Professional Paper SJ94-PP2

PROJECTED AQUIFER DRAWDOWNS MURPHREE WELLFIELD, GAINESVILLE REGIONAL UTILITIES ALACHUA COUNTY, FLORIDA

by

Paula Fischl

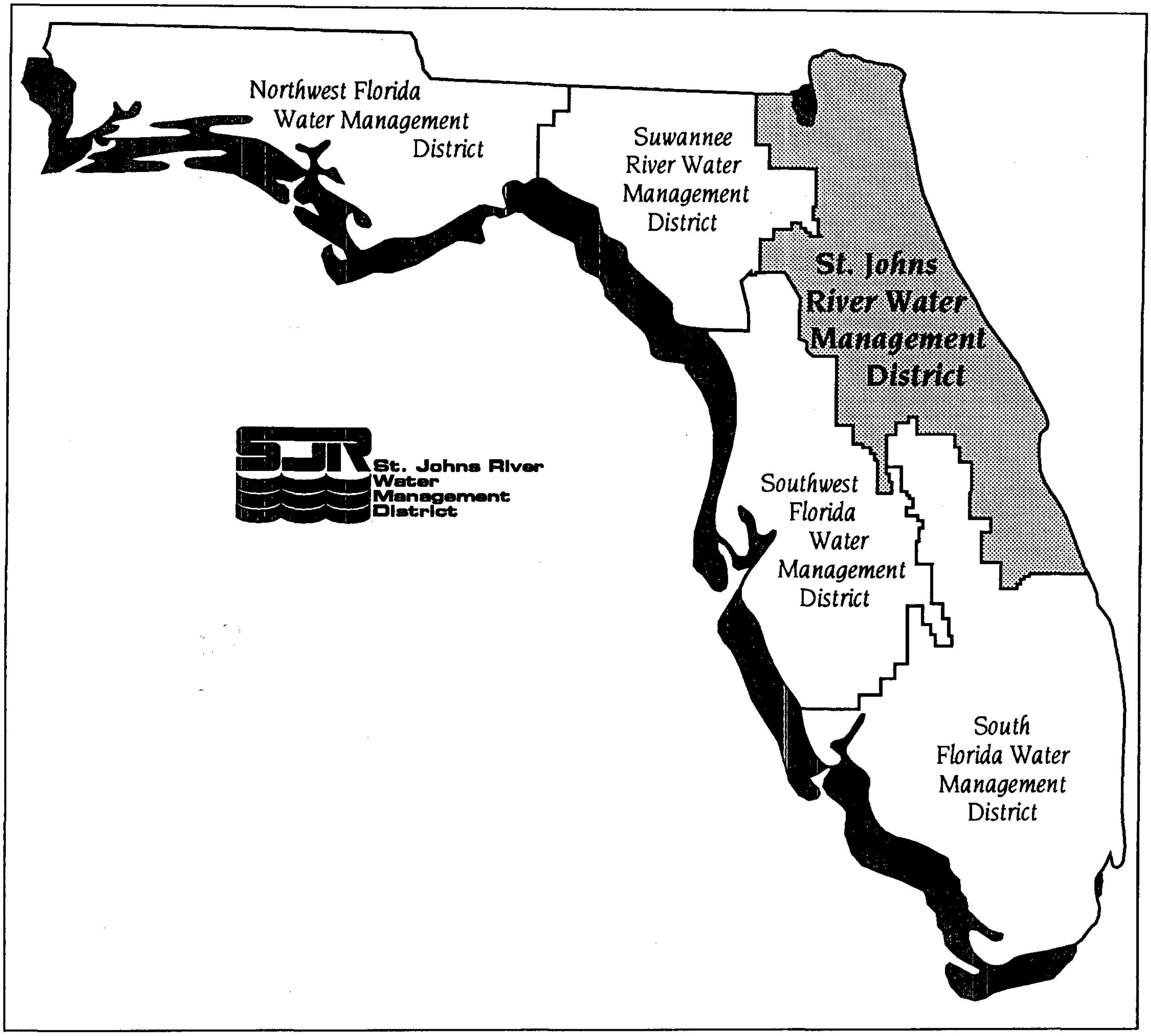
Professional Geologist
License No. PG0000707

January 26, 1994

Seal

St. Johns River Water Management District
Palatka, Florida

1994



The **St. Johns River Water Management District** (SJRWMD) was created by the Florida Legislature in 1972 to be one of five water management districts in Florida. It includes all or part of 19 counties in northeast Florida. The mission of SJRWMD is to manage water resources to ensure their continued availability while maximizing environmental and economic benefits. It accomplishes its mission through regulation; applied research; assistance to federal, state, and local governments; operation and maintenance of water control works; and land acquisition and management.

Professional papers are published to disseminate information collected by SJRWMD in pursuit of its mission. Copies of this report can be obtained from:

Library
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Phone: (904) 329-4132

ABSTRACT. This paper is part of an assessment of water supply needs and sources, in which the St. Johns River Water Management District has been required to identify areas expected to have inadequate water resources to meet the water supply demand in 2010. A linear analytical ground water model, DRAWDOWN, was used to simulate changes in the potentiometric surface of the Upper Floridan aquifer (UFA) based on 2010 projected pumpages at the Gainesville Regional Utilities' Murphree Wellfield. The model calculates the drawdown in a two-layered, coupled, leaky-artesian aquifer system. The method assumes homogeneous, isotropic, and steady-state conditions. Simulated 1988 drawdowns ranged from 34.7 to 58.3 ft for UFA and from 0.8 to 1.1 ft for the surficial aquifer system (SAS). Simulated 2010 drawdowns ranged from 47.1 to 72.7 ft for UFA and from 1.0 to 1.6 ft for SAS. The change in drawdown from 1988 to 2010 ranged from 12.2 to 17.2 ft for UFA and from 0.3 to 0.5 ft for SAS. The simulated drawdowns for projected pumpages at the Murphree Wellfield have a pronounced effect on the elevation of the potentiometric surface of UFA and little effect on SAS.

