TECHNICAL PUBLICATION 76-2

April, 1976

PREDICTIVE WATER DEMAND MODEL FOR CENTRAL AND SOUTHERN FLORIDA

TECHNICAL PUBLICATION: No. 76-2

April 1976

PREDICTIVE WATER DEMAND MODEL FOR CENTRAL AND SOUTHERN FLORIDA

by

Nagendra Khanal

#69

"This public document was promulgated at an annual cost of $226.42, or $.453 per copy to inform the public regarding water resource studies of the District." RPD-126 R987 25.

Resource Planning Department
Central and Southern Florida Flood Control District
West Palm Beach, Florida 33402

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SYNOPSIS

A predictive water demand model (strictly speaking, a requirement model as the price of water is not taken into account, assuming it to be exogeneous) was developed; based on the social, economic and environmental parameters in the demand model for the central and southern Florida area. The model is validated by using the historic pumpage records for the three counties in the Gold Coast area. It has also been validated on municipality levels for urban areas which are in suburban counties.

The coefficient of determination between the population served and the municipal water pumped is .892. When two other significant parameters (average rainfall/year and median family income) are incorporated in the demand model, the coefficient of determination is improved to .913; a marginal accuracy might be significant in the near future when the scarcity of the natural resources becomes critical. For the present it can be concluded, based on the results of this study, that future water requirements can be predicted reliably if good population projections can be made for the above stated area.

A second model developed is based on the long monthly pumpage records of 5 large utility companies to estimate the seasonal variation of the average yearly water demand. It was determined from this model that the maximum monthly requirement is around 21 percent of the average yearly demand for the FCD area based on this study.

INTRODUCTION

Conventional forecasting of urban water demand simply assumes the demand increases proportionately in some relation to the increase in population; a forecasted population multiplied by a per capita use figure to determine the average annual demand. Fair, Geyer, and Okum (3) in their book on water and waste water engineering, point out that figures derived from these forecasts "generalize the experience" of the engineers of the area. Furthermore, they state that the requirement approach enjoys a certain rudimentary logic. Water use is assumed to be perfectly correlated with population. Using this basic approach to water supply requirements forecasting, many investigators have attempted to "generalize the experience."

Conventional water supply management begins with the premise that water is necessary for life, then proceeds to lay down requirements for increasing water use by grand engineering designs which hope to repeat the tradition of earlier successes in water resources planning. This kind of conventional forecasting works, to an extent, due to the fact that population is the most significant determinant of the model, but excludes factors such as climate, income, type of housing, population density, and price of water. In recent studies by Burke (1), Howe, Linawever (4), and Turnovsky (8), these factors have all been shown to have measureable effects on per capita consumption of water. Thus, it is more appropriate to speak of the demand for water, given certain values of these factors, than to assume a rigid water requirement for a given year.

The Central and Southern Florida Flood Control District recognizes the importance of the above stated socio-economic and environmental parameters influencing the quantity of water demanded for municipal uses, and in an attempt to quantify the importance of the above stated variables for our local conditions, this study is undertaken.

Under the provisions of the Florida Water Resources Act of 1972, (Chapter 373), the use of surface and groundwater in the District falls within the permitting responsibilities delegated to the District by the Department of Environmental Regulation. The District must then be in a position to evaluate intelligently applications for water use permits, whether they be municipal, industrial or agricultural.

HISTORICAL BACKGROUND

The first attempt to study the effect that price has on the quantity of water demand by residential customers for household or indoor uses and for outside uses was made at Johns Hopkins University by Charles W. Howe and L. P. Linewever (4). They formulated models of residential water demand and estimated the relevant parameters from cross sectional data. They showed the dependence of water demand on the price charged. Their major findings were: a) domestic demands are relatively inelastic with respect to price and b) sprinkling demands are elastic with respect to price. They studied 39 areas, 10 in the western United States (metered with public sewer), 11 in the eastern United States, 5 metered with septic tanks, 8 flat rate public water and sewer, 5 apartment area buildings, but not individually metered. They differentiated between the domestic demand and the sprinkling demand. The parameters used in these two demand models were as follows:

Domestic Demand

$$q_{a,d} = f\ (v,\ a,\ dp,\ k,\ pw) \tag{1}$$

Where,

$q_{a,d}$ = average annual quantity demanded for domestic purposes in gallons per dwelling unit per day (gpd/du),

v = market value of the dwelling unit in thousands of dollars,

dp = number of persons per dwelling unit,

a = age of the dwelling unit,

k = average water pressure in psi,

pw = the sum of water and sewer charges that vary with water use, evaluated at the block rate applicable to the average domestic use in each study area.

Theoretical consideration fails to specify a unique functional form, so that both linear and multiplicative forms were fitted to the above parameters as follows:

$$q_{a}, d = A_0 V^{A_1} a^{A_2} dp^{A_3} K^{A_4} Pw^{A_5} u \qquad (2)$$

Transforming this to linear form one gets:

$$\log, q_a, d = \log A_0 + A_1 \log V + A_2 \log a + A_3 \log dp + A_4 \log K + A_5 \log Pw + \log u \qquad (3)$$

Sprinkler Demand

The multiplicative equation form for the sprinkler demand was developed based on the following parameters:

qs, s = average summer sprinkling demand in gallons per dwelling unit per day.

q max, s = Maximum day sprinkling demands in gallons per dwelling unit per day.

b = irrigable area per dwelling unit.

Ws = maximum day potential evapotranspiration in inches.

rs = summer precipitation, in inches.

ps = marginal commodity charge applicable to average summer total rates of use.

Thus, the sprinkler demand function takes the form of:

$$qs, s = B_0 \, b \quad (Ws - 0.6 \, r_s)^{B_2} \, ps^{B_3} \, v^{B_4} \, u \qquad (4)$$

The physical requirement b (Ws - 0.6 r_s) is very likely to be modified as a function of the economic status of the household v, and price.

Maximum sprinkling day demand will occur at a time when previous rainfall has been dissipated and when temperature, humidity, thermal radiation, and wind lead to a maximum rate of evapotranspiration. On such days the physical requirement would be b w max. For these days the maximum day demand equation was fitted as:

$$q_{max, s} = B_0 \, b^{B1} \, w\,max^{B2} \, ps^{B3} \, v^{B4} \, u \qquad (5)$$

The final equations that were developed for the domestic and the sprinkler demand were:

a) $q_{a, d} = 206 + 2.47\ V - 1.30\ Rw$ (6)

b) $q_{s, s} = 1{,}130\ Ps^{-.703}\ V^{.429}$ (7)

c) $q_{max, s} = 3{,}400\ W_{max}^{2.06}\ V^{.413}$ (8)

The "R" or the coefficient of correlation for the above equations is .847.

Turnovsky (8) has developed models based on consumer theory. Starting with an individual's utility function ($u\ (x_i ....x_n)$) where x_i is the amount consumed of commodity i, the demand function is $x_i = f_i\ (Pi........ ....Pn, u)$, $i = 1..........n$.

Where,

pi = price of commodity i, and

u = consumers income.

