GROUND-WATER QUALITY IN GEORGIA FOR 1989

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GROUND-WATER MANAGEMENT PROGRAM

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INTRODUCTION

PURPOSE AND SCOPE

This report is the sixth annual summary of ground-water quality in Georgia. These evaluations are one of 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. Four components constitute EPD's ground-water quality assessment program. These components include:

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

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

3. Special studies that are conducted in order to address specific water quality issues. An ongoing survey of nitrite/nitrate levels in shallow wells located in the farm belt (currently being conducted by the Geologic Survey Branch in cooperation with Georgia Southern University) is an example of this type of study.

4. Sampling of ground water at environmental facilities such as municipal solid waste landfills, RCRA facilities, sludge disposal facilities, etc. EPD's Land Protection and Water Protection Branches have the primary responsibility for monitoring these facilities.

Analyses of water samples collected for the Georgia Ground-Water Monitoring Network during calendar year 1989 and from previous years are
the data base for this summary. Representative water samples were collected from 140 wells and springs in 1989. A review of the 1989 data, and comparison of these data with analyses of samples collected as early as 1984, indicates that ground-water quality at most of the 140 sampling sites generally has changed little and remains excellent.

GROUND-WATER QUALITY CONTROLS

The quality of water from a well is the end result of complex physical and biochemical processes. Some of the more significant controls are the quality and chemistry of the water entering the ground-water flow system, the reactions of infiltrating water with the soils and rocks that are encountered, and the effects of the well and pump system.

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

The well and pump system can have a strong influence on the quality of the well water. Well casings 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. Improperly constructed wells, on the other hand, can present a conduit for local pollution to enter the ground-water flow system.

HYDROGEOLOGIC PROVINCES OF GEORGIA

Three hydrogeologic provinces in Georgia are defined by their general geologic and hydrologic characteristics (Figure 1-1). These
provinces include:
1. The Coastal Plain Province of south Georgia
2. The Piedmont and Blue Ridge Provinces, which include all but the northwest corner of northern Georgia
3. The Valley and Ridge Province of northwest Georgia
Each of these provinces is described in greater detail below.

Coastal Plain Province

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

The Coastal Plain contains the State's major confined (artesian) aquifers. Confined aquifers are those which are overlain by a layer of impermeable material (e.g., clay or shale) and contain water at greater-than-atmospheric pressures. Water enters the aquifers in their up-dip outcrop areas where the permeable rocks of the aquifer are exposed. Many of the Coastal Plain aquifers are unconfined in their up-dip outcrop areas, but become confined in down-dip areas to the southeast, where they are overlain by successively younger rock formations. Ground-water flow through confined Coastal Plain aquifers is generally to the south and southeast, in the direction of dip of the rocks.
Figure 1-1. - The three hydrogeologic provinces of Georgia.
Rocks forming the seven major confined aquifers in the Coastal Plain range in age from Cretaceous to Miocene. Horizontal and vertical changes in the permeability of the rock units that form these aquifers and the quality of ground water they contain determine the thickness and extent of the aquifers. Several aquifers may be present in a single geographic area, forming a vertical 'stack'.

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

Piedmont and Blue Ridge Provinces

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

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

REGIONAL GROUND-WATER QUALITY PROBLEMS

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

Only a few occurrences of polluted or contaminated ground waters are known from north Georgia. Aquifers in the outcrop areas of Cretaceous sediments south of the Fall Line typically yield acidic water that may require treatment. The acidity occurs naturally, and results from the inability of the sandy aquifer sediments to buffer acidic rainwater and acid-producing reactions between infiltrating water and soils and sediments. Nitrite/nitrate concentrations in ground water from the karstic areas of both southwestern and northwestern Georgia are within drinking-water standards, but are somewhat higher than levels found in other areas of the State.

The Floridan aquifer system includes two areas of naturally-occurring reduced ground-water quality in addition to its karstic plain in southwestern Georgia. The Gulf Trough, a narrow, linear geologic feature extending from southwestern Decatur County through central
Bulloch County, typically yields water with high total dissolved solids concentrations. Elevated levels of barium, sulfate and radionuclides are common in ground water from the Gulf Trough. High levels of total dissolved solids also are common to the lower section of the Floridan aquifer system along the Georgia coast. Ground-water withdrawals have allowed upconing of brine from deeper parts of the aquifer in the Brunswick area.
MONITORING STATIONS

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

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

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

EPD's concern over pesticides in ground water warranted the addition of 22 shallow wells as monitoring stations and an expanded pesticides analysis program for samples from two other Monitoring Network wells during 1988 and 1989. Three of the recently added wells were sampled during 1988. Nineteen shallow wells located in agricultural areas of the Coastal Plain Province were sampled for the first time in 1989. Most of the wells are the source of domestic drinking-water supplies. Two of the new wells are screened in the Jacksonian Aquifer System (J7,J8), six are screened in the Floridan Aquifer System (PA50 - PA55), and eleven are screened in the Miocene Aquifer System (MI5 - MI15). The increased number of monitoring stations necessitated a
reduction in the frequency of sample collection from some of the other Monitoring Network wells, especially those located in confined aquifers of south-central and coastal Georgia.

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. Examples of non-point source pollution include acid rain and regional land-use activities (for example, application of agricultural chemicals on crop lands).

It should be noted that the data of the Ground-Water Monitoring Network are representative of water quality in only limited areas of the State. Monitoring water quality at 140 sites located throughout the State provides an indication of ground-water quality at the localities sampled and at depths corresponding to the screened interval in the well at each station in the Monitoring Network. Caution should be exercised in drawing broad conclusions and applying any results reported in this study to ground waters that are not being monitored.

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

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

ANALYSES

Analyses are available for 167 water samples collected during 1989 from 137 wells and three springs. Annual analyses of water samples from 28 of the wells span six years with the addition of the 1989 data. For 1984, the first year of the Ground-Water Monitoring Network, hydrogeologists sampled water from 39 wells located in the Piedmont, Blue Ridge, and Coastal Plain Provinces. Nine of these wells have been sampled each year since 1984. Water samples were collected state-wide from 84 wells and three springs in 1985, 25 wells and three springs in 1986, 123 wells and three springs in 1987, and 112 wells and three springs in 1988.

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, sulfate, nitrite/nitrate, chlorinated pesticides (Organics Screen #2), phenoxy herbicides (Organics Screen #4) 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 are tested. These additional chemical
screens are listed in the Appendix (Tables A-2, A-3, and A-4). Tables 2-2a and 2-2b summarize the significance of the common major constituents of a water-quality analysis.

The Drinking Water Program of the Georgia Environmental Protection Division has established Maximum Contaminant Levels (MCLs) for some of the parameters that are included in the analyses performed on Ground Water Monitoring Network samples. Primary Maximum Contaminant Levels are established for parameters that may have adverse effects on the public health when the Primary MCLs are exceeded. Secondary Maximum Contaminant Levels are established for parameters that may give drinking water an objectionable odor or color, and consequently cause persons served by public water systems to discontinue its use. The Primary and Secondary MCLs for Ground Water Monitoring Network parameters are given in Tables A-1, A-2 and A-4 in the Appendix.

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

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

Hydrogeologists monitor water quality parameters prior to sample collection. Measurements of pH, dissolved oxygen content, specific
conductivity, temperature and ionic potential are observed using field instruments. The instruments are mounted in a manifold that captures flow at the pump system discharge point before the water is exposed to atmospheric conditions. Typical trends include a lowering of pH, dissolved oxygen content and specific conductivity, and a transition towards the mean annual air temperature with increased purging time. The hydraulic flow characteristics of unconfined aquifers and pump effects often 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 Georgia Geologic Survey contain records of the field measurements. The sample bottles are filled and then immediately placed in an ice water bath to preserve the water quality. After one to two hours, the bottles are transferred to a dry cooler refrigerated with an ice tray. The hydrogeologists then transport the samples to the laboratories for analysis on or before the Friday of the week in which they are collected. EPD laboratories in Atlanta perform all analyses except for organic chemical screens 1, 2, 3, 4, 5, and 7 (Appendix, Tables A-1 and A-2). The Agricultural Services Laboratory of the Cooperative Extension Service at the University of Georgia in Athens performs these organic screens.
<table>
<thead>
<tr>
<th>Aquifer System</th>
<th>Number of Monitoring Stations</th>
<th>Primary Stratigraphic Equivalents</th>
<th>Age of Aquifer Formations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cretaceous</td>
<td>20 (16 sampled in 1989)</td>
<td>Ripley Formation, Cusseta Sand, Blufftown Formation, Eutaw Formation, and Tuscaloosa Formation</td>
<td>Late Cretaceous</td>
</tr>
<tr>
<td>Providence</td>
<td>4</td>
<td>Providence Sand</td>
<td>Late Cretaceous</td>
</tr>
<tr>
<td>Clayton</td>
<td>7 (6 sampled in 1989)</td>
<td>Clayton Formation</td>
<td>Paleocene</td>
</tr>
<tr>
<td>Claiborne</td>
<td>9 (7 sampled in 1989)</td>
<td>Tallahatta Formation</td>
<td>Middle Eocene</td>
</tr>
<tr>
<td>Jacksonian</td>
<td>10 (9 sampled in 1989)</td>
<td>Barnwell Group</td>
<td>Late Eocene</td>
</tr>
<tr>
<td>Floridan</td>
<td>58 (54 sampled in 1989)</td>
<td>Suwannee Limestone, Ocala Group, Bridgeboro Limestone and Claibornian Carbonates</td>
<td>Middle Eocene to Oligocene</td>
</tr>
<tr>
<td>Miocene</td>
<td>15</td>
<td>Altamaha Formation and Hawthorne Group</td>
<td>Miocene</td>
</tr>
<tr>
<td>Blue Ridge</td>
<td>4</td>
<td>Corbin Gneiss Complex, Snowbird Group, Walden Creek Group, Great Smoky Group and Murphy Marble Belt Group</td>
<td>Predominately Paleozoic and Precambrian</td>
</tr>
<tr>
<td>Valley and Ridge</td>
<td>9</td>
<td>Shady Dolomite, Knox Group, and Chickamauga Group</td>
<td>Paleozoic, mostly Cambrian and Ordovician</td>
</tr>
</tbody>
</table>
Table 2-2a. - The significance of parameters of a basic water quality analysis, cations (Wait, 1960)

