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PROJECTED 2020 AQUIFER DRAWDOWNS AT THE CITY OF VERO BEACH AND INDIAN RIVER COUNTY WELLFIELDS

by

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Palatka, Florida

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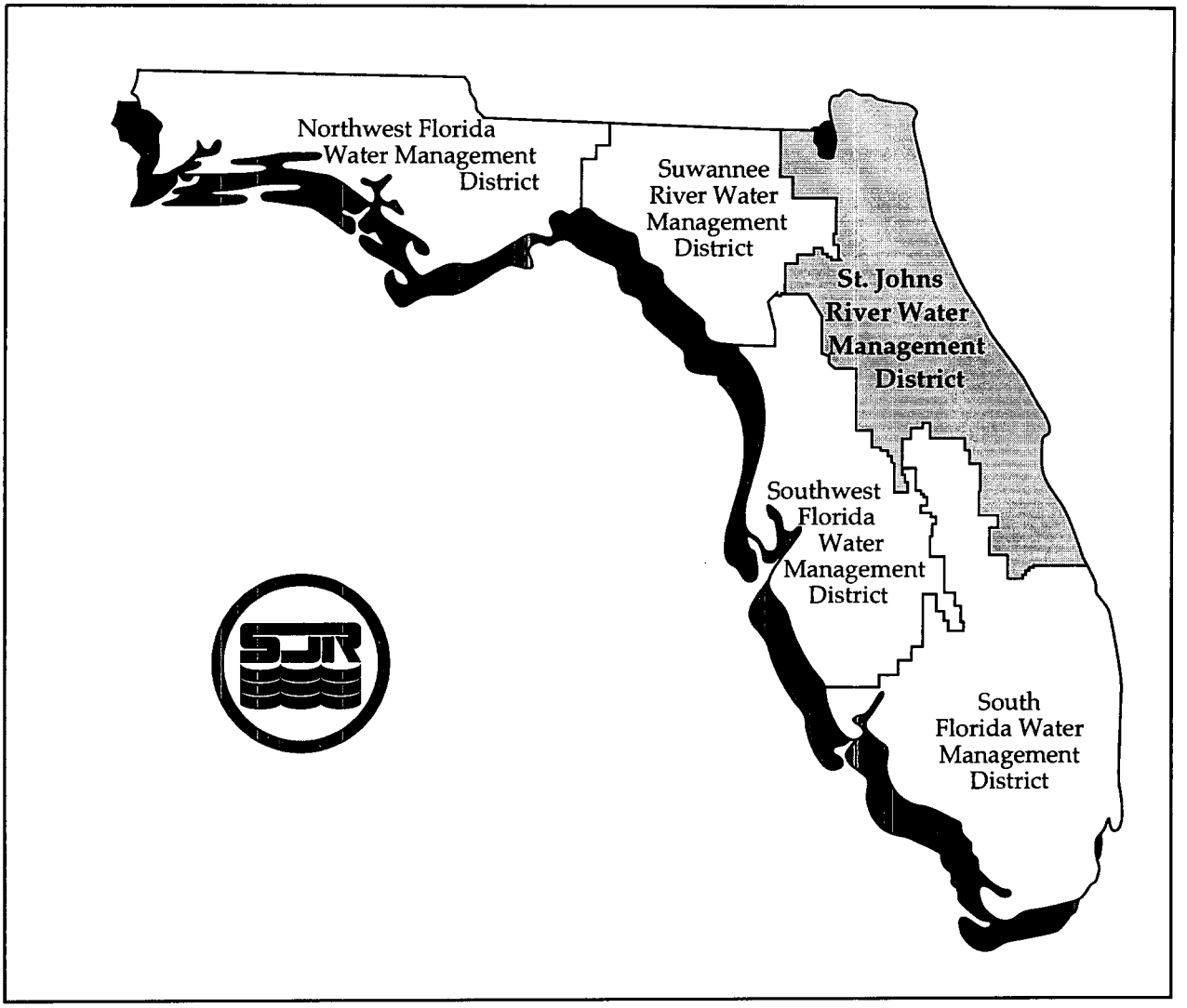

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Projected 2020 Aquifer Drawdowns at the City of Vero Beach and Indian River County Wellfields

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ABSTRACT

This paper supports a water supply assessment performed by the St. Johns River Water Management District pursuant to the requirements of Subparagraph 373.036(2)(b)4, *Florida Statutes*. An analytical model, MLTLAY, was used to simulate changes in the potentiometric surfaces of the surficial aquifer system (SAS) and the Floridan aquifer system (FAS), based on 2010, 2015, and 2020 projected pumpages at the city of Vero Beach and Indian River County wellfields. The MLTLAY model calculates drawdowns in a multilayered, leaky-artesian aquifer system. The model assumes homogeneous, isotropic, and steady-state conditions. Simulated drawdowns for 1995 pumpage at the wells ranged from 2.68 to 27.03 feet (ft) for SAS and from 4.81 to 10.55 ft for FAS. Simulated drawdowns for 2020 pumpage ranged from 10.71 to 39.79 ft for SAS and from 19.08 to 28.95 ft for FAS. The simulated drawdowns for projected pumpages at these wellfields have a pronounced effect on the elevation of the potentiometric surfaces of SAS and FAS. Maximum projected 2020 drawdown (39.79 ft) in SAS comprises 50–80% of the production zone thickness. Such a decrease in water levels in SAS will reduce the natural discharge of SAS to the ocean. The 2010, 2015, and 2020 drawdowns in FAS at the southern model boundary are in excess of 13, 15, and 20 ft, respectively. This suggests that Floridan aquifer wells will cease to flow at the Indian River/St Lucie county border as early as 2015. There are no significant wetland concerns at the city of Vero Beach and Indian River County wellfields because most of the vegetation at land surface is not expected to be adversely impacted by projected water level declines in SAS. The area is highly urbanized. The vegetation consists of sand-pine scrub on the ridge area that grades into pine flatwoods interspersed with wet prairie.

INTRODUCTION

The St. Johns River Water Management District (SJRWMD) performs water supply assessments pursuant to the requirements of Subparagraph 373.036(2)(b)4, *Florida Statutes (FS)*. As part of this assessment process, SJRWMD identifies priority water resource caution areas, which are areas where existing and reasonably anticipated sources of water and water conservation efforts are not adequate to supply water for all existing legal uses and reasonably anticipated future needs and to sustain the water resources and related natural systems during a 20-year planning horizon. Regional numerical groundwater models and local analytical groundwater models are used as part of this overall assessment.

The purpose of this paper is twofold: (1) to use geohydrologic data collected since Toth 1994 to better refine the groundwater model of the city of Vero Beach and Indian

River County wellfields and (2) to provide an analysis[1] of the projected 2010, 2015, and 2020 pumping impacts to the surficial aquifer system and the Upper Floridan aquifer as a result of projected groundwater withdrawals from these wellfields.

Toth 1994 indicated a need to acquire better information on the transmissivity of the Upper Floridan aquifer in the area of Indian River County's north reverse osmosis (RO) plant and on the leakance of the upper confining unit in that area. Because of this need, Missimer International (1996) conducted an aquifer performance test in the area of Indian River County's north RO plant.

The South Florida Water Management District (SFWMD) established a Floridan aquifer protection criterion for the upper East Coast Planning Area, which borders Indian River County to the south and includes all of St. Lucie County. The criterion states "groundwater level drawdowns induced by water use withdrawals should not cause water levels in the Floridan aquifer to fall below land surface any time during a 12-month drought condition that occurs as frequently as once every 10 years" (SFWMD 1998). SFWMD is concerned about vertical saltwater intrusion, or upconing, and wants to minimize it by restricting drawdowns to land surface elevation.

WATER USE

The city of Vero Beach withdraws water from both the surficial aquifer system and the Floridan aquifer system. Indian River County withdraws water only from the Floridan aquifer system. In 1995, the city of Vero Beach withdrew a total of 6.91 million gallons per day (mgd) (Ten Eyck 1997a) and plans to withdraw 7.65 mgd in 2010, 8.18 mgd in 2015, and 8.73 mgd in 2020 (Ten Eyck 1997b, 1997c). In 1995, Indian River County withdrew 3.73 mgd from wells at the south RO plant and at the North Beach plant (Florence 1997). From its north RO plant, Indian River County plans to withdraw 5.75 mgd in 2010, 7.44 mgd in 2015, and 8.88 mgd in 2020. At its south RO plant, Indian River County plans to withdraw 7.26 mgd in 2010, 8.76 mgd in 2015, and 10.20 mgd in 2020 (McCain 1998). Indian River County closed and abandoned its North Beach plant in December 1997.

The water demand projections for 2010, 2015, and 2020 for the city of Vero Beach and Indian River County are based on population projections and average day water demand projections, respectively. They are consistent with projections in Vergara 1998.