Much of Turnovsky's work concentrates on determining how the individual responds to parameter changes. His basic equation concerning the domestic demand and the industrial demand are as follows:

<u>Domestic Demand Based on Consumer Theory</u>

$$X_i = A_0 + A_1\ S_1^2 + A_2\ P_i + A_3\ hi + A_4\ Ri \qquad (9)$$

Where,

X_i = planned per capita consumption in town i in gallons/day,

S_1^2 = variance of supply in town i in gallons/day squared,

Pi = average price of water in town is given by metered revenue divided by metered gallons used, in cents per 1,000 gallons,

hi = index of per capita housing space given by average number of rooms per dwelling units in town i/median number of occupants per dwelling unit in town i,

Ri= percentage of population under 18 in town i,

IPi = index of per capita industrial production in town i.

Industrial Demand

$$X_i = B_o + B_1 S_i^2 pi + B_3 IPi \quad (10)$$

These predictive models were applied to Massachusetts data.

Thompson and Young (7) developed linear equations for water demand models based on the form of derivation for certain types of substitutions in a steam electric generating plant. These linear approximated demand functions were used to evaluate proposed investments in water resources regulation.

Burke (1) recently made a comprehensive model study concerning the water demand for the conterminous United States. The approach taken into consideration to the maximum extent possible, was an accommodation of the myriad impacts on water requirements generated by demographic, social, economic, and environmental factors. Sixteen variables (estimated population served in millions, value added by manufacturing in millions, number of families, precipitation in inches per year, median family income in dollars, family income under $3,000 in percent, family income over $10,000 in percent, median value of housing units in dollars, manufacturer's all employees annual average, manufacturer's production workers annual average, and the number of retail establishments) were used to predict the water pumpage in gallons.. A few of the salient points worthy of note from Burke's study are as follows:

a) All the parameters used in the model were obtained from two, and only two, readily available sources. They are:

1) City and County data books - USDC - Census Bureau, and

2) Inventory of Municipal Water Facilities - Public Health Service publication, HEW, Washington, D. C.

b) Prediction equations were developed for the State of Florida based on 18 Florida cities with a population in excess of 25,000.

The equation he developed was log linear in nature. Among the 18 parameters for the Florida condition, it was stated that only the following parameters were significant towards increasing the correlation coefficient. The important parameters for Florida conditions were:

a) Estimated population served (in millions).

b) Number of families.

c) Precipitation (inches/year).

d) Median family income (dollars).

The functional form that was developed is:

$$Y = f\ (X1,\ X2,\ X3,\ X4) \tag{11}$$

Where,

Y = water demanded.

The type of equation used was multiplicative in nature.

$$Y = A\ x_1^{\ B}\ x_2^{\ S}\ x_3^{\ T} x_4^{\ D} \tag{12}$$

Transforming it to linear form one obtains:

$$\text{Log } Y = \log A + B \log x_1 + S \log x_2 + T \log x_3 + D \log x_4 \tag{13}$$

The coefficient of determination was stated to be .946 for the above developed prediction equation.

A water demand model similar to Burke's model is investigated here to determine a functional relation between the quantity of water demanded and the social, economic, and environmental parameters that influence the quantity demanded for the municipalities within central and southern Florida. No restriction is placed on the size of population served in this study.

FCD WATER DEMAND MODELS

Municipal Demand

Kreitman, et. al., (5) made a comprehensive study concerning the water consumption trends within central and southern Florida. Their study was meant to display the gross per capita values and the nature of the distribution within central and southern Florida. The water consumption data were compiled from forty-six municipal and private suppliers. The mean and the standard deviation values of water consumption for the year 1973 were estimated to be 197 and 87 gallons per capita per day. They fitted the data to the Gaussian distribution and banded it with the 90 percent confidence interval band.

The U. S. Geological Survey (12) also compiles municipal pumpage data for the State of Florida on an annual basis. The mean per capita consumption from the survey data was determined to be around 150 gpcd for the year 1973. It was stated in Kreitman et.al.'s (5) report that the discrepancy between the two mean values is due to the fact that several of the per capita groups in the upper limit were not represented in the USGS sample, even though their sample size was larger than the FCD's.

Having known the present average per capita consumption, this study spins off from there. This particular study is geared towards formulating easy to use water demand models to enable rapid determination of municipalities water requirements for future years, without recourse to detailed on-site data collection and investigation. More specifically, this study is an attempt to provide a tool for rapidly estimating, with reasonable accuracy, the future water requirements of cities in central and southern Florida with the aim to improve and supplement the existing apparatus on the quantification of water demand.

As stated earlier, this model is being approached in a similar fashion as was approached by Burke (1). Burke's model used Florida cities with populations in excess of 25,000. This study places no limitation on the size of population served. The following parameters were selected to represent the FCD water demand model:

a)	Population served	X1
b)	Number of people per dwelling unit	X2
c)	Rainfall, inches per year	X3
d)	Median family income	X4
e)	Population per square mile	X5
f)	Percentage of population 18 years and over	X6
g)	Percentage of population 65 years and over	X7
h)	Quantity of water pumped daily	Y

In functional notation, the above written variables are written as:

$$Y = f\ (X1,\ X2,\ X3,\ X4,\ X5,\ X6,\ X7) \qquad (14)$$

The appropriate form of the equation proposed to be fitted is:

$$Y = AX1^{a}\ X2^{b}\ X3^{c}\ X4^{d}\ X5^{e}\ X6^{f}\ X6^{g} \qquad (15)$$

Transforming the above form of equation to linear form, one obtains:

$$\log Y = \log A + a\log X1 + b\log X2 + c\log X3 + d\log X4 + e\log X5 + f\log X6 + g\log X7 \qquad (16)$$

Data Collection

Data on the parameters as outlined above, to be used in the predictive water demand model, were abstracted from the following sources:

a) Florida League of Cities 1972: Compilation on water, solid waste, sewer and electicity (updated to 1974 figures).

b) 1970 Florida census of population (updated to 1974 figures).

c) National Oceanic and Atmospheric Administration (formerly U. S. Weather Bureau).

Samples

The social, economic and environmental parameters were abstracted for the following municipalities from the counties which are within the FCD boundaries. They are presented in Appendix A. The median family income was projected based on 3 percent geometric growth figure for the year 1974.

Presented in tabular form are the counties and the number of municipalities within the counties which are included in the water demand model (see Map 1).

TABLE 1 COUNTIES AND THE NUMBER OF MUNICIPALITIES WITHIN THE COUNTY

County	Number of Municipalities Within the County
Polk	6
Highlands	3
Palm Beach	13
Lee	6
Dade	7
Seminole	2
Hendry	2
Broward	10

TABLE 1 (Continued)

County	Number of Municipalities Within the County
Volusia	6
St. Lucie	1
Osceola	1
Orange	4
Brevard	3
Monroe	1
Glades	1
Okeechobee	1
Martin	1
Indian River	1
Total	69

RESULTS AND DISCUSSION

The proposed statistical model as depicted by Equation (16) was run in the CDC 3100 computer located in-house. A standard multivariate analysis package stored on disk was used.

Presented below in tabular form is the bi-variate statistical table, which simply shows the partial correlation coefficient between the dependent variable, which in this case is the municipal water pumped, with respect to the independent variables.

TABLE 2 BIVARIATE STATISTICAL TABLE OF THE PROPOSED MODEL

Independent Variables	"R" Partial Correlation Coefficient With the Quantity of Water Pumped
Population Served	.944
Average Persons Per Unit	.055
Rainfall Inches/Year	.369
Median Family Income	.509

Table 2 (Continued)

Population Per Square Mile	.563
Percentage of Population 18 Years and Over	.177
Percentage of Population 65 Years and Over	-.053

From the table above, it can be seen that population served has the highest correlation with the quantity of water pumped. Population per square mile and the median family income have linear correlation in excess of 50 percent. If actual population data is not available, data based on zoning (land use) and social status of the people (median family income) can be used in water demand projections.