<table>
<thead>
<tr>
<th>PARAMETER(S)</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (Hydrogen ion concentration)</td>
<td>pH is a measure of the concentration of the hydrogen ion. Values of pH less than 7.0 denote acidity and values greater than 7.0 indicate alkalinity. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline waters may also attack metals. A pH range between 6.0 and 8.5 is considered acceptable.</td>
</tr>
<tr>
<td>Calcium and magnesium *</td>
<td>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 multiplying the parts per million of calcium by 2.5 and that of magnesium by 4.1. Water Class</td>
</tr>
<tr>
<td></td>
<td>Soft                                      Less than 60</td>
</tr>
<tr>
<td></td>
<td>Moderately Hard                          60 to 120</td>
</tr>
<tr>
<td></td>
<td>Hard                                      121 to 180</td>
</tr>
<tr>
<td></td>
<td>Very Hard                                 More than 180</td>
</tr>
<tr>
<td>Sodium and potassium *</td>
<td>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.</td>
</tr>
<tr>
<td>Iron and manganese</td>
<td>More than 300 parts per billion of iron stains objects red or reddish brown and more than 50 parts per billion of manganese stains objects black. Larger quantities cause unpleasant taste and favor growth of iron bacteria but do not endanger health.</td>
</tr>
</tbody>
</table>

*Major alkali metals present in most ground waters.
<table>
<thead>
<tr>
<th>PARAMETER(S)</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride</td>
<td>Chloride salts in excess of 100 parts per million give a salty taste to water. Large quantities make the water corrosive. Water that contains excessive amounts of chloride is not suitable for irrigation. It is recommended that chloride content should not exceed 250 parts per million.</td>
</tr>
<tr>
<td>Nitrite/nitrate</td>
<td>Concentrations much greater than the local average may suggest pollution. Excessive amounts of nitrogen in drinking or formula water of infants may cause a type of methemoglobinemia (&quot;blue babies&quot;). Nitrite/nitrate in concentrations greater than 10 parts per million (as nitrogen) is considered to be a health hazard.</td>
</tr>
<tr>
<td>Sulfate</td>
<td>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 parts per million have a laxative effect, but 500 parts per million is considered safe.</td>
</tr>
</tbody>
</table>
OVERVIEW

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

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

1. Recharge (or outcrop) areas, which are located in regions that are geologically up-dip and generally to the north of confined portions of these aquifers.
2. Up-dip, confined areas, which are located in regions that are proximal to the recharge areas, yet are confined by overlying geologic formations. These areas are generally south to southeast of the recharge areas.
3. Down-dip, confined areas, located to the south and southeast in the deeper, confined portions of the aquifers distal to the recharge areas.

The two major hydrogeologic provinces of north Georgia, the Piedmont/Blue Ridge Province and the Valley and Ridge Province, are characterized by smaller-scale and more localized ground-water flow patterns in aquifers that are typically unconfined. Deeper regional flow systems are less developed in northern Georgia than in the Coastal Plain Province because of the discontinuous nature of permeable features in the north Georgia aquifers. Ground-water flow in the Piedmont/Blue Ridge Province is generally controlled by geologic discontinuities (such as fractures) and compositional changes within the aquifer. Local physiographic features, such as hills and valleys, may influence local ground-water flow patterns. Many of the factors controlling ground-water flow in the Piedmont/Blue Ridge Province are also present in the Valley.
and Ridge Province. In addition, widespread development of karst features (for example, caves, springs and solution-enlarged voids) may significantly enhance porosity and permeability in localized areas, and exert a strong influence on local ground-water flow patterns.
Figure 3-1. - The seven major aquifer systems of the Coastal Plain Province.
CRETAEOUS AQUIFER SYSTEM

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

Water quality of the Cretaceous aquifer system, excluding the Providence aquifer system (discussed separately in this report), was monitored in 16 wells. All of these wells are located in up-dip areas in or adjacent to outcrop and surface recharge areas for the Cretaceous aquifer system. No down-dip wells were sampled during 1989.

Water from the wells in the up-dip area was typically acidic, to the point of being corrosive, and soft. Three wells in outcrop areas adjacent to the Chattahoochee River yielded basic water. Iron and manganese concentrations were generally low, although one well in Macon County yielded water containing 740 parts per billion iron. The State Secondary Maximum Contaminant Level (MCL) for iron is 300 parts per billion. Figures 3-3 and 3-4 show trends in iron and manganese concentrations for wells that have historically yielded water with high levels of these metals. Concentrations of major alkali metals (calcium, magnesium, potassium and sodium) were generally either low or below detection limits. Other trace metals (aluminum, copper, strontium and zinc) were commonly present in minor amounts.

Chloride and sulfate levels were low (less than 15 parts per
million chloride and 10 parts per million sulfate) in all of the samples collected. Water samples from eight of the wells in the up-dip area contained detectable levels of nitrite/nitrate. The highest values, 0.23 to 0.98 parts per million, were measured in samples from five wells in middle Georgia and in a Richmond County well. Figure 3-5 shows trends in levels of combined nitrite/nitrate (reported as parts per million nitrogen) for wells that have historically yielded water with high nitrite/nitrate levels. Most of these wells show an overall decrease in nitrite/nitrate levels when compared to previous years, although one up-dip well showed a slight increase.
Iron concentrations exceed drinking-water limits
Nitrite/nitrate concentrations exceed 0.45 parts per million
Soft water
General recharge area (from Davis, et al., 1988)

Figure 3-2. - Water quality of the Cretaceous aquifer system.
Figure 3-3. - Iron concentrations in selected wells in the Cretaceous aquifer.
Figure 3-4. - Manganese concentrations in selected wells in the Cretaceous and Jacksonian aquifers.
Figure 3-5. - Nitrite/nitrate concentrations in selected wells in the Cretaceous and Providence aquifers.
PROVIDENCE AQUIFER SYSTEM

Sand and coquina limestone 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 3-6). In its up-dip extent, the aquifer system thickens both to the east and to the west of a broad area adjacent to the Flint River. Areas where the thickness of the Providence exceeds 300 feet are known in Pulaski County, and similar thicknesses have been projected in the vicinity of Baker, Calhoun and Early Counties (Clarke, et al., 1983).

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

Water quality in the Providence aquifer system was monitored in one outcrop-area well and in two up-dip and one down-dip wells where the system is confined. Water from the outcrop-area well was acidic and soft. The wells in the confined areas yielded water that was basic and soft to moderately hard. Manganese levels were below 15 parts per billion in the water samples from all four wells. Water from the down-dip well in the confined area of the aquifer contained 1,200 parts per billion of iron. Figure 3-7 shows trends in iron concentrations in this well. Calcium, magnesium, potassium, sodium and strontium were the only other cations that were commonly detected. Chloride and sulfate concentrations were low, less than 14 parts per million, in all samples. Minor nitrite/nitrate levels were present in the water samples from the one well located in the up-dip outcrop area. Figure 3-5 shows that nitrite/nitrate concentrations in this well have decreased since 1988.
One well in the up-dip, confined portion of the Providence aquifer yielded water containing 2 parts per billion of tetrachloroethylene when it was sampled during March (Figure 3-8). This well, located in Americus, Sumter County, was resampled in June, at which time no tetrachloroethylene was detected. Tetrachloroethylene is a common industrial solvent used in dry cleaning and degreasing applications.
- Iron concentrations exceed drinking-water limits
- Nitrates/nitrite concentrations exceed 0.45 parts per million
- Soft water
- Moderately hard water
- General recharge area (from Davis, et al., 1988)

Figure 3-6. - Water quality of the Providence aquifer system.
Figure 3-7. - Iron concentrations in selected wells in the Providence and Clayton aquifers.
Figure 3-8. - Tetrachloroethylene concentration in selected wells.
CLAYTON AQUIFER SYSTEM

The Clayton aquifer system of southwestern Georgia is developed 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 3-9). Aquifer thickness varies irregularly, ranging from 50 feet near outcrop areas to 265 feet in southeastern Mitchell County (Clarke, et al., 1984). Both the Flint River, to the east, and the Chattahoochee River, to the west, are areas of discharge for the aquifer system in its up-dip extent. Leakage from the underlying Providence aquifer system and the overlying Wilcox confining zone is significant in down-dip areas (Clarke, et al., 1984). The Clayton Formation and Providence Formation merge to form a single aquifer unit in up-dip areas (Long, 1989). In areas east of the Ocmulgee River, the combination of these two aquifers is referred to as the Dublin aquifer system (Clarke, et al., 1985).

Six wells were used to monitor water quality of the Clayton aquifer system. These sample stations included five wells in confined, up-dip areas of the Clayton aquifer, and one well in the confined, down-dip area of the aquifer.

All water samples from the confined-area wells were slightly basic and non-corrosive. The water samples from wells in the up-dip area were hard to very hard. Iron and manganese concentrations exceeded drinking-water limits in samples from the western-most well. Manganese levels in this well have decreased over the last three years (Figure 3-10), but still exceed the Secondary Maximum Contaminant Level for public drinking water. Concentrations of iron in the same well for the same period have also decreased, but also remain above levels considered acceptable for public drinking water (Figure 3-7). Trace amounts of gold, barium, bismuth, cobalt, molybdenum, strontium, vanadium and zinc and the major alkali metals were the other common cations. The water sample from the one down-dip well was moderately hard, with iron levels that exceeded public drinking-water limits.
Chloride content was uniformly low, less than 10 parts per million, in all samples. Sulfate levels were less than 20 parts per million in the water from all sample stations except for a well adjacent to the Chattahoochee River. Nitrite/nitrate concentrations were below detection limits in all of the samples analyzed.
Iron concentrations exceed drinking-water limits
Iron and manganese concentrations exceed drinking-water limits
- Soft water
- Moderately hard water
- Hard water
- Very hard water

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

Figure 3-9. - Water quality of the Clayton aquifer system.
Figure 3-10. - Manganese concentrations in selected wells in the Clayton and Claiborne aquifers.
Sands of the Middle Eocene Claiborne Group are the primary members of the Claiborne aquifer system of southwestern Georgia. Claiborne Group sands crop out in a belt extending from northern Early County through western Dooly County (Figure 3-11). Limited recharge may be derived down-dip in the vicinity of Albany in Dougherty County by leakage from the overlying Floridan aquifer system (Hicks, et al., 1981). Discharge boundaries of the aquifer system are the Ocmulgee River, to the east, and the Chattahoochee River, to the west.

