3.3	1.3	4.3	0.53	--	16	30	1U	25U	0.24	0.5U	5.81	0.24	53	Zn=20 Cu=9	10
	Well Name:		J.M. Huber #6															
	County:		Twiggs															
	Date Sampled:		1994/09/22															
GWN-K7		4.90	1.9	0.4U	1.84	0.38	--	13	10	1U	25U	0.32	0.5U	1.05	0.32	24	Zn=40 Pb=30 Mo=5	2,3,4
	Well Name:		Jones County #4															
	County:		Jones															
	Date Sampled:		1994/09/22															
GWN-K9		3.87	1.3	0.4U	0.69	0.24	--	5U	500	5U	440	0.61	0.5U	9.3	0.24	53		
	Well Name:		Marshallville #1															
	County:		Macon															
	Date Sampled:		1994/09/21															
GWN-K18A		4.72	1.3	5U	1.3	1U	10U	10U	20U	10U	50U	1.6	0.1U	3.6	0.16	22		2,3,4,10
	Well Name:		Buena Vista #6															
	County:		Marion															
	Date Sampled:		1994/09/21															
GWN-K19		4.86	1.6	0.4U	0.6	0.3	--	5	20	5U	30	1.74	0.5U	2.0	0.2U	10	Cu=6 V=5	1,2,3,4,5, 10
	Well Name:		Hephzibah Murphy St. Well															
	County:		Richmond															
	Date Sampled:		1994/09/28															

Table A-4. 1994 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		7.04	1.7	0.58	47	0.87	--	20	100	5U	30	3.8	5.0	7.13	0.75	302	Ag=7 As=0.7 Zn=7	3,4
	Well Name:		Unadilla #3															
	County:		Dooly															
	Date Sampled:		1994/09/21															
GWN-CL4		4.51	4.3	5U	2	1.3	15	17	20U	62	50U	6.2	0.1U	2U	2.8	55	Cu=52 Zn=64 C6H6=10 xylene (o)=tr	1,2,3,4,5, 10
	Well Name:		Plains #3															
	County:		Sumter															
	Date Sampled:		1994/09/21															
GWN-CL8		6.01	1.9	2.0	9.8	1.07	--	30	660	50	30	1.03	0.5U	8.3	0.26	91	Ag=10 Mo=5 Pb=40 V=50 Zn=460	1,2,3,4,5
	Well Name:		Flint River Nursery office well															
	County:		Dooly															
	Date Sampled:		1994/09/21															

Table A-5. 1994 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		7.12	3.8	5U	55	1U	25	20	20U	10U	50U	8.3	0.1U	2U	1.8	265		1,2,3,4,5
	Well Name:		Hudlow house well															
	County:		Burke															
	Date Sampled:		1994/09/29															
GWN-J2A		7.45	1.3	5U	51	1U	56	40	20U	10U	50U	1.6	0.1U	2U	0.5	246		1,2,3,4,5,10
	Well Name:		Oakwood Village Mobile Home Park #2															
	County:		Burke															
	Date Sampled:		1994/09/29															
GWN-J3		7.72	10	2.01	37	6.4	--	701	210	130	70	17.4	0.5U	3.39	0.2U	230	As=3 Cu=80 Pb=40 V=43 Zn=70	1,2,3,4,5,10
	Well Name:		Black house well															
	County:		Emanuel															
	Date Sampled:		1994/09/29															
GWN-J4		6.68	3.4	5U	48	2.3	180	10U	67	36	50U	3.0	0.1	6.4	0.1	251		1,2,3,4,5
	Well Name:		Wrightsville #4															
	County:		Johnson															
	Date Sampled:		1994/09/28															
GWN-J5		7.40	3.2	2.31	65	2.42	--	9	30	30	30	1.73	0.5U	29.1	0.21	392	Zn=10	1,2,3,4,5,10
	Well Name:		Cochran #3															
	County:		Bleckley															
	Date Sampled:		1994/09/21															
GWN-J7		4.62	4.1	0.52	2.62	1.78	--	28	30	5U	70	6.14	0.5U	0.66	3.71	40	Cu=7 Pb=30 V=15 Zn=20	1,2,3,4,5
	Well Name:		Templeton liovestock well															
	County:		Burke															
	Date Sampled:		1994/09/28															
GWN-J8		4.66	5.5	0.4U	9.56	1.78	--	42	10	70	80	8.38	0.4U	0.52	10.7	130	Be=3 Cu=20 Ni=10 V=18 Zn=30	1,2,3,4,5
	Well Name:		Kahn house well															
	County:		Jefferson															
	Date Sampled:		1994/09/28															