A recent study by Berry and Bonem (2) approached the development of a water demand model based on the median family income. The linear correlation was determined to be .875. The FCD study shows the correlation coefficient of this variable with respect to quantity of water pumped for the central and southern Florida condition to be .510.

Burke's (1) study pointed out the significant effect of annual precipitation towards improving the coefficient of determination for the Florida condition in particular. This study also shows that effect. The linear coefficient of correlation between the annual average rainfall versus the quantity of water pumped is .369.

In the table following, are presented the regression coefficients and the associated standard errors of each of the independent parameters used in the water demand model.

TABLE 3 REGRESSION COEFFICIENTS AND THE ASSOCIATED ERRORS

VARIABLE	COEFFICIENT (LOG)	STANDARD ERROR (LOG)
X0	6.847	
X1	0.986	.049
X2	0.294	1.789
X3	2.948	.884
X4	-0.694	.649
X6	0.075	.087
X7	-1.975	2.504
X8	0.172	0.373

The water demand equation using the above listed regression coefficients is written as follows:

$$\log Y = 6.847 + .986 \log X1 + .294 \log X2 + 2.948 \log X3 - .694 \log X4 + .075\ X6 - 1.975 \log X7 + .172 \log X8 \quad (17)$$

The coefficient of determination determined by use of the above listed parameter is .913. In the above regression derived equation some of the coefficients have errors which are in excess of 100 percent. Use of these kinds of parameters tends to make the derived equation less stable. The parameters that are not stable are: 1) the number of persons per unit, 2) population per square mile, 3) percentage of population 18 years and over, and 4) percentage of population 65 years and over. The above stated parameters were deleted from the water demand model and a second run was made. The parameters that were retained for the second run are as follows:

Municipal Pumpage = f (population served, average rainfall/year, and the median family income) (18)

The regression coefficients derived from the model are stable. They are presented below in tabular form.

TABLE 4 STABLE VARIABLES AND THEIR COEFFICIENTS

VARIABLES	REGRESSION COEFFICIENTS
X0	-1.715
X1	0.992
X3	2.517
X4	-0.357

The final predictive equation based on the above regression coefficients is as follows:

$$\text{Log } Y = -1.715 + .992 \log X1 + 2.517 \log X3 - 0.347 \log X4 \qquad (19)$$

The coefficient of determination for the above equation is .911. The above equation is fitted to the data from 69 municipalities which are within the FCD boundaries. The observed and the computed pumpage figures are presented in Appendix B.

Another run was made for the 69 municipalities which are within the FCD boundaries with total population served by each municipality as being the only independent variable. The coefficient of determination for this model is .892.

The predictive equation derived is as follows:

$$\text{Log } Y = 5.012 + 1.012 \text{ Log Population.} \qquad (20)$$

Emphasis is being placed presently on the lower east coast for development of the Water Use and Water Supply Plan. The counties that are within the lower east coast are Palm Beach, Broward and Dade. To estimate the municipal water demands of the three counties in the lower east coast, a special run was made based on the data for these counties only. The equation developed is as follows:

$$\text{Log } Y = 97.66 + .999 \log X1 - 2.847 \log X3 - 8.827 \log X4 \qquad (21)$$

The coefficient of determination for the above equation is .882.

Another run was made for the lower east coast municipalities with total population served as being the only independent variable. The coefficient of determination for this model is .864.

The equation derived is as follows:

$$\text{Log } Y = 5.485 + .9841 \ln . X1 \qquad (22)$$

It is appropriate to state here, that in the strictest sense of the word, the predictive water demand model presented in this study is in reality a water requirement model, since no consideration was given to the effects of price on the quantity of water demanded. This is due to the fact that the model was approached from the management aspect of a large complex water resource system. It is assumed that the pricing of water lies within the utility company, a reasonable assumption for our situation.

The mathematical structure as written above is assumed to describe the expansion path or relationship that water demand can be expected to have with each variable. The above equations, (19, 20, 21 and 22) by themselves cannot project the future water demand values. The variables which are incorporated in the model must first be projected, using an average rate of growth (geometric growth) from past years of record and extending into the future. These values are then transformed to logarithmic form and inserted into the appropriate equations (19, 20, 21 and 22) to obtain the projected future water demand for any municipality incorporated in the model. (See Figure 2).

Researchers in the field of applied mathematics and statistics might question the stability of the derived regression coefficients on the grounds that "structural" changes resulting from very many exogeneous factors such as migration, automation, or other circumstances will tend to cause relative elasticities of different variables to change the coefficients derived from the model. If one can posit at the time that a model's structure is finalized, research on using the model - and more importantly - on modifying, changing, or adapting it to reflect apparent changes in structure over time will continue; then the instability of coefficients is no longer a valid argument.

Simply stated, research is an on-going process and if changes are known or even likely, the demand functions can be refitted to the data. As time progresses, with the availability of better statistical data, it is even probable that the structure or methodology of the model posed here might change to reflect the improvements in data availability.

Validation of the General Predictive Equation

The predictive equation that was derived in the previous chapter for the lower east coast is as follows:

Pumpage = 5.485 + .984 x Ln. Population

This equation was derived based on the 1970 census figures updated to 1974 population and the quantity of water pumped for the year 1974. For the whole lower east coast the equation predicts the quantity of water required for the year 1974 with a high degree of accuracy. However, the equation was derived using only one year of record for the whole region. In order to develop additional levels of confidence for the predictive equation, it was considered appropriate that several years of data be compiled and compared against the computed values. In addition, it was decided that the equation be developed or the general equation be updated for each of the lower east coast counties. In this exercise, the essential constraint assumed that the [illegible] of the county population must water demand representing at least 60 percent of the county population must be represented in the predictive equation.

Dade County. For Dade County, the Miami-Dade Water and Sewer Authority supplies water to almost 80 percent of the county population. The utility company provided ten years of pumpage data and the population being served. The general predictive equation as stated above was used to compute the water requirements for the years 1965-1974 inclusive. The percentage of error between the predicted and the historic pumpage varies from -3 to +12 percent. The average error is +6.4 percent. The general equation is slightly modified in order to reduce the error between the actual and the predicted value. The average percentage error is 1.4 percent. The calculations are presented in Tables 7 and 8.

Broward County. For Broward County, the Cities of Hollywood, Fort Lauderdale, Pompano and Deerfield Beach were contacted. The summation of population served by these suppliers represents 65 percent of the county population. Average quantity of daily water pumped and the total number of population served were tabulated for the years 1970-1974 inclusive. The same general equation that was developed for the whole lower east coast was used to compute the water requirements. The percentage error difference between the predicted and the actual pumpage varies from +10 to -1 percent; however, the average error is only +1%. The lower percentage error between the predicted and the actual pumpage figure shows that the predictive equation can also be used for future water requirements for Broward County. (Table 6).