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

Ground-water samples of the Claiborne aquifer system were collected from three outcrop-area wells and from four wells in down-dip areas where the aquifer is confined. Water samples from wells in the outcrop areas were acidic, to the point of being corrosive, and soft. Iron concentrations exceeded drinking-water limits in one outcrop-area well in Lee County, and water from two wells in Sumter and Randolph Counties exceeded acceptable limits for manganese. Wells in the down-dip areas yielded water that was basic and moderately hard to very hard. Water from one down-dip well in Dougherty County exceeded the Secondary Maximum Contaminant Level for iron, but the remainder of the wells in the down-dip area yielded water with acceptable iron and manganese levels. Figures 3-12 and 3-10 show trends in iron and manganese concentrations for wells that have historically yielded water with high levels of these metals. Aluminum, barium, bismuth, cobalt, copper, gold, molybdenum, strontium, vanadium, yttrium and zinc were also detected.
Chloride and sulfate concentrations in the water samples were uniformly low. Further down dip, in Thomas County, water in the Claiborne aquifer system is highly mineralized (Sever, 1966). Nitrite/nitrate levels of 3.5 and 7.6 parts per million nitrogen were measured in water samples from two of the three outcrop-area wells. Concentrations have increased from 6.33 (average of two analyses) to 7.6 parts per million in the water samples collected from a Shellman, Randolph County, well since sampling began in 1986 (Figure 3-13). A well in Sumter County has shown an increase from 1.15 to 3.5 parts per million nitrite/nitrate since 1985. One well in Unadilla, Dooly County, located in the confined portion of the aquifer, yielded water containing 7.9 parts per million nitrite/nitrate. In previous years, nitrite/nitrate levels in this well had never exceeded 0.2 parts per million. The same Dooly County well contained 0.45 parts per billion of the herbicide Dinoseb. Nitrite/nitrate levels were below detection limits in water samples from other wells in the confined portion of the Claiborne aquifer.
Iron concentrations exceed drinking-water limits
Manganese concentrations exceed drinking-water limits
Nitrite/nitrate concentrations exceed 0.45 parts per million
- Soft water
- Moderately hard water
- Hard water

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

Figure 3-11. - Water quality of the Claiborne aquifer system.
Figure 3-12. Iron concentrations in selected wells in the Claiborne aquifer.
Figure 3-13. - Nitrite/nitrate concentrations in selected wells in the Claiborne aquifer.
The Jacksonian aquifer system of central and east-central Georgia is developed in sands of the Eocene Barnwell Group. Outcrops of sand and clay of the Barnwell Group extend from Macon and Peach Counties eastward to Burke and Richmond Counties (Figure 3-14). Aquifer sands form a northern clastic facies of the Barnwell Group and grade southward into less permeable silts and clays of a transition facies (Vincent, 1982). The water-bearing sands are relatively thin, generally ranging from ten to fifty feet in thickness. Limestones equivalent to the Barnwell Group form a southern carbonate facies and are included in the Floridan aquifer system. The Savannah River and Ocmulgee River are eastern and western discharge boundaries respectively for the up-dip flow system of the Jacksonian aquifer system.

Water quality in the Jacksonian aquifer system was monitored in seven wells in the clastic facies and two wells in the transition facies. Two of the clastic facies wells, located in Burke and Jefferson Counties, were sampled for the first time in 1989. Water from the aquifer system was generally basic and varied from soft to very hard. Iron levels in all samples were below the Secondary Maximum Contaminant Level for drinking water. Manganese exceeded drinking water limits in water from one transition-facies well in Emanuel County and one clastic-facies well in Jefferson County. Figure 3-4 shows trends in concentration for wells that have historically yielded water high in manganese. Water from one well in Jefferson County exceeded Primary Maximum Contaminant Levels for silver. High levels of silver can lead to a condition known as argyria, with symptoms including discoloration of the skin and mucous membranes. The major alkali metals and aluminum, antimony, barium, bismuth, cobalt, copper, gold, molybdenum, strontium, tin, vanadium and zinc were the other common cations.

Chloride and sulfate levels were 11 parts per million or less in all samples. Nitrite/nitrate concentrations ranged from below detection limits up to 0.34 parts per million in the water samples from six of the wells. Two clastic-facies wells in Burke County contained 2.1 and 2.3 parts per million nitrite/nitrate. These concentrations are within the
range of previous measurements from wells in the same area. The new monitoring station in Jefferson County yielded water containing 7.1 parts per million nitrite/nitrate, the highest level yet measured from a Monitoring Network station in the Jacksonian aquifer. Figure 3-15 summarizes trends in nitrite/nitrate levels for the Jacksonian aquifer.
○ Manganese concentrations exceed drinking-water limits
ⅹ Nitrite/nitrate concentrations exceed 0.45 parts per million
• Soft water
▲ Moderately hard water
■ Hard water
♦ Very hard

General recharge area (from Davis, et al., 1988)
— Facies boundary (from Vincent, 1982)

Figure 3-14. - Water quality of the Jacksonian aquifer system.
Figure 3-15. - Nitrite/nitrate concentrations in selected wells in the Jacksonian aquifer.
FLORIDAN AQUIFER SYSTEM

The Floridan aquifer system, formerly known as the Principal Artesian aquifer system, consists of Eocene and Oligocene limestones and dolostones that underlie most of the Coastal Plain Province (Figure 3-1). Other units are included locally in the aquifer. The aquifer is a major source of ground water for much of its outcrop area and throughout its down-dip extent to the south and east.

Floridan aquifer system carbonates form a single permeable zone in up-dip areas. There are two permeable zones in down-dip areas (Miller, 1986). The upper water-bearing units of the Floridan are the Eocene Ocala Group and the Oligocene Suwannee Limestone (Crews and Huddleston, 1984). These limestones crop out in the Dougherty Plain (a karstic area in southwestern Georgia) and in adjacent areas along strike to the northeast (Figure 3-16). 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, which consists of dolomitic limestone of middle and lower Eocene age and pelletal, vuggy, dolomitic limestone of Paleocene age, is deeply buried and not widely used, except in several municipal and industrial wells in the Savannah area (Clarke et al., 1990). From its up-dip limit, defined in the east by clays of the Barnwell Group, the aquifer thickens to well over 700 feet in coastal Georgia. A dense limestone facies along the trend of the Gulf Trough locally limits ground-water quality and availability (Kellam and Gorday, 1990). The Gulf Trough is a linear depositional feature in the Ocala Group that extends from southwestern Decatur County through central Bulloch County.

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

Ground-water samples were collected from 54 wells completed in the Floridan aquifer system. Six wells that are located in recharge areas of the Floridan were sampled for the first time in 1989. All of the water samples were neutral to basic and moderately hard to very hard. Iron and manganese exceeded drinking-water limits in water from only six wells. Trends in iron and manganese levels in selected wells screened in the Floridan aquifer are shown in Figures 3-17 and 3-18. Aluminum, barium, bismuth, cobalt, gold, molybdenum, strontium, tin, vanadium and zinc were other common trace metals, with copper, silver and titanium occurring less frequently. Barium levels in water samples from a well in Fitzgerald, Ben Hill County, exceeded the drinking-water maximum. Silver was detected above the Primary Maximum Contaminant Level in an outcrop-area well in Burke County.

Chloride and sulfate concentrations in the water samples commonly were below 10 parts per million. Chloride and sulfate levels were highest (90.2 and 168.1 parts per million, respectively) in water from a Brunswick, Glynn County monitoring well. Concentrations of sulfate were highest (49 to 168.1 parts per million) in water samples from the Glynn County well and in fourteen wells located within and south of the Gulf Trough.

Most of the water samples collected from the recharge area of the Floridan aquifer contained detectable amounts of nitrite/nitrate. Levels of nitrite/nitrate in this area ranged from 0.08 to 6.06 parts per million. Nitrite/nitrate was also detected in two wells located in the up-dip, confined portion of the aquifer. One of these wells, located in Bulloch County, yielded water containing 6.0 parts per million nitrite/nitrate. When previously sampled in 1988, water from this well contained only 0.03 parts per million nitrite/nitrate. Most of the wells in the down-dip, confined portion of the Floridan aquifer did not contain detectable levels of nitrite/nitrate. Trends in nitrite/nitrate
levels in selected wells in the Floridan Aquifer are presented in Figures 3-19a and b.

Organic compounds were detected in water samples from three wells screened in the Floridan Aquifer. Bis (2-ethylhexyl) phthalate was detected in two wells located in Chatham and Lowndes Counties. Samples from these wells contained 127 and 38.6 parts per billion bis (2-ethylhexyl) phthalate, respectively. This compound is a common component of lubricating oils, frequently used in pumps. It is possible that this contamination may be coming from the lubricants used on the pump, and therefore may not actually be present in the aquifer itself. Water from a shallow monitoring well in Albany, Dougherty County, continued to contain traces of volatile organic compounds. Tetrachloroethylene was detected in a sample from this well at a level of 1.5 parts per billion (Figure 3-8).
Figure 3-16. - Water quality of the Floridan aquifer system.
Figure 3-17: Iron concentrations in selected wells during 1984-1989.
Figure 3-18. - Manganese concentrations in selected wells in the Floridan aquifer.
Figure 3-19a. - Nitrite/nitrate concentrations in selected wells in the Floridan aquifer.
Figure 3-19b. - Nitrite/nitrate concentrations in selected wells in the Floridan aquifer (continued).
MIocene Aquifer System

Much of south-central and southeastern Georgia lies within outcrop areas of the Miocene Altamaha Formation and Hawthorne Group (Figure 3-8). Discontinuous lens-shaped bodies of sand, 50 to 80 feet thick, are the main permeable units. Miocene clays and sandy clays are thickest, more than 500 feet, in Wayne County (Watson, 1982).