Table A-6. 1994 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		--	45	5U	29	12	360	11	20U	10U	50U	70.1	0.3	12.4	0.1U	462		
	Well Name:		Thunderbolt #1															
	County:		Chatham															
	Date Sampled:		1994/09/29															
GWN-PA2		--	11	5U	25	7.6	280	12	20U	10U	50U	3.9	0.3	4.9	0.1U	217		
	Well Name:		Savannah #6															
	County:		Chatham															
	Date Sampled:		1994/09/29															
GWN-PA4		--	50	5U	35	24	1200	10U	20U	10U	50U	40.4	0.7	122.6	0.1U	594		
	Well Name:		Tybee island #1															
	County:		Chatham															
	Date Sampled:		1994/09/29															
GWN-PA5A		8.01	16	5U	26	14	430	30	20U	10U	50U	5.3	0.5	34.5	0.1U	301		10
	Well Name:		Interstate Paper #2															
	County:		Liberty															
	Date Sampled:		1994/02/01															
GWN-PA6		--	14	tr (5U)	24	12	360	22	20U	10U	tr (50U)	4.4	0.4	22.3	0.1U	267	Ag=tr Ni=tr Au=tr V=tr Cu=tr Y=tr Co=tr Zn=tr Cu=tr Zr=tr	10
	Well Name:		Hinesville #5															
	County:		Liberty															
	Date Sampled:		1994/02/01															
GWN-PA7		7.80	24	5U	45	27	720	51	110	10U	50U	26.1	0.5	147	0.1U	540		10
	Well Name:		Darien #2 South															
	County:		McIntosh															
	Date Sampled:		1994/02/01															
GWN-PA8		7.83	17	5U	32	17	540	72	20U	10U	50U	7.0	0.4	52.3	0.1U	349		10
	Well Name:		ITT Rayonier #4D															
	County:		Wayne															
	Date Sampled:		1994/02/01															
GWN-PA9C		7.59	800	19	160	110	2600	68	270	10U	50U	1770.0	0.34	398	0.1U	5568	Cu=27	
	Well Name:		Miller Ball Park TW25															
	County:		Glynn															
	Date Sampled:		1994/02/02															