City of Vero Beach and Indian River County Wellfields

In 1995, the city of Vero Beach withdrew water from 25 surficial aquifer system wells and six Upper Floridan aquifer wells at its wellfield (Figure 1). Pumpage for each well was based on metered water use reported by the city (Ten Eyck 1997a). The total metered water use for 1995 was 6.91 mgd.

The number of wells in the city of Vero Beach wellfield is not expected to change by the year 2020. The 2010, 2015, and 2020 individual well pumpages were obtained from Ten Eyck (1997b, 1997c).

The 2010, 2015, and 2020 individual well pumpages from the surficial aquifer were estimated to range from 100 to 600 gallons per minute (gpm). The 2010, 2015, and 2020 projected pumpages from the three Upper Floridan aquifer wells are estimated to range between 542 and 549 gpm. Projected 2010, 2015, and 2020 individual well

[1]This analysis is based on water use projections made in 1997 and 1998.

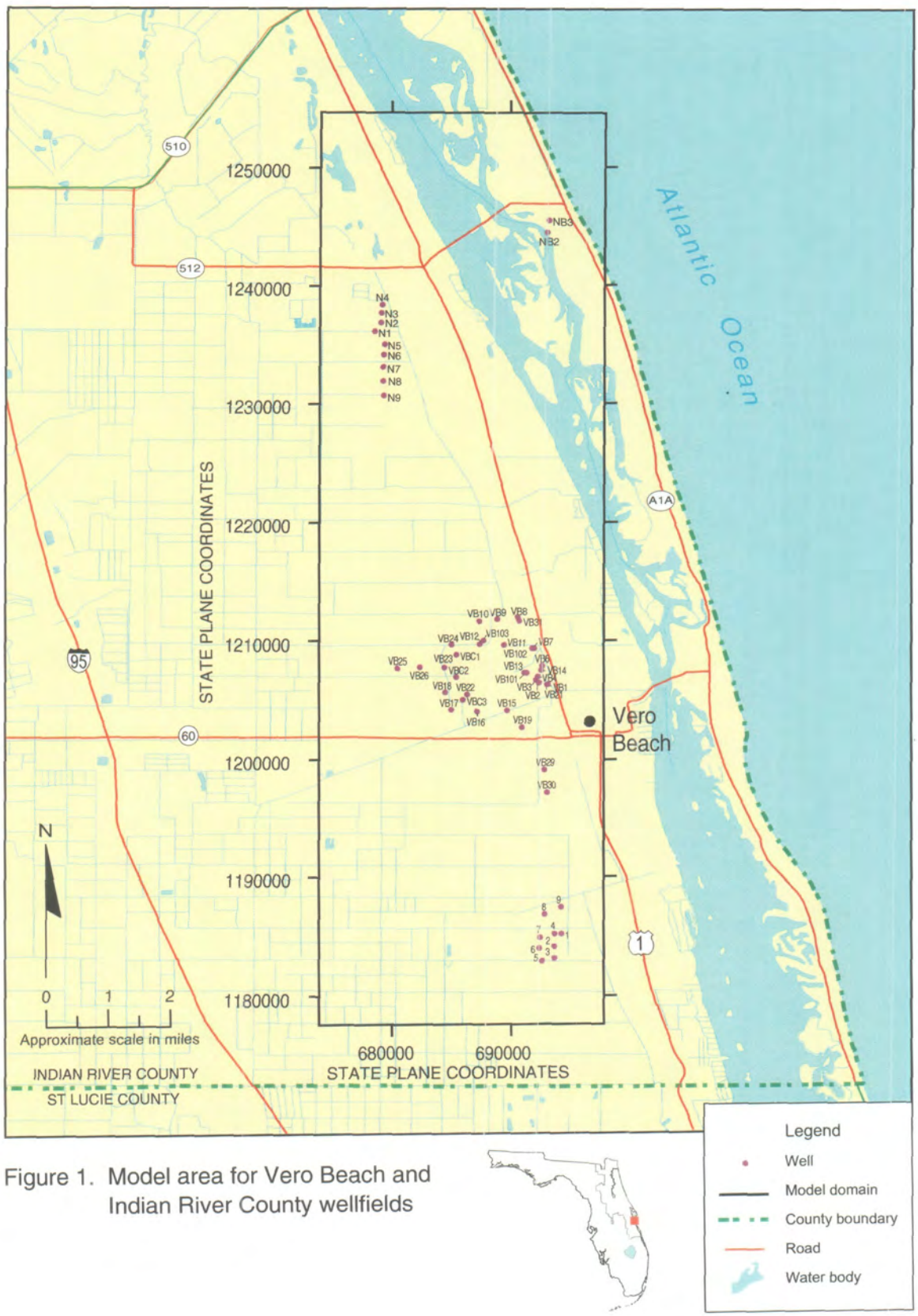

Figure 1. Model area for Vero Beach and Indian River County wellfields

pumpages range from 0.14 to 0.86 mgd (Table 1).

In 1995, Indian River County withdrew water from six wells at its south RO plant and two wells at its North Beach plant (Figure 1). The individual well pumpages for Indian River County in 1995 were obtained by dividing the total well pumpages at each plant by the number of wells at the plant. In 1995, Indian River County withdrew 3.33 mgd from its south RO plant and 0.40 mgd at North Beach.

In 1998, Indian River County utilized three wells at its north RO plant and six wells at its south RO plant. In 2010, Indian River County plans to increase to five wells at its north RO plant and six wells at its south RO plant. In 2015, the number of wells at each plant is expected to increase to seven. In 2020, Indian River County plans to have nine wells at each plant. The locations of the proposed wells were obtained from McCain 1997 and 1998.

The individual well pumpages for Indian River County were obtained by dividing the total pumpage for each plant by the number of wells. The projected total pumpages for Indian River County are, for the north plant, 5.75 mgd in 2010, 7.44 mgd in 2015, and 8.88 mgd in 2020, and for the south plant, 7.26 mgd in 2010, 8.76 mgd in 2015, and 10.20 mgd in 2020. Individual projected well pumpages range between

Table 1. Surficial aquifer well locations and pumpage values used in the MLTLAY model, city of Vero Beach wellfield

Well	Latitude	Longitude	Pumpage (mgd)			
			1995	2010	2015	2020
VB1	273906.0	802410.8	0.15	0.43	0.43	0.43
VB2	273907.5	802419.0	0.10			
VB3	273910.3	802421.8	0.10			0.14
VB4	273912.8	802420.0	0.11			
VB7	273936.5	802423.5	0.01			
VB8	274001.6	802437.8	0.10			0.36
VB9	274000.8	802457.9	0.11			
VB10	273959.4	802414.9	0.08			
VB11	273939.0	802451.3	0.02			
VB12	273940.9	802414.2	0.19			
VB13	273916.5	802432.3	0.02			
VB15	273844.3	802449.5	0.46	0.43	0.43	0.43
VB16	273843.7	802518.0	0.10	0.22	0.22	0.22
VB17	273845.3	802541.8	0.14	0.14	0.14	0.14
VB18	273900.3	802547.4	0.30	0.29	0.29	0.29
VB22	273858.4	802526.8	0.29	0.29	0.29	0.29
VB23	273920.8	802548.0	0.08	0.29	0.29	0.29
VB24	273939.7	802541.0	0.22	0.29	0.29	0.29
VB25	273920.4	802631.9	0.20		0.53	0.58
VB26	273921.4	802610.8	0.17			
VB29	273754.6	802413.8	0.46	0.84	0.84	0.84
VB30	273734.7	802412.7	0.34	0.86	0.86	0.86
VBC1	273931.4	802536.6	0.21	0.50	0.50	0.50
VBC2	273912.5	802537.0	0.23	0.29	0.29	0.29
VBC3	273853.5	802530.5	0.46	0.43	0.43	0.43

Note: mgd = million gallons per day

Latitude and longitude determined by global positioning system.
Blank cells indicate wells not pumped.

681 and 799 gpm for the north plant and 785 and 875 gpm for the south plant. Projected 2010, 2015, and 2020 individual well pumpages range from 0.98 to 1.26 mgd (Table 2).