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

Water quality of the Miocene aquifer system was monitored in fifteen wells, eleven of which were first sampled in 1989. Water samples varied from acidic to basic, with pH values ranging between 4.3 to 8.1 (standard pH units). Most of the water samples were soft to moderately hard, but wells in Brooks, Glynn, and Screven Counties yielded hard water. Water samples from six wells in Bulloch, Colquitt, Cook, Screven and Thomas Counties contained iron at concentrations in excess of acceptable drinking water limits (Figure 3-21). Manganese was detected above Secondary Maximum Contaminant Levels in water from four wells in Appling, Bulloch, Coffee, and Screven Counties (Figure 3-22). Aluminum, barium, strontium, titanium, zinc, and the major alkali metals were other commonly detected cations in the Miocene aquifer system water samples. Bismuth, Copper, and tin were less commonly detected trace metals.

Chloride levels were less than 25 parts per million in all of the samples analyzed. The highest chloride levels (over 20 parts per million) were recorded from stations in Colquitt, Glynn, and Thomas Counties. Sulfate levels were highest (38.9 parts per million) in a Glynn County well, but were 4 parts per million or less in all of the other wells. Detectable levels of nitrite/nitrate, ranging from 0.05 to
14.70 parts per million, were found in eight of the fifteen wells sampled. All eight of these wells were sampled for the first time in 1989. A residential well in Bulloch County contained 14.7 parts per million of nitrite/nitrate. This is the first Monitoring Network well to exceed drinking water limits for nitrite/nitrate (Figure 3-23).
- Iron concentrations exceed drinking-water limits
- Manganese concentrations exceed drinking-water limits
- Iron and manganese concentrations exceed drinking-water limits
- Nitrite/nitrate concentrations exceed 0.45 parts per million
  - Soft water
  - Moderately hard water
  - Hard water

Figure 3-20. - Water quality of the Miocene aquifer system.
Figure 3-21. - Iron concentrations in selected wells in the Miocene aquifer.
Figure 3-22. Manganese concentrations in selected wells in the Miocene aquifer.
Figure 3-23. - Nitrite/nitrate concentrations in selected wells in the Miocene aquifer.
PIEDMONT/BLUE RIDGE UNCONFINED AQUIFERS

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

Ground-water samples were collected from seventeen wells in the Piedmont Province and four wells in the Blue Ridge Province (Figure 3-9). Water from wells in the crystalline-rock aquifers was generally non-corrosive and soft to moderately hard, although one Piedmont well in Jackson County yielded hard water. Iron and manganese levels exceeded drinking-water limits in water samples from eleven of the Piedmont wells and two of the Blue Ridge wells (Figures 3-25a and b, 3-26a and b, 3-27 and 3-28). Aluminum, barium, bismuth, strontium and zinc were common trace metal constituents. Less commonly detected trace metals included antimony, cobalt, gold, molybdenum, nickel, silver, thallium, tin, titanium, vanadium and zirconium. A Piedmont well in Riverdale, Clayton County, exceeded Secondary Maximum Contaminant Levels for silver. Analysis of a water sample taken from a Franklin County (Piedmont) well detected thallium (a highly toxic metal) at a level of 94 parts per billion. The same sample also contained 30,000 parts per billion iron. Because excessive amounts of iron in a sample can result in spurious estimates of thallium content, this analysis for thallium may not be valid. Subsequent water samples collected from this well have not contained detectable levels of thallium.

Chloride and sulfate concentrations in the water samples were typically below 20 parts per million. Nitrite/nitrate was present in water from five of the wells (Figure 3-29). Four of these wells yielded water with nitrite/nitrate levels greater than 0.45 parts per million. The highest concentration measured was 3.2 parts per million. For most
monitoring stations, nitrite/nitrate concentrations monitored in 1989 were approximately the same as levels reported in samples collected during 1988 from the same wells. One Blue Ridge well showed an increase in nitrite/nitrate from below detection limits in 1988 to 1.9 parts per million in 1989.

Traces of volatile organic compounds continued to be detected in samples from wells in Fulton and Rockdale Counties. Water samples collected in April and October of 1989 from a monitoring well at Fort McPherson, Fulton County, contained ethylbenzene and P, M, and O xylene. Other organic compounds, including trimethyl benzene, ethylmethyl benzene, 1,2 dichloropropane and toluene, were detected from the same well in October, but were not detected in April. An unused well in Conyers, Rockdale County, yielded water containing tetrachloroethylene at a concentration of 7.8 parts per billion (Figure 3-8) and 1.6 parts per billion trichloroethylene.
Iron concentrations exceed drinking-water limits
Manganese concentrations exceed drinking-water limits
Iron and manganese concentrations exceed drinking-water limits
Nitrite/nitrate concentrations exceed 0.45 parts per million
- Soft water
  - Moderately hard water
  - Hard water

Figure 3-24. - Water quality of the Piedmont/Blue Ridge unconfined aquifers.
Figure 3-25a. - Iron concentrations in selected wells in the Piedmont aquifer.
Figure 3-25b. - Iron concentrations in selected wells in the Piedmont aquifer (continued).
Figure 3-26a. - Manganese concentrations in selected wells in the Piedmont aquifer.
Figure 3-26b. - Manganese concentrations in selected wells in the Piedmont aquifer (continued).
Figure 3-27. - Iron concentrations in selected wells and springs in the Blue Ridge and Valley & Ridge aquifers.
Figure 3-28. Manganese concentrations in selected wells in the Blue Ridge and Valley & Ridge aquifers.
Figure 3-29. - Nitrite/nitrate concentrations in selected wells in the Piedmont and Blue Ridge aquifers.
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 bottom outcrops of dolostones and limestones of the Cambro-Ordovician Knox Group are the locations of most higher-yielding wells and springs that are suitable for municipal supplies.

Water quality in the Valley and Ridge unconfined aquifers was monitored in five wells and three springs located across the Province (Figure 3-30). Three of these wells and all three springs produced water from Knox Group carbonates. The other wells represent water quality in the Ordovician Chickamauga Group of Walker County and the Cambrian Shady Dolomite of Bartow County. Water from the Valley and Ridge monitoring stations was typically basic and moderately hard to very hard. Iron and manganese concentrations were below drinking-water limits in all of the water samples analyzed. Barium, bismuth, strontium and tin were the most common trace metal constituents.

Chloride and sulfate concentrations were typically less than five parts per million. A water sample from a well in Walker County contained 12.2 parts per million chloride and 66 parts per million sulfate. Detectable levels of nitrite/nitrate were present in all but one of the water samples. Concentrations ranged from 0.30 to 2.80 parts per million in water from eight of the wells and springs. The nitrite/nitrate levels measured in 1989 were generally within previously established ranges for water from these monitoring stations. Four of the stations showed moderate decreases in nitrite/nitrate levels since 1988, while two stations showed slight to moderate increases over the same period.
Nitrite/nitrate concentrations exceed 0.45 parts per million

- Moderately hard water
- Hard water
- Very hard water

Figure 3-30. - Water quality of the Valley and Ridge unconfined aquifer.
Figure 3-31a. - Nitrite/nitrate concentrations in selected wells and springs in the Valley and Ridge aquifer.
Figure 3-31b. - Nitrite/nitrate concentrations in selected wells in the Valley and Ridge aquifer (continued).
SUMMARY AND CONCLUSIONS

Hydrogeologists collected 167 water samples for analysis from 137 wells and three springs for the Ground-Water Monitoring Network in 1989. These wells and springs represent the ten major aquifer systems of the State:

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

Analyses of water samples collected in 1989 were compared with analyses for the Ground-Water Monitoring Network dating back to 1984, permitting the recognition of temporal trends. Tables 4-1a through 4-1c list the major contaminants and pollutants that were detected at stations of the Ground-Water Monitoring Network during 1989. Although isolated ground-water quality problems were documented during 1989 at specific localities, the quality of water from the majority of the Ground-Water Monitoring Network stations remains excellent.

An increasing occurrence of detectable levels of nitrite/nitrate in samples collected from some monitoring stations is the only apparent adverse trend in ground-water quality in Georgia. Few wells or springs yielded water samples in 1989 with nitrite/nitrate concentrations that exceeded previously established ranges. Samples from Coastal Plain aquifers with the highest nitrite/nitrate levels were, in most cases, from wells in outcrop areas. The first occurrence of nitrite/nitrate levels greater than the Primary Maximum Contaminant Level of 10 parts per million nitrogen was recorded from a domestic well in the Miocene aquifer. Because this well had not been sampled prior to 1989, it is not yet possible to determine if the nitrite/nitrate level is increasing or decreasing at this station.
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. Some nitrite/nitrate may come from natural sources, and some may be man-made. The most common sources of man-made dissolved nitrogen are septic systems, agricultural wastes and fertilizers (Freeze and Cherry, 1979). Dissolved nitrogen is also present in rainwater, derived from terrestrial vegetation and volatilization of fertilizers (Drever, 1988). The conversion of other nitrogen species to nitrate occurs in aerobic environments (i.e. recharge areas). Anaerobic conditions, as are commonly developed along the flow path of ground water, foster the denitrification process. However, this process is inhibited by the lack of denitrifying bacteria in ground water (Freeze and Cherry, 1979).

Iron and manganese were the most commonly detected metals in the samples analyzed. Although minor increases or decreases in levels of iron and manganese were noted for some stations, no long-term trends in concentrations of these metals were documented for the majority of the wells and springs sampled.

