Sonenshein, R.S., and Koszalka, E.J., 1996, Trends in water-table altitude (1984-93) and saltwater intrusion (1974-93) in the Biscayne aquifer, Dade County, Florida

INTRODUCTION

Changing demands on water from the Biscayne aquifer and the interior wetlands (the Everglades) in Dade County, Florida (fig. 1), have resulted in a need to evaluate trends in water levels, movement of the coastal freshwater-saltwater interface, and seepage of saltwater from tidal canals. The Biscayne aquifer has been designated the "sole source of public-water supply" for the county. The Biscayne aquifer in Dade County consists of a wedge-shaped sequence of sedimentary deposits of the upper, most permeable zones of the surficial aquifer system (fig. 2). The Biscayne aquifer, as defined by Fish and Stewart (1991, p. 11-12), is composed primarily (from land surface downward) of the: Pamlico Sand, Miami Oolite, Anastasia Formation, Key Largo Limestone, and Fort Thompson Formation (all of Pleistocene age), with hydraulic conductivities commonly exceeding 10,000 ft/d (feet per day). Highly permeable beds of the Tamiami Formation of Pliocene and late Miocene age, which are contiguous with the overlying formations of the Biscayne aquifer and where at least 10 ft (feet) of the section has a horizontal hydraulic conductivity of 1,000 ft/d or greater, are also defined as part of the Biscayne aquifer. Water in the Biscayne aquifer is unconfined and responds rapidly to stresses on the system, including drainage and recharge from canals, recharge from rainfall, evapotranspiration, and pumpage from supply wells.

A canal and levee system (fig. 1) is the primary means of controlling water levels in the Biscayne aquifer. Due to high hydraulic conductivity in the bottom and side materials of most of the canals and the high water-table altitude, canal stages generally reflect water levels in the Biscayne aquifer. Levees are used to impound water in the remnant areas of the Everglades in the western part of Dade County, which include Water-Conservation Areas 3A and 3B and Everglades National Park. Through a network of pumps and control structures, canals are used to augment ground-water supplies and for flood control. Surface water is moved toward well fields from the water-conservation areas during periods of low water and is released to the ocean during periods of high water.

Ground-water withdrawals from the Biscayne aquifer accounted for greater than 95 percent of the total freshwater withdrawals in Dade County in 1990 (Marella, 1992). Most of the freshwater withdrawn from the Biscayne aquifer is for public supply (64 percent) and agriculture (26 percent). The Hialeah-Miami Springs, Northwest, Alexander Orr, Snapper Creek, and Southwest Well Fields, operated by the Miami-Dade Water and Sewer Department, are the primary sources of public-water supply in Dade County (fig. 1). These well fields, from which large volumes of water are pumped from a relatively small area, affect the regional pattern of water levels and ground-water flow in the Biscayne aquifer. Other sources of withdrawals from the Biscayne aquifer, including small municipal well fields, domestic supply wells, and agricultural supply wells, are spread throughout the county, with each withdrawal site having only a localized effect on water levels and flows in the Biscayne aquifer.

Monitoring of water levels and investigation of saltwater intrusion in Dade County by the U.S. Geological Survey began in the late 1930's and continues in cooperation with various Federal, State and local agencies. The data collected are used to assist water officials in the management of the ground-water resources and in planning future needs for water in Dade County. The most recent water-table map for Dade County, April 1988, was prepared by Lietz (1991). Recent studies included a synopsis of saltwater intrusion in Dade County (Klein and Waller, 1985) and an evaluation of saltwater intrusion in the Hialeah-Miami Springs area (Klein and Ratzlaff, 1989).

This map report, prepared in cooperation with the Miami-Dade Water and Sewer Department, depicts the altitude of the water table in the Biscayne aquifer in Dade County and documents the movement of the saltwater interface at selected locations in the Biscayne aquifer. The information presented in this report includes the following: (1) maps showing the altitude of the water table in the Biscayne aquifer in Dade County for May and November 1993; (2) hydrographs of selected wells throughout Dade County showing daily maximum water levels and water-level duration curves for water years 1984-93; and (3) graphs showing chloride concentrations in water at selected wells throughout Dade County for water years 1974-93. The selected wells are located at or near the coastal freshwater-saltwater interface or near tidal canals. Changes in chloride concentrations are evaluated to describe the movement of the interface and seepage of saltwater from tidal canals.

DATA COMPILATION

Ground-water-level data from 73 continuous recording stations and 62 miscellaneous measurement stations, surface-water stage data from 97 sites, and chloride data from 10 wells were used in this study to evaluate trends in water levels, movement of the coastal freshwater-saltwater interface, and seepage of saltwater from tidal canals in Dade County. All of the stations were part of existing networks, operated by various agencies that monitor water resources in Dade County. These agencies include the U.S. Geological Survey, Metro-Dade Department of Environmental Resources Management, Everglades National Park, and the South Florida Water Management District. The ground-water-level and surface-water stage data were used to construct contour maps that depict the altitude of the water table in the Biscayne aquifer in Dade County at the end of the dry (May) and wet (November) seasons in 1993. The chloride data were used to indicate the movement of the coastal saltwater interface and saline ground water that has seeped from tidal canals in response to changing hydrologic conditions.

The combined effects of low rainfall and high urban and agricultural water use typically cause the water table to be at its lowest level at the end of the dry season. Peak water levels might occur at different times of the year at different stations because of localized rainfall events; however, the altitude of the water table at the end of the wet season can be used to denote the cumulative effects of rainfall, water use, and water-management practices during the wet season. Variations in hydrologic or measuring conditions, such as nonsimultaneous measurements of water levels in wells and stages in canals, vertical water-level variations in the aquifer, variable effects of pumping at well fields, changes in canal control structures, and changing climatic conditions, were considered in constructing the water-table contours. Thus, the water-table contours might not conform exactly with instantaneous water-level or stage measurements.