METHODS

The methods used in this study were

1. Use of the MLTLAY model (SJRWMD, n.d.) to predict drawdowns in the surficial and Floridan aquifer systems.
2. Drawdowns calculated by the model are based on the assumption that all wells pump 100% of the time, which is a worst-case scenario.
3. Use of aquifer characteristics determined from the north county aquifer performance test to improve projected drawdowns for the Floridan aquifer system (Missimer International 1996).
4. A comparison of projected Floridan aquifer drawdowns at the Indian River County/St. Lucie County border with the May 1996 potentiometric surface to determine if this surface is projected to be depressed below 20 feet (ft) above

Table 2. Floridan aquifer well locations and pumpage values used in the MLTLAY model, city of Vero Beach and Indian River County wellfields

Well	Latitude	Longitude	Pumpage (mgd)			
			1995	2010	2015	2020
City of Vero Beach						
VB31	273959.3	802437.7	0.01			
VB101	273915.6	802431.6	1.06	0.78	0.78	0.78
VB102	273936.6	802424.6	0.56	0.78	0.78	0.78
VB103	273943.6	802511.5	0.63	0.79	0.79	0.79
Indian River County, North Beach Plant						
NB2	274523.7	802409.8	0.20			
NB3	274533.9	802408.3	0.20			
Indian River County, South Reverse Osmosis Plant						
1	273536.8	802359.3	0.56	1.21	1.25	1.13
2	273526.0	802406.3	0.55	1.21	1.25	1.13
3	273516.2	802406.5	0.56	1.21	1.25	1.14
4	273536.8	802406.2	0.55	1.21	1.25	1.13
5	273514.0	802417.5	0.56	1.21	1.25	1.13
6	273524.4	802420.0	0.55	1.21	1.25	1.14
7	273534	802420			1.26	1.13
8	273553	802415				1.13
9	273559	802400				1.14
Indian River County, North Reverse Osmosis Plant						
N1	274401.6	802652.1		1.15	1.06	0.99
N2	274409.1	802646.4		1.15	1.06	0.98
N3	274417.5	802646.3		1.15	1.07	0.99
N4	274424	802645		1.15	1.06	0.98
N5	274351	802643		1.15	1.06	0.99
N6	274342	802644			1.07	0.98
N7	274332	802644			1.06	0.99
N8	274320	802644				0.98
N9	274308	802644				1.00

Note: mgd = million gallons per day

Latitude and longitude determined by global positioning system except where there is no decimal extension.
Blank cells indicate wells not pumped.

mean sea level (msl). A potentiometric surface depressed below 20 ft msl will cause Floridan aquifer water levels to fall below land surface, resulting in the cessation of natural flow from Floridan aquifer wells.

HYDROGEOLOGY

The hydrogeology at the city of Vero Beach and Indian River County wellfields consists of the following units in descending order: the surficial aquifer or water table, the upper confining unit or Hawthorn Group, and the Upper Floridan aquifer. A more thorough description of the hydrogeology can be found in Gee and Jenson (1979) and Toth (1994).

Aquifer characteristics for the Upper Floridan aquifer were obtained from aquifer performance tests (Geraghty & Miller 1981; Missimer International 1996). Aquifer characteristics for the surficial aquifer were also obtained from aquifer performance tests (Gee and Jenson 1980). The values used in the model for the surficial aquifer are in Toth 1994.

Floridan Aquifer System

Aquifer characteristics for the Floridan aquifer system were derived from aquifer performance tests (Geraghty & Miller 1981; Missimer International 1996). The transmissivity for the Floridan aquifer at the north county RO site was 678,000 gallons per day per foot (gpd/ft) (Missimer International 1996). The transmissivity at the south RO site was 408,000 gpd/ft (Geraghty & Miller 1981). Because the transmissivities are so different between the north and south RO sites, two model simulations were performed. Wells for the city of Vero Beach, the North Beach plant, and the south county RO plant were included in one simulation and wells for the north county RO plant were included in the other. The total drawdowns were obtained by superimposing the drawdowns from the two simulations. The transmissivity at the north county RO site would produce less drawdown than that at the south county site for the same pumpage. The same leakance value was used for both simulations for the upper confining unit. The leakance value used was 0.0000097 gallons per day per square foot per foot ($gpd/ft^2/ft$) (Missimer International 1996).

The value used for the leakance for the upper confining unit is considerably smaller than that obtained from the aquifer performance tests—0.0056 $gpd/ft^2/ft$ in Missimer International 1996 and 0.0035 $gpd/ft^2/ft$ in Geraghty & Miller 1981. The reason for the difference is that Missimer International could not get a reasonable model-derived potentiometric surface for the Upper Floridan aquifer using the larger values (0.0056 $gpd/ft^2/ft$) in its MODFLOW model for the north county RO plant. The value used is similar to that used by Tibbals (1990) for the area. The value from Geraghty & Miller (1981) was used in Toth (1994). The smaller leakance would produce greater drawdowns in the Floridan aquifer because of less leakance from above and essentially no drawdown in the overlying surficial aquifer. The Floridan and surficial aquifer systems are separated by 200–300 ft of confining unit (Schiner et al. 1988).

Other aquifer characteristics used in the models include the transmissivity of the surficial aquifer system (30,000 gpd/ft) and the leakance of the semiconfining unit for the surficial aquifer system (0.0041 $gpd/ft^2/ft$) (Toth 1994). The leakance value for the semiconfining unit for the surficial aquifer system was obtained as a result of trial-and-error during the calibration process for the surficial aquifer drawdowns in Toth (1994). The difference between measured and calculated drawdowns in Toth was less than 3 ft at most monitor wells.

Evapotranspiration Reduction Coefficient

The evapotranspiration (ET) reduction coefficient (E) describes the rate at which ET is reduced per unit of water table drawdown. In other words, when water levels in the surficial aquifer decline, less water is made available to ET and more water is captured by pumpage. The value (0.00055 ft/day/ft) used for E in the model was obtained from a graph in Tibbals (1990, p. E10) which relates estimated average ET to water table depth. The average measured depth to water in the wellfield is 5 ft, which corresponds to this value of E. Increasing E reduces the calculated water table drawdowns.

WELLFIELD MODEL

Impacts to the groundwater flow system resulting from withdrawals at the city of Vero Beach and Indian River County wellfields were evaluated using the MLTLAY model (SJRWMD, n.d.). The MLTLAY model uses a linear analytical solution for a multilayered, leaky artesian aquifer system to calculate the amount of drawdown in the surficial aquifer system and the Upper Floridan aquifer. The method assumes that homogeneous and isotropic conditions prevail in the surficial and Floridan aquifer systems. The model simulates steady-state conditions and considers the flow of water through multiple aquifers separated by semipervious leaky layers. The model also has the capability of simulating the withdrawal of water from either the surficial aquifer system or the Upper Floridan aquifer, or from both simultaneously.

Because the transmissivity of the Floridan aquifer system differs between the north county RO site and the south county RO site, the MLTLAY model was run twice. In the first run, drawdowns were calculated for wells in the city of Vero Beach, at the North Beach plant, and at the south county RO plant. In the second run, drawdowns were calculated for wells at the north county RO plant. Total drawdown was obtained by superimposing the drawdowns from the two runs.

The model domain was chosen to be large enough to include the most significant drawdown in the area around the wellfield. However, drawdowns actually occur beyond the extent of the model domain. Unlike numerical models where drawdowns are constrained by the boundary, the model boundary does not affect the drawdown calculation in an analytical model because the domain is considered to be infinite. The dimensions of the model domain were 24,000 ft wide and 77,000 ft long. A coordinate spacing of 100 ft was used between grid nodes. The origin for the model domain was at 674,003 ft for x and 1,177,652 ft for y (Figure 1).

RESULTS

The simulated drawdowns in the potentiometric surface of the surficial aquifer system at the wells ranged from 2.68 to 27.03 ft resulting from 1995 withdrawals and from 10.71 to 39.79 ft resulting from 2020 withdrawals (Table 3). Projected 2020 drawdowns in the surficial aquifer system at the wells are as much as 23.31 ft greater than calculated 1995 drawdowns. The maximum projected 2020 drawdown (39.79 ft) in the surficial aquifer is very large and comprises 50–80% of the production zone thickness. Because the producing zone of the surficial aquifer is 50–80 ft thick (Schiner et al. 1988), the 2020 yield from the surficial aquifer may decrease. If the yield decreases, additional surficial aquifer wells would be required to meet the demand.

Table 3. Simulated drawdowns (in feet) in the potentiometric surface of the surficial aquifer system, city of Vero Beach wellfields

Well	Simulated Drawdown (feet)			
	1995	2010	2015	2020
VB1	9.72	19.78	19.80	20.82
VB2	9.30			
VB3	9.40			10.71
VB4	9.34			
VB6	3.73			
VB7	2.68			
VB8	6.07			16.48
VB9	7.33			
VB10	6.33			
VB11	4.41			
VB12	11.89			
VB13	4.88			
VB15	22.50	21.79	21.84	22.12
VB16	10.94	15.90	16.02	16.16
VB17	12.70	13.39	13.67	13.76
VB18	19.44	19.72	20.22	20.34
VB19	3.80			
VB22	21.55	22.10	22.32	22.49
VB23	10.37	19.84	20.47	20.65
VB24	14.18	18.54	18.93	19.16
VB25	10.33		24.44	26.42
VB26	11.21			
VB29	21.19	38.94	38.95	39.00
VB30	16.48	39.76	39.77	39.79
VBC1	14.86	27.68	28.05	28.28
VBC2	17.35	21.01	21.40	21.58
VBC3	27.03	26.91	27.14	27.28

Blank cells indicate wells not pumped.