Palm Beach County. Pumpage data and the population served by Pahokee, Palm Springs, Boca Raton, Delray, Lake Worth, Riviera Beach and West Palm

Beach were made available for the years 1970-1974 through the courtesy of the utility companies. They were summed up, and the general predictive equation for the lower east coast was used to compute water requirements. The general equation predicted lower water requirement figures than the actual historic. The general equation was then slightly modified as follows:

$$\text{Pumpage} = 5.485 + 1.01 \text{ Ln. Population}$$

With the modified equation the percentage error variation between the predicted and the historic pumpage is from -5 to +3 percent. However, the average error is only +1.2 percent, well within the standard error figure (Table 5).

For the "Water Use and Water Supply Development Plan" future population has to be estimated. The University of Florida at Gainesville has projected the county-wide population for the year 2000.for the State of Florida. Based on land use plans or development guides with the county land use restrictions, an estimate of future population was made by the FCD staff. These two projections match fairly well for the lower east coast counties. These projected populations were used to estimate the quantity of water required by each county by the year 2000. Dade County, by the year 2000 will be requiring almost 390 million gallons of water per day for potable water supply purposes. Broward County will require 270 million gallons per day, and Palm Beach County 255 million gallons.

It has been repeatedly stated by demographers that population projection beyond 10 years is speculative, and no confidence level can be attached to it. Projection of population has been made here for 24 years. It is appropriate then to state that these figures have to be updated, as the years progress. The objective of using these projected populations was only to show the order of magnitude of the water requirement for future years. However, in the development of the "Water Use and Water Supply Development Plan" the approach taken by the District is not simply to develop a plan to meet the water requirement for the projected population, but rather to show the levels of demand that the water resources of the region can support under various alternative water supply options.

The future water requirements of the three counties are presented in Tables 9, 10, and 11 and also in Figures 3, 4 and 5.

The above validation for the lower east coast demonstrates the power of the simple predictive equation to compute future water requirements of the three counties. By induction, it can be shown that the same general equation or a slight modification could be used to estimate the future water requirements of other counties.

An attempt was made to collect historic pumpage data for a few of the urban counties - i.e., Lee, Orange, St. Lucie and Martin. There are, however, only a few utility companies in these counties and they do not serve, on the aggregate, 60 percent of the county population. Therefore, at the present time the prediction equation can not be validated for these counties on a county-wide level as the constraint on population can not be met. Additional analysis on a municipality level is presented in the next chapter.

TABLE 5. PREDICTIVE EQUATION CHECK USING PAST POPULATION AND PUMPAGE RECORDS FOR PALM BEACH COUNTY (Pahokee, Palm Springs, Boca Raton, Delray Beach, Lake Worth, Lantana, Riviera Beach, West Palm Beach and Boynton Beach.

Year	Past Population	Log Population	5.485 + 1.01 Log Population	Average Daily Pumpage x 10^6 gals.	Historic Average Daily x10^6 gals.	Error	%
1964							
1965							
1966							
1967							
1968							
1969							
1970	172,458			46.90	48.60	- 1.70	- 1
1971	182,850			49.75	50.24	- .49	+ 3
1972	195,850			53.30	51.50	± 1.80	+ 2
1973	210,815			57.44	56.22	+ 1.22	+ 2
1974	221,841			60.50	63.96	- 3.46	- 5
Average Error							+ 1.2%

TABLE 6. PREDICTIVE EQUATION CHECK USING PAST POPULATION AND PUMPAGE RECORDS FOR BROWARD COUNTY (Hollywood, Fort Lauderdale, Pompano Beach and Deerfield Beach, Combined)

Year	Past Population	Log Population	5.485 + 1984 Log Population	Average Daily Pumpage x 10^6 gals.	Historic Average Daily x10^6 gals.	Error	%
1964							
1965							
1966							
1967							
1968							
1969							
1970	368,077			72.27	65.72	+ 6.55	+ 10
1971	374,993			73.61	71.91	+ 1.70	+ 2
1972	377,540			74.10	77.09	- 2.99	- 4
1973	406,766			79.78	81.67	- 1.89	- 2
1974	433,747			84.94	86.11	- 1.17	- 1
Average Error							+ 1.0%

TABLE 7. PREDICTIVE EQUATION CHECK USING PAST POPULATION AND PUMPAGE RECORDS
Miami-Dade Water & Sewer Authority

Year	Past Population	Log Population	5.485 + .984 Log Population	Average Daily Pumpage x 10^6 gals.	Historic Average Daily x10^6 gals.	Error	%
1964							
1965	700,000	13.46	18.73	136.2	140.5	- 4.3	- 3
1966	730,000	13.50	18.77	142.0	146.5	- 4.5	- 3
1967	750,000	13.52	18.80	146.0	133.2	+12.8	+ 9
1968	770,000	13.55	18.82	149.0	136.9	+12.1	+ 9
1969	790,000	13.58	18.85	153.6	137.1	+16.5	+12
1970	900,000	13.71	18.92	164.6	153.0	+11.6	+ 7
1971	920,000	13.73	19.00	178.5	159.1	+19.4	+12
1972	940,000	13.76	19.02	182.0	162.7	+19.3	+12
1973	975,000	13.79	19.05	187.6	177.2	+10.4	+ 5
1974	1,000,000	13.82	19.08	193.3	187.4	+ 5.9	+ 3
Average Error							+ 6.4 %

TABLE 8. PREDICTIVE EQUATION CHECK USING PAST POPULATION AND PUMPAGE RECORDS Miami-Dade Water & Sewer Authority.

Year	Past Population	Log Population	5.485 + .980 Log Population	Average Daily Pumpage x 10^6 gals.	Historic Average Daily x 10^6 gals.	Error	%
1964							
1965	700,000			129.1	140.5	- 11.4	- 8
1966	730,000			134.2	146.5	- 12.3	- 8
1967	750,000			136.9	133.2	+ 3.7	+ 3
1968	770,000			141.0	136.9	+ 4.1	+ 3
1969	790,000			145.1	137.1	+ 8.0	+ 6
1970	900,000			164.8	153.0	+ 11.8	+ 8
1971	920,000			168.1	159.1	+ 9.0	+ 6
1972	940,000			173.1	162.7	+ 10.4	+ 6
1973	975,000			178.3	177.2	+ 1.1	+ 1
1974	1,000,000			183.7	187.4	- 4.7	- 3
Average Error							+ 1.4%

TABLE 9. PROJECTED WATER REQUIREMENTS - PALM BEACH COUNTY

Water Requirement = 5.485 + 1.01 x Ln. Population

Year	Projected Population	5.485 + 1.01 x Projected Ln. Population	Forecasted Water Requirement x 10^6 gals.
		POPULATION - LAND USE PLAN	
1980	577,558	18.88	158.97
1990	692,012	19.07	190.08
2000	805,894	19.22	222.55
		POPULATION - U. OF FLORIDA	
1980	543,000	18.82	149.36
1990	730,200	19.12	201.45
2000	928,800	19.36	256.86

TABLE 10. PROJECTED WATER REQUIREMENTS - BROWARD COUNTY

Water Requirement = 5.485 + .98 x Ln. Population

Year	Projected Population	5.485 + .98 x Projected Ln. Population	Forecasted Water Requirement x 10^6 gals.
		POPULATION - LAND USE PLAN	
1980	945,000	18.97	172.99
1990	1,140,900	19.15	208.06
2000	1,403,000	19.36	254.83
		POPULATION - U. OF FLORIDA	
1980	985,700	19.01	180.28
1990	1,245,400	19.24	226.72
2000	1,504,300	19.42	272.83