The presence of organic compounds was again documented in water from a few of the wells sampled. Because of the sporadic nature of the occurrence of organic compounds in most of these wells, spatial and temporal trends in levels of organic pollutants cannot be defined at this time.
<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Well ID, parameter, and detected value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cretaceous</td>
<td>GWN-K9 Iron = 740 ug/L</td>
</tr>
<tr>
<td></td>
<td>GWN-K10 NO$_2$/NO$_3$ = 0.98 &amp; 0.8 mgN/L</td>
</tr>
<tr>
<td>Providence</td>
<td>GWN-PD1 Iron = 1,600 ug/L</td>
</tr>
<tr>
<td></td>
<td>GWN-PD2A NO$_2$/NO$_3$ = 0.47 mgN/L</td>
</tr>
<tr>
<td></td>
<td>GWN-PD4A Tetrachloroethylene = 2.0 ug/L</td>
</tr>
<tr>
<td>Clayton</td>
<td>GWN-CT1 Iron = 590 ug/L</td>
</tr>
<tr>
<td></td>
<td>GWN-CT6B Iron = 4,100 ug/L</td>
</tr>
<tr>
<td></td>
<td>Manganese = 100 ug/L</td>
</tr>
<tr>
<td>Claiborne</td>
<td>GWN-CL1 Iron = 350 ug/L</td>
</tr>
<tr>
<td></td>
<td>GWN-CL2 NO$_2$/NO$_3$ = 7.9 mgN/L</td>
</tr>
<tr>
<td></td>
<td>GWN-CL3 Iron = 1,200 ug/L</td>
</tr>
<tr>
<td></td>
<td>GWN-CL4 Manganese = 62 ug/L</td>
</tr>
<tr>
<td></td>
<td>NO$_2$/NO$_3$ = 3.5 mgN/L</td>
</tr>
<tr>
<td></td>
<td>GWN-CL5 Manganese = 450 ug/L</td>
</tr>
<tr>
<td></td>
<td>NO$_2$/NO$_3$ = 7.6 mgN/L</td>
</tr>
<tr>
<td>Jacksonian</td>
<td>GWN-J1B NO$_2$/NO$_3$ = 2.1 mgN/L</td>
</tr>
<tr>
<td></td>
<td>GWN-J3 Manganese = 130 ug/L</td>
</tr>
<tr>
<td></td>
<td>GWN-J7 NO$_2$/NO$_3$ = 2.3 mgN/L</td>
</tr>
<tr>
<td></td>
<td>GWN-J8 Manganese = 72 ug/L</td>
</tr>
<tr>
<td></td>
<td>NO$_2$/NO$_3$ = 7.1 mgN/L</td>
</tr>
<tr>
<td></td>
<td>Silver = 62 ug/L</td>
</tr>
<tr>
<td>Floridan</td>
<td>GWN-PA2A Bis (2-Ethylhexyl)- phthalate = 127</td>
</tr>
<tr>
<td>(Principal</td>
<td>GWN-PA9B Iron = 1,200 ug/L</td>
</tr>
<tr>
<td>Artesian)</td>
<td>GWN-PA14 NO$_2$/NO$_3$ = 6.0 mgN/L</td>
</tr>
<tr>
<td></td>
<td>GWN-PA18 Manganese = 56 ug/L</td>
</tr>
<tr>
<td></td>
<td>GWN-PA21 Bis (2-Ethylhexyl)- phthalate = 38.6</td>
</tr>
<tr>
<td></td>
<td>GWN-PA24 NO$_2$/NO$_3$ = 1.2 &amp; 1.3 mgN/L</td>
</tr>
<tr>
<td></td>
<td>GWN-PA25 NO$_2$/NO$_3$ = 1.2 &amp; 1.2 mgN/L</td>
</tr>
<tr>
<td></td>
<td>GWN-PA26 NO$_2$/NO$_3$ = 1.8 &amp; 1.4 mgN/L</td>
</tr>
<tr>
<td></td>
<td>GWN-PA33 Barium = 2,500 ug/L</td>
</tr>
<tr>
<td></td>
<td>GWN-PA37 Iron = 400 ug/L</td>
</tr>
<tr>
<td></td>
<td>NO$_2$/NO$_3$ = 1.7 mgN/L</td>
</tr>
<tr>
<td></td>
<td>GWN-PA40 NO$_2$/NO$_3$ = 0.9 &amp; 1.27 mgN/L</td>
</tr>
<tr>
<td></td>
<td>GWN-PA41 NO$_2$/NO$_3$ = 2.0 &amp; 2.8 mgN/L</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene = 1.5 ug/L</td>
</tr>
<tr>
<td></td>
<td>GWN-PA42 NO$_2$/NO$_3$ = 2.71 &amp; 3.5 mgN/L</td>
</tr>
<tr>
<td></td>
<td>GWN-PA43 NO$_2$/NO$_3$ = 1.3 &amp; 1.4 mgN/L</td>
</tr>
</tbody>
</table>

* Metals are reported only when detected at levels above the maximum contaminant level. Nitrite/nitrate (NO$_2$/NO$_3$) levels less than 0.45 mgN/L are not reported. Two values indicate two sampling dates.
Table 4-1b. - Contaminants and pollutants detected during 1989 in stations of the Ground-Water Monitoring Network, by aquifer (cont’d.)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Well ID, parameter, and detected value *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floridan (Principal Artesian), continued</td>
<td></td>
</tr>
<tr>
<td>GWN-PA46A</td>
<td>NO$_2$/NO$_3$ = 1.13 mgN/L</td>
</tr>
<tr>
<td>GWN-PA47</td>
<td>NO$_2$/NO$_3$ = 1.29 &amp; 6.06 mgN/L</td>
</tr>
<tr>
<td>GWN-PA48</td>
<td>Iron = 680 ug/L</td>
</tr>
<tr>
<td></td>
<td>NO$_2$/NO$_3$ = 1.49 &amp; 1.9 mgN/L</td>
</tr>
<tr>
<td>GWN-PA50</td>
<td>NO$_2$/NO$_3$ = 0.74 mgN/L</td>
</tr>
<tr>
<td>GWN-PA51</td>
<td>NO$_2$/NO$_3$ = 1.7 mgN/L</td>
</tr>
<tr>
<td>GWN-PA52</td>
<td>NO$_2$/NO$_3$ = 3.4 mgN/L</td>
</tr>
<tr>
<td>GWN-PA53</td>
<td>NO$_2$/NO$_3$ = 3.7 mgN/L</td>
</tr>
<tr>
<td>GWN-PA55</td>
<td>Silver = 64 ug/L</td>
</tr>
<tr>
<td>Miocene</td>
<td></td>
</tr>
<tr>
<td>GWN-M11</td>
<td>Iron = 400 &amp; 300 ug/L</td>
</tr>
<tr>
<td>GWN-M14</td>
<td>Iron = 410 ug/L</td>
</tr>
<tr>
<td></td>
<td>Manganese = 110 ug/L</td>
</tr>
<tr>
<td>GWN-M15</td>
<td>Manganese = 170 ug/L</td>
</tr>
<tr>
<td></td>
<td>NO$_2$/NO$_3$ = 6.2 mgN/L</td>
</tr>
<tr>
<td>GWN-M16</td>
<td>Manganese = 62 ug/L</td>
</tr>
<tr>
<td></td>
<td>NO$_2$/NO$_3$ = 7.8 mgN/L</td>
</tr>
<tr>
<td>GWN-M17</td>
<td>NO$_2$/NO$_3$ = 6.4 mgN/L</td>
</tr>
<tr>
<td>GWN-M18</td>
<td>Iron = 730 ug/L</td>
</tr>
<tr>
<td>GWN-M19</td>
<td>Iron = 1,300 ug/L</td>
</tr>
<tr>
<td></td>
<td>NO$_2$/NO$_3$ = 2.8 mgN/L</td>
</tr>
<tr>
<td>GWN-M10</td>
<td>NO$_2$/NO$_3$ = 8.2 mgN/L</td>
</tr>
<tr>
<td>GWN-M11</td>
<td>Iron = 500 ug/L</td>
</tr>
<tr>
<td></td>
<td>NO$_2$/NO$_3$ = 0.86 mgN/L</td>
</tr>
<tr>
<td>GWN-M13</td>
<td>Iron = 2,400 ug/L</td>
</tr>
<tr>
<td></td>
<td>Manganese = 220 ug/L</td>
</tr>
<tr>
<td>GWN-M15</td>
<td>NO$_2$/NO$_3$ = 14.7 mgN/L (Over MCL)</td>
</tr>
<tr>
<td>Piedmont</td>
<td></td>
</tr>
<tr>
<td>GWN-P1B</td>
<td>Iron = 2,500 ug/L</td>
</tr>
<tr>
<td></td>
<td>Manganese = 59 ug/L</td>
</tr>
<tr>
<td>GWN-P2</td>
<td>Iron = 1,500 ug/L</td>
</tr>
<tr>
<td></td>
<td>Manganese = 86 ug/L</td>
</tr>
<tr>
<td></td>
<td>NO$_2$/NO$_3$ = 1.1 mgN/L</td>
</tr>
<tr>
<td></td>
<td>Silver = 52 ug/L</td>
</tr>
<tr>
<td>GWN-P3</td>
<td>Iron = 980 &amp; 6,300 ug/L</td>
</tr>
<tr>
<td></td>
<td>Manganese = 62 ug/L</td>
</tr>
<tr>
<td></td>
<td>Ethylbenzene = 1 &amp; 1.3 ug/L</td>
</tr>
<tr>
<td></td>
<td>p, m &amp; o Xylenes = 2 &amp; 7.4 ug/L</td>
</tr>
<tr>
<td></td>
<td>Trimethyl benzene = 2 ug/L</td>
</tr>
<tr>
<td></td>
<td>Ethylmethyl benzene = 2 ug/L</td>
</tr>
<tr>
<td></td>
<td>Toluene = 5.9 ug/L</td>
</tr>
<tr>
<td></td>
<td>1,2 Dichloropropane = 1.7 ug/L</td>
</tr>
</tbody>
</table>

* Metals are reported only when detected at levels above the maximum contaminant level. Nitrite/nitrate (NO$_2$/NO$_3$) levels less than 0.45 mgN/L are not reported. Two values indicate two sampling dates.
Table 4-1c. - Contaminants and pollutants detected during 1989 in stations of the Ground-Water Monitoring Network, by aquifer (cont'd.)