Table A-6 (Continued). 1994 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-PA10B		7.29	68	5U	78	42	770	39	20U	10U	50U	123.6	0.6	155.8	0.1U	1024		10
	Well Name:		Gilman Paper #11															
	County:		Camden															
	Date Sampled:		1994/02/02															
GWN-PA11		7.43	22	5U	73	36	630	33	27	10U	50U	32.2	0.5	169.2	0.1U	714		10
	Well Name:		St. Marys #2															
	County:		Camden															
	Date Sampled:		1994/02/02															
GWN-PA12		7.27	23	5U	70	29	510	33	41	10U	50U	37.2	0.4	150.8	0.1U	633		10
	Well Name:		Folkston #3															
	County:		Charlton															
	Date Sampled:		1994/02/02															
GWN-PA13		7.52	16	5U	42	17	340	70	20U	10U	50U	15.0	0.3	55.2	0.1U	395		10
	Well Name:		Waycross #3															
	County:		Ware															
	Date Sampled:		1994/02/02															
GWN-PA14		8.07	6.5	5U	34	5.1	200	32	20U	10U	50U	2.6	0.2	5.1	0.1U	220		10
	Well Name:		Statesboro #7															
	County:		Bulloch															
	Date Sampled:		1994/01/27															
GWN-PA15		8.20	8.0	4.2	28	8.7	410	10U	51	10U	50U	2.0	0.3	6.1	0.1U	223		10
	Well Name:		King Finishing Co. fire well															
	County:		Screven															
	Date Sampled:		1994/01/27															
GWN-PA16		8.06	4.9	5U	48	3.1	200	10U	27	36	50U	5.2	0.1	6.3	0.1U	267		
	Well Name:		Millen #1															
	County:		Jenkins															
	Date Sampled:		1994/01/27															
GWN-PA17		7.73	4.3	5U	52	1.6	140	180	150	10U	58	3.8	0.8	tr (2U)	tr (0.1U)	248		
	Well Name:		Swainsboro #7															
	County:		Emanuel															
	Date Sampled:		1994/04/06															

Table A-6 (Continued). 1994 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-PA18		8.04	10	5U	30	3.2	240	25	20U	52	50U	3.6	0.1	3.0	0.1U	211		10
	Well Name:		Metter #1															
	County:		Candler															
	Date Sampled:		1994/01/27															
GWN-PA19		7.85	11	1.6	47	1.8	460	56	44	28	tr (50U)	8.2	0.3	78.6	0.1U	393		10
	Well Name:		Douglas #4															
	County:		Coffee															
	Date Sampled:		1994/02/23															
GWN-PA20		7.73	5.0	5U	46	16	190	27	20U	10U	50U	3.2	0.2	67.1	0.1U	348		10
	Well Name:		Lakeland #2															
	County:		Lanier															
	Date Sampled:		1994/02/18															
GWN-PA21A		8.00	3.1	5U	38	8.0	110	14	20U	15	50	2.8	0.2	27.9	0.1U	254		
	Well Name:		Valdosta New #4															
	County:		Lowndes															
	Date Sampled:		1994/02/18															
GWN-PA22		7.94	7.2	5U	47	19	310	22	20U	10U	65	7.0	0.5	68.7	0.1U	389		10
	Well Name:		Thomasville #6															
	County:		Thomas															
	Date Sampled:		1994/02/17															
GWN-PA23		7.88	15	2.3	36	1.5	360	120	tr (20U)	tr (10U)	60	6.7	0.3	42.8	0.1U	340	Mo=12	
	Well Name:		Cairo #8															
	County:		Grady															
	Date Sampled:		1994/02/17															
GWN-PA24		7.86	2.5	5U	41	3.2	37	10U	20U	10U	50U	2.6	0.1U	tr (2U)	1.2	212		1,2,3,4,5,10
	Well Name:		Bainbridge #1															
	County:		Decatur															
	Date Sampled:		1994/03/22															
GWN-PA24		7.68	2.0	5U	38	3.3	36	10U	20U	10U	50U	2.93	0.1U	2U	1.39	223	P=0.06	1,2,10
	Well Name:		Bainbridge #1															
	County:		Decatur															
	Date Sampled:		1994/08/09 (special for Alberto flood)															