TABLE 11. PROJECTED WATER REQUIREMENTS - DADE COUNTY

Water Requirements = 5.485 + .980 x Ln. Population

Year	Projected Population	5.485 + .980 x Projected Ln. Population	Forecasted Water Requirement x 10^6 gals.
		POPULATION - LAND USE PLAN	
1980	1,610,000	19.49	291.60
1990	1,930,000	19.67	348.29
2000	2,160,000	19.78	388.92
		POPULATION- U. OF FLORIDA	
1980	1,511,000	19.43	274.02
1990	1,861,000	19.63	336.09
2000	2,165,800	19.78	389.95

Validation of the Water Requirement Predictive Equation on a Municipality Level

The water requirement predictive equation that was developed, based only on 1974 population for the whole FCD region, is as follows:

Total Average Daily Pumpage = 5.012 + 1.012 x Ln. Population (1)

Another water requirement predictive equation that was explicitly developed for the lower east coast is as follows:

Total Average Daily Pumpage = 5.485 + .984 x Ln. Population (2)

The predictive water requirement equation (2) developed for the lower east coast was validated on a county level by data obtained from municipalities serving at least 60 percent of the county population, for each of the lower east coast counties.

The constraint on population which was imposed in the validation process of the lower east coast could not be met for other FCD areas because of the large rural population not on municipal water supply systems. However, it was decided to use the predictive equation for the whole FCD region to see how far off the fit was; at least for the populous urban areas.

With the above-stated reasoning, the following municipalities were contacted concerning the population they serve and the average daily quantity of water they pump. These municipalities are: Orlando, Vero Beach, Fort Myers and Fort Pierce.

Orlando Utilities: The original equation was slightly modified to reduce the error between the historic and the calculated pumpage. The error varied from a high of +8 to -6 percent, the average error being less than 1 percent. It can be stated then, that the fit between the historic and the predicted pumpage is good.

Vero Beach Utilities: The fit for this utility company is also good as the average error is only +3 percent.

Fort Myers Utilities: The slight modified predictive equation predicts the water requirement close to the historic pumpage. The average error between the predicted and the actual historic error is within 10 percent.

Fort Pierce Utilities: The general predictive equation or a modification of it does not fit the historic data. The error varies from +24 to -5 percent, the average being +10 percent. It can only be stated, based on other county and municipal validation processes, that the data might have inherent errors.

TABLE 12. PREDICTIVE EQUATION CHECK USING THE PAST POPULATION AND PUMPAGE RECORDS. Vero Beach Utility Company.

$$\text{Log } Y = 5.012 + 1.000 \times \text{Log Population}$$

Year	Past Population	Log Population	5.012 + 1.000 Log Population	Average Daily Pumpage $\times 10^6$ gals.	Historic Average Daily $\times 10^6$ gals.	Error	%
1964							
1965							
1966							
1967							
1968							
1969							
1971	19,491	9.88		2.93	2.58	+ .35	+ 14
1972	21,392	9.97		3.21	3.10	+ .11	+ 4
1973	23,173	10.05		3.48	3.31	+ .17	+ 5
1974	24,549	10.11		3.69	3.80	- .11	- 3
1975	24,913	10.13		3.76	3.91	- .15	- 4
Average Error							+ 3.2%

TABLE 13. PREDICTIVE EQUATION CHECK USING PAST POPULATION AND PUMPAGE RECORDS Orlando Utility Company.

Log Y = 5.012 + 1.037 x Log Population

Year	Past Population	Log Population	5.012 + 1.037 Log Population	Average Daily Pumpage x 10^6 gals.	Historic Daily Average x 10^6 gals.	Error	%
1964							
1965							
1966							
1967							
1968							
1970	149,900	11.92		35.07	32.40	+ 2.67	+ 8
1971	153,709	11.94		35.81	34.13	+ 1.68	+ 5
1972	158,479	11.97		36.94	36.97	- .07	- 0
1973	160,998	11.99		37.72	39.27	- 1.53	- 4
1974	164,907	12.01		38.51	40.97	- 2.46	- 6
1975	165,669	12.02		38.90	40.98	- 2.08	- 5
Average Error							-.33%

TABLE 14. PREDICTIVE EQUATION CHECK USING PAST POPULATION AND PUMPAGE RECORDS Fort Pierce Utility Company.

Log Y = 5.012 + .990 x Log Population

Year	Past Population	Log Population	5.012 + .990 Log Population	Average Daily Pumpage x 10^6 gals.	Historic Daily Average x10^6 gals.	Error	%
1964							
1965							
1966							
1967							
1968							
1969							
1971	34,300	10.44		4.62	3.86	+ .76	+ 20
1972	36,771	10.51		4.95	3.98	+ .97	+ 24
1973	37,684	10.53		5.05	4.52	+ .53	+ 12
1974	38,115	10.55		5.16	5.24	- .08	- 2
1975	38,017	10.55		5.16	5.43	- .27	- 5
Average Error							+ 9.80%

TABLE 15. PREDICTIVE EQUATION CHECK USING PAST POPULATION AND PUMPAGE RECORDS Fort Myers Utility Company.

Log Y = 5.012 + 1.000 x Log Population

Year	Past Population	Log Population	5.012 + 1.000 Log Population	Average Daily Pumpage x 10^6 gals.	Historic Average Daily x 10^6 gals.	Error	%
1964							
1965							
1966							
1967							
1968							
1969							
1971	34,524	10.45		5.18	4.91	+ .27	+ 5
1972	35,038	10.46		5.24	5.06	+ .18	+ 4
1973	35,560	10.48		5.40	5.64	- .24	
1974	36,375	10.50		5.50	5.69	- .19	- 3
1975	37,884	10.54		5.70	5.83	- .13	- 2
Average Error							0%

SEASONAL DEMAND ESTIMATION

Monthly groundwater pumpage can be considered as a time series defined by the values P_1, P_2... of a variable P (Pumpage) at times t_1, t_2.... Thus, pumpage P is a function of time t, symbolized as P = f (t). Characteristic movements of time series may be classified into four main types, often referred to as components, and they are: 1) long term or trend, 2) cyclical variation about the trend line, 3) seasonal variation, and 4) irregular, random, or unaccounted movements. The long term or trend movement can be estimated by various methods. The first chapter of this report dealt with that. This chapter is entirely devoted to seasonal variation of pumpage.

Seasonal Variation

This refers to the identical, or almost identical, patterns which a time series appears to follow during corresponding months of successive years. Such movements are due to recurring events which take place annually, as for instance, the sudden increase of department store sales before Christmas, the increase in municipal pumpage during dry months for lawn sprinkling, etc.

Concerning the groundwater pumpage, the climatological situation of the central Florida area is such that almost 70 percent of the annual rain falls during the months of June through September. During this period, it is assumed for purposes of this study, that the moisture content of the soils are at field capacity, no lawn irrigation is anticipated, and the groundwater pumpage is at the lowest annual level. As time progresses, however, the moisture content of the soil starts to decline and people start to irrigate their lawns; the pumpage goes up gradually. Finally, during the dry period (April through May) the pumpage reaches its peak. This phenomenon reoccurs every year. The objective of this study is to estimate this peak demand so that the quantity of water demanded during the critical period can be best estimated.