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Well ID, parameter, and detected value *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piedmont (continued)</td>
<td></td>
</tr>
<tr>
<td>GWN-P4B</td>
<td>Iron = 6,300 µg/L</td>
</tr>
<tr>
<td></td>
<td>NO₂/NO₃ = 0.47 mgN/L</td>
</tr>
<tr>
<td>GWN-P6A</td>
<td>Manganese = 86 µg/L</td>
</tr>
<tr>
<td>GWN-P9</td>
<td>Iron = 2,000 µg/L</td>
</tr>
<tr>
<td></td>
<td>Manganese = 260 µg/L</td>
</tr>
<tr>
<td>GWN-P10A</td>
<td>Iron = 30,000 µg/L</td>
</tr>
<tr>
<td></td>
<td>Manganese = 760 µg/L</td>
</tr>
<tr>
<td></td>
<td>Thallium = 94 µg/L (No MCL established for thallium)</td>
</tr>
<tr>
<td>GWN-P12</td>
<td>NO₂/NO₃ = 3.2 mgN/L</td>
</tr>
<tr>
<td>GWN-P13</td>
<td>Iron = 440 µg/L</td>
</tr>
<tr>
<td></td>
<td>Manganese = 78 µg/L</td>
</tr>
<tr>
<td></td>
<td>Trichloroethylene = 1.6 µg/L</td>
</tr>
<tr>
<td></td>
<td>Tetrachloroethylene = 7.8 µg/L</td>
</tr>
<tr>
<td>GWN-P15A</td>
<td>Iron = 480 &amp; 480 µg/L</td>
</tr>
<tr>
<td></td>
<td>Manganese = 86 &amp; 88 µg/L</td>
</tr>
<tr>
<td>GWN-P16C</td>
<td>Iron = 3,500 µg/L</td>
</tr>
<tr>
<td></td>
<td>Manganese = 110 µg/L</td>
</tr>
<tr>
<td>Blue Ridge</td>
<td></td>
</tr>
<tr>
<td>GWN-BR1</td>
<td>Manganese = 63 µg/L</td>
</tr>
<tr>
<td>GWN-BR2B</td>
<td>Iron = 300 µg/L</td>
</tr>
<tr>
<td>GWN-BR4</td>
<td>NO₂/NO₃ = 1.9 mgN/L</td>
</tr>
<tr>
<td>Valley and Ridge</td>
<td></td>
</tr>
<tr>
<td>GWN-VR3</td>
<td>NO₂/NO₃ = 0.5 mgN/L</td>
</tr>
<tr>
<td>GWN-VR5</td>
<td>NO₂/NO₃ = 2.8 mgN/L</td>
</tr>
<tr>
<td>GWN-VR8</td>
<td>NO₂/NO₃ = 1.9 mgN/L</td>
</tr>
<tr>
<td>GWN-VR9</td>
<td>NO₂/NO₃ = 1.0 mgN/L</td>
</tr>
</tbody>
</table>

* Metals are reported only when detected at levels above the maximum contaminant level. Nitrite/nitrate (NO₂/NO₃) levels less than 0.45 mgN/L are not reported. Two values indicate two sampling dates.
REFERENCES CITED


Environmental Protection Division, 1989, Rules for Safe Drinking Water, Chapter 391-3-5, Revised June 1989, Georgia Department of Natural Resources 63 p.


APPENDIX: ANALYSES OF SAMPLES COLLECTED DURING 1989
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 five 'indicator' parameters, twelve common pesticides and industrial chemicals and thirty metals. Analyses for additional parameters may be included for samples that are collected from an area where a possibility of ground-water pollution exists due to regional activities. These optional screens include tests for agricultural chemicals, coal-tar creosote, phenols and anilines and volatile organic compounds (Tables A-1 through A-4). Because parameters other than the five 'indicators' and eight of the metals of the Standard Analysis were detected very rarely, other parameters are listed in the appendix only when they were detected.

For this appendix, the following abbreviations are used:
SU = standard units
mg/L = milligrams per liter (parts per million)
mgN/L = milligrams per liter (parts per million), as nitrogen
ug/L = micrograms per liter (parts per billion) and 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
D = for minimum values reported for a parameter, indicates that the parameter was detected below the usual detection limit (usually used when the minimum would otherwise be below the detection limit)

Underlined values listed for a parameter in the water quality data summaries indicates that the parameter was detected at levels above the Maximum Contaminant Level (MCL) listed in the Rules for Safe Drinking Water. Values that are both underlined and enclosed in parentheses indicate detected pollutants for which no MCL has been established.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Typical Detection Limit / MCL *</th>
<th>Parameter</th>
<th>Typical Detection Limit / MCL *</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>(NA) SU</td>
<td>ICP SCREEN, Cont.</td>
<td></td>
</tr>
<tr>
<td>Spec. Cond.</td>
<td>1.0 / NA umho/cm</td>
<td>Silver</td>
<td>30 / 50 ug/L</td>
</tr>
<tr>
<td>Chloride</td>
<td>0.1 / 250 mg/L</td>
<td>Aluminum</td>
<td>50 / NA ug/L</td>
</tr>
<tr>
<td>Sulfate</td>
<td>2.0 / 250 mg/L</td>
<td>Arsenic **</td>
<td>10 / 50 ug/L</td>
</tr>
<tr>
<td>Nitrite/nitrate</td>
<td>0.02 / 10 mg/LN</td>
<td>Gold</td>
<td>10 / NA ug/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Barium</td>
<td>10 / 1000 ug/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beryllium</td>
<td>10 / NA ug/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bismuth</td>
<td>30 / NA ug/L</td>
</tr>
<tr>
<td>ORGANIC SCREEN #2</td>
<td></td>
<td>Cadmium</td>
<td>5.0 / 10 ug/L</td>
</tr>
<tr>
<td>(Chlorinated Pesticides)</td>
<td></td>
<td>Cobalt</td>
<td>10 / NA ug/L</td>
</tr>
<tr>
<td>Dicofol</td>
<td>0.10 / NA ug/L</td>
<td>Chromium</td>
<td>10 / 50 ug/L</td>
</tr>
<tr>
<td>Endrin</td>
<td>0.03 / 0.2 ug/L</td>
<td>Copper</td>
<td>20 / 1000 ug/L</td>
</tr>
<tr>
<td>Lindane</td>
<td>0.008 / 4.0 ug/L</td>
<td>Iron</td>
<td>10 / 300 ug/L</td>
</tr>
<tr>
<td>Methoxychlor</td>
<td>0.30 / 100 ug/L</td>
<td>Manganese</td>
<td>10 / 50 ug/L</td>
</tr>
<tr>
<td>PCB's</td>
<td>0.60 / NA ug/L</td>
<td>Molybdenum</td>
<td>10 / NA ug/L</td>
</tr>
<tr>
<td>Permethrin</td>
<td>0.30 / NA ug/L</td>
<td>Nickel</td>
<td>20 / NA ug/L</td>
</tr>
<tr>
<td>Toxaphene</td>
<td>1.20 / 5.0 ug/L</td>
<td>Lead</td>
<td>25 / 50 ug/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Antimony</td>
<td>40 ug/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Selenium **</td>
<td>5 / 10 ug/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tin</td>
<td>20 / NA ug/L</td>
</tr>
<tr>
<td>ORGANIC SCREEN #4</td>
<td></td>
<td>Strontium</td>
<td>10 / NA ug/L</td>
</tr>
<tr>
<td>(Phenoxy Herbicides)</td>
<td></td>
<td>Titanium</td>
<td>10 / NA ug/L</td>
</tr>
<tr>
<td>2,4-D</td>
<td>5.2 / 100 ug/L</td>
<td>Thallium</td>
<td>40 / NA ug/L</td>
</tr>
<tr>
<td>Acifluorfen</td>
<td>0.2 / NA ug/L</td>
<td>Vanadium</td>
<td>10 / NA ug/L</td>
</tr>
<tr>
<td>Chloramben</td>
<td>0.2 / NA ug/L</td>
<td>Yttrium</td>
<td>10 / NA ug/L</td>
</tr>
<tr>
<td>Silvex</td>
<td>0.1 / 10 ug/L</td>
<td>Zinc</td>
<td>20 / 5000 ug/L</td>
</tr>
<tr>
<td>Trichlorfon</td>
<td>2.0 / NA ug/L</td>
<td>Zirconium</td>
<td>10 / NA ug/L</td>
</tr>
<tr>
<td>ICP METAL SCREEN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>1.0 / NA mg/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>1.0 / NA mg/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>1.0 / NA mg/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>5.0 / NA mg/L</td>
<td>** Analyzed by atomic absorption graphite furnace</td>
<td></td>
</tr>
</tbody>
</table>

* MCL = Maximum Contaminant Level from the Georgia Rules for Safe Drinking Water, 1989 (1 = Primary, 2 = Secondary, NA = no MCL established)
Table A-2. - Additional water-quality analyses: cyanide, mercury and Organic Screens #1, #3, #5 and #7

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Typical Detection Limit</th>
<th>Parameter</th>
<th>Typical Detection Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyanide</td>
<td>0.05 ug/L</td>
<td>Mercury</td>
<td>0.2 / 2.0 ug/L*</td>
</tr>
</tbody>
</table>

**ORGANIC SCREEN #1**

(Herbicides (H)/Insecticides (I))