Table A-6 (Continued). 1994 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-PA25		7.51	4.1	5U	58	1U	25	10U	20U	10U	50U	3.9	0.1U	tr(2U)	0.1U	275		1,2,3,4,5,10
	Well Name:		Donalsonville 7th Street Well															
	County:		Seminole															
	Date Sampled:		1994/03/22															
GWN-PA25		7.71	3.7	5U	55	1U	25	10U	20U	10U	50U	4.39	0.1U	2U	1.32	120.1	P=50	1,2,10
	Well Name:		Donalsonville 7th Street Well															
	County:		Seminole															
	Date Sampled:		1994/08/09 (special for Alberto flood)															
GWN-PA26		7.62	2.6	5U	47	1U	20	10U	20U	10U	50U	2.7	0.1U	tr (2U)	1.5	221		1,2,3,4,5,10
	Well Name:		Colquitt #3															
	County:		Miller															
	Date Sampled:		1994/03/22															
GWN-PA26		7.68	2.6	5U	44	1U	19	10U	20U	10U	50U	3.00	0.1U	2U	1.63	120.1	P=50	1,2,10
	Well Name:		Colquitt #3															
	County:		Miller															
	Date Sampled:		1994/08/09 (special for Alberto flood)															
GWN-PA27		7.72	2.4	5U	47	1.1	37	10	20U	10U	50U	2.0	tr (0.1U)	tr (2U)	0.2	218		1,2,3,4,5,10
	Well Name:		Camilla New Well															
	County:		Mitchell															
	Date Sampled:		1994/03/23															
GWN-PA27		7.85	1.9	5U	44	1.1	36	11	20U	10U	50U	2.41	0.1U	2U	0.31	223	P=70	1,2,10
	Well Name:		Camilla New Well															
	County:		Mitchell															
	Date Sampled:		1994/08/09 (special for Alberto flood)															
GWN-PA28		7.97	27	5U	40	21	2000	88	20U	10U	53	8.4	0.6	118	0.1U	468		10
	Well Name:		Moultrie #1															
	County:		Colquitt															
	Date Sampled:		1994/02/21															
GWN-PA29		7.90	3.7	5U	44	14	270	12	67	35	53	3.1	0.2	48.6	0.1U	323		
	Well Name:		Adel #6															
	County:		Cook															
	Date Sampled:		1994/02/17															

Table A-6 (Continued). 1994 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-PA30		7.82	5.1	1.3	45	16	230	50	170	37	72	3.5	0.2	60.0	0.1U	346			
	Well Name:	Amoco/Nashville Mills #2																	
	County:	Berrien																	
	Date Sampled:	1994/02/18																	
GWN-PA31		7.37	2.9	tr (5U)	45	8.0	270	67	20U	tr (10U)	50	2.0	0.1	2U	0.1U	271	Au=tr	Ni=tr	
	Well Name:	Tifton #6															Bi=tr	Sn=tr	
	County:	Tift															Co=tr	V=tr	
	Date Sampled:	1994/02/24															Cr=tr	Zn=tr	
																	Cu=tr	Zr=tr	
																	Mo=tr		
GWN-PA32		7.52	2.7	tr (5U)	35	4.8	150	78	140	29	tr (50U)	2.2	tr (0.1U)	tr (2U)	0.1U	198	Cu=tr		10
	Well Name:	Ocilla #3															Sn=tr		
	County:	Irwin															V=tr		
	Date Sampled:	1994/02/23															Zn=tr		
GWN-PA33		8.01	3.4	tr (5U)	24	8.4	270	2200	20U	15	tr (50U)	2.0	0.1	2U	0.1U	174	Cu=tr		10
	Well Name:	Fitzgerald Well C															Ni=tr		
	County:	Ben Hill															V=tr		
	Date Sampled:	1994/02/23															Zn=tr		
GWN-PA39		7.80	3.5	5U	48	8.3	390	170	20U	10U	50U	3.0	0.1	2.2	tr (0.1U)	289	CHCl3=tr		10
	Well Name:	Sylvester #1																	
	County:	Worth																	
	Date Sampled:	1994/04/05																	
GWN-PA40		7.49	2.8	5U	59	1.0	49	17	20U	10U	50U	2.9	tr (0.1U)	tr (2U)	1.3	280			10
	Well Name:	Merck and Co. #8																	
	County:	Dougherty																	
	Date Sampled:	1994/03/23																	
GWN-PA40		7.60	2.5	5U	58	1.1	51	18	20U	10U	50U	3.6	0.1U	2U	1.7	291	P=0.07		1,2,10
	Well Name:	Merck and Co. #8																	
	County:	Dougherty																	
	Date Sampled:	1994/08/10 (special for Alberto flood)																	
GWN-PA43		7.49	3.2	5U	49	1U	39	10U	20U	10U	50U	2.8	0.1U	tr (2U)	1.5	236			2,3,4,5
	Well Name:	Newton #1																	
	County:	Baker																	
	Date Sampled:	1994/03/23																	

Table A-6 (Continued). 1994 Ground-Water Quality Analyses of the Floridan Aquifer System.