Hydrographs of eight observation wells, representative of five areas in Dade County (listed in table 1), were constructed showing long-term daily maximum water levels in water years 1984-93 and a comparison of water-level duration curves for water years 1988 and 1993. The hydrographs were used to depict trends in water levels by indicating changes in annual highs and lows and long-term increases or decreases in water levels in general at a site. The water-level duration curves plot the percent of time that a given water level was equaled or exceeded during a specified time period. A steep slope indicates a high variability in the water level at a site. A comparison of duration curves for different time periods at the same site can indicate the effects of differences in rainfall and management practices on water levels at the site.

Chloride concentrations in water at 10 observation wells, located at or near the saltwater interface or near tidal canals representative of four areas in Dade County (listed in table 1) are shown for a 20-year period (water years 1974-93). Changes in chloride concentrations indicate the movement of the coastal saltwater interface and saline ground water that has seeped from tidal canals in response to changing hydrologic conditions. Generally, there is a time lag in the movement of the coastal interface in response to changes in water levels, with regional long-term changes having a greater effect than seasonal changes (Parker and others, 1955, p. 611). Additionally, the boundary between the freshwater and saltwater is not a sharp interface, but a transition zone which has been reported to be between 200 and 600 ft wide (Klein and Waller, 1985). Background chloride concentrations in ground water from the Biscayne aquifer are generally less than 100 mg/L (milligrams per liter). Concentrations greater than 100 mg/L are generally considered to be evidence of contamination. Because the saltwater interface slopes inland from the coast, the depth of the open interval for the observation wells must be considered when chloride concentrations from these wells are used to evaluate the movement of saline water within the Biscayne aquifer.

WATER-TABLE TRENDS AND SALTWATER INTRUSION IN THE BISCAYNE AQUIFER

The water table in Dade County is characterized, in general, by an area of highest water levels in Conservation Area 3A, located in the northwestern corner of the county (fig. 1), with water levels gradually decreasing to sea level to the east and the south. On May 5, 1993, the water level in Conservation Area 3A was 9.6 ft above sea level (fig. 3); on November 2, 1993, the water level was 10.2 ft above sea level (fig. 4). Controls on the water levels in the eastern part of Dade County are evident by comparing the shape of the contours in the east to those in the uncontrolled Everglades National Park in the southwest. On both water-table maps (figs. 3 and 4), the contours in the east generally pass through the control structures located on the canals. The canals closer to the Everglades (especially in southern Dade County) recharge water to the aquifer, and the canals closer to the coast discharge water from the aquifer.

During 1993, there were depressions in the water table caused by pumping at three large municipal well fields (Hialeah-Miami Springs, Alexander Orr, and Southwest Well Fields). A drawdown of about 6 ft from water levels outside of the cone of depression was recorded at the Hialeah-Miami Springs Well Field, with a water level of 4.6 ft below sea level on May 5 and a water level of 4.7 ft below sea level on November 2 in the center of the cone. For the Alexander Orr Well Field, the drawdown was about 11 ft with a water level of 7.7 ft below sea level on May 5 and a water level of 7.5 ft below sea level on November 2 in the center of the cone. Drawdown at the Southwest Well Field varied between the two seasons. On May 5, the drawdown was about 4 ft in the center of the cone with a water level of 0.7 ft above sea level; on November 2, the drawdown was about 4.5 ft in the center of the cone with a water level of 1.1 ft above sea level.

Western Dade County

The area of Dade County west of the levee system is predominantly undeveloped, consisting primarily of Conservation Areas 3A and 3B and Everglades National Park (fig. 1), with small agricultural areas. This area is located inland, far from the coastal saltwater interface, and thus, saltwater intrusion is not a threat in this region. Annual low water levels at well G-1502, located at the western edge of an agricultural area, were between 3 and 5 ft for the 1984-88 water years, below 3 ft for the 1989-92 water years, and almost 6 ft for the 1993 water year (fig. 5). The increase in water levels in water year 1993 is evident from a comparison of the duration curves for water years 1988 and 1993 (fig. 5). The 1993 curve is relatively flat and is similar to the 1988 curve for exceedance values less than 40 percent. However, for exceedance values greater than 40 percent, the 1988 curve decreases to almost 2 ft below the 1993 curve, an indication that the Everglades was significantly wetter in 1993 than 1988. Based on the evidence from the hydrograph and the duration curves, water levels for the 1993 water year can be considered very high when compared to the previous water years (1984-92).

Southeastern Dade County

The canal system in southeastern Dade County, initially completed in 1967, was designed not only to prevent flooding but also to prevent excessive drainage, allowing for the inland movement of the saltwater interface. Subsequently, the primary changes to the system have been the addition of control structures and pump stations in response to changes in needs for water-level controls. The hydrograph of well G-614 (fig. 6) indicates that the annual low water levels were lower in the 1989-92 water years than in the 1985-88 and 1993 water years, similar to the trends at well G-1502 in western Dade County. The similarity in low water levels between water years 1988 and 1993 is apparent from the duration curves (fig. 6). There is a difference between water years 1988 and 1993 for exceedance values less than 50 percent due to two periods of very high water levels in 1988.

The initial operation of the canal system in southeastern Dade County appeared to have halted the movement of the coastal saltwater interface that was evident prior to the development of the canal system. Inland movement of the interface was not apparent between 1980 and 1984 (Klein and Waller, 1985). Chloride concentrations in water at well G-3162 (fig. 7) decreased during this time period, indicating that the saltwater interface may have moved seaward. However, between 1984 and 1990, chloride concentrations increased from 100 to 1,000 mg/L, an indication that the saltwater interface moved inland during that time period. Since 1990, chloride concentrations have remained stable at about 1,000 mg/L, suggesting a possible halt to the inland movement of the interface. This is contradictory to the water-level trends at well G-614, where annual lows were lower in water years 1989-92 than water years 1985-88. However, because of the time lag in response to the movement of the interface to water levels, it is possible that the movement of the interface is in response to earlier changes in water levels.