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Typical Detection Limit</th>
<th>Parameter</th>
<th>Typical Detection Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrazine</td>
<td>H 0.30 ug/L</td>
<td>Malathion</td>
<td>I 1.40 ug/L</td>
</tr>
<tr>
<td>Azodrin</td>
<td>I 1.00 ug/L</td>
<td>Metolachlor</td>
<td>H 1.00 ug/L</td>
</tr>
<tr>
<td>Chlorpyrifos</td>
<td>I 0.80 ug/L</td>
<td>Metribuzin</td>
<td>H 0.90 ug/L</td>
</tr>
<tr>
<td>Dasanit</td>
<td>I 0.60 ug/L</td>
<td>Mevinphos</td>
<td>H 1.40 ug/L</td>
</tr>
<tr>
<td>DCPA</td>
<td>H 0.01 ug/L</td>
<td>Parathion (E)</td>
<td>I 0.08 ug/L</td>
</tr>
<tr>
<td>Demeton</td>
<td>I 1.00 ug/L</td>
<td>Parathion (M)</td>
<td>I 0.10 ug/L</td>
</tr>
<tr>
<td>Diazinon</td>
<td>I 1.00 ug/L</td>
<td>Pebulate</td>
<td>H 0.60 ug/L</td>
</tr>
<tr>
<td>Dimethoate</td>
<td>I 0.50 ug/L</td>
<td>Pendimethalin</td>
<td>H 0.80 ug/L</td>
</tr>
<tr>
<td>Di-Syston</td>
<td>I 1.00 ug/L</td>
<td>Phorate</td>
<td>I 1.00 ug/L</td>
</tr>
<tr>
<td>Eptam</td>
<td>H 0.50 ug/L</td>
<td>Profluralin</td>
<td>H 0.90 ug/L</td>
</tr>
<tr>
<td>Ethoprop</td>
<td>I 0.50 ug/L</td>
<td>Simazine</td>
<td>H 0.90 ug/L</td>
</tr>
<tr>
<td>Fonophos</td>
<td>I 0.50 ug/L</td>
<td>Sutan</td>
<td>H 0.70 ug/L</td>
</tr>
<tr>
<td>Guthion</td>
<td>I 2.00 ug/L</td>
<td>Trifluralin</td>
<td>H 1.00 ug/L</td>
</tr>
<tr>
<td>Isopropalin</td>
<td>H 1.00 ug/L</td>
<td>Vernam</td>
<td>H 0.50 ug/L</td>
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**ORGANIC SCREEN #3**

Dinoseb 0.10 ug/L (Herbicide)

**ORGANIC SCREEN #5**

(Herbicides (H)/Insecticides (I))

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Typical Detection Limit</th>
<th>Parameter</th>
<th>Typical Detection Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbaryl</td>
<td>I 10.0 ug/L</td>
<td>Linuron</td>
<td>H 1.0 ug/L</td>
</tr>
<tr>
<td>Carbofuran</td>
<td>I 2.0 ug/L</td>
<td>Methomyl</td>
<td>I 3.0 ug/L</td>
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<tr>
<td>Diuron</td>
<td>H 1.0 ug/L</td>
<td>Monuron</td>
<td>H 1.0 ug/L</td>
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<tr>
<td>Fluometuron</td>
<td>H 1.0 ug/L</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ORGANIC SCREEN #7**

EDB 1.0 ug/L  (fumigant, gasoline additive)

* Primary Maximum Contaminant Level for Mercury.
### Table A-3. Additional water-quality analyses: Organic Screens #8 and #9

#### ORGANIC SCREEN #8
*(Extractable Organics: Coal-tar Creosote)*

<table>
<thead>
<tr>
<th>Parameter</th>
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<tr>
<td>Naphthalene</td>
<td>10 µg/L</td>
</tr>
<tr>
<td>2-Chloronaphthalene</td>
<td>10 µg/L</td>
</tr>
<tr>
<td>Acenaphthylene</td>
<td>10 µg/L</td>
</tr>
<tr>
<td>Acenaphthene</td>
<td>10 µg/L</td>
</tr>
<tr>
<td>Fluorene</td>
<td>10 µg/L</td>
</tr>
<tr>
<td>Phenanthrene</td>
<td>10 µg/L</td>
</tr>
<tr>
<td>Anthracene</td>
<td>10 µg/L</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>10 µg/L</td>
</tr>
<tr>
<td>Pyrene</td>
<td>10 µg/L</td>
</tr>
<tr>
<td>Benzo(A)Anthracene</td>
<td>10 µg/L</td>
</tr>
<tr>
<td>Benzo(B)Fluoranthene</td>
<td>10 µg/L</td>
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<tr>
<td>Benzo(K)Fluoranthene</td>
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<tr>
<td>Benzo-A-Pyrene</td>
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<tr>
<td>Indeno(1,2,3-CD)Pyrene</td>
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<tr>
<td>Benzo(GHI)Perylene</td>
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#### ORGANIC SCREEN #9
*(Extractable Organics: Phenols and Aniline)*

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<tr>
<td>2-Chlorophenol</td>
<td>10 µg/L</td>
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<tr>
<td>2-Nitrophenol</td>
<td>10 µg/L</td>
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<tr>
<td>Phenol</td>
<td>10 µg/L</td>
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<tr>
<td>2,4-Dimethylphenol</td>
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<tr>
<td>2,4-Dichlorophenol</td>
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<tr>
<td>2,4,6-Trichlorophenol</td>
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<tr>
<td>Parachlorometra Cresol</td>
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<td>2,4-Dinitrophenol</td>
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<td>4,6-Dinitro-O-Cresol</td>
<td>50 µg/L</td>
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<td>Pentachlorophenol</td>
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<tr>
<td>4-Nitrophenol</td>
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<td>Parameter</td>
<td>Typical Detection Limit / Primary MCL</td>
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<tr>
<td>Methylene chloride</td>
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<tr>
<td>Trichlorofluoromethane</td>
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<td>1 ug/L / 5 ug/L</td>
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<td>1,2-Trans-dichloroethylene</td>
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<tr>
<td>Chloroform *</td>
<td>1 ug/L / *</td>
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<tr>
<td>Dichlorobromomethane *</td>
<td>1 ug/L / *</td>
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<tr>
<td>Chlorodibromomethane *</td>
<td>1 ug/L / *</td>
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<tr>
<td>Bromoform *</td>
<td>1 ug/L / *</td>
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<td>1,2-Dichloroethane</td>
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<td>1,1,1-Trichloroethane</td>
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<td>Carbon tetrachloride</td>
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<td>1,2-Dichloropropane</td>
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<td>Trans-1,3-dichloropropene</td>
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<td>Trichloroethylene</td>
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<td>Benzene</td>
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<td>Carbon disulfide</td>
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<tr>
<td>Vinyl chloride</td>
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<tr>
<td>2-Hexanone</td>
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<td>Methyl isobutyl ketone</td>
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<td>Styrene</td>
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<td>Xylene (Total of o, m, and p-xylenes)</td>
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<td>Average:</td>
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<td>pH</td>
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</table>

Average: 7.48 16.37 0.85 U 42.57 0.65 U 418.25 3.0 U 2.5 8.98 0.094 10 U 102.75 226.6
Maximum: 8.9 43 2.3 88.0 2.6 1,600 12 11.1 13.7 0.47 10 U 220 350
Minimum: 5.9 6.0 1.0 U 1.6 2.0 U 20 U 10 U 2.0 U 2.0 U 0.02 U 10 U 14 52
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<th>pH</th>
<th>Ca</th>
<th>Mg</th>
<th>Na</th>
<th>K</th>
<th>Fe</th>
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<th>SO4</th>
<th>NO2</th>
<th>NO3</th>
<th>Ba</th>
<th>Sr</th>
<th>Spec. Cond.</th>
<th>Other Parameters Detected</th>
<th>Other Screens Tested</th>
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<td>SU mg/L</td>
<td>mg/L</td>
<td>mg/L</td>
<td>mg/L</td>
<td>ug/L</td>
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<td>37.0</td>
<td>2.6</td>
<td>590</td>
<td>11</td>
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<td>11.2</td>
<td>0.02 U</td>
<td>10 U</td>
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## Water Quality for the Clayton Aquifer System

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<th>Na</th>
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<th>NO₃</th>
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## WATER QUALITY FOR THE CLAIBORNE AQUIFER SYSTEM

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<th>K</th>
<th>Fe</th>
<th>Mn</th>
<th>Cl</th>
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<th>NO2</th>
<th>NO3</th>
<th>Ba</th>
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<th>Spec. Cond.</th>
<th>Other Parameters Detected</th>
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<td>ug/L</td>
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<td>unho/cm</td>
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|      |  GWN-CL1 | 7.3 | 56.0 | 8.8 | 9.3 | 2.9 | 350 | 10 U | 4.1 | 3.0 | 0.02 | U | 10 | U | 380 | 340 | Au = 32 | B1 = 14 | Co = 14 | Mo = 14 | V = 15 |                      |                      |
|      | WELL NAME: | TW 5 - Albany | COUNTY: | Dougherty | DATE SAMPLED: | 10/25/1989 |       |     |     |     |     |     |     |          |                       |                  |

|      |  GWN-CL2 | 7.2 | 46.0 | 1.0 U | 1.7 | 2.0 U | 20 U | 10 U | 1.8 | 0.1 | 7.9 | 10 | 110 | 204 | (Dinoseb = 0.45) | 1, 3, 5 |                      |                      |
|      | WELL NAME: | Unadilla #3 | COUNTY: | Dooly | DATE SAMPLED: | 10/16/1989 |       |     |     |     |     |     |     |          |                       |                  |

|      |  GWN-CL3 | 5.1 | 1.3 | 1.0 U | 1.5 | 2.0 U | 20 U | 1200 | 14 | 2.1 | 2.0 U | 0.02 | U | 10 | U | 11 | 20 | Al = 38 | 1, 3, 5 |                      |                      |
|      | WELL NAME: | Pete Long TW 2 | COUNTY: | Lee | DATE SAMPLED: | 10/16/1989 |       |     |     |     |     |     |     |          |                       |                  |

|      |  GWN-CL4 | 4.6 | 4.4 | 1.5 | 4.8 | 2.0 U | 20 U | 62 | 7.2 | 2.0 U | 3.50 | 20 U | 17 | 65 | Al = 45 | Cu = 130 | Y = 14 | Zn = 29 |                      | 1, 3, 5, 7, 10 |
|      | WELL NAME: | Plains #3 | COUNTY: | Sumter | DATE SAMPLED: | 03/30/1989 |       |     |     |     |     |     |     |          |                       |                  |

|      |  GWN-CL5 | 4.3 | 4.7 | 2.4 | 3.0 | 3.1 | 20 U | 450 | 10.9 | 2.0 U | 7.60 | 56 | 34 | 102 | Al = 210 | Co = 27 | Y = 55 |                      |                      |
|      | WELL NAME: | Shellman #2 | COUNTY: | Randolph | DATE SAMPLED: | 10/17/1989 |       |     |     |     |     |     |     |          |                       |                  |

|      |  GWN-CL6 | 7.7 | 36.0 | 8.1 | 19.0 | 3.8 | 71 | 10 U | 4.1 | 3.2 | 0.02 | U | 10 | U | 430 | 225 |                      | 1, 3, 5 |                      |                      |
|      | WELL NAME: | Georgia Tubing Company Well | COUNTY: | Early | DATE SAMPLED: | 11/28/1989 |       |     |     |     |     |     |     |          |                       |                  |