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-PA43		7.65	2.5	5U	46	1U	37	10U	20U	10U	50U	3.5	0.1U	2U	1.95	240	P=0.06		1,2,10
	Well Name:		Newton #1																
	County:		Baker																
	Date Sampled:		1994/08/10 (special for Alberto flood)																
GWN-PA44		7.67	2.6	tr (5U)	33	4.2	290	150	20U	tr (10U)	tr (50U)	1.9	0.2	tr (2U)	0.1U	182	Au=tr Cu=tr Ni=tr	V=tr Zn=tr Zr=tr	10
	Well Name:		Sycamore #2																
	County:		Turner																
	Date Sampled:		1994/02/24																
GWN-PA45		7.57	2.1	tr (5U)	56	1.1	72	66	tr (20U)	10U	tr (50U)	2.2	tr (0.1U)	tr (2U)	0.1U	241	Cr=tr Cu=tr Mo=tr	Ni=tr V=tr	10
	Well Name:		Abbeville #1																
	County:		Wilcox																
	Date Sampled:		1994/02/23																
GWN-PA46B		7.58	3.1	5U	47	1.0	31	45	20U	10U	50U	6.2	0.1U	2U	3.7	259	P=0.08		1,2,10
	Well Name:		Wenona Mobile Home Park well																
	County:		Crisp																
	Date Sampled:		1994/08/10																
GWN-PA49		7.74	2.1	tr (5U)	42	0.63	25	19	20U	10U	tr (50U)	2.4	tr (0.1U)	tr (2U)	1.2	198	Cr=tr Cu=tr Mo=tr	V=tr Zn=tr	1,2,3,4,5
	Well Name:		Harmony Church well																
	County:		Dooly																
	Date Sampled:		1994/02/24																
GWN-PA51		7.66	2.9	5U	47	1U	21	10U	20U	10U	50U	2.6	0.1U	tr (2U)	0.8	225	Zn=22		1,2,3,4,5
	Well Name:		J.L. Adams house well																
	County:		Mitchell																
	Date Sampled:		1994/03/24																
GWN-PA51		7.81	2.9	5U	45	1U	21	10U	20U	10U	50U	3.8	0.1U	2U	1.6	239	Zn=21		1,2,10
	Well Name:		J.L. Adams house well																
	County:		Mitchell																
	Date Sampled:		1994/08/09 (special for Alberto flood)																
GWN-PA52		8.13	2.2	5U	40	1U	24	10U	10U	10U	50U	3.2	0.1U	tr (2U)	2.6	200	Zn=48		1,2,3,4,5
	Well Name:		James Simmons house well																
	County:		Mitchell																
	Date Sampled:		1994/03/22																

Table A-6 (Continued). 1994 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-PA52		8.04	2.3	5U	38	1U	23	10U	20U	10U	50U	4.2	0.1U	2U	3.1	206	Zn=55	1,2,10
	Well Name:	James Simmons house well																
	County:	Mitchell																
	Date Sampled:	1994/08/10 (special for Alberto flood)																
GWN-PA53		8.14	3.4	5U	39	1.1	26	13	20U	10U	50U	6.5	0.1U	2U	4.08	220	Zn=33	1,2,10
	Well Name:	Lorene Cato house well																
	County:	Decatur																
	Date Sampled:	1994/08/09																