South-Central Dade County

Pumpage from the three large well fields (Alexander Orr, Snapper Creek, and Southwest Well Fields) and the management of stages in the canal system (fig. 1) are major factors influencing water levels and the movement of the saltwater interface in south-central Dade County. The hydrograph of well G-860 (fig. 8A), located outside the cone of depression of the well fields, indicates that annual low water levels were lower in the 1989-92 water years than in the 1984-88 and 1993 water years. This water-level pattern is similar to the trends at well G-1502 (fig. 5) in western Dade County. The duration curves for well G-860 for water years 1988 and 1993 (fig. 8B) are almost identical despite differences in the appearance of the water levels. Three periods of drawdown are evident from the hydrograph during the summer of 1993, an indication of a more sporadic rainfall pattern for that period than during the summer of 1988. The hydrograph of well G-1074B (fig. 8A), located in the center of the Alexander Orr Well Field, indicates a decreasing trend in water levels beginning in water year 1988. The duration curves for well G-1074B (fig. 8B) show a water-level decrease of more than 4 ft for the 50 percent exceedance value between the 1988 and 1993 water years. This decrease in water levels at well G-1074B is probably due to an increase in average daily pumpages from the well field and not to a lowering of regional water levels. No long-term trends are evident for water levels at well G-3073, located in the center of the Snapper Creek Well Field, based on the hydrograph and the similarity of the duration curves for the 1988 and 1993 water years (fig. 8A-B).

The coastal saltwater interface appeared to be stationary from the early 1960's to 1984 (Klein and Waller, 1985). Graphs of chloride concentrations in water at three wells (G-432, G-896, and G-1604) show increased concentrations from 1989 to 1993 (fig. 9). Based on these readings, the saltwater interface has moved inland of well G-432, well G-896 is located in the transition zone of the saltwater interface, and well G-1604 is located at the leading edge of the saltwater interface. The movement of the saltwater interface in this area is most likely due to the decreased water levels at the Alexander Orr Well Field.

North-Central Dade County

Pumpage from the Hialeah-Miami Springs and Northwest Well Fields (fig. 1) is the major factor influencing water levels and the movement of the saltwater interface in north-central Dade County. The Hialeah-Miami Springs Well Field was initially completed in 1925 with a capacity of 10 Mgal/d (million gallons per day). The most recent expansion, completed in 1973, resulted in a capacity of 135 Mgal/d. Pumpage was significantly reduced from 1984 to 1992 because of industrial contamination in the supply wells, and the majority of the pumpage was transferred to the Northwest Well Field. The completion of a treatment facility in 1992 resulted in the majority of the pumpage being transferred back to the Hialeah-Miami Springs Well Field.

The hydrograph of well G-3 (fig. 10A), located in the Hialeah-Miami Springs Well Field, indicates no long-term trends in water levels were apparent until a 4-ft decline toward the end of water year 1992. The duration curves for well G-3 (fig. 10B) indicate a water-level decrease of between 2 and 4 ft from the 1988 to 1993 water years. This decrease in water levels is due to the large increase in pumpage from the well field beginning in 1992. The hydrograph of well G-3259A (fig. 10A), located 1 mi (mile) east of the Northwest Well Field, showed no long-term trend until a 5-ft rise toward the end of water year 1991. The duration curves for well G-3259A (fig. 10B) indicate a water-level increase of between 2 and 5 ft from the 1988 to 1993 water years. This increase in water levels is due to the reduction in pumpage from the well field beginning in 1992.

Saltwater intrusion is considered a major threat to the Hialeah-Miami Springs Well Field, with evidence of contamination as early as 1939 (Klein and Ratzlaff, 1989). Two possible sources of saltwater to the well field are nearby tidal reaches of the Miami Canal and the Tamiami Canal (fig. 1) and the coastal interface. Prior to the construction of the first control structure on the Miami Canal at NW 36th Street in 1943, chloride concentrations greater than 10,000 mg/L were reported in the canal during extreme dry periods as far inland as the well field. Even after the control structure was installed, chloride concentrations as high as 1,000 mg/L were reported in the canal near the well field because of tidal water seeping around the control structure and operation of the structure to permit boat passages (Parker and others, 1955, p. 631-639). The first coastal structure along the Tamiami Canal was installed in 1946 downstream of the FEC Canal (Parker and others, 1955, p. 659). The structure was replaced in 1971 with a temporary structure about 2.5 mi downstream, and then in 1976 with a permanent structure (fig. 1, S-25B) another 0.5 mi downstream (Klein and Ratzlaff, 1989). These structures prevented the movement of tidal canal water to the south and west of the well field. The source of high chloride concentrations in water at observation wells, either from canal seepage or from the coastal interface, is difficult to determine due to this inland movement of tidal canal water in the Miami and Tamiami Canals prior to the installation of the present control structures.

Variations in chloride concentrations in water at three observation wells (G-548, G-571, and G-1351), with open intervals between about 90 and 100 ft below land surface near the Hialeah-Miami Springs Well Field (fig. 1), indicate the possible effects of the changing pumpage rates and the installation of the control structures. Chloride concentrations in water at all three wells (fig. 11) peaked in about 1980, 4 years after the completion of structure S-25B on the Tamiami Canal and 4 years prior to the decrease in pumpage from the well field. The rate of increase in chloride concentrations began to drop in 1976, the year structure S-25B was completed.

Chloride concentrations in water at wells G-548 and G-571, located farther from the Tamiami Canal than well G-1351, have steadily decreased since 1980 from peak concentrations of about 1,000 mg/L to concentrations near background levels of less than 100 mg/L in 1993. Part of the decrease might be related to the decrease in pumpage from the Hialeah-Miami Springs Well Field beginning in 1984. Chloride concentrations in water at well G-1351 were constant at about 1,500 mg/L from 1981 to 1986. From 1987 to 1993, chloride concentrations in water at this well fluctuated between background levels of about 50 mg/L and a maximum of 1,100 mg/L. This may be an indication that the well is located near the edge of a saltwater source (either seepage from tidal water or the coastal interface). However, there has been a downward trend in chloride concentrations at this well.

Results indicate that the high chloride concentrations in water at wells G-548, G-571, and G-1351 might be due to seepage from tidal canals. However, more information is needed to determine if the saline water is from recent seepage or from seepage that occurred prior to the construction of the control structures.