Section 17-40.50(1), *Florida Administrative Code,* requires the St. Johns River Water Management District (SJRWMD) to identify "specific geographical areas that have water resource problems which have become critical or are anticipated to become critical within the next 20 years." As part of this identification, SJRWMD is assessing water supply needs and sources to determine those areas expected to have inadequate water resources to meet the projected 2010 water supply demand. Regional numerical ground water models and local analytical ground water models were used as part of this overall assessment.

The evaluation discussed here is based on the results of an analytical model, which was used to simulate the impacts associated with ground water withdrawals at the Gainesville Regional Utilities' (GRU) Murphree Wellfield (Figures 1 and 2). The evaluation was used ultimately as part of the overall assessment of water supply needs and sources to arrive at the projected 2010 districtwide elevation of the potentiometric surface of the Floridan aquifer system and the elevation of the water level of the surficial aquifer system.

Within the area covered by the Murphree Wellfield, there are three primary aquifer systems: the surficial, the intermediate, and the Floridan. The wells at the Murphree Wellfield are drilled into the Floridan aquifer system. The surficial aquifer system, at the location of the wellfield, is composed of sands and clayey sands. This unit is underlain by the Hawthorn Group, which acts as both an intermediate confining unit and an intermediate aquifer. The Hawthorn Group separates the surficial aquifer and Floridan aquifer systems. Beneath the Hawthorn Group are the limestone formations of the Ocala Group and the Avon Park Formation. These formations form part of the Upper Floridan aquifer. A middle semiconfining unit exists at some locations within the Floridan aquifer system, separating it into an Upper Floridan aquifer and a Lower Floridan aquifer. The middle semiconfining unit is not persistent, although it appears to exist at the location of the wellfield.

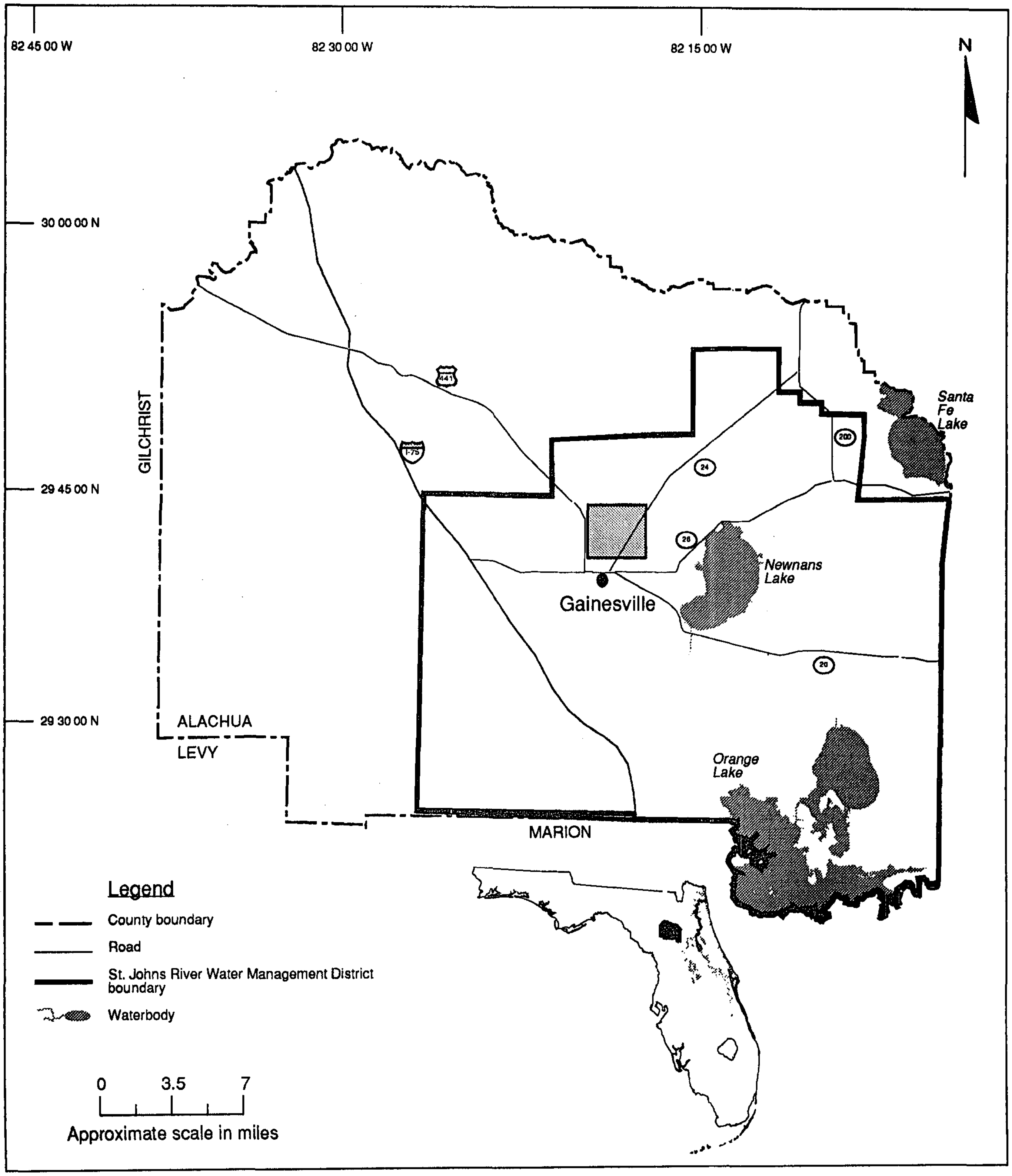


Figure 1. DRAWDOWN model domain for the Murphree Wellfield belonging to Gainesville Regional Utilities. *Model domain is within the shaded box north of Gainesville.*