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**Average:**
- pH: 7.78
- Ca: 68.49
- Mg: 1.33
- Na: 1.59
- K: 1.59
- Fe: 2.00
- Mn: 1.20
- Cl: 5.50
- NO3: 2.00
- SO4: 1.00
- Sr: 0.20
- Ba: 0.10

**Maximum:**
- pH: 7.80
- Ca: 69.00
- Mg: 2.00
- Na: 2.60
- K: 2.00
- Fe: 100.0
- Mn: 400.0
- Cl: 5.50
- NO3: 2.00
- SO4: 1.00
- Sr: 0.20
- Ba: 0.10

**Minimum:**
- pH: 7.70
- Ca: 68.00
- Mg: 1.30
- Na: 1.30
- K: 1.30
- Fe: 2.00
- Mn: 1.20
- Cl: 5.50
- NO3: 2.00
- SO4: 1.00
- Sr: 0.20
- Ba: 0.10
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For GWN-PA21, Bis [2-ethylhexyl]-phthalate = 38.6.
### Water Quality for the Floridan Aquifer System

<p>| Parameter | pH | Ca  | Mg  | Na  | K  | Fe  | Mn  | Cl  | SO₄ | NO₂ | NO₃ &amp; | Ba  | Sr  | Spec. Cond. | Other Parameters Detected | Other Screens Tested |
|-----------|----|-----|-----|-----|----|-----|-----|-----|-----|-----|       |     |     |            |                          |                  |
| Units     | SU | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | mg/L | ug/L | ug/L | umhos/cm | ug/l                      |                  |
| GWN-PA23  | 7.6 | 39.0 | 16.0 | 12.0 | 5.0 U | 20 U | 10 U | 6.4 | 34.0 | 0.02 U | 190 |     | 350   | 332 | Mo = 25 |                          | 10               |
| WELL NAME | Cairo #8 | COUNTY: Grady | DATE SAMPLED: 02/22/1989 |                  |      |     |      |     |      |        |     |     |       |      |         |                          |                  |
| GWN-PA24  | 7.7 | 38.0 | 3.2  | 2.2  | 5.0 U | 20 U | 10 U | 3.3 | 2.0 U | 1.20 U | 20 U | 38  | 216   |    |            |                          | 3, 7, 10         |
| WELL NAME | Bainbridge #1 | COUNTY: Decatur | DATE SAMPLED: 02/22/1989 |                  |      |     |      |     |      |        |     |     |       |      |         |                          |                  |
| GWN-PA24  | 7.8 | 37.0 | 3.3  | 1.8  | 5.0 U | 20 U | 10 U | 3.1 | 2.0 U | 1.30 U | 10 U | 36  | 223   |    |            |                          | 1, 3, 5, 7, 10   |
| WELL NAME | Bainbridge #1 | COUNTY: Decatur | DATE SAMPLED: 07/11/1989 |                  |      |     |      |     |      |        |     |     |       |      |         |                          |                  |
| GWN-PA25  | 7.4 | 56.0 | 1.0 U | 4.2  | 5.0 U | 20 U | 10 U | 4.7 | 2.0 U | 1.20 U | 20 U | 26  | 274   |    |            |                          | 3, 7, 10         |
| WELL NAME | Donaldsonville, East 7th Street Well | COUNTY: Seminole | DATE SAMPLED: 02/22/1989 |                  |      |     |      |     |      |        |     |     |       |      |         |                          |                  |
| GWN-PA25  | 7.6 | 52.0 | 1.0 U | 3.4  | 5.0 U | 20 U | 10 U | 4.6 | 2.0 U | 1.20 U | 10 U | 24  | 292   |    | Sn = 26 |                          | 1, 3, 5, 10, CN  |
| WELL NAME | Donaldsonville, East 7th Street Well | COUNTY: Seminole | DATE SAMPLED: 07/11/1989 |                  |      |     |      |     |      |        |     |     |       |      |         |                          |                  |
| GWN-PA25  | 7.4 | 49.0 | 1.0 U | 2.4  | 5.0 U | 20 U | 10 U | 3.4 | 2.0 U | 1.80 U | 20 U | 21  | 227   |    |            |                          | 3, 10            |
| WELL NAME | Colquitt #3 | COUNTY: Miller | DATE SAMPLED: 02/23/1989 |                  |      |     |      |     |      |        |     |     |       |      |         |                          |                  |</p>
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<p>| GWN-PA35  | 7.7| 30.0| 13.0| 6.0 | 5.0 | 64  | 29  | 3.5 | 6.9 | 0.02 | U    | 90  | 490 | 266 |                     |                       |
| WELL NAME: Mount Vernon New Well | COUNTY: Montgomery | DATE SAMPLED: 06/14/1989 |
| GWN-PA36  | 7.9| 30.0| 5.4 | 12.0| 5.0 | 32  | 38  | 3.8 | 3.0 | 0.02 | U    | 140 | 370 | 227 | Zn = 35 | CN                      |                     |
| WELL NAME: Vidalia #1 (Sixth Street Well) | COUNTY: Toombs | DATE SAMPLED: 06/14/1989 |
| GWN-PA37  | 7.5| 47.0| 1.0 | 2.0 | 2.0 | 400 | 10  | 3.7 | 2.0 | 1.70 | U    | 20  | 25  | 233 | Zn = 65 |                       |                     |
| WELL NAME: Hogan Monitoring Well | COUNTY: Laurens | DATE SAMPLED: 01/26/1989 |
| GWN-PA38  | 7.5| 46.0| 1.3 | 2.1 | 5.0 | 20  | 10  | 2.2 | 2.0 | 0.08 | U    | 110 | 96  | 234 |                     | 1, 3, 5, 10          |
| WELL NAME: Eastman #4 | COUNTY: Dodge | DATE SAMPLED: 06/13/1989 |
| GWN-PA39  | 7.5| 42.0| 7.4 | 3.8 | 5.0 | 20  | 10  | 2.7 | 1.8 | 0.02 | U    | 220 | 410 | 231 |                     | 3, 7, 10             |
| WELL NAME: Sylvester #1 | COUNTY: Worth | DATE SAMPLED: 02/21/1989 |
| GWN-PA39  | 7.5| 48.0| 6.7 | 3.4 | 5.0 | 20  | 10  | 2.5 | 2.0 | 0.02 | U    | 210 | 360 | 294 |                     | 1, 3, 5, 10          |
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<th>Cl</th>
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<th>NO₂ &amp; NO₃</th>
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WATER QUALITY FOR THE FLORIDAN AQUIFER SYSTEM
# Water Quality for the Floridan Aquifer System

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**Average:**

- pH: 7.59
- Ca: 46.64
- Mg: 8.99
- Na: 9.79
- K: 0.46 U
- Fe: 58.35
- Mn: 5.8 U
- Cl: 8.22
- SO₄: 27.0
- NO₂: 0.49
- NO₃: 62.65
- Ba: 279.46
- Sr: 329.78

**Maximum:**

- pH: 8.00
- Ca: 120
- Mg: 53
- Na: 110
- K: 4.1
- Fe: 1,200
- Mn: 98
- Cl: 90.2
- SO₄: 168.1
- NO₂: 6.06
- NO₃: 2,500
- Ba: 2,300
- Sr: 1,380

**Minimum:**

- pH: 7.00
- Ca: 23
- Mg: 1.6
- Na: 2.0 U
- K: 20 U
- Fe: 10 U
- Mn: 2.0 U
- Cl: 2.0 U
- SO₄: 2.0 U
- NO₂: 0.02 U
- NO₃: 10 U
- Ba: 180
- Sr: 180

**Units:**

- mg/L
- ug/L
- mgN/L
- umho/cm
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Maximum: 8.1 56 14.0 22.0 4.0 2,400 220 24.6 38.9 14.70 260 440 496
Minimum: 4.3 1.7 1.0 U 1.7 2.0 U 20 U 10 U 2.5 2.0 U 0.02 U 10 U 10 U 25
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Other Parameters Detected:
- NO2
- BA
- Sr
- Specific Cond.: Cl
- umho/cm
- umho/L
- mg/L
- mg/mL
- ug/L
- ug/mL
- 10 mg/L
- 10 mg/mL
- 10 ug/L
- 10 ug/mL

Notes:
- Al = 120 mg/L
- Zn = 22 ug/L
- Trichloromethylkene = 1.6 ug/L
- Trichloroacetylhyene = 7.8 ug/L
## WATER QUALITY FOR THE PIEDMONT UNCONFINED AQUIFER SYSTEM

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| GWN-P18C  | 7.1 | 12.0 | 2.1 | 3.3 | 5.0 | 3,500 | 110 | 1.0 | U  | 10.0 | 0.02 | U  | 10 | U  | 67 | 93 | Au = 11 | In = 47 |

**WELL NAME:** Mt. Airy #4, Chase Road Well  
**COUNTY:** Habersham  
**DATE SAMPLED:** 05/23/1989

**Average:** 6.57 15.52 3.95 9.94 1.76 U 2,888.5 92.1 4.47 13.66 0.27 34.16 90.9 163.3

**Maximum:** 7.9 33.0 10.0 36.0 4.5 30,000 760 18.8 85.0 3.2 140 350 326

**Minimum:** 3.4 1.0 1.0 U 1.6 2.0 U 20 U 10 U 2.0 U 2.0 U 0.02 U 10 U 10 U 32

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Minimum: 6.5 11.0 1.0 U 4.7 5.0 U 20 U 10 U 1.0 U/ 2.0 U 0.02 U 10 U 63 105

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For convenience in selecting our reports from your bookshelves, they are color-keyed across the spine by subject as follows:

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Editor: Patricia A. Allgood

Cartographer: Don Shellenberger

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