Northeastern Dade County

The canal system is the major factor influencing water levels and the movement of the saltwater interface in northeastern Dade County. Snake Creek, Biscayne, and Little River Canals (fig. 1) are used to drain the area, maintaining a very flat water-table gradient between the upper reaches of the Miami Canal in eastern Dade County and the coast. The hydrograph of well G-852 (fig. 12), located near the coast, indicates no apparent long-term trends. The duration curves for well G-852 (fig. 12) in water years 1988 and 1993 are almost identical. The only difference is at higher water levels, which is due to a higher peak water level in 1993 than in 1988. Changes in pumpages from the nearby small municipal well fields and changes in pumpages and water-management practices in the vicinity of the Hialeah-Miami Springs Well Field located to the south (fig. 1) have had no apparent effects on water levels in this area.

Previous studies provide little information on the movement of the coastal saltwater interface in northeastern Dade County. Prior to the installation of coastal control structures in the 1940's on the Snake Creek, Biscayne, and Little River Canals, tidal saltwater movement occurred inland in the canals as far as the Red Road Canal (fig. 1) during extreme dry periods (Parker and others, 1955, p. 632). Thus, there was seepage of saline water into the aquifer throughout much of the area during this time period. Seepage is no longer a concern in this area, but the location of the coastal saltwater interface is being monitored.

Chloride concentrations in water at three observation wells (F-279, G-430, and G-894), located near the Biscayne Canal (fig. 1), give an indication of the movement of the coastal saltwater interface over a 20-year period from 1974 to 1993 (fig. 13). Chloride concentrations in water at well F-279, located 0.5 mi south-southwest of well G-894, ranged from 990 to 2,200 mg/L in 1974-93, with a trend toward higher concentrations in the latter part of the period. Chloride concentrations in water at well G-430, located 0.8 mi west of well G-894, remained at background levels throughout the 1974-93 period, indicating that the saltwater interface was located between wells G-894 and G-430 during that period. Chloride concentrations in water at well G-894 increased slowly from 1,000 mg/L in 1974 to 1,900 mg/L in 1980, when the concentrations began to decline to background levels of about 50 mg/L in 1993. The decline in chloride concentrations coincides with the shutting down of the North Miami Well Field near well G-894 between 1977 and 1982, and thus, local conditions might have influenced the movement of the saltwater interface. Two possibilities may account for the difference in trends in chloride concentrations at wells F-279 and G-894.: (1) well F-279 is completed at a significantly deeper depth than well G-894 (table 1), and (2) pumpage from the well field near well G-894 probably does not influence the movement of the saltwater interface at well F-279.

SUMMARY AND CONCLUSIONS

This report presents water-table maps of the Biscayne aquifer in Dade County for the dry and wet seasons in 1993 and documents trends in water levels and chloride concentrations in water at selected observation wells over time. Long-term hydrographs and water-level duration curves are included for continuous recorder observation wells representative of different areas of Dade County in water years 1984-93. Graphs showing chloride concentrations for 10 observation wells over a 20-year period (1974-93) are evaluated to document movement of the freshwater-saltwater interface and seepage of saltwater from tidal canals.

The water table in Dade County is characterized by an area of highest water levels in Conservation Area 3A in the northwestern corner of Dade County, with water levels gradually decreasing to sea level to the east and south. In 1993, the altitude of the water table in the Biscayne aquifer in Dade County ranged from 9.6 ft (May 5) and 10.2 ft (November 2) above sea level in Conservation Area 3A to 7.7 ft (May 5) and 7.5 ft (November 2) below sea level at the Alexander Orr Well Field. Three large wells fields (Hialeah-Miami Springs, Alexander Orr, and Southwest Well Fields) had drawdowns ranging from 4 to 11 ft.

Annual low water levels were found to be lower in western and southeastern Dade County in water years 1989-92 than 1985-88. Water levels in western Dade County were significantly higher in water year 1993 than 1988 for exceedance values greater than 40 percent, an indication that the Everglades was significantly wetter in water year 1993 than 1988. In southeastern Dade County, water-level durations were similar for water years 1988 and 1993, except for low exceedance values (less than 50 percent) due to two periods of very high water levels in 1988. No long-term trends in water levels were evident for northeastern Dade County.

Water levels in central Dade County were affected by pumpage from large well fields. Trends outside the cones of depression were similar to those in western and southeastern Dade County; however, no difference was noted in the duration curves for water years 1988 and 1993. A trend toward lower water levels at the Alexander Orr Well Field began in 1988, as confirmed by the 4-ft difference in the duration curves between water years 1988 and 1993 at the 50 percent exceedance value. Decreasing and increasing pumping rates at the Northwest and Hialeah-Miami Springs Well Fields, respectively, resulted in 4- to 5-ft changes in water levels.

The coastal saltwater interface moved inland in southeastern Dade County from 1984 to 1990 and in south-central Dade County from 1989 to 1993. In the vicinity of the Hialeah-Miami Springs Well Field in north-central Dade County, the saltwater interface has moved toward the coast in response to decreased pumpage at the well field from 1984 to 1992. The presence of saltwater appears to be the result of seepage from tidal canals; however, more information is needed to determine when the seepage occurred. In northeastern Dade County, the coastal saltwater interface has moved seaward near the North Miami Well Field, which was shut down between 1977 and 1982; however, the interface appears to have moved slightly inland south of the well field.