Simulated drawdowns in the potentiometric surface of the Upper Floridan aquifer at the Floridan aquifer production wells ranged from 4.81 to 10.55 ft in 1995 and 19.08 to 28.95 ft in 2020. Projected 2020 drawdowns in the potentiometric surface of the Upper Floridan aquifer at the wells are as much as 20.09 ft greater than calculated 1995 drawdowns (Table 4). Contour maps of simulated drawdowns in the city of Vero Beach and Indian River County wellfields were prepared for 1995, 2010, 2015, and 2020 for the surficial aquifer system and the Upper Floridan aquifer (Figures 2–9). Contour maps of differences in drawdowns between 1995 and 2020 were prepared for the surficial aquifer system and the Upper Floridan aquifer (Figures 10 and 11). Figures 2–9 show the localized effect that pumping of these wells has on the aquifers. In reality, the effect of the pumping extends beyond the model domain. There are no significant wetland concerns at the city of Vero Beach and Indian River County wellfields because most of the vegetation at land surface is not expected to be adversely impacted by projected water level declines in the surficial aquifer system. The area is highly urbanized. The vegetation consists of sand-pine scrub on the ridge area that grades into pine flatwoods interspersed with wet prairie.

Table 4. Simulated drawdowns (in feet) in the potentiometric surface of the Floridan aquifer system, city of Vero Beach and Indian River County wellfields

Well	Simulated drawdown (feet)			
	1995	2010	2015	2020
City of Vero Beach				
VB14	7.36			
VB21	7.11			
VB31	6.76			
VB101	10.37	15.96	18.26	20.51
VB102	8.79	15.81	18.09	20.30
VB103	8.68	15.56	17.85	20.06
Indian River County, North Beach				
NB2	4.85			
NB3	4.81			
Indian River County, South County Reverse Osmosis Plant				
1	10.29	22.00	25.65	28.46
2	10.55	22.59	26.38	28.82
3	10.31	22.09	25.68	27.91
4	10.41	22.25	26.12	28.95
5	10.18	21.80	25.42	27.62
6	10.32	22.08	26.08	28.46
7			25.80	28.50
8				27.43
9				26.78
Indian River County, North County Reverse Osmosis Plant				
N1		15.26	17.83	19.84
N2		15.44	17.86	19.80
N3		15.33	17.72	19.50
N4		14.98	17.22	19.08
N5		14.95	17.88	20.05
N6			17.78	20.09
N7			17.40	19.98
N8				19.72
N9				19.33

Blank cells indicate wells not pumped.

DISCUSSION

The 2020 Floridan aquifer drawdown at the southern model boundary is in excess of 18 ft (Figure 9). This boundary is approximately 1 mile north of the Indian River/St. Lucie county border. Because the May 1996 potentiometric surface of the Floridan aquifer is about 34 ft msl in this area (Phelps et al. 1996) and because the average topographic elevation is about 20 ft msl, the projected drawdowns suggest that Floridan aquifer wells will cease to flow naturally at the Indian River/St. Lucie border in 2020. In fact, the projected drawdowns in the Floridan aquifer at the southern model boundary are in excess of 13 ft in 2010 and 15 ft in 2015 (see Figures 5 and 7). This suggests that Floridan aquifer wells will cease to flow at the Indian River/St. Lucie county border as early as 2015.

One of the goals of the Upper East Coast Water Supply Plan of the South Florida Water Management District is to prevent the Floridan aquifer potentiometric surface from being lowered to the extent that Floridan aquifer wells cease to flow

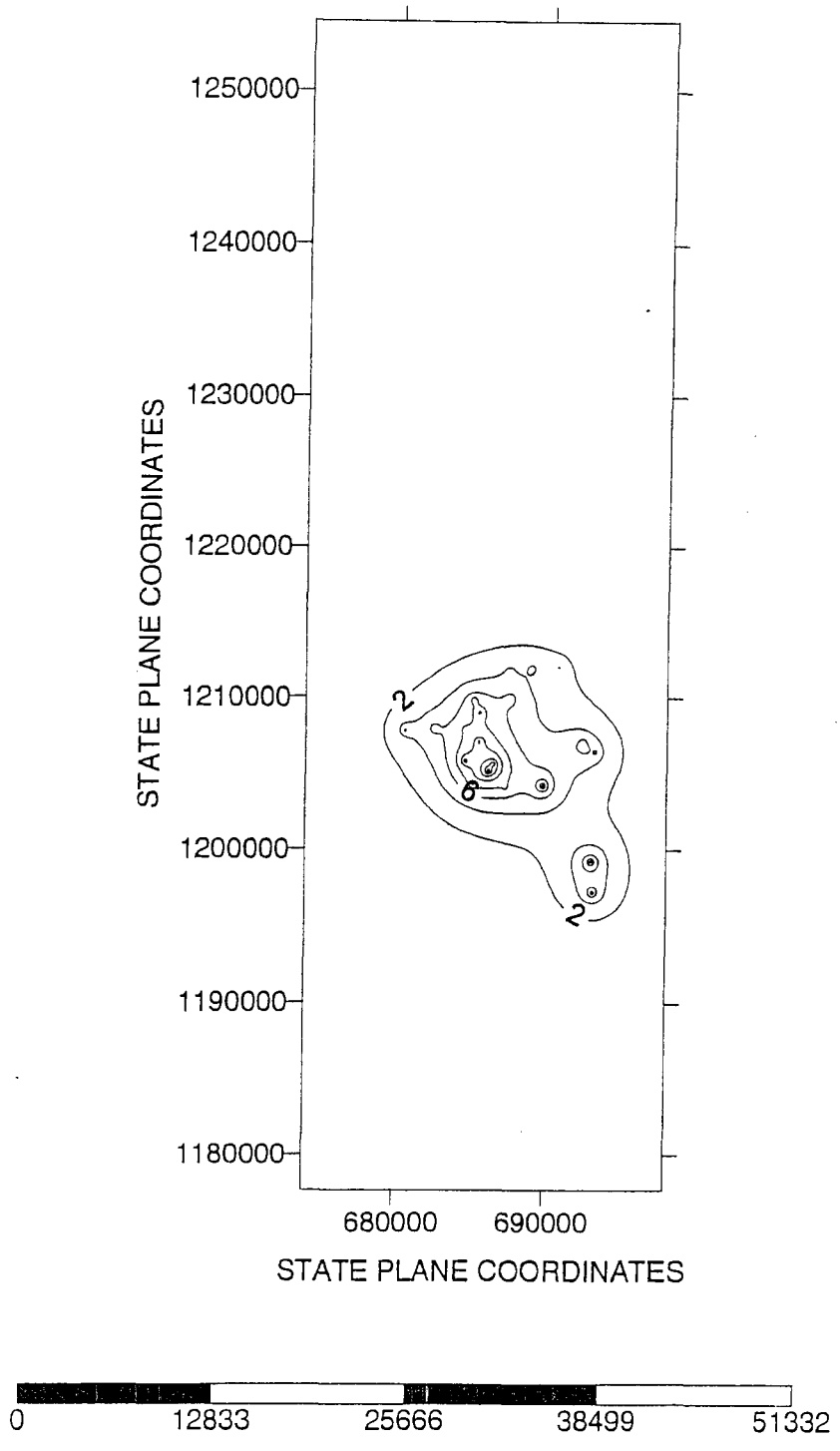

Figure 2. Simulated drawdowns in the surficial aquifer system for 1995 pumpage, Vero Beach and Indian River County wellfields (measured in feet)