Method of Analysis

To estimate the seasonal variation one must see how the data in the time series vary from month to month throughout the year. A set of values showing relative values of a variable during the months of the year is called a seasonal index for the variable. If for example, one knows the pumpage during January, February, March, etc., are 101, 115, 118, ... percent of the average monthly pumpage for the whole year, the numbers 101, 115, and 118 provide the seasonal index for the year and are sometimes referred to as the seasonal index numbers. The mean seasonal index for the whole year should be 100%, i.e., the sum of the index numbers should add to 1,200%.

Various methods are available for computing a seasonal index. The method which has been used here is the average percentage method. In this method the data for each month of a year is expressed as percentages of the average for the year. The percentages for corresponding months of different years are then averaged, using the mean.

The resulting 12 percentages give the seasonal index. If their mean is not 100 percent (i.e., if the sum is not 1,200%) these should be adjusted by multiplying by a scaled factor.

Data Collection

Monthly pumpage data were compiled from Delray Beach, Miami-Dade, West Palm Beach, Boca Raton, and Belle Glade. Belle Glade has only 8 years of data whereas the remainder of the utility companies have more than 15 years of record. The monthly pumpage and the total for the year are presented in Tables in Appendix C. By dividing the yearly records by 12, an average value was obtained. The monthly values for a particular year divided by the average value of that year gives the monthly percentage of the yearly values which are presented in Tables in Appendix D. These were then averaged and the seasonal pumpage variation was obtained. It can be seen from Tables in Appendix D and also from Figures 3-6 that the monthly pumpage for Delray Beach varies from .80 to 1.25 percent, the maximum occuring during the dry month of April. For Boca Raton, the variation is from .78 percent to 1.29 percent, the maximum also occuring during the month of April. Miami-Dade's maximum monthly pumpage is only 12 percent over and above the monthly average. West Palm Beach's maximum monthly pumpage is 1.18 percent of the average. The City of Belle Glade is the only one where the maximum month occurs during the month of December. Due to lack of at least 10 years of data, Belle Glade was eliminated from further calculations. Averaging the municipalities' peak monthly pumpage (excluding Belle Glade), the average peak monthly pumpage for the central and southern area is estimated to be around 21 percent over and above the average figure.

SUMMARY

1. A predictive water demand model (in a strict sense a requirement model since the price of water demanded was not incorporated) was set up using the social, economic, and environmental parameters for municipalities within the FCD area. Data from 19 counties with 69 municipalities that are within the FCD boundaries were used in the development of the model.
2. A computer run was made with seven independent parameters that were thought to have significant effects on the amount of municipal pumpage. These parameters were: a) a population served, b) number of persons per dwelling unit, c) rainfall inches/year, d) median family income, e) population per square mile, f) percentage of population 18 years and over, and g) percentage of population 65 years and over.
3. The coefficient of determination was determined to be .913 for the general model with all seven parameters included. However, some of the regression coefficients determined from the model showed the error to be in excess of 100 percent. These variables were: a) average persons per unit, b) population per square mile, c) percentage of population 18 years and over, and d) percentage of population 65 years and over. They were deleted from the predictive water demand model.
4. A second computer run was made with the stable parameters which are: a) population served, b) average rainfall/year, and c) median family income. The coefficient of determination for the above model was determined to be .911.
5. The coefficient of determination between the population served and the quantity of water pumped was determined to be .892 for the same set of data.

6. Presently, the primary emphasis in the Resource Planning Department of the District is being placed on the development of a "Water Use and Water Supply Development Plan" for the lower east coast (Palm Beach, Broward, and Dade Counties). A separate computer run was made incorporating the seven parameters as stated above for these three counties. The coefficient of determination was determined to be .882. Population served alone was also correlated against the quantity of water pumped - the coefficient of determination was determined to be .864.

7. The general predictive model was updated and validated on the county level for the lower east coast area. It was assumed in the validation process that the water demand representing at least 60 percent of the county population must be represented in the predictive equation. For Dade County, the Miami Sewer and Water Authority provides 80% of the county population with its potable water. Pumpage data for the years 1965-1974 were compared against those calculated by use of the predictive equation. For the period of record, the average percentage error is found to be 1.4 percent.

   The population criteria as established above was met for Broward County by summing the population served by cities of Hollywood, Fort Lauderdale, Pompano Beach and Deerfield Beach. Five years (1970-1974) of historic pumpage data was compared against the one obtained by use of the predictive equation. The average error between the predicted and the historic pumpage values is within 1 percent.

   Pumpage data and the population served by Pahokee, Palm Springs, Boca Raton, Delray Beach, Lake Worth, Riviera Beach and West Palm Beach were also compiled for the years 1970-1974, inclusive. The modified predictive equation was used to compute the water requirement figures for the above stated years. The average error between computed and historic pumpage values is within 1.2 percent.

8. The water requirement for future years for the three lower east coast counties has been projected. The future water requirement is based on two sets of population projections; (a) population projection based on University of Florida's study, and (b) land use projections. The average daily quantity of water that will be required to support the projected population for the three counties would be 390 million gallons per day for Dade County, 270 million gallons per day for Broward County and 255 million gallons per day for Palm Beach County. These figures are projected 24 years from now and are very speculative. The population projection has to be revised as the years progress and water requirements must be recalculated.

9. The population constraint imposed in the validation process for the lower east coast area could not be used for other counties because of the large rural populations. However, the equation was used in the more populous urban areas. The predictive equation was checked for the following municipalities: Orlando, Vero Beach, Fort Myers and Fort Pierce. The average error between the computed and the historic pumpage figures is within the 3 percent level for the four municipalities. The average error is, however, in excess of 10 percent for the municipality of Fort Pierce alone.

10. A second statistical model was used to quantify the amount of water being used for lawn irrigation purposes during dry months of the year.

11. Based on the analysis of the 5 largest utility companies' monthly pumpage records, it was determined that the peak monthly pumpage varied from 12 percent (Miami) to 29 percent (Boca Raton) of the average yearly pumpage.

CONCLUSIONS

It is concluded from this study that population served is the most determinant parameter of the water demand model for the Central and Southern Florida Flood Control District area. There is a slight increase (2 percent) in the coefficient of determination if socio-economic and meteorologic parameters, namely the median family income and the average annual rainfall, are included in the water demand model. However, this is a marginal increase and subsequent incorporation of these parameters into the working model is not anticipated.

The methodology presented in this report permits the estimation of future water demands. The Water Use and Water Supply Development Plan being prepared by the District will evaluate the levels of water demand that can be supported by the water resources of the region, given the present conditions and various alternative water supply development options, and will utilize this methodology. The two sets of projected population are presented herein only to illustrate the magnitude of potential water requirements.

The water requirement model developed here will also have application to the evaluation of water use applications.

The second model shows the monthly variation of yearly pumpage, and is important for planning purposes in that it permits estimation of water requirements for drought months. Also, if only the average daily per capita consumption figure is available, this in turn can be converted to each monthly water requirement. It is also concluded from this study that the peak monthly pumpage rate is 21 percent of the average yearly pumpage.

LITERATURE CITED

1) Burke, T. R., 1970. "Municipal Water Demand Model for the Conterminous United States." Water Resources Bulletin, Vol. 6, No. 4.

2) Berry, D. W., and Bonem, Gilbert W., 1974. "Predicting the Municipal Demand of Water." W.R.R., Vol. 10, No. 6.

3) Fair, M. A., Geyer, J. C., and Okum, D.A., 1958. "Water and Waste Water Engineering." John Wiley & Sons, Inc.