Table A-7. 1994 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		7.65	7.6	5U	24	13	120	20	20U	28	50U	2.2	0.4	3.4	0.1U	250		1,3,4,5,10
	Well Name: County: Date Sampled:		McMillan house well Cook 1994/10/27															
GWN-MI2		5.16	2.9	5U	31	1U	10U	10U	20U	10U	50U	2.1	0.4	2U	0.1	39		1,3,4,5,8,9, 10
	Well Name: County: Date Sampled:		Boutwell house well Lowndes 1994/10/27															
GWN-MI5		5.09	5.7	5U	6.1	1.7	30	78	83	110	430	10.4	tr (0.1U)	2.8	1.6	72		1,2,3,4
	Well Name: County: Date Sampled:		Carter house well Appling 1994/04/07															
GWN-MI7		4.05	5.3	5U	6.3	5.3	54	98	20U	15	730	10.9	0.1U	2U	0.1U	166		1,2,3,4
	Well Name: County: Date Sampled:		Chaudoin house well Irwin 1994/10/26															
GWN-MI8A		4.64	2.4	5.6	5.8	4.7	52	120	20U	74	740	40.1	0.11	2U	10.3	262	Zn=50	1,2,3,4,5
	Well Name: County: Date Sampled:		Barry house well Colquitt 1994/04/18															
GWN-MI10B		6.37	7.7	6.2	9.7	6.2	89	220	230	160	50U	2.2	0.3	2U	0.1U	137		1,2,3,4,5
	Well Name: County: Date Sampled:		Calhoun house well Colquitt 1994/10/24															
GWN-MI13		7.49	2.3	5U	54	0.76	48	24	2200	210	50U	3.2	tr (0.1U)	tr (2U)	0.1U	257		1,2,3,4,5
	Well Name: County: Date Sampled:		Taylor house well Screven 1994/04/06															
GWN-MI15		4.37	1.7	5U	11	7.8	100	60	28	16	220	8.1	tr (0.1U)	tr (2U)	14.1	165		1,2,3,4,5
	Well Name: County: Date Sampled:		Aldrich house well Bulloch 1994/04/06															

Table A-8. 1994 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		6.27	2.1	5U	17	1U	89	16	69	10U	50U	1U	0.1U	4.75	0.1U	155	Zn=70	
	Well Name:		Hiawassee #7															
	County:		Towns															
	Date Sampled:		1994/08/02															
GWN-BR2A		5.06	3.8	5U	3.4	1.5	42	50	20U	18	50U	3.54	0.1U	1.61	1.5	60		10
	Well Name:		Notla Water Auth. #3															
	County:		Union															
	Date Sampled:		1994/08/03															
GWN-BR3A		6.20	4.5	5U	3.2	1.5	25	26	20U	72	50U	4.37	0.1U	2U	1.7	52	Zn=20	
	Well Name:		Dawsonville City Spring															
	County:		Dawson															
	Date Sampled:		1994/08/02															
GWN-BR4		5.88	8.2	5U	10	2.2	100	10U	20U	10U	50U	4.73	0.1U	1.19	1.9	109		
	Well Name:		Morganton Old Well															
	County:		Fannin															
	Date Sampled:		1994/08/02															
GWN-P2		6.42	9.8	5U	12	1.4	80	24	56	10U	50U	2.0	0.1	2.0	1.0	113	naphthalene=tr Zn=51	10
	Well Name:		Riverdale Delta Drive Well															
	County:		Clayton															
	Date Sampled:		1994/08/23															
GWN-P4C		5.91	7.7	5U	6.7	1.1	72	21	20U	10U	50U	1.3	0.3	2U	1.1	78		10
	Well Name:		Barton Brands #3															
	County:		Fulton															
	Date Sampled:		1994/08/22															
GWN-P6B		7.30	7.8	5U	17	2.4	44	10U	20U	85	50U	2.3	0.3	5.6	0.1U	128		
	Well Name:		Shiloh #1															
	County:		Harris															
	Date Sampled:		1994/09/22															
GWN-P7		6.29	7.7	5U	11	4.3	70	50	20U	10U	50U	1.2	0.3	2U	1.2	116		10
	Well Name:		Hampton #6															
	County:		Henry															
	Date Sampled:		1994/08/22															