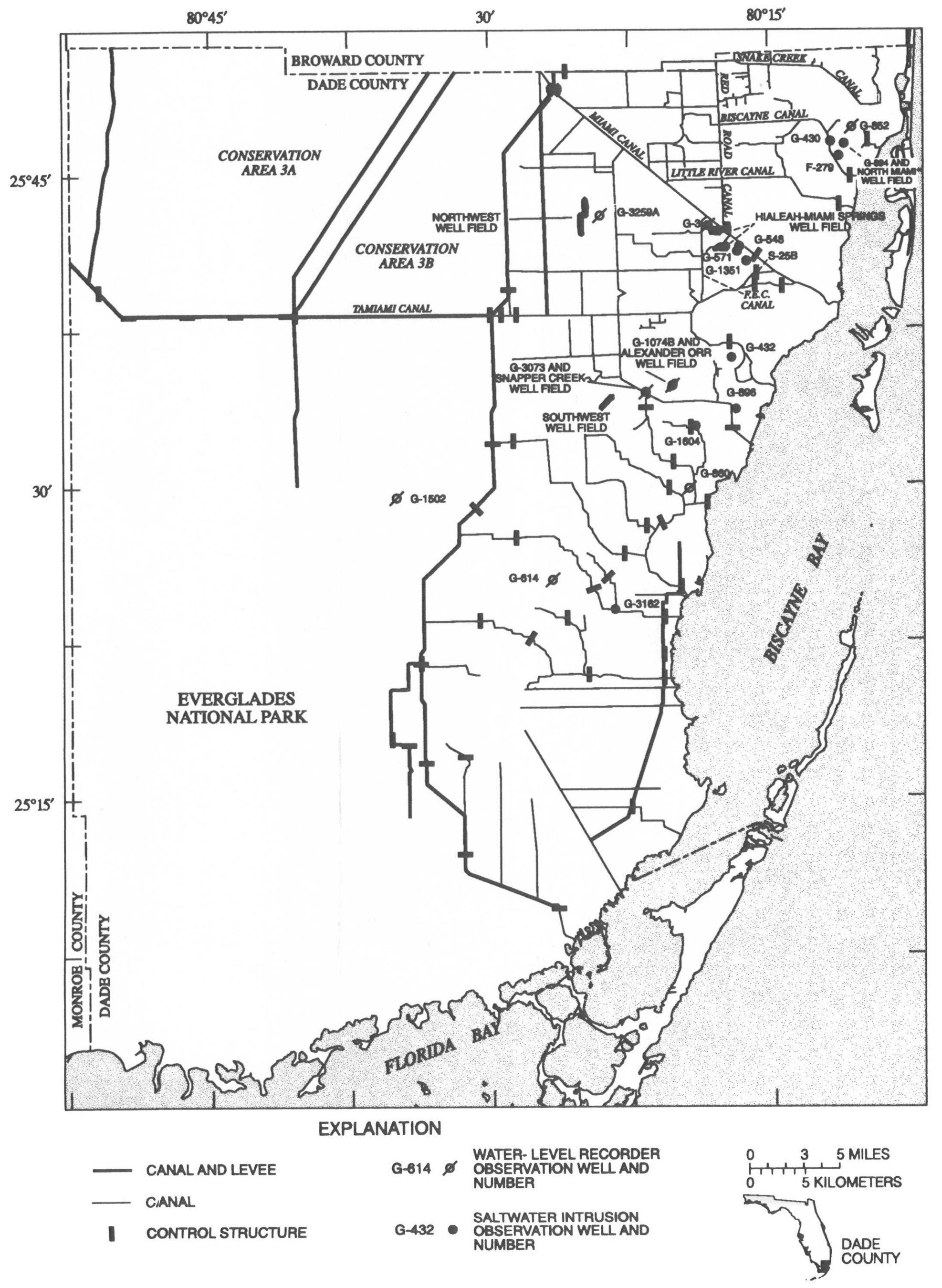

Figure 1. Dade County showing the location of major well fields, canals, levees, and selected observation wells.

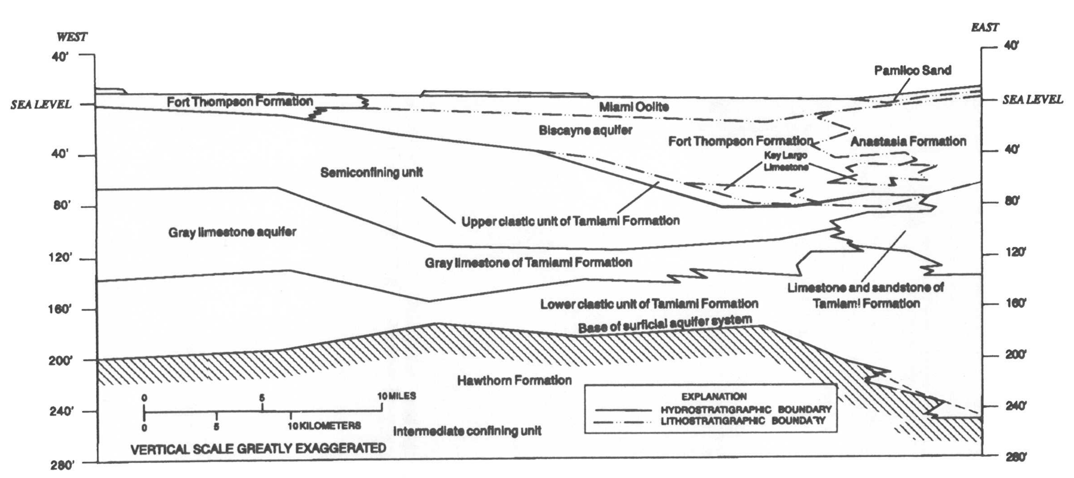

Figure 2. Geologic formations, aquifers, and confining units of the surficial aquifer system in central Dade County, (from Fish, 1991).

Table 1. Inventory data for selected saltwater intrusion and water-level observation wells

[The depth to bottom of casing for wells F-279 and G-3 is unknown. USGS, U.S. Geological Survey; Type of finish: OE, open end; OH, open hole; S, screen; Use of well: SI, saltwater intrusion; WL, water level]

Local well number	USGS site identification number	Lati-tude	Longi-tude	Open interval (feet below land surface)	Type of finish	Area of Dade County	Use of well
F-279	255315080111501	255315	0801115	117	OH	Northeast	SI
G-3	254950080180801	254950	0801808	20	OH	North-central	WL
G-430	255357080114201	255357	0801142	97-98	OH	Northeast	SI
G-432	254335080170501	254335	0801705	98-100	OH	South-central	SI
G-548	254855080163701	254855	0801637	91-97	OH	North-central	SI
G-571	254841080164401	254841	0801644	94	OE	North-central	SI
G-614	253258080264301	253258	0802643	18-20	OH	Southeast	WL
G-852	255437080103201	255437	0801032	10-20	OH	Northeast	WL
G-860	253718080192301	253718	0801923	10-20	OH	South-central	WL
G-894	255350080105801	255350	0801058	74-76	OH	Northeast	SI
G-896	254107080165201	254107	0801652	60-74	OH	South-central	SI
G-1074B	254215080201503	254215	0802015	17-39	OH	South-central	WL
G-1351	254813080161501	254813	0801615	100-103	OH	North-central	SI
G-1502	252656080350301	253656	0803503	11-31	OH	West	WL
G-1604	254019080190201	254019	0801902	62	OE	South-central	SI
G-3073	254157080214001	254157	0802140	20	OE	South-central	WL
G-3162	253202080232601	253132	0802325	82-92	S	Southeast	SI
G-3259A	255026080240302	255026	0802403	20-60	OH	North-central	WL