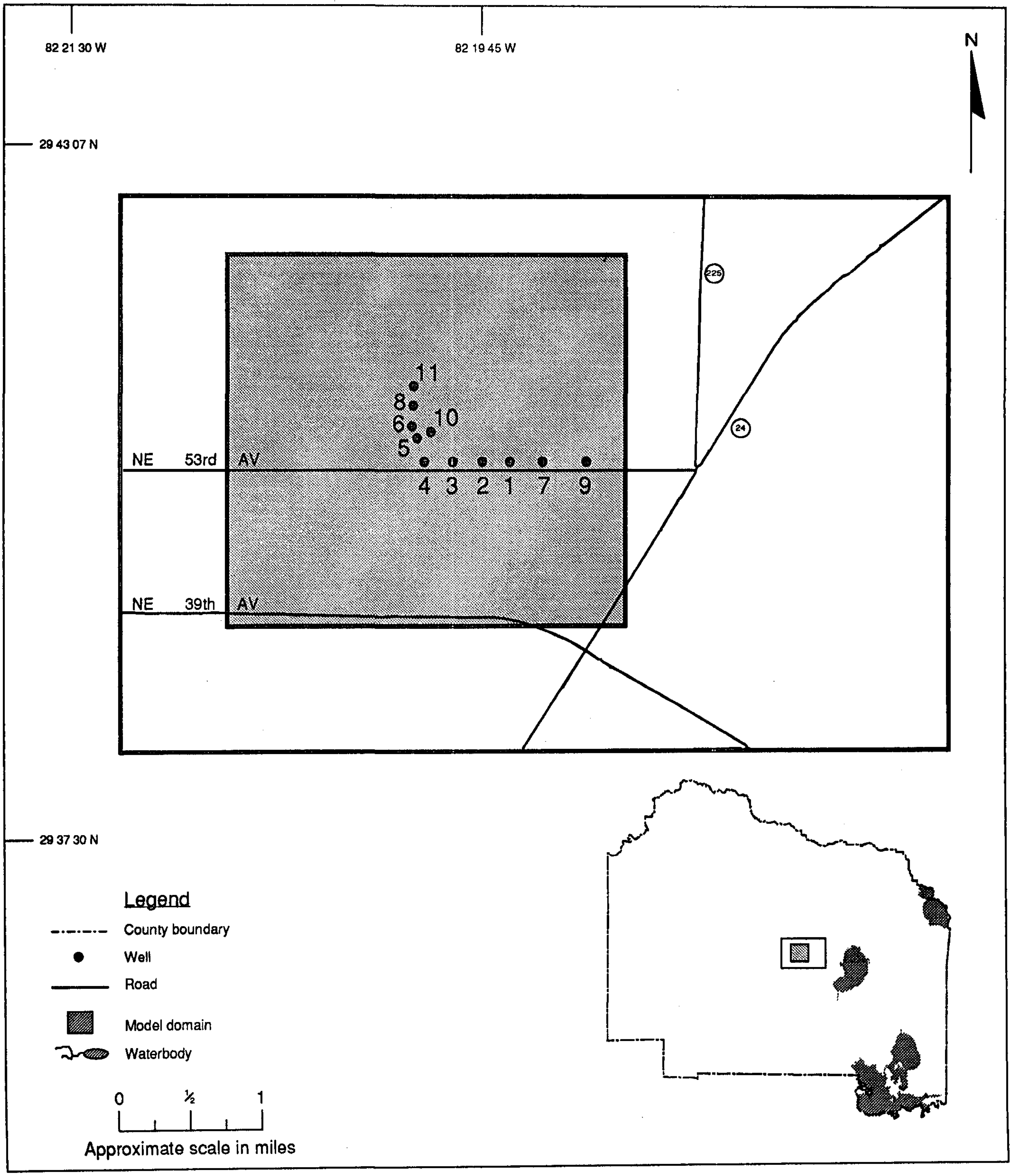


Figure 2. **Location of wells in the Murphree Wellfield used in the DRAWDOWN model**

In 1988, GRU operated eight wells at the Murphree Wellfield. Since 1988, three new wells have been drilled at the Murphree Wellfield, making the total number of wells eleven. No new wells are expected to be drilled at the Murphree Wellfield between now and 1996. GRU intends to expand its existing capacity before 2010; however, at this time it is uncertain where the new additional wells will be located. Approximately 80 percent of the water withdrawn from this wellfield is used for residential household use (SJRWMD 1990), 6 percent is used for commercial and industrial purposes, and 14 percent is used for water utility purposes and power production.

METHODS

The Murphree Wellfield was examined using a modified version of the DRAWDOWN model (SJRWMD unpublished). The model uses a linear analytical solution to calculate the amount of drawdown in a coupled, two-layered, leaky-artesian aquifer (Motz 1981). The model was modified to allow upward leakage from the Lower Floridan aquifer. The method assumes that homogeneous and isotropic conditions are present in the aquifer system. The model simulated steady-state conditions. The model does not account for aquifer gradient; therefore, the natural aquifer gradient was assumed to be flat.

The model domain was chosen to be large enough to include the most significant drawdown in the area around the wellfield. Drawdowns actually occur beyond the extent of the model domain. The model domain, which is 12,000 feet (ft) long and 12,000 ft wide, was selected so that the wells would be approximately in the center.

Aquifer characteristics used in the model include transmissivity of the Upper Floridan aquifer and the surficial aquifer system, leakance, and evapotranspiration reduction (Table 1). The transmissivity of the Upper Floridan aquifer (measured in

Table 1. Aquifer characteristics used in the DRAWDOWN model, Murphree Wellfield

Aquifer Characteristics	Value
Evapotranspiration reduction coefficient	0.0003 (ft/day)/ft
Transmissivity—surficial aquifer	2,000 gpd/ft
Leakance—intermediate confining unit	6.5×10^{-5} (gpd/ft^2)/ft
Transmissivity—Upper Floridan aquifer	200,000 gpd/ft
Leakance—middle semiconfining unit	1.5×10^{-3} (gpd/ft^2)/ft

Note: gpd = gallons per day
ft = feet

gallons per day per foot) is based on the results of a MODFLOW model of the wellfield completed by CH2M HILL (John Regan, GRU, pers. com. 1993). The transmissivity of the surficial aquifer system was determined using Equation 1.

$$\textit{Transmissivity} = \textit{aquifer thickness} \cdot \textit{hydraulic conductivity} \qquad (1)$$