Table A-8 (Continued). 1994 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-P9		6.28	15	4.4	20.0	9.4	--	50	1600	170	25U	7.87	0.5U	55.9	0.22	288		
	Well Name:		Gray #4															
	County:		Jones															
	Date Sampled:		1994/09/22															
GWN-P12		5.87	13	5U	11	2.2	69	35	20U	10U	50U	11.0	0.1U	4.7	3.5	137	Zn=38	
	Well Name:		Specialty Brands #1															
	County:		Meriwether															
	Date Sampled:		1994/09/22															
GWN-P14		5.01	1.4	5U	1U	1U	10U	28	20U	10U	50U	1.5	0.1U	2U	0.33	17		
	Well Name:		Upson County Sunset Village well															
	County:		Upson															
	Date Sampled:		1994/09/22															
GWN-P15A		7.24	7.8	5U	17	4.2	92	58	480	81	50U	2.0	0.1U	3.1	0.2	159	Zn=290	10
	Well Name:		Bolton garden well															
	County:		DeKalb															
	Date Sampled:		1994/08/23															
GWN-P16C		6.17	2.2	5U	6.4	1.3	45	10U	900	230	50U	1U	tr (0.1U)	6.60	tr (0.1U)	58	Zn=35	10
	Well Name:		Mt. Airy #4															
	County:		Habersham															
	Date Sampled:		1994/04/07															

Table A-9. 1994 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		7.91	1.6	5U	25	14	17	10U	20U	10U	50U	1.7	0.1U	2U	0.1U	222		10
	Well Name:		Floyd County Kingston Rd, Well															
	County:		Floyd															
	Date Sampled:		1994/08/25															
GWN-VR3		7.62	1.5	5U	30	13	24	77	20U	10U	50U	11.7	0.2	42.3	0.1U	237		10
	Well Name:		Chickamauga/Crawfish Spring															
	County:		Walker															
	Date Sampled:		1994/08/25															
GWN-VR4		7.20	16	5U	73	18	630	110	30	18	50U	7.9	0.1U	3.5	2.8	519		10
	Well Name:		Coats-American #3															
	County:		Walker															
	Date Sampled:		1994/08/30															
GWN-VR5		7.08	5.2	5U	74	3.7	170	100	20U	10U	50U	2.7	0.1U	2U	1.0	387	methyl-tert-butyl ether =23	10
	Well Name:		Chattooga County #4															
	County:		Chattooga															
	Date Sampled:		1994/08/30															
GWN-VR6		7.51	5.1	5U	27	16	210	600	20U	10U	50U	4.1	0.1U	4.4	0.8	258	tetrachloroethylene=tr	10
	Well Name:		Chemical Products Corp. East Well															
	County:		Bartow															
	Date Sampled:		1994/08/25															
GWN-VR7		7.50	1U	5U	27	13	23	31	20U	10U	50U	1.1	0.1U	2U	0.4	219		10
	Well Name:		Adairsville/Lewis Spring															
	County:		Bartow															
	Date Sampled:		1994/08/25															
GWN-VR8		7.71	1.6	5U	32	14	22	13	20U	10U	50U	1.6	0.1U	2.1	0.6	256		10
	Well Name:		Cedartown Spring															
	County:		Polk															
	Date Sampled:		1994/08/25															
GWN-VR9		7.21	1.5	5U	35	12	25	10	20U	10U	50U	1.9	0.1U	2.1	0.6	252		10
	Well Name:		Polk County #2															
	County:		Polk															
	Date Sampled:		1994/08/25															

Cartographer: Donald L. Shellenberger

Quantity: 100/Cost: $505.75