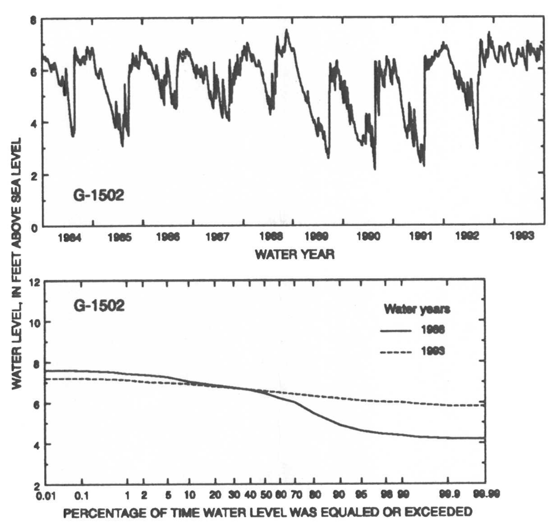

Figure 5. Hydrographs of well G-1502 in western Dade County showing daily maximum water levels for water years 1984-93 and water-level duration curves for water years 1988 and 1993.

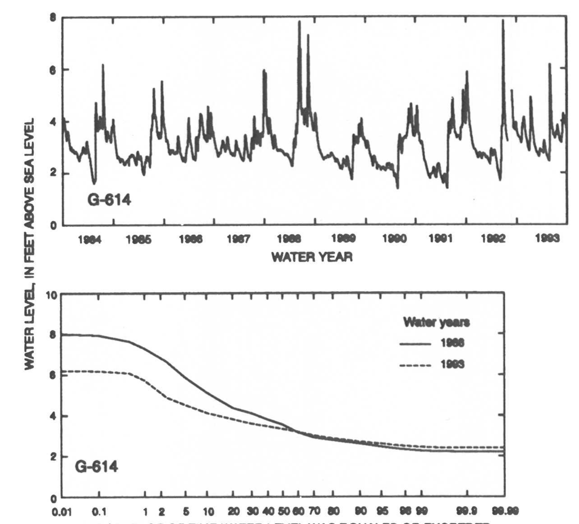

Figure 6. Hydrographs of well G-614 in southeastern Dade County showing daily maximum water levels for water years 1984-93 and water-level duration curves for water years 1988 and 1993.

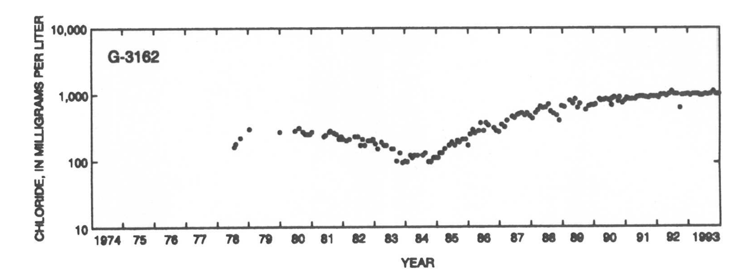

Figure 7. Chloride concentrations in water at well G-3162 in southeastern Dade County, 1974-93.

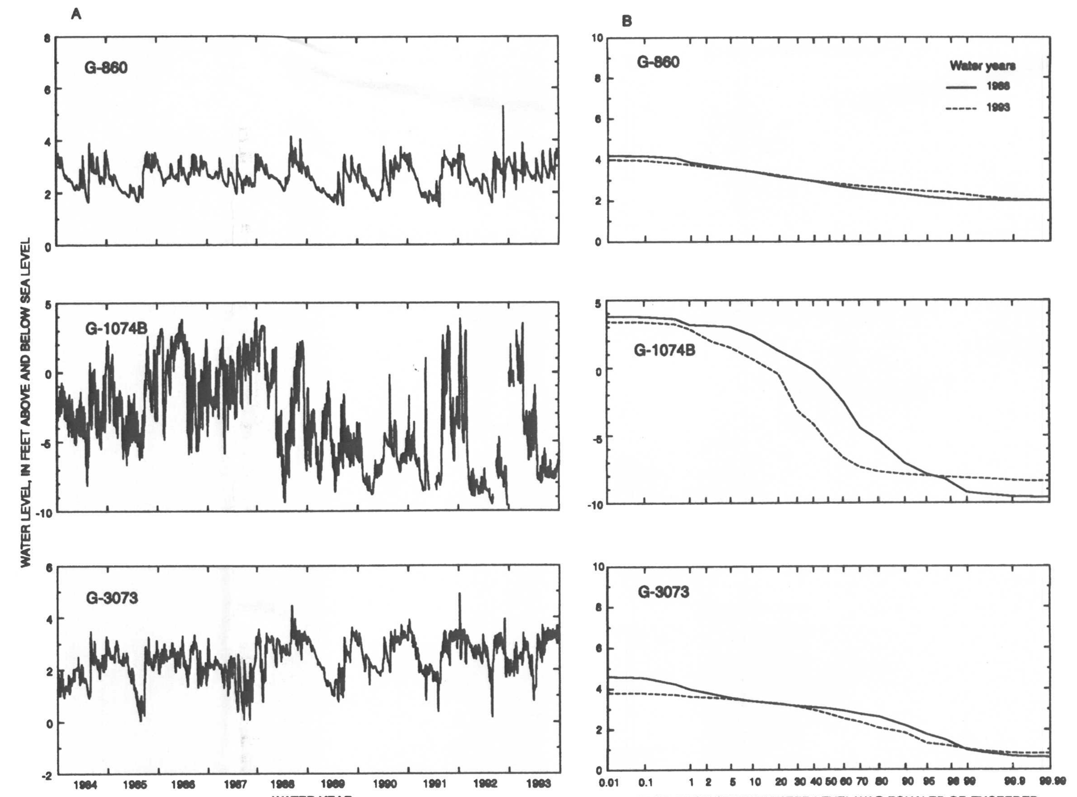

Figure 8. (A) Hydrographs of wells G-860, G-1074B, and G-3073 in south-central Dade County showing daily maximum water levels for water years 1984-93, and (B) water-level duration curves for water years 1988 and 1993.