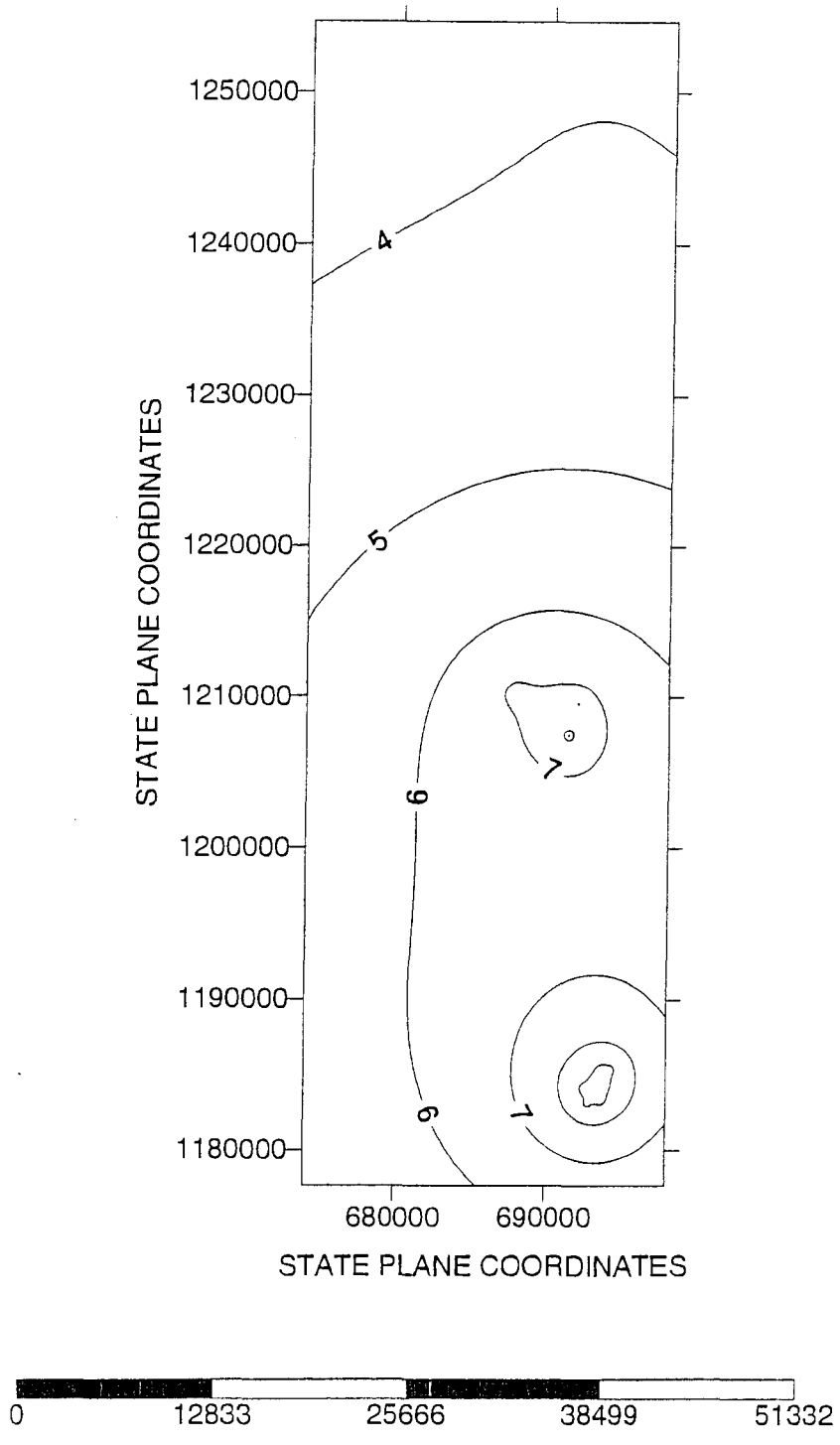

Figure 3. Simulated drawdowns in the Floridan aquifer system for 1995 pumpage, Vero Beach and Indian River County wellfields (measured in feet)

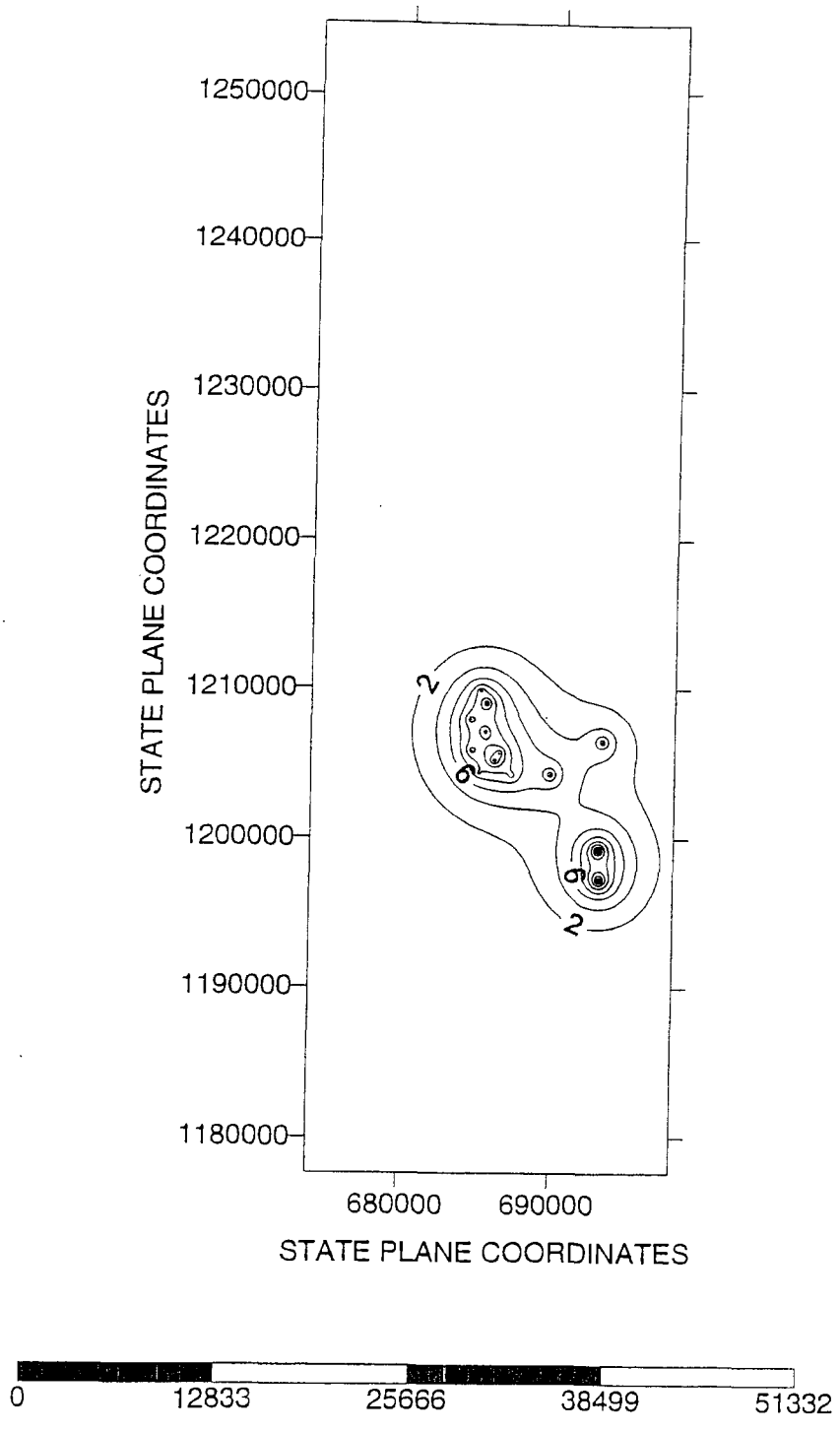

Figure 4. Simulated drawdowns in the surficial aquifer system for 2010 pumpage, Vero Beach and Indian River County wellfields (measured in feet)