4) Howe, C. W., and Linaweaver, F. P., Jr., 1969. "The Impact of Price on Residential Water Demand and its Relation to System Design and Price Structure." Water Resources Research, Vol. 3, No. 1.

5) Kreitman, A., Walker, R. H., and Beck, J. A., 1974. "Water Consumption Trends Within the Central and Southern Florida Flood Control District." Technical Publication #74-3.

6) Marshall,G., and Loucks, D. P., 1971. "Some Long Run Effects of Water Pricing Policies." Water Resources Research, Vol. 17, No. 6.

7) Thompson, R. G., and Young, H. P., 1973. "Forecasting Water Use for Policy Making." Water Resources Research, Vol. 9, No. 4.

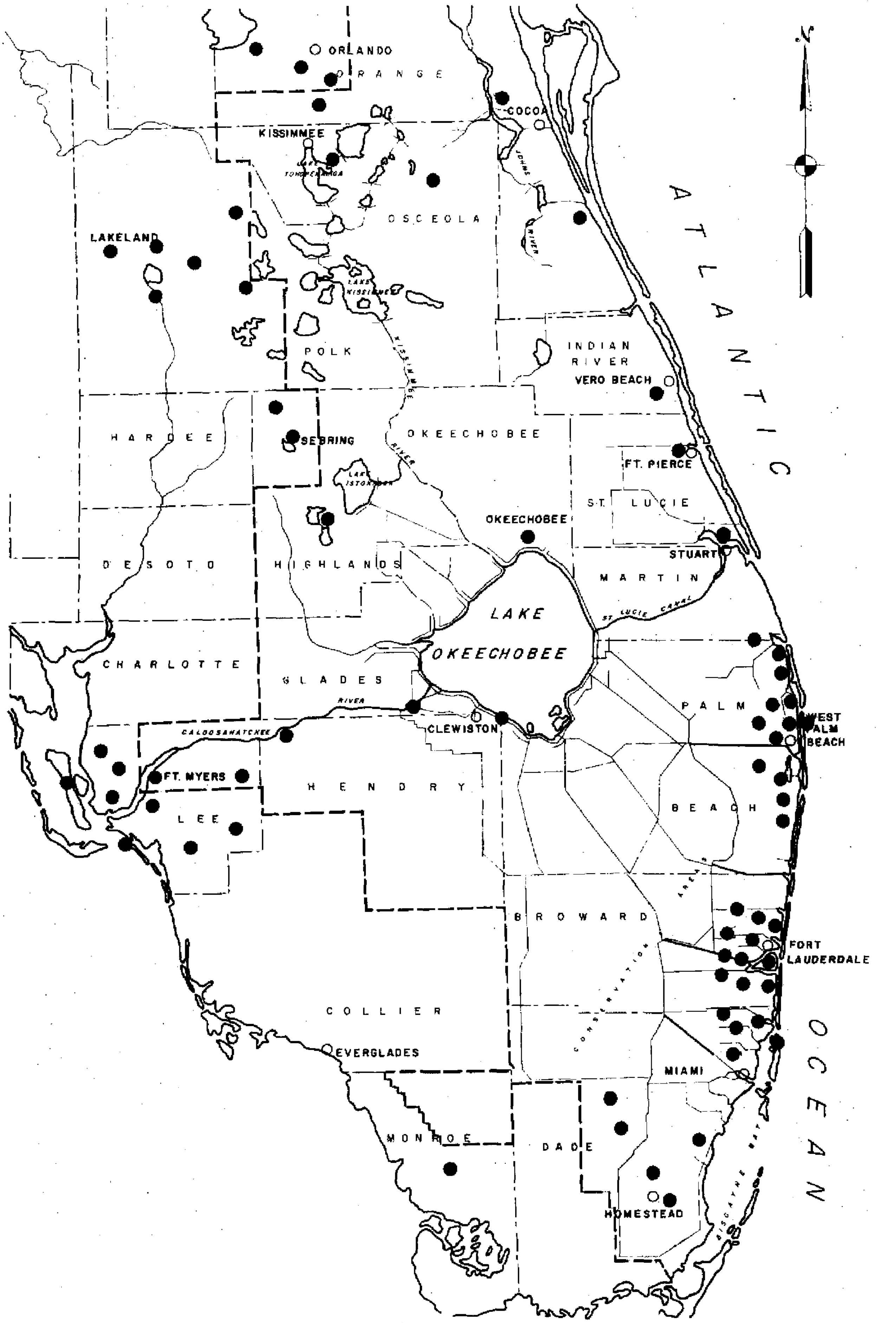
8) Turnovsky, S. J., 1969. "The Demand for Water: Some Empirical Evidence on Consumer's Response to a Commodity Uncertain in Supply." Water Resources Research, Vol. 5, No. 2.

9) United States Department of Commerce, 1970. "Census of Population Detailed Characteristics, Florida."

10) United States Weather Bureau. "Annual Rainfall Values for Central and Southern Florida."

11) U. S. Geological Survey. "Water Use by Selected Municipalities in Florida."

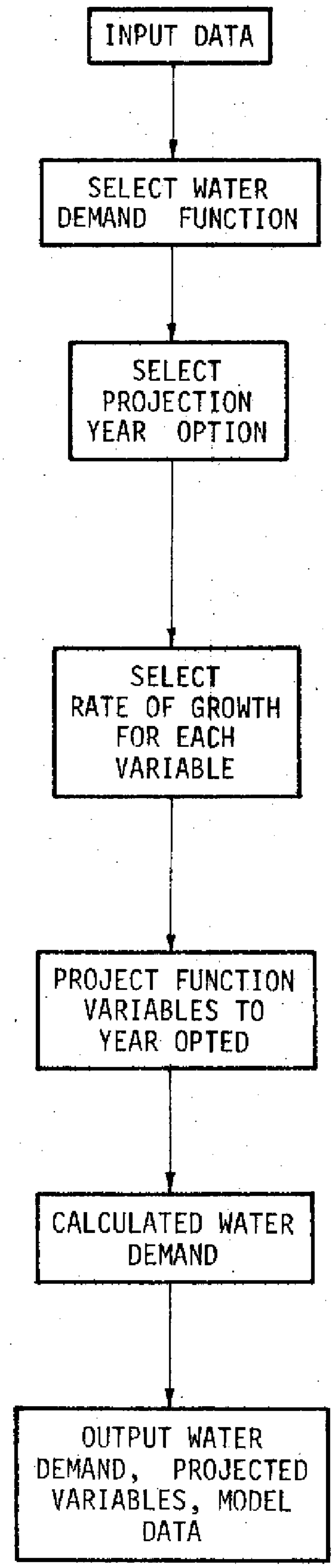
12) Whiteford, P. W., "Residential Water Demand Forecasting," 1972. Water Resources Research, Vol. 8, No. 4.