GeoSys (1991, p. 3) indicated that the thickness of the surficial layer of sediments is 0-30 ft; an average of 20 ft was assumed. Geologic information indicates that the surficial sediments are composed of sands and clayey sands (GeoSys 1991, p. 3). Based on the composition of the surficial unit and the surficial layer thickness, a hydraulic conductivity of 100 gallons per day per square foot was used to calculate the transmissivity of the surficial aquifer system (Freeze and Cherry 1979, p. 29). The intermediate confining unit leakance, measured in gallons per day per square foot divided by feet, is based on the MODFLOW model (John Regan, GRU, pers. com. 1993). The middle semiconfining unit leakance also is based on the MODFLOW model (John Regan, GRU, pers. com. 1993). The leakance represents the flux of water flowing from one aquifer to another. The evapotranspiration reduction coefficient, measured in feet per day per foot, was determined using a graph from Tibbals (1990, p. E10). The evapotranspiration reduction coefficient describes the rate at which evapotranspiration is reduced per unit of water table drawdown and is based upon a depth to the water table of 18 ft below land surface.

Well pumpage rates for 1988 and 2010, measured in million gallons per day (mgd), were used in the model (Table 2). Pumpage for each well was calculated as the product of pump capacity and the percentage of time each well was in service in 1988 (GeoSys 1991, p. 11). Pump capacities were derived from the 1990 Consumptive Use Permit (CUP) application (SJRWMD 1990). The sum of the 1988 pumpages (19.96848 mgd) correlates closely with the actual ground water withdrawal for GRU in 1988. Florence (1990) gave 19.990 mgd as the 1988 ground water withdrawal from the Murphree Wellfield.

The 2010 projected pumpage for the Murphree Wellfield is estimated to be 29.5 mgd (David Richardson, GRU, pers. com. 1993). An assumption used in the model was that the additional pumpage from 1988 to 2010 would be accounted for by the three new wells; however, the percentage of time the new wells would be in service was unknown. The projected change in pumpage was calculated and the change was divided by three, then applied to each new well. In reality, well 10 cannot pump more than 3 mgd; however, the difference between the calculated and real pumpage is not significant for the purpose of this modeling effort.

Table 2. Pumpage values used in the DRAWDOWN model, Murphree Wellfield

Well	Latitude	Longitude	Calculated 1988 Pumpage (mgd)	Projected 2010 Pumpage (mgd)
1	294211	821748	3.52800	3.52800
2	294211	821757	3.52800	3.52800
3	294211	821806	1.90512	1.90512
4	294211	821816	4.13280	4.13280
5	294218	821819	2.32848	2.32848
6	294220	821820	0.96768	0.96768
7	294211	821737	1.20960	1.20960
8	294226	821820	2.36880	2.36880
9*	294211	821723		3.17700
10*	294219	821815		3.17700
11*	294232	821820		3.17700

Note: mgd = million gallons per day
*Wells constructed after 1988

RESULTS

The model calculated the drawdowns. These drawdowns are based on the assumption that all wells were pumping 100 percent of the time; however, the wells are actually pumped on a rotated basis. The wells in the model were allowed to pump 100 percent of the time because the purpose of using the model was to examine the long-term regional impacts of the wellfield. Consequently, site-specific results, which would be sensitive to the number of wells pumping and the amount of time each well was pumped, were not necessary. The simulated 1988 and 2010 drawdowns are consistent with the drawdowns modeled by GeoSys for GRU's 1991 CUP application (GeoSys 1991).

The change in simulated drawdowns from 1988 to 2010 at the wells ranged from 12.2 to 17.2 ft for the Upper Floridan aquifer and from 0.3 to 0.5 ft for the surficial aquifer system (Table 3). Simulated 1988 drawdowns ranged from 34.7 to 58.3 ft for the Upper Floridan aquifer and from 0.8 to 1.1 ft for the surficial aquifer system. Simulated 2010 drawdowns ranged from 47.1 to 72.7 ft for the Upper Floridan aquifer and from 1.0 to 1.6 ft for the surficial aquifer system.

