

## Saltwater Intrusion and the Minimum Aquifer Level in the Southern Water Use Caution Area

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### ABSTRACT

#### BACKGROUND

The Southwest Florida Water Management District (District) is one of five water management districts in the State of Florida charged with protecting the water resources of the state. The District is located in west-central Florida and encompasses an area of about 26,000 square kilometers (km<sup>2</sup> or 10,000 square miles). Florida law requires the water management districts to annually update and submit a schedule for establishing minimum flows and levels (MFLs) on priority water bodies. MFLs are the levels or flows in priority water bodies “. . . at which further withdrawals would be significantly harmful to the water resources of the area.” In the District’s southern ground-water basin, an area of about 13,200 km<sup>2</sup> (or 5,100 square miles; also referred to as the Southern Water Use Caution Area), historical increases in ground-water withdrawals have resulted in saltwater intrusion in coastal portions of the Upper Floridan aquifer, the principal source of water supply in the region. The Governing Board of the District declared that saltwater intrusion in the area is of regional significance and that the Upper Floridan aquifer is a MFLs priority water body. They further directed that a minimum aquifer level be established to achieve the management goal of slowing the rate of saltwater intrusion. This paper describes the background and approach to establishing a minimum aquifer level in the southern portion of the District.

The geology underlying west-central Florida consists of a series of clastic sediments overlying carbonate rocks. At the surface, and extending from a few to several tens of meters (m) thick, is the unconfined surficial aquifer generally comprised of unconsolidated sediments. Underlying the surficial is the confined intermediate aquifer system (IAS) which consists of a series of thin, interbedded limestone and phosphatic clays of generally low permeability, and functions as a confining unit that separates the surficial and Upper Floridan aquifers. The third aquifer system, the confined Floridan aquifer system (FAS), is divided into the Upper Floridan aquifer (UFA) and the Lower Floridan aquifer (LFA), which are separated by a middle confining unit consisting of evaporite materials of extremely low permeability. The UFA consists of upper (UPZ) and lower (LPZ) permeability zones. The LPZ is generally 5 to 10 times more permeable than the UPZ. Yields from large diameter wells completed into the LPZ can reach 7.6 to 11.4 cubic meters per minute (or 2,000 to 3,000 gallons per minute). The LFA in the region consists of highly brackish water and is generally not used.

In 1999, total estimated water use in the southern basin was 2,903,860 cubic meters per day (m<sup>3</sup>/d; or 767 million gallons per day (Mgal/d)) with 2,574,480 m<sup>3</sup>/d (or 680 Mgal/d; 89 percent) coming from ground water and 329,380 m<sup>3</sup>/d (or 87 Mgal/d; 11 percent) coming from surface water. Major uses of ground water have historically been for agricultural irrigation and mining of phosphate ore. Locations of agricultural withdrawals are distributed throughout the basin, whereas, phosphate mining has been concentrated in the north-central portion of the basin. Since the 1970s, there has been a shift in water use from the mining industry to other water use types. This is

reflected in ground-water level fluctuations, where the 1990s was a period of water level recovery in the northern portion of the basin and continued water level decline in southern portions of the basin.

In 1993, the District completed a hydrologic assessment of the coastal area of the basin that included a detailed review and analysis of water levels and water quality data. The study concluded that ground-water levels had declined, and that significant, regional, saltwater intrusion was occurring and posed a limiting constraint on ground-water development in the area. It was also concluded that ground-water withdrawals within the basin, but outside the coastal area, also contributed to water-level declines in the area and should be managed as well. The District continues to monitor for long-term changes in water-quality at dedicated monitor wells. From these wells, it has been shown that the saltwater-freshwater transition zone in the LPZ is relatively sharp in the northern half of the SWUCA and becomes more diffuse in the southern half. The transition zone, as a surface, is inclined about one or two degrees from the horizontal.

As part of the technical support necessary for development of a management strategy for the region, methodologies were developed to estimate the number of wells potentially “at risk” to future saltwater intrusion. This information was provided to the District’s Governing Board to assist them in their understanding of the consequences of different policy decisions. Predictive scenarios included continued withdrawals for a period of 50 years from current conditions at a variety of pumping rates in the basin. The condition of being “at risk” was assessed using a threshold for chloride concentration of 1,000 milligrams per liter. Under current conditions, there are about 63 wells “at risk” to saltwater intrusion and that are permitted to pump 31,420 m<sup>3</sup>/d (or 8.3 Mgal/d) and estimated to have pumped 23,850 m<sup>3</sup>/d (or 6.3 Mgal/d) during the period 1995 to 1999. If withdrawals are increased and maintained at the rate of 3,028,800 m<sup>3</sup>/d (or 800 Mgal/d) over the next 50 years, an additional 63 wells permitted to pump 28,770 m<sup>3</sup>/d (or 7.6 Mgal/d) and estimated to pump 47,700 m<sup>3</sup>/d (or 12.6 Mgal/d) will be at risk.

