

Saltwater Intrusion Monitoring in the Biscayne Aquifer near Florida City, Miami-Dade County, Florida: 1996-2007

Christopher J Peters¹ and *Jolynn Reynolds²*

¹CH2M HILL, Deerfield Beach, FL, USA

²Florida Keys Aqueduct Authority, Key West, FL, USA

ABSTRACT

This paper documents changes in Biscayne Aquifer water quality monitored by the Florida Keys Aqueduct Authority's (FKAA's) saltwater intrusion monitoring (SWIM) program. Over 12 years of monthly data indicate that the 250 mg/L chloride concentration isochlor has remained stable in a relatively shallow interval (35 to 55 feet below land surface (ft bls)); however, inland migration has occurred at a greater depth (55 to 65 ft bls) in some areas. During this period, groundwater withdrawals for public supply have increased by approximately 10 million gallons per day and the area has experienced a severe drought. Continued monitoring is needed to ensure that groundwater withdrawals do not cause degradation of the portions of the Biscayne Aquifer used for groundwater supply.

INTRODUCTION

Saltwater intrusion has been a problem for South Florida water managers since the early 20th century. Parker et al. (1955) identified saltwater intrusion in the Miami area resulting from groundwater pumping and from the construction of uncontrolled canals, which lowered the water table in the Biscayne Aquifer and allowed saline water encroachment. The construction of the C-111 canal in southeastern Miami-Dade County in the early 1960's allowed saltwater to migrate inland during the 1970-1971 drought (Klein and Waller 1985). Meyer (1974) notes that storm surges from hurricanes have also contributed to saltwater intrusion in low-lying areas of southeastern Miami-Dade County. Sonenshein (1996) delineated the 1995 position of the fresh/salt water interface in Miami-Dade County using water quality and geophysical data.

The FKAA is the sole water supplier for residents of and visitors to the Florida Keys. At its wellfield and treatment plant near Florida City, the FKAA withdraws groundwater from the unconfined Biscayne Aquifer and pumps the treated water over 130 miles to Key West, serving customers throughout the Keys. The FKAA expects to meet future increases in demand through reverse-osmosis treatment of brackish water from the deeper Floridan aquifer; however the Biscayne Aquifer will remain an important resource for the FKAA and other utilities in the area (Miami-Dade Water and Sewer Department, Florida City, and the City of Homestead).