Table 3. Simulated drawdowns in the Murphree Wellfield for 1988 and 2010

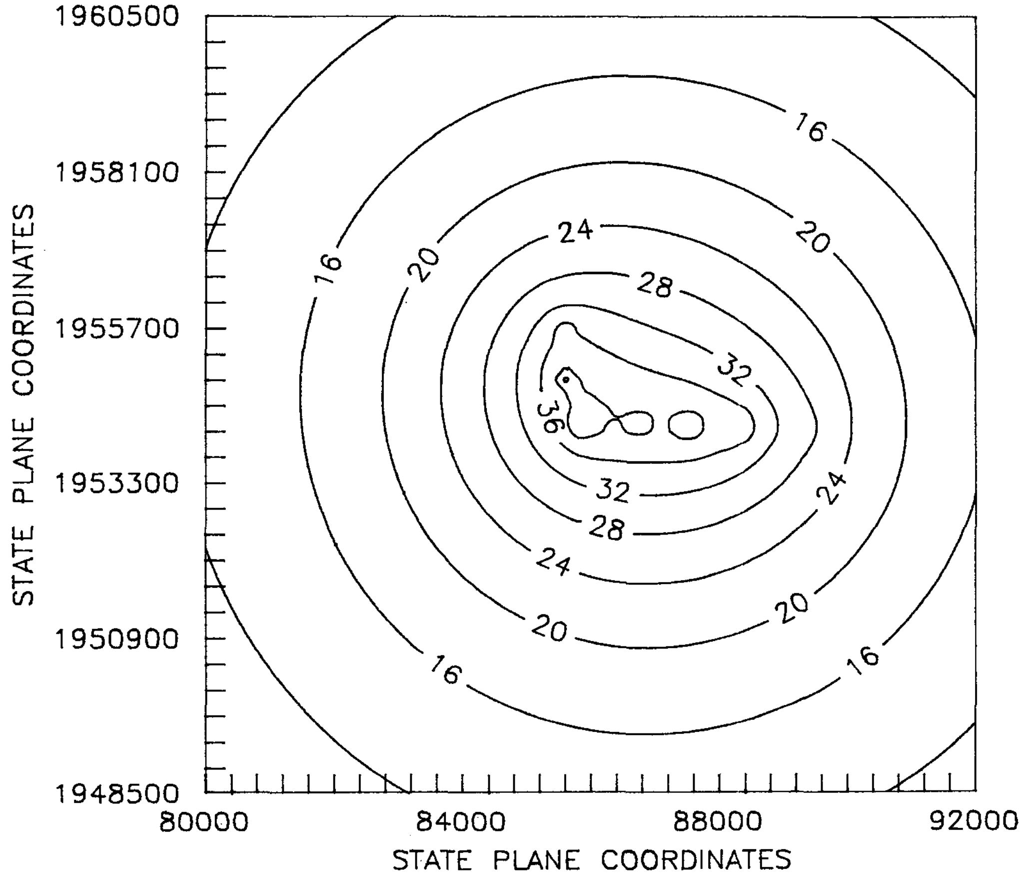
Well	Simulated 1988 Drawdown (feet)		Simulated 2010 Drawdown (feet)		Drawdown Difference (feet)	
	Upper Floridan Aquifer	Surficial Aquifer System	Upper Floridan Aquifer	Surficial Aquifer System	Upper Floridan Aquifer	Surficial Aquifer System
1	52.4	1.1	64.6	1.4	12.2	0.3
2	55.3	1.1	68.0	1.5	12.7	0.4
3	48.0	1.1	61.7	1.5	13.7	0.4
4	58.3	1.1	72.7	1.5	14.4	0.4
5	49.5	1.1	66.6	1.5	17.1	0.4
6	42.8	1.1	60.0	1.5	17.2	0.4
7	34.7	0.8	47.1	1.2	12.4	0.4
8	45.3	1.0	62.4	1.5	17.1	0.5
9*			50.8	1.0	NA	NA
10*			71.2	1.6	NA	NA
11*			61.1	1.3	NA	NA

Note: NA = not applicable
*Wells constructed after 1988

Simulated drawdowns in the Murphree Wellfield were contoured for 1988 and 2010 for the Upper Floridan aquifer and the surficial aquifer system (Figures 3-6). Differences between the drawdown in 1988 and in 2010 were contoured for the Upper Floridan aquifer and the surficial aquifer system (Figures 7 and 8). Figures 3-6 show the localized effect that pumping of these wells has on the aquifer. In reality, the effect of the pumping extends beyond the model domain.

Discussion

The simulated and observed drawdowns measured at the wells (Coates 1993, p. 41) compare closely and are rather large. The large drawdowns are due partly to the proximity of the wells within the wellfield. The installation of three new wells since 1988 has had the effect of increasing the size of the drawdown (Figures 7 and 8). Much of the change in drawdown that is expected, based upon the DRAWDOWN model, is due to these wells.



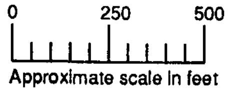
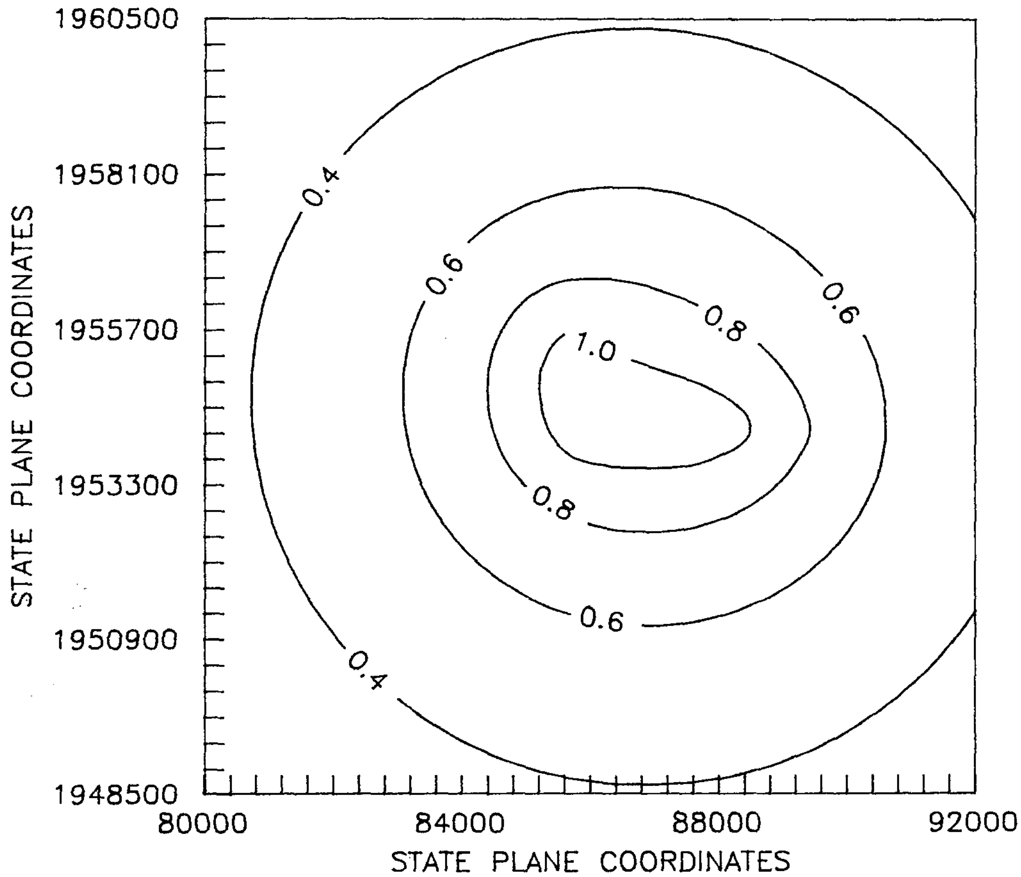


Figure 3. Simulated 1988 drawdown for the Upper Floridan aquifer at the Murphree Wellfield (measured in feet)