## **PREVIOUS MANAGEMENT APPROACH**

In 1994, the District proposed to establish a minimum aquifer level over the entire southern ground-water basin to preserve the freshwater resources of the Upper Floridan aquifer and stabilize lake levels in the recharge areas. A fundamental underpinning of the management strategy that was developed was the Governing Board's acknowledgement that the water resource problems of the area had developed over the long-term and could not be corrected immediately without serious socio-economic consequences. The principal concept integrated within the strategy was to gradually reduce existing withdrawals while not allowing new withdrawals to take place.

The management strategy was to be implemented through a new water use permitting rule. Though the approach used to calculate the proposed minimum aquifer level was found to be scientifically valid during a legal challenge, the level was withdrawn due to the invalidation of other parts of the proposed rule and because of previous agreements made with water users in the region. In 1997 the Florida Legislature directed each of the water management districts to establish a priority list for establishing MFLs. The Upper Floridan aquifer in the southern ground-water basin was identified as a priority water body and placed on the priority schedule for establishment of a minimum aquifer level by the end of 2002.

## **METHODOLOGY FOR ESTABLISHING A MINIMUM AQUIFER LEVEL**

The principal concerns regarding saltwater intrusion are the effects to the freshwater resource and existing water supplies. Through characterization of the saltwater interface and solute transport modeling, potential risks associated with continued movement of the interface over the next 50 years were quantified. Estimates of the reductions in ground-water withdrawals that would be required to halt movement of the interface were also developed. The Governing Board of the District understood that significant reductions in the current rates of ground-water withdrawals would be required to halt or reverse movement of the interface. They also understood that, saltwater intrusion will continue to occur even if the future distribution and rates of ground-water withdrawals remain the same as current. In order to minimize the disruption to current water supplies, the Board directed that the goal for establishing the minimum aquifer level would be to reduce the rate of movement of the interface so that the number of wells at risk to future saltwater intrusion could be minimized.

The methodology proposed for establishing a minimum aquifer level is to calculate a single value average potentiometric surface over the area of interest. This is similar to the approach previously proposed by the District. Basing the minimum aquifer level on a single average value, addresses the regional nature of saltwater intrusion in the basin and avoids micro-management of individual water use permit holders.

### **Area of Resource Concern**

In the current effort, the District decided to establish a minimum aquifer level for an identified “area of resource concern.” This is in contrast to the District’s previous approach where a minimum aquifer level over the entire ground-water basin was proposed. The “area of resource concern” for which the minimum aquifer level is being established is an area encompassing 1,834 km<sup>2</sup> (or 708 square miles) along the coast. In 1990, this area was designated a “Most Impacted Area (MIA)” because of the long-term water level declines that had occurred and concerns over saltwater intrusion. Since 1990, permitted ground-water withdrawals from the Upper Floridan aquifer in the area have been capped. Actual ground-water withdrawals in the area have averaged about 378,600 m<sup>3</sup>/d (or 100 Mgal/d) in recent years.

### **Reference Period**

Because the rate of movement of the interface is slow relative to annual water level changes, it was decided to evaluate changes in long-term water levels as represented by ten-year moving averages. Ten-years was chosen to represent “long term” because it is a period of sufficient length to incorporate high and low rainfall years, and it is not too long so that the period average is leveraged with data from earlier years, when withdrawals were occurring under different management goals. Since regional saltwater intrusion occurs slowly, ten years is sufficiently long so that management decisions are not unduly influenced by short-term events.

Annual-average and ten-year moving average ground-water levels for 16 wells within and adjacent to the coastal area were analyzed. Over the 1990s and early 2000s, the highest ten-year average water levels generally occurred during the period from 1990 to 1999. If water levels in the region were maintained at or above the levels for this period, a slowing or reduction in the rate of saltwater intrusion as compared to other ten-year periods ending in the 1990s and early 2000s would result. Therefore, the reference period for which the minimum aquifer level was calculated, is the period 1990 to 1999.

### **Minimum Aquifer Level**

The methodology for calculating the minimum aquifer level relies on annual average water level data from 16 wells over the period 1990 to 1999. Ten of the 16 wells selected were located Barcelo.doc

within the coastal area of concern and the remaining six wells were in adjacent areas. The decadal average for each well was calculated as the average of the annual average data. Using the decadal averages for the 16 wells, the Arc/INFO® Triangular Irregular Network (TIN) routine was used to calculate the decadal average potentiometric surface for the coastal area of concern. The calculated average potentiometric surface for the period 1990 to 1999 was 3.90 meters (or 12.8 feet) and is the proposed minimum aquifer level. For comparison, average water levels for the ten-year periods ending in 2000 and 2001 were 3.84 meters (or 12.6 feet) and 3.66 meters (or 12.0 feet), respectively.

Since current water levels are below the proposed minimum aquifer level, and as required by Florida law, the District is developing a strategy to recover water levels in the region to the minimum aquifer level. The strategy will include regulatory elements, and identify projects that will contribute to water level recovery in the region and provide alternative sources of water for future reasonable and beneficial uses.

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