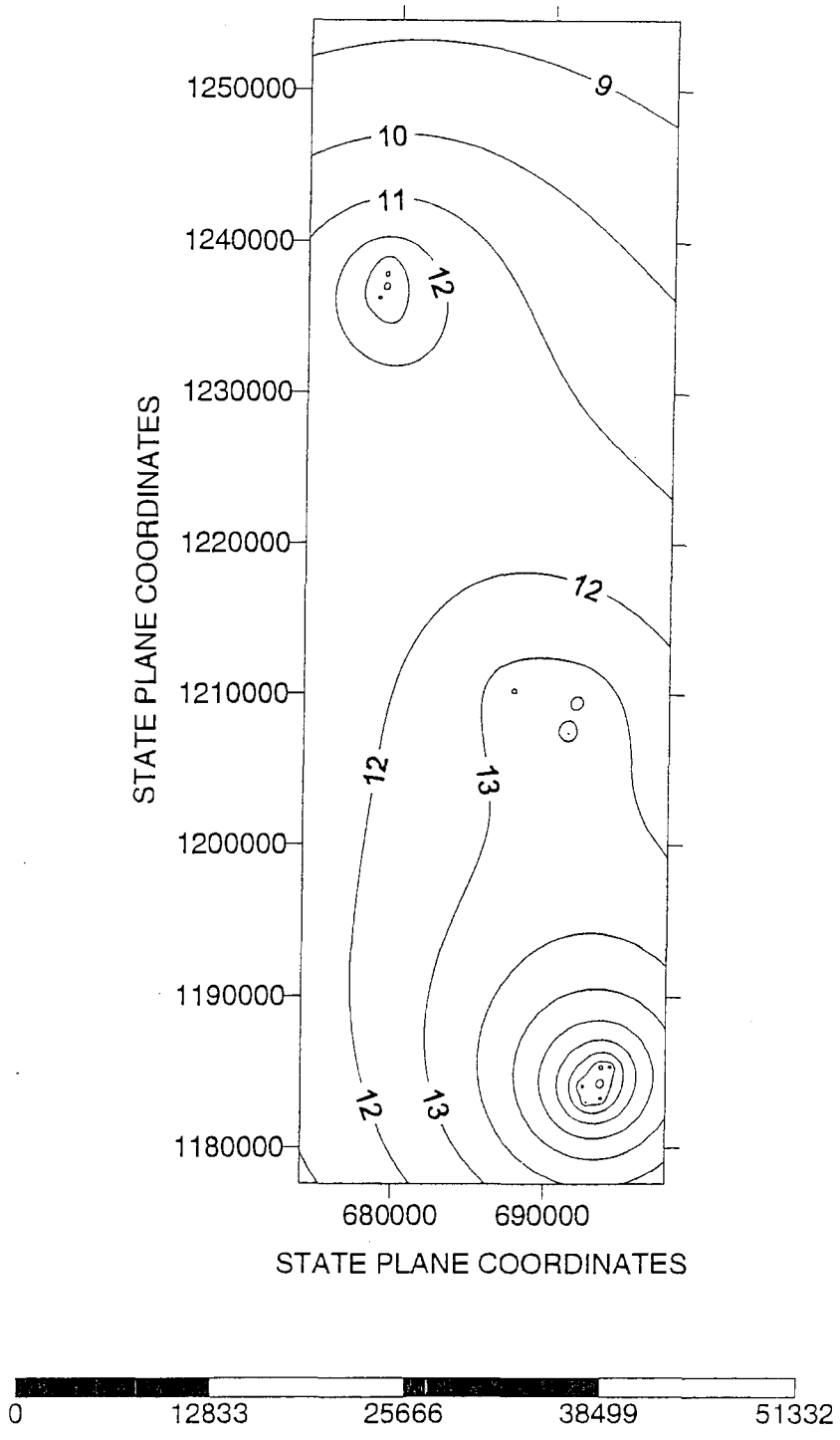

Figure 5. Simulated drawdowns in the Floridan aquifer system for 2010 pumpage, Vero Beach and Indian River County wellfields (measured in feet)

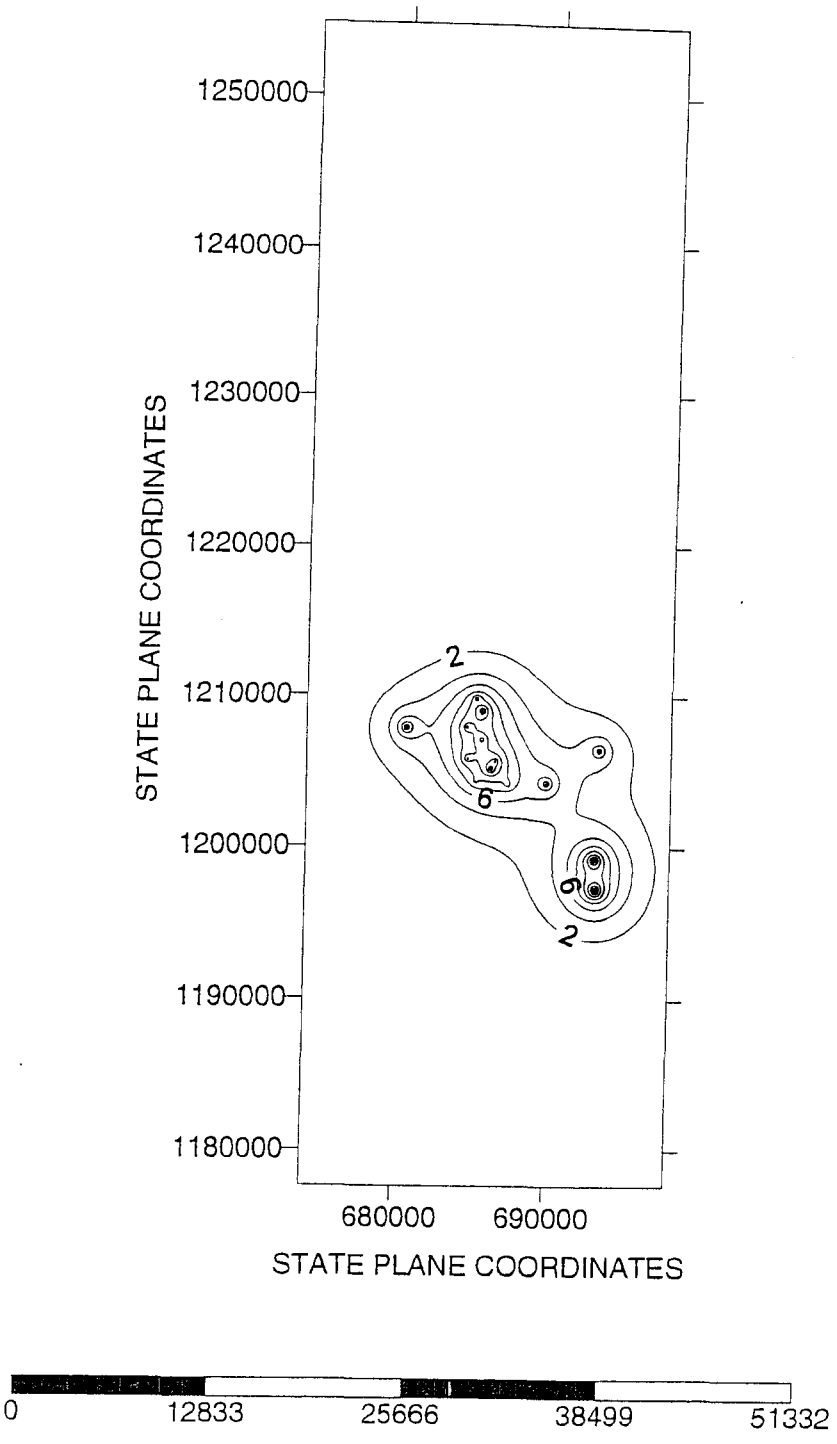

Figure 6. Simulated drawdowns in the surficial aquifer system for 2015 pumpage, Vero Beach and Indian River County wellfields (measured in feet)

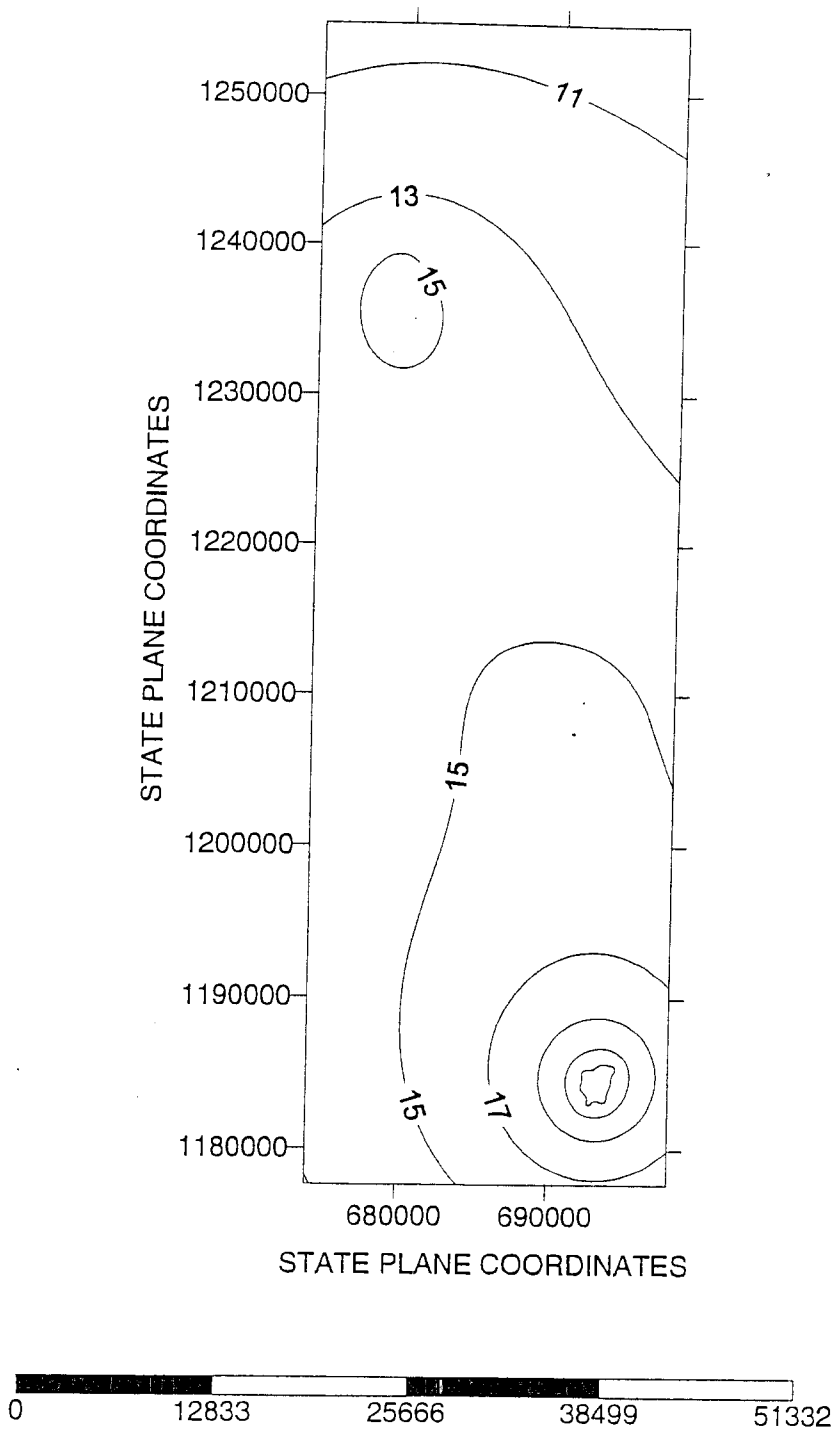

Figure 7. Simulated drawdowns in the Floridan aquifer system for 2015 pumpage, Vero Beach and Indian River County wellfields (measured in feet)