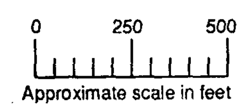
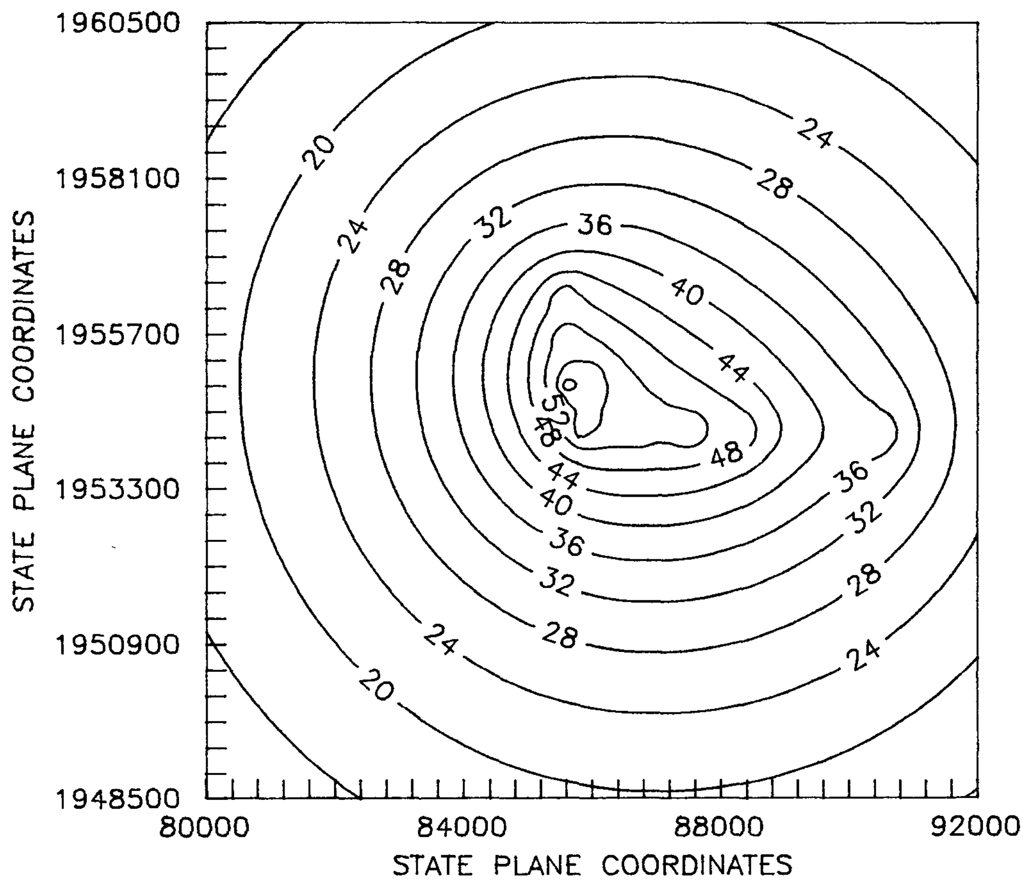


Figure 4. **Simulated 1988 drawdown for the surficial aquifer system at the Murphree Wellfield (measured in feet)**



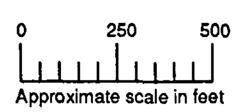


Figure 5. Simulated 2010 drawdown for the Upper Floridan aquifer at the Murphree Wellfield (measured in feet)