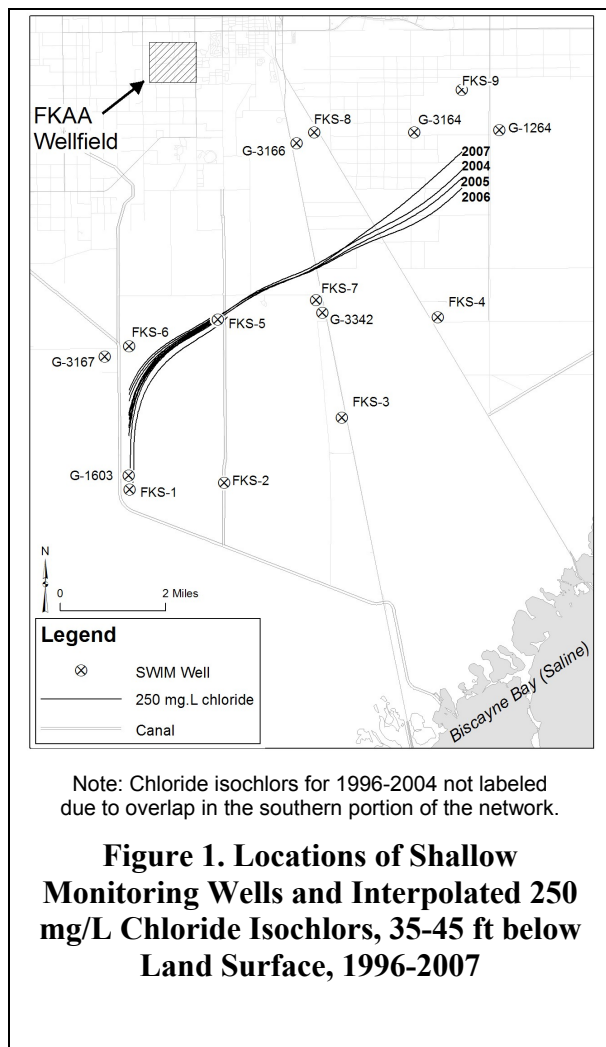
DATA COLLECTION METHODS AND ANALYSIS

The FKAA has monitored saltwater intrusion in the Biscayne Aquifer since 1991. Its SWIM network consists of 15 monitoring wells of different depths, some with multiple sampling depths. Chloride concentrations, conductivity, and water table elevations are monitored monthly in each well. The two intervals with the greatest number of sampling points are 35 to 45 ft bls (shallow) and 55 to 65 ft bls (deep). Water quality parameters are measured in the field (conductivity) and in the FKAA's water quality laboratory (chloride).

The multiquadratic radial basis function interpolation algorithm in SURFER (Golden Software 2007) was used to contour the annual average chloride concentration observed in the shallow and deep sampling intervals. The 250 mg/L chloride concentration isochlor was selected for this analysis because it is a secondary drinking water standard and its movement can serve as an indicator of saltwater intrusion occurring between the 250 mg/L isochlor and the saline source.

RESULTS

Figure 1 depicts the estimated location of the 250 mg/L chloride isochlor for each year from 1996 through 2007. The year-to-year configurations are fairly similar in the southern part of the monitoring network, indicating little to no water quality change in this interval of the Biscayne Aquifer.



Although the 250 mg/L chloride isochlor moves to the northwest near well G-3164 between 2006 and 2007, seaward movement is evident from 2004 through 2006, illustrating the dynamic nature of saline water intrusion in the area.

During the period from 1995 through 2005, total combined groundwater withdrawals by area utilities (FKAA, Miami-Dade Water and Sewer Department, Florida City, the City of Homestead, and Homestead Air Reserve Base) have increased from approximately 30 million gallons per day to approximately 40 million gallons per day (South Florida Water Management District (SFWMD), 2006). South Florida was affected by a severe drought during the 2000-2001 dry season, which resulted in lower groundwater elevations (Verdi, et al. 2006). As a result of the drought, water deliveries through the SFWMD's regional canal system were reduced, further lowering groundwater elevations in southern Miami-Dade County (SFWMD 2006).

Greater movement of the 250 mg/L isochlor is observed at the deeper interval of 55 to 65 ft bls (Figure 2). From 1996 through 2001, the 250 mg/L chloride isochlor moved inland and then retreated towards Biscayne Bay south of wells FKS-5, and FKS-6. In one year (2002) the 250 mg/L isochlor moved westward past well G-1264, which previously had chloride concentrations below 250 mg/L. Additional wells (FKS-7, -8, and -9) were installed in 2004 to provide additional information about Biscayne Aquifer water quality in this area.