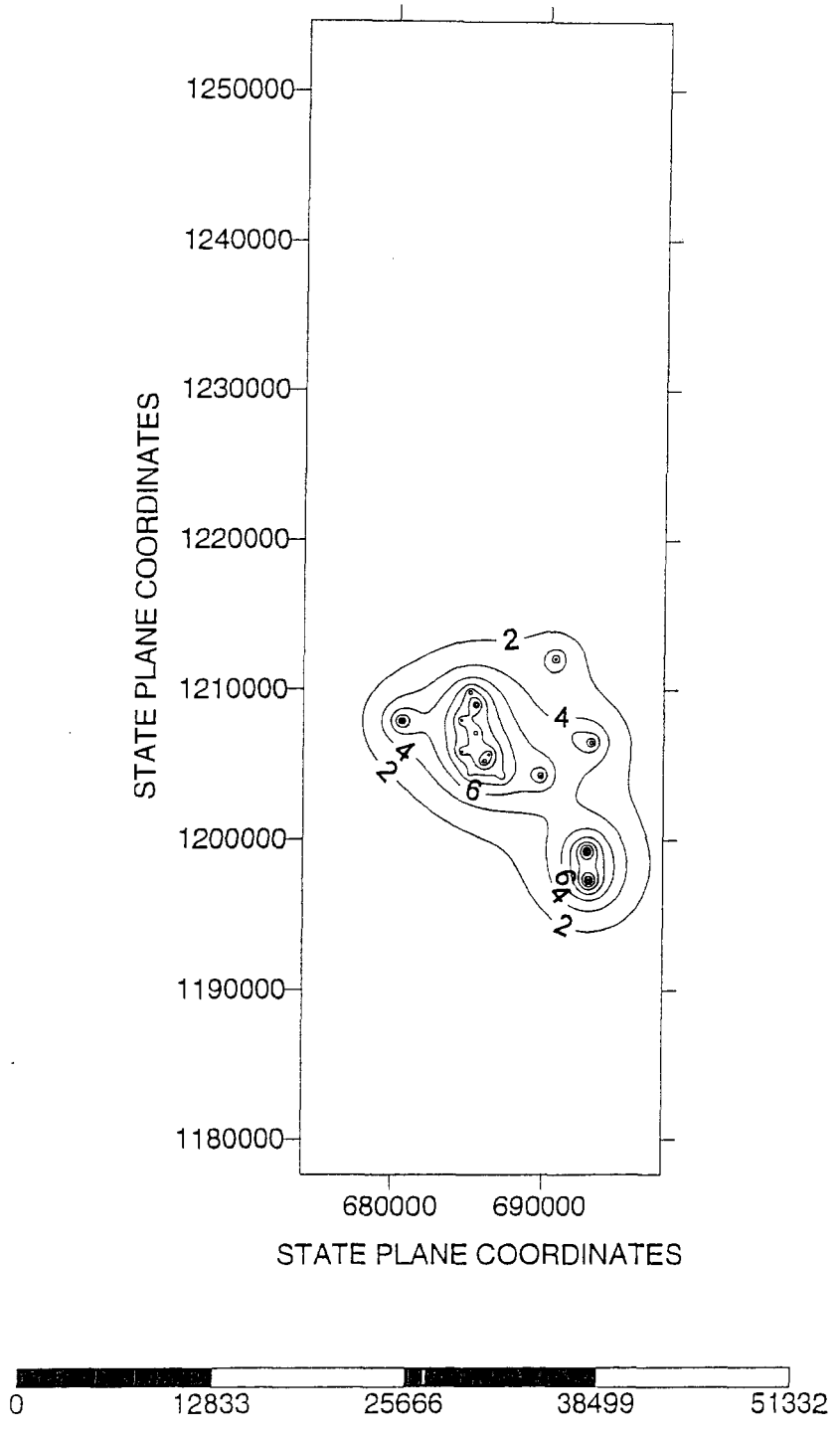

Figure 8. Simulated drawdowns in the surficial aquifer system for 2020 pumpage, Vero Beach and Indian River County wellfields (measured in feet)

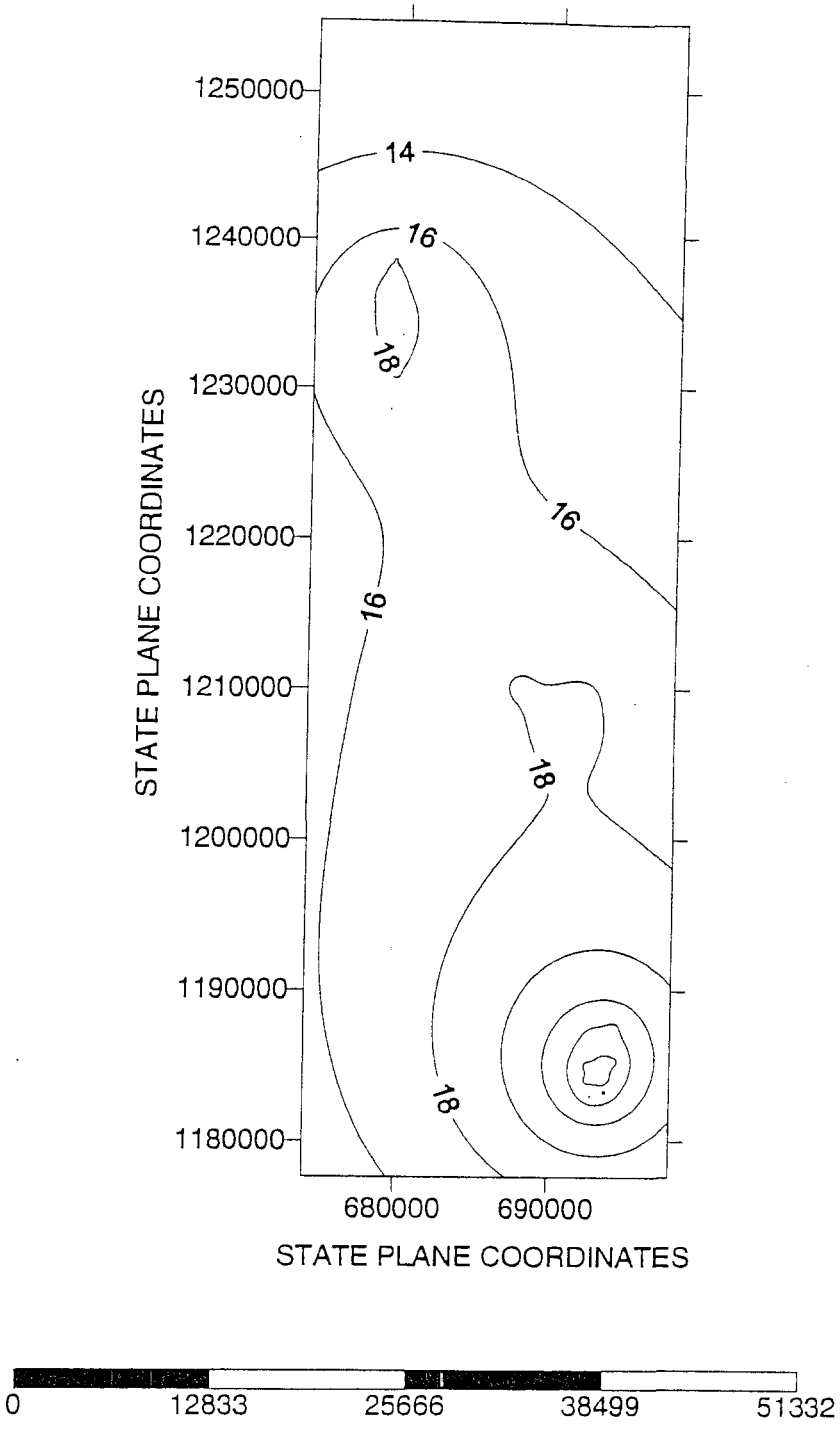

Figure 9. Simulated drawdowns in the Floridan aquifer system for 2020 pumpage, Vero Beach and Indian River County wellfields (measured in feet)