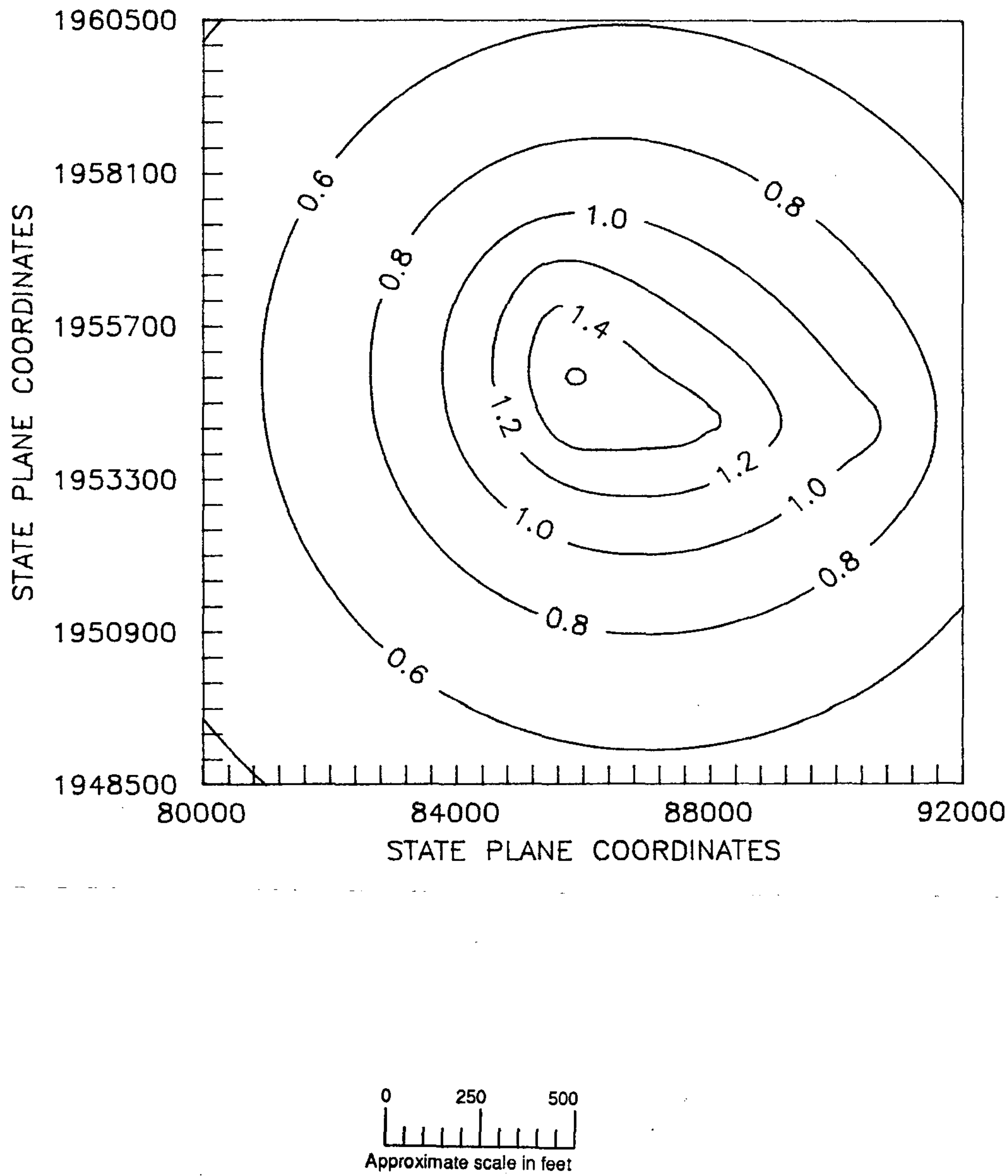


Figure 6. **Simulated 2010 drawdown for the surficial aquifer system at the Murphree Wellfield (measured in feet)**

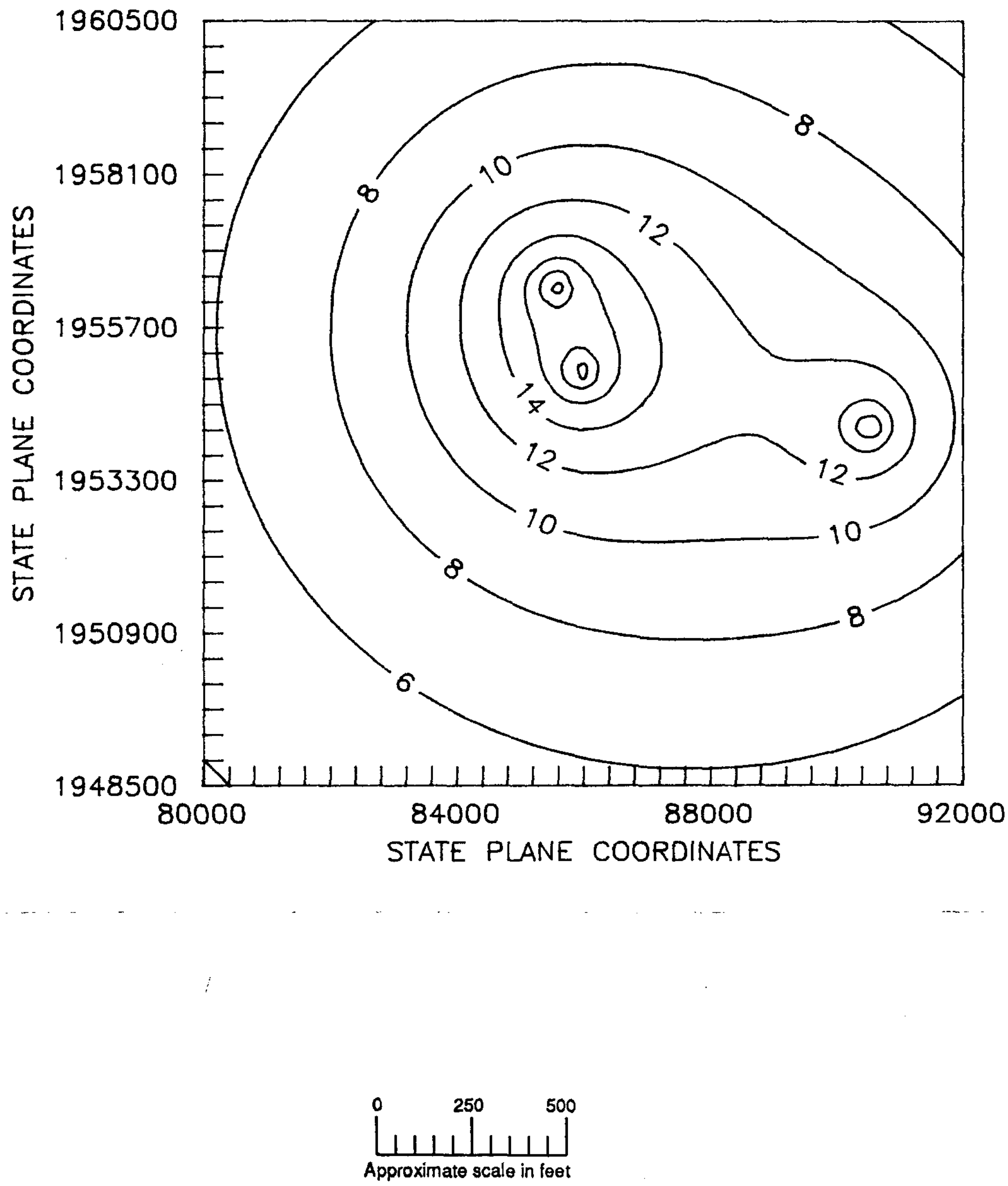


Figure 7. **Difference in simulated drawdowns between 1988 and 2010 for the Upper Floridan aquifer at the Murphree Wellfield (measured in feet)**