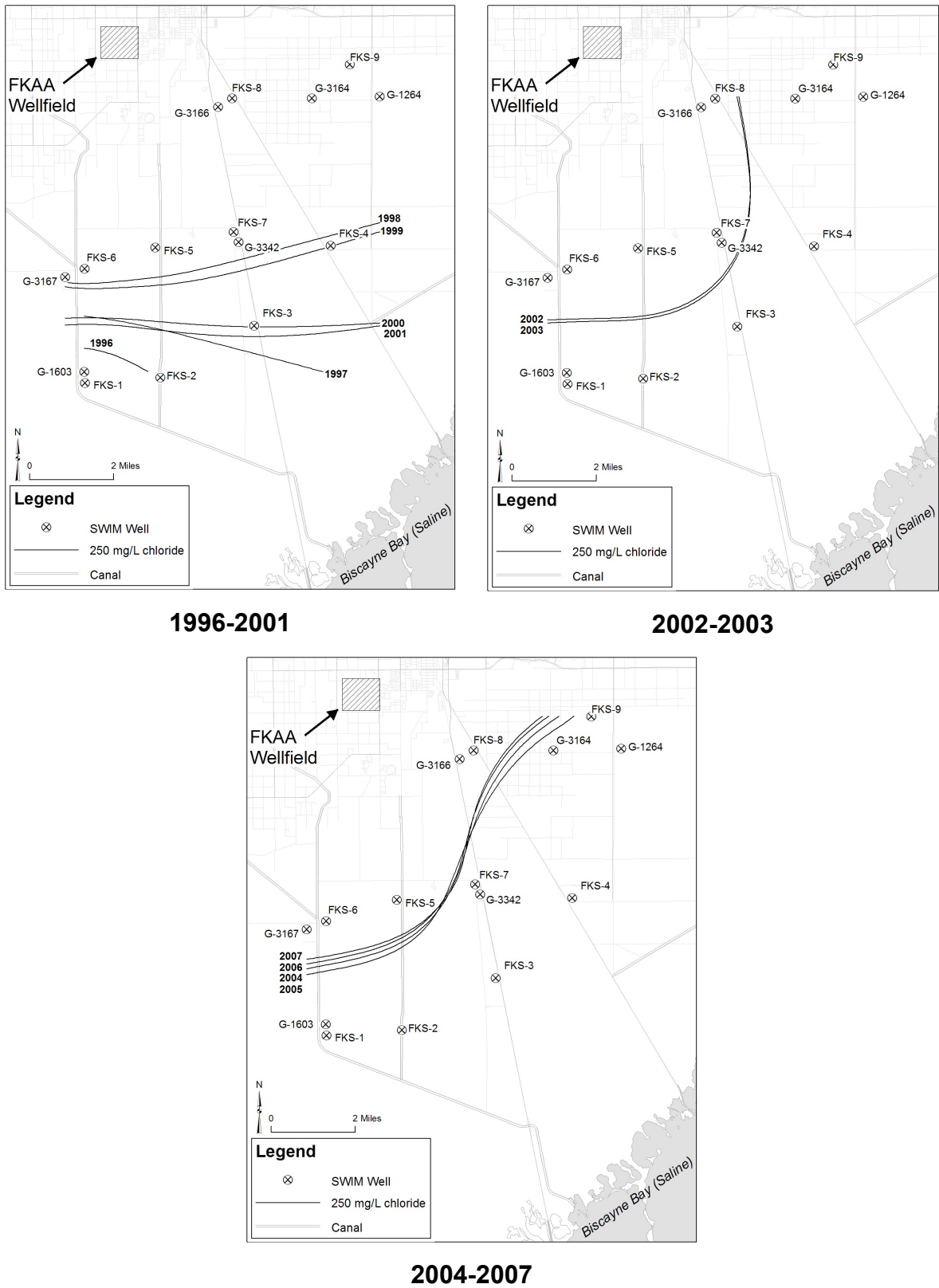


Figure 2. Locations of Deep Monitoring Wells and Interpolated 250 mg/L Chloride Isochlors, 55-65 ft below Land Surface, 1996-2007

DISCUSSION AND CONCLUSIONS

Over the past 10 years, groundwater withdrawals for public supply from the Biscayne Aquifer have increased by approximately 33 percent in southern Miami-Dade County. A severe drought in 2001 resulted in lower regional water levels in area canals and decreased fresh-water recharge to the Biscayne Aquifer. The effect of increased pumpage and reduced recharge can be seen in maps of the 250 mg/L chloride concentration isochlor in the area. At shallow depths (35-45 ft bls) there is little change; however some landward encroachment has occurred at greater depths in the vicinity of well G-1264. The concurrent stability of the shallow contour and the movement of the deeper contour are consistent with the typical wedge-shaped profile of the saltwater interface where encroachment is first observed at greater depths.

The FKAA is constructing a reverse-osmosis water treatment plant to treat brackish water from the Floridan Aquifer. Under its recently-authorized SFWMD water use permit, the FKAA's future Biscayne Aquifer average day withdrawals will be reduced from 19.93 to 17.8 mgd with a dry-season limitation of 17 mgd . This reduction in the FKAA's Biscayne Aquifer pumpage (along with expected future pumpage reductions by adjacent water suppliers) should increase the seaward fresh-water gradient and decrease the potential for further saltwater intrusion.

Continued monitoring to assess the position of the saline water interface is necessary to protect groundwater supplies in the Biscayne Aquifer in southern Miami-Dade County. The FKAA's SWIM network should be expanded to include additional wells to monitor the deeper intervals of the Biscayne Aquifer between the FKAA's wellfield and wells FKS-7, -8, and -9 where there are currently no monitoring wells between the saltwater interface and the FKAA's wellfield.

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Contact Information: Christopher Peters, CH2M HILL, 800 Fairway Drive, Suite 350, Deerfield Beach, FL 33441 USA, Phone: 954.426.4008, Fax: 954.698.6010, Email: chris.peters@ch2m.com