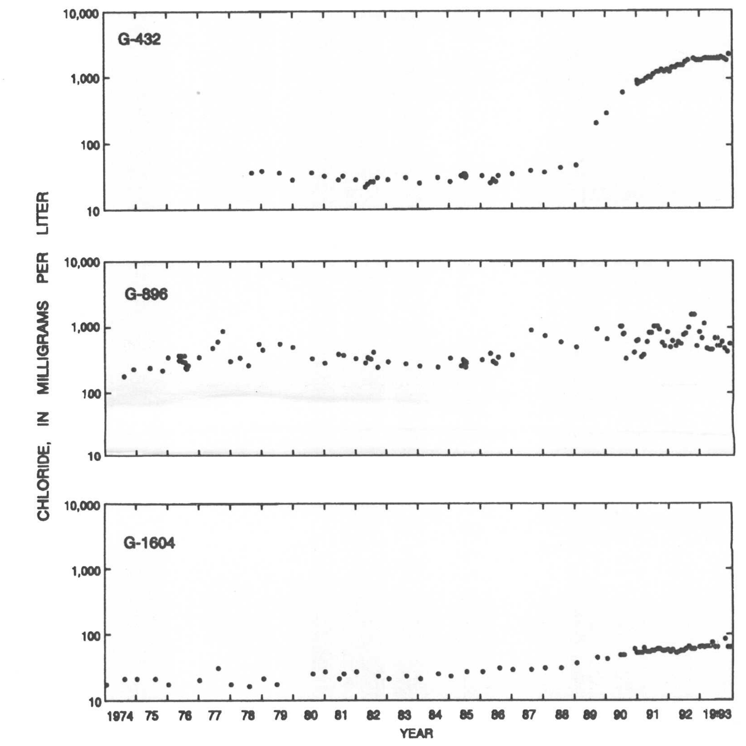

Figure 9. Chloride concentrations in water at wells G-432, G-896, and G-1604 in south-central Dade County, 1974-93.

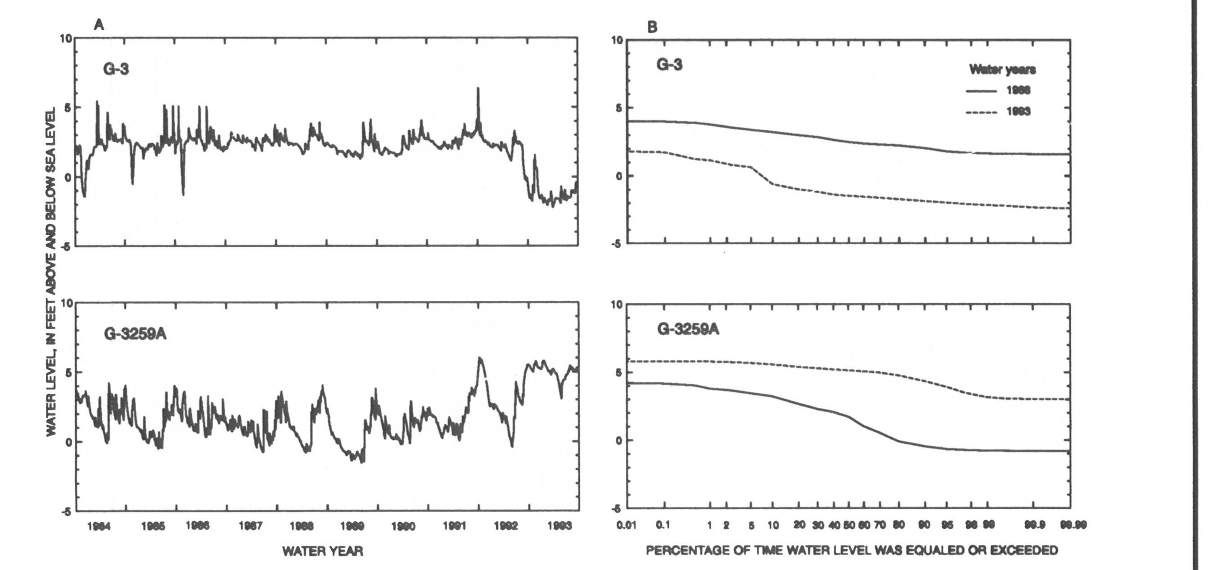

Figure 10. (A) Hydrographs of wells G-3 and G-3259A in north-central Dade County showing daily maximum water levels for water years 1984-93, and (B) water-level duration curves for water years 1988 and 1993.