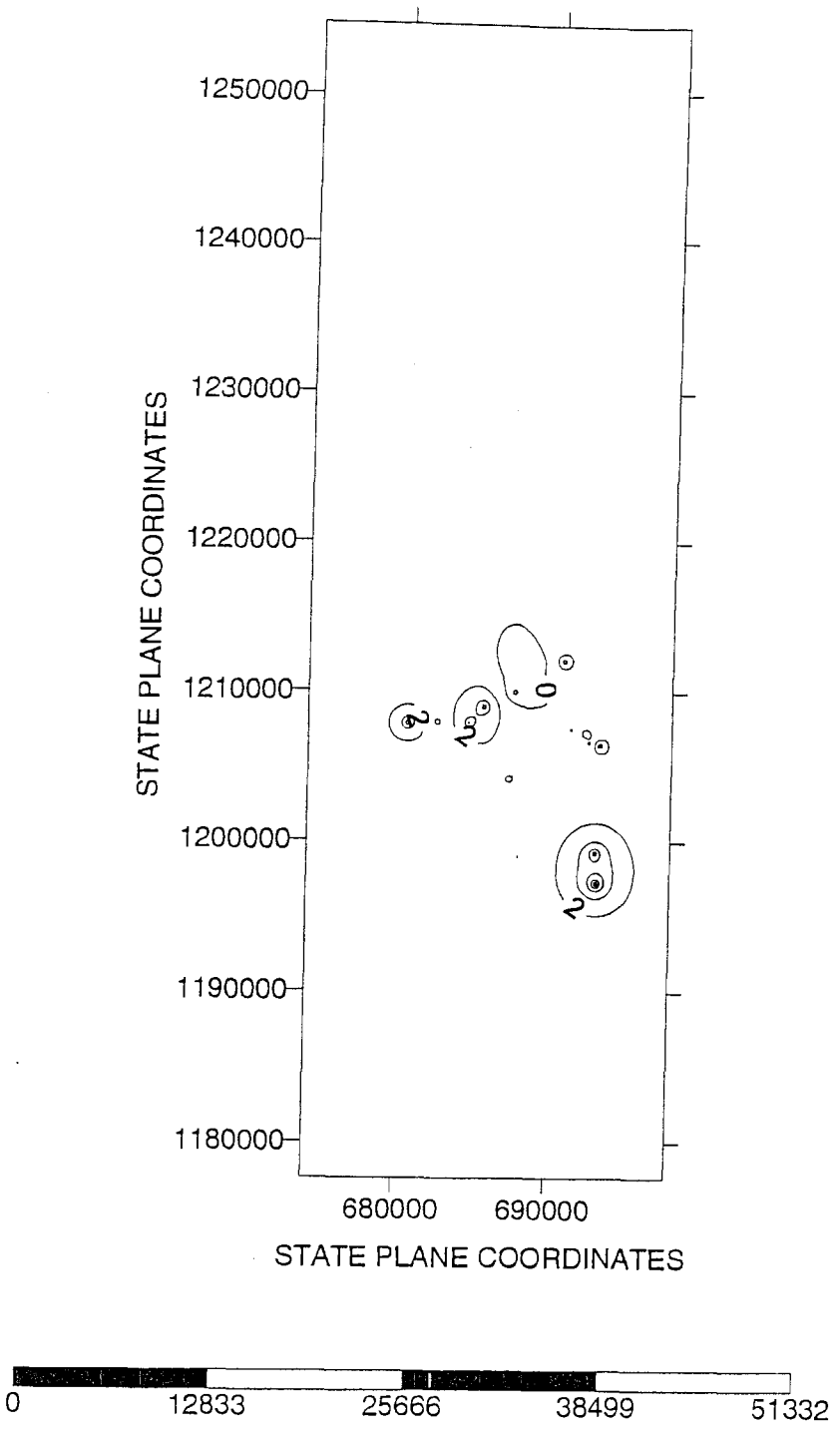

Figure 10. Difference in the simulated drawdowns for the surficial aquifer system between 2020 and 1995 pumpages, Vero Beach and Indian River County wellfields (measured in feet)

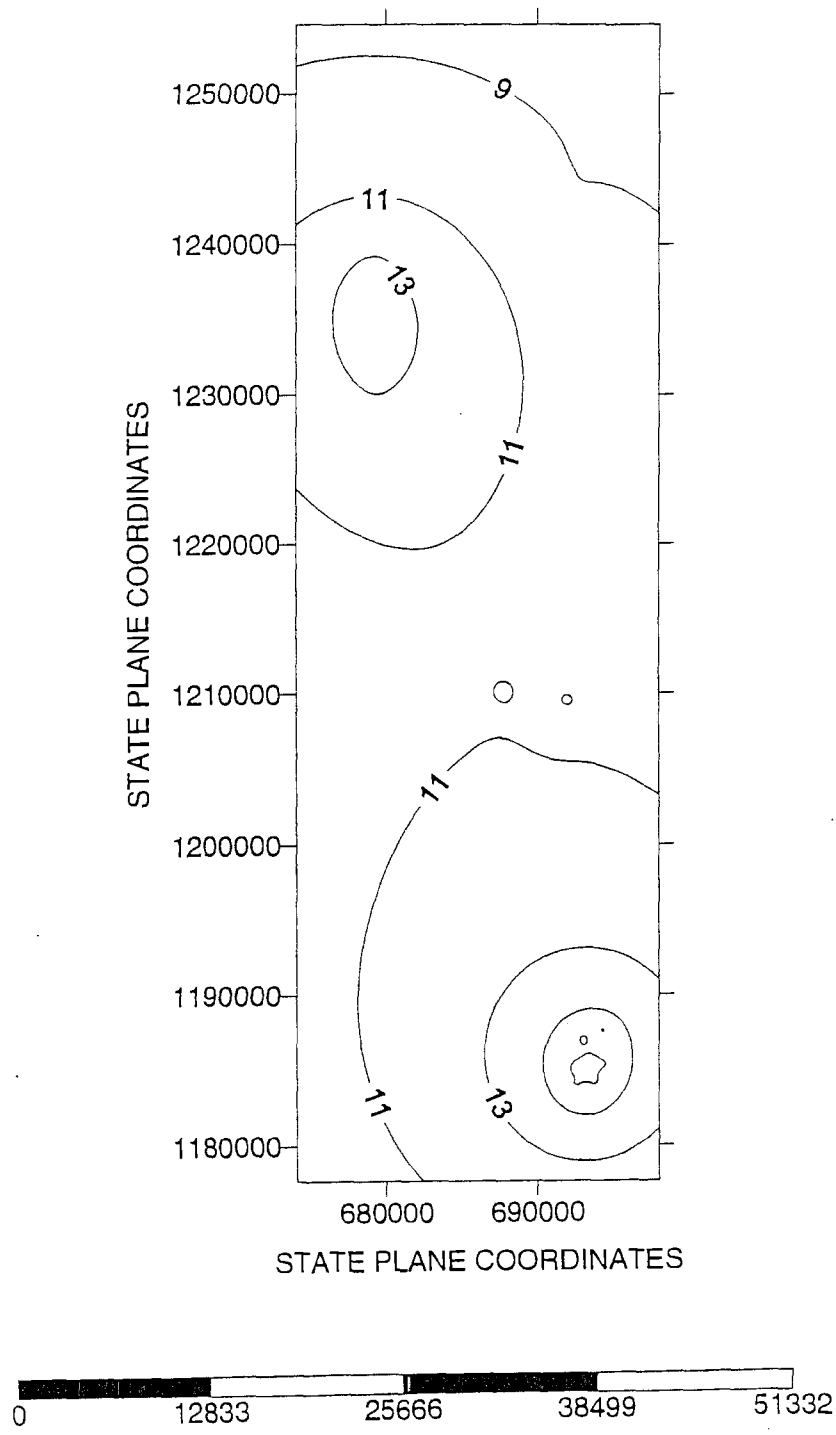

Figure 11. Difference in the simulated drawdowns for the Floridan aquifer system between 2020 and 1995 pumpages, Vero Beach and Indian River County wellfields (measured in feet)

naturally. The projected drawdowns computed in this study suggest that that goal would probably not be met in 2015 and 2020.

The projected drawdowns in both surficial and Floridan aquifer wells are considerable. A surficial aquifer drawdown comprising 50–80% of its productive zone thickness will reduce the natural discharge to the ocean. A drawdown of 29 ft at Floridan aquifer production wells will lower water levels to below land surface. This drawdown may lead to vertical saltwater upconing in the Floridan aquifer. The potential for such upconing should be evaluated in more detail.

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