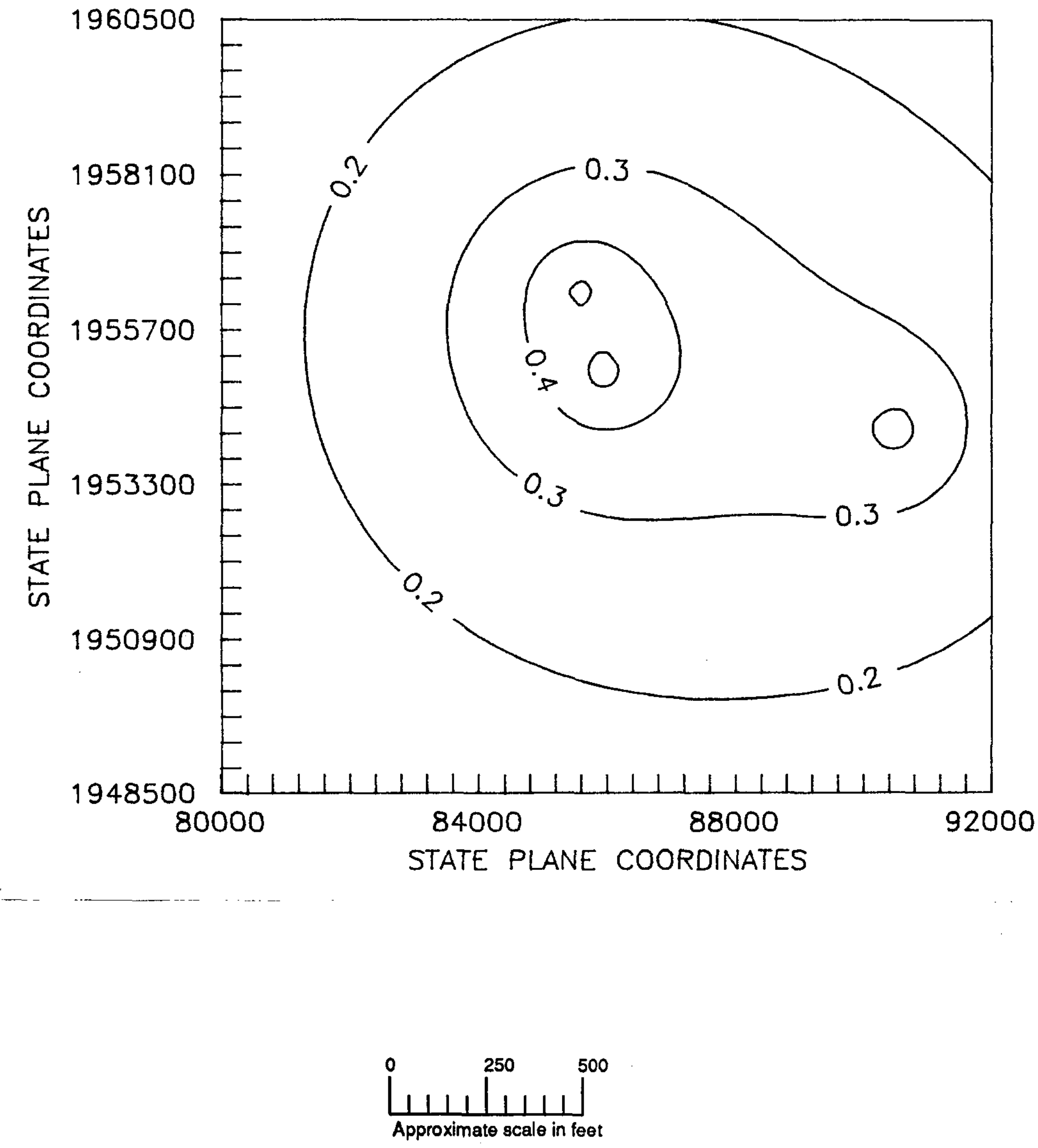


Figure 8. **Difference in simulated drawdowns between 1988 and 2010 for the surficial aquifer system at the Murphree Wellfield (measured in feet)**

After having conducted a wellfield test on the Murphree Wellfield, GRU believes more wells will be needed to meet the future municipal water supply demands. From a water resources perspective, if further wells are considered, GRU should plan carefully because of the potential impact of any additional drawdown. GRU should consider the impact of additional pumping on the water quality of the wells. There is currently evidence suggesting that, after extended periods of pumping, the water quality in certain GRU wells begins to decline. In light of this, any further stresses on the system caused by additional wells should be considered carefully.

CONCLUSION

Based on the results of the model, increased pumpage at the Murphree Wellfield between 1988 and 2010 will cause approximately 15 ft of additional drawdown in the elevation of the potentiometric surface of the Upper Floridan aquifer and will have little impact on the elevation of the water level of the surficial aquifer system.

REFERENCES

CH2M HILL. 1993. *Evaluation and modeling of the Floridan aquifer system in the vicinity of the Murphree Well Field.* Technical Memorandum No. 4. Gainesville, Fla.

Coates, K.E. 1993. *A groundwater management model for the Walter E. Murphree Well Field.* Gainesville, Fla.: University of Florida.

Florence, B.L. 1990. *Annual water use survey: 1988.* Technical Publication SJ90-12. Palatka, Fla.: St. Johns River Water Management District.

Freeze, R.A., and J.A. Cherry. 1979. *Groundwater.* Englewood Cliffs, N.J.: Prentice-Hall.

GeoSys. 1991. *Murphree wellfield pumping projections.* Prepared for Gainesville Regional Utilities. Submitted to the St. Johns River Water Management District for a 1991 Consumptive Use Permit application. Gainesville, Fla.

Motz, L.H. 1981. Well-field drawdowns using coupled aquifer model. *Ground Water* 19(2):172-179.

SJRWMD. 1990. Gainesville Regional Utilities, Consumptive Use Permit Application. Consumptive Use Permit File #2-001-0006ANGM. Palatka, Fla.: St. Johns River Water Management District.

———. Unpublished. Computer program modified by St. Johns River Water Management District. Palatka, Fla.

Tibbals, C.H. 1990. *Hydrology of the Floridan aquifer in east-central Florida.* Professional Paper 1403-E. Tallahassee, Fla.: U.S. Geological Survey.

CONVERSION TABLE

Multiply	By	To Obtain
foot (ft)	0.3048	meter (m)
million gallons per day (mgd)	3.785×10^3	cubic meters per day (m^3/d)
gallons per day per foot (gpd/ft)	1.242×10^{-2}	square meters per day (m^2/d)
gallons per day per square foot (gpd/ft^2)	4.075×10^{-2}	meters per day (m/d)
gallons per day per square per foot ([gpd/ft^2]/ft)	0.1337	meters per day per meter ([m/d]/m)
foot per day per foot ([ft/d]/ft)	1.0	meters per day per meter ([m/d]/m)