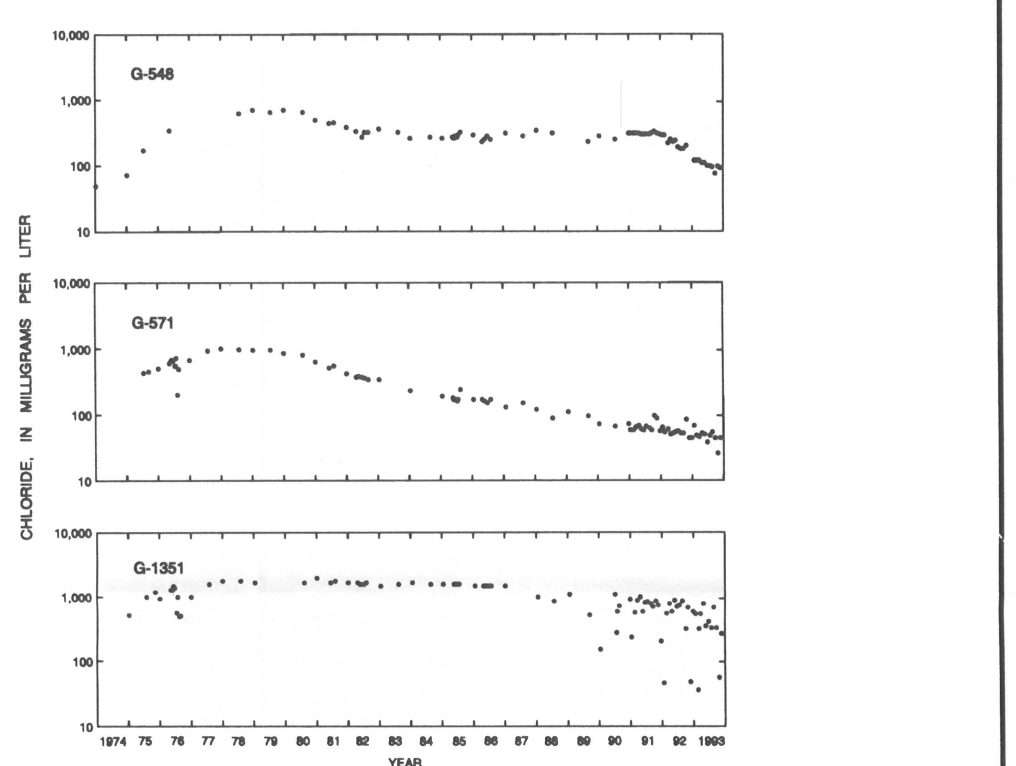

Figure 11. Chloride concentrations in water at wells G-548, G-571, and G-1351 in north-central Dade County, 1974-93.

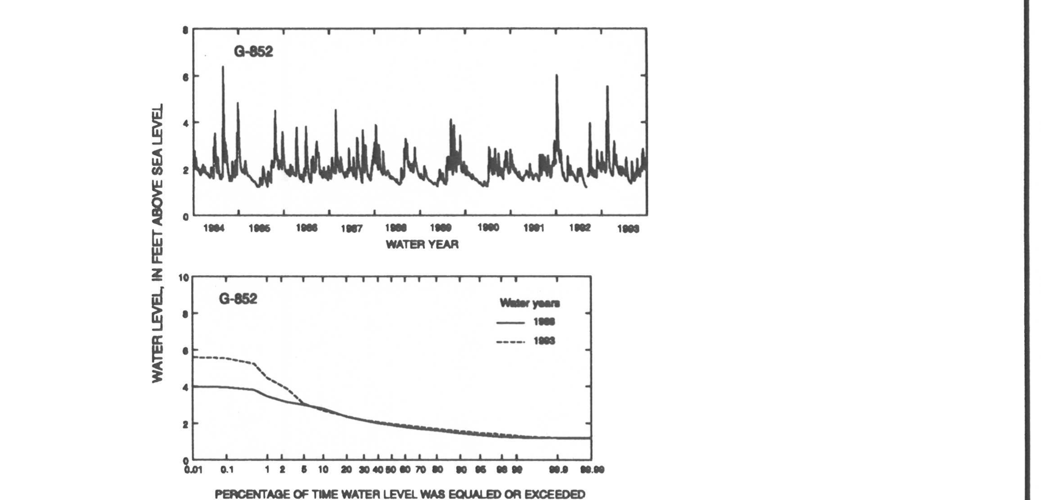

Figure 12. Hydrographs of well G-852 in northeastern Dade County showing daily maximum water levels for water years 1984-93 and water-level duration curves for water years 1988 and 1993.

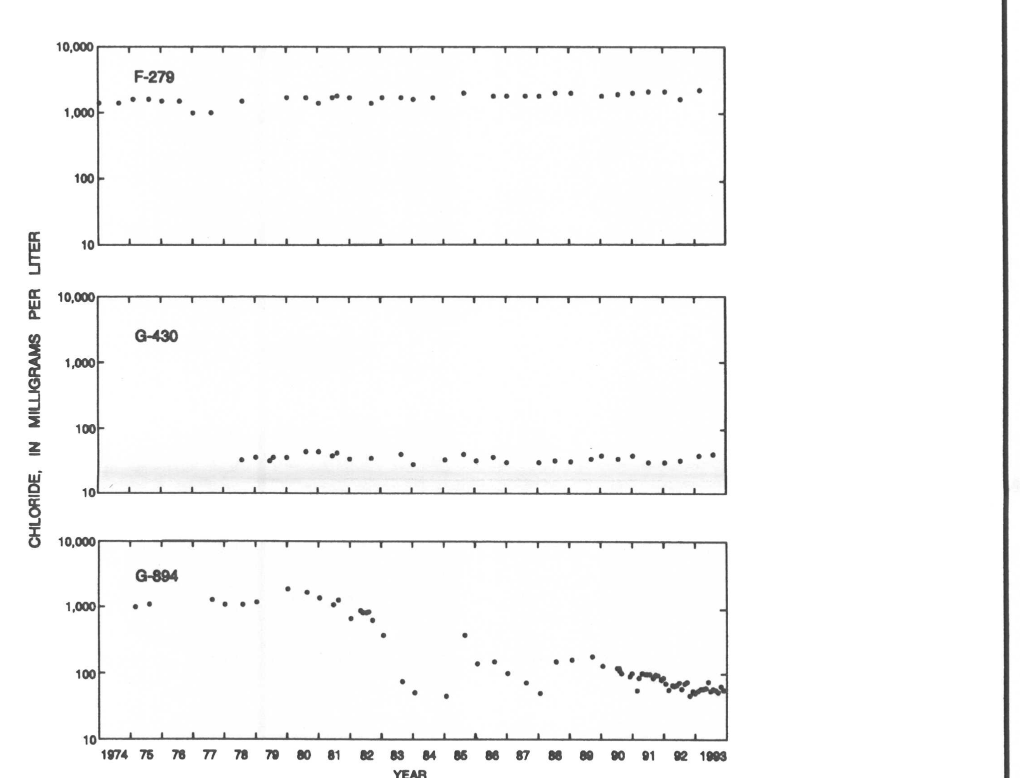

Figure 13. Chloride concentrations in water at wells F-279, G-430, and G-894 in northeastern Dade County, 1974-93.

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By
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1996