LOCATION OF 69 SAMPLE SITES

FIGURE I

Figure 2. Water Demand Model - Flow Chart



APPENDIX A

SOCIAL, ECONOMIC, AND ENVIRONMENTAL PARAMETERS FOR THE WATER DEMAND MODEL

COUNTY	POPULATION IN 1,000's	NUMBER OF PEOPLE PER D. UNIT	RAINFALL INCHES PER YEAR	MEDIAN FAMILY INCOME $1,000's	DAILY PUMPAGE MGD	POPULATION PER SQUARE MILE	PERCENTILE OF POPULATION 18 YEARS AND OVER	65 YEARS AND OVER
Polk	12.0	3.1	52.0	7.98	1.40	123	65.6	12.6
	17.0	3.1	52.0	7.98	2.58	123	65.6	12.6
	13.0	3.1	52.0	7.98	1.55	123	65.6	12.6
	81.5				15.63			
	14.0				2.10			
	45.0				5.10			
Highland	8.5	2.8	52.0	6.21	.96	30	69.1	21.1
	.7				.19			
	13.0				2.60			
Palm Beach	22.0	2.8	62.0	9.65	3.48	173	70.1	17.3
	45.0				13.09			
	24.0				5.69			
	23.7				7.03			
	26.0				4.71			
	7.6				1.41			
	16.9				4.46			
	69.7				18.02			
	10.0				5.71			
	10.0				5.33			
	7.6				2.00			
	25.1				4.60			
	9.3				4.90			
Lee	16.0	2.8	52.0	8.35	1.50	134	71.1	18.8
	30.8				5.64			
	8.0				1.52			
	26.0				3.23			
	9.5				.55			
	5.0				.64			

SOCIAL, ECONOMIC, AND ENVIRONMENTAL PARAMETERS
FOR THE WATER DEMAND MODEL

COUNTY	POPULATION IN 1,000's	NUMBER OF PEOPLE PER D. UNIT	RAINFALL INCHES PER YEAR	MEDIAN FAMILY INCOME $1,000's	DAILY PUMPAGE MGD	POPULATION PER SQUARE MILE	PERCENTILE OF POPULATION 18 YEARS AND OVER	PERCENTILE OF POPULATION 65 YEARS AND OVER
Dade	15.5	2.9	60.0	9.79	4.33	621	70.6	13.7
	14.5				6.37			
	17.5				5.16			
	844.0				177.21			
	55.0				10.15			
	14.0				2.09			
	95.0				23.28			
Seminole	14.8	3.2	52.0	9.43	1.40	274	62.4	9.3
	25.0				4.35			
Hendry	2.2	3.2	52.0	7.47	.21	10	60.1	6.9
		4.7		1.03				
Broward	6.7	2.7	61.0	10.07	1.00	509	71.8	18.0
	9.6				1.78			
	20.0				4.61			
	205.0				42.74			
	30.8				4.56			
	124.0				13.50			
	13.5				3.38			
	23.0				2.40			
	19.0				2.59			
	58.7				14.98			
Volusia	63.0	2.7	52.0	7.46	9.58	160	73.0	22.3
	18.0				2.38			
	8.7				.79			
	12.1				2.14			
	27.6				2.79			
	5.2				1.01			

SOCIAL, ECONOMIC, AND ENVIRONMENTAL PARAMETERS
FOR THE WATER DEMAND MODEL

COUNTY	POPULATION IN 1,000's	NUMBER OF PEOPLE PER D. UNIT	RAINFALL INCHES PER YEAR	MEDIAN FAMILY INCOME $1,000's	DAILY PUMPAGE MGD	POPULATION PER SQUARE MILE	PERCENTILE OF POPULATION 18 YEARS AND OVER	PERCENTILE OF POPULATION 65 YEARS AND OVER
St. Lucie	31.5	3.0	56.0	6.74	4.52	87	65.8	14.6
Osceola	3.03	3.3	52.0	6.60	.46	15	60.7	12.0
Orange	8.05 190.00 9.0 53.8	3.1	52.0	9.41	1.47 39.26 1.30 11.88	372	65.2	9.7
Brevard	125.00 66.70 34.00	3.3 3.3	53.0	11.79	14.07 8.57 3.81	288	61.1	5.6
Monroe	27.50	3.1	56.0	7.77	3.00	51	70.1	8.6
Glades	1.20	3.2	52.0	6.53	.20	5	61.7	9.6
Okeechobee	4.50	3.5	52.0	6.90	.97	14	57.1	8.1
Martin	8.00	2.7	60.0	7.72	1.98	50	71.9	21.0
Indian River	16.00	2.9	56.0	7.72	3.40	71	66.7	17.3

APPENDIX B

ANALYSIS OF VARIANCE TABLE , REGRESSION COEFFICIENTS , AND STATISTICS OF FIT FOR VARIABLE X 5 - WDMODEL

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
REGRESSION	3	94.47300390	31.49100130	223.81388865
DEVIATIONS	65	9.14561244	.14070173	
TOTAL	68	103.61861634		

R-SQUARE = .91173775 SIGMA = .37510229

SOURCE	SS FOR X(I) ADJ	SS IF X(I) LAST	T FOR H0 B(I)=0	B VALUES	STD ERROR B	STD B VALUES
X 0				-1.71516926		
X 1	92.48169519	66.81140551	21.79092097	.99277896	.04555929	.92677483
X 3	1.87479823	1.76879194	3.54559117	2.51799969	.71017767	.16199925
X 4	.11651049	.11651049	-0.90998197	-0.35711448	.39244126	-0.04635070

SET	EXPECTED	OBSERVED	DIFFERENCE
1	14.37125206	14.15198279	.21926927
2	14.11813489	13.77468856	.34344633
3	14.71704362	14.76329996	-0.04625634
4	15.34800523	15.06254285	.28546238
5	16.05845775	16.38735914	-0.32890139
6	15.43438830	15.55422081	-0.11983251
7	14.64053293	14.22097567	.41955727
8	14.91608942	15.28107810	-0.36498868
9	14.51973506	14.15198279	.36775227
10	13.46441444	13.84506936	-0.38065492
11	16.60551982	16.45955543	.14596439
12	14.11139042	13.81551056	.29587986
13	14.84629928	15.66711003	-0.82081075
14	14.46844891	14.39212392	.07632498
15	16.04159909	16.07518815	-0.03358906
16	14.79516940	15.34373842	-0.54856901
17	14.79788237	14.68261105	.11527133
18	15.42190035	15.76569726	-0.34379692
19	17.50759040	17.57064581	-0.06305541
20	15.29234000	15.54539462	-0.25305462
21	13.95239100	14.23422089	-0.28182990
22	15.12253488	14.98799270	.13454218
23	15.57776981	15.32402255	.25374725
24	14.45071678	14.25376549	.19695129
25	15.62739291	15.33283318	.29455973
26	17.08549039	16.41820024	.66729015
27	14.07608369	13.57978822	.49629547
28	15.03299358	15.45644714	-0.42345356
29	14.51866577	14.54305917	-0.02439340
30	12.71079082	12.25486281	.45592801
31	16.27311511	16.56470270	-0.29158759
32	11.70791752	12.15477935	-0.44686183

33	14.52428961	14.55744790	-0.03315829
34	15.51385301	15.36519847	.14865455
35	15.51385301	15.36519847	.14865455
36	14.29929628	14.15910026	.14019601
37	14.80691365	15.03338627	-0.22647262
38	14.12300032	13.21767356	.90532676
39	13.91602389	14.20077296	-0.28474907
40	15.98194664	15.96377829	.01816835
41	18.88101560	18.99284603	-0.11183042
42	15.33587078	14.69097930	.64489148
43	15.39061933	14.91412285	.47649648
44	12.15687736	12.20607265	-0.04919529
45	14.40358402	14.57631639	-0.17273236
46	16.16985684	16.13298426	.03687257
47	16.71245393	16.96310518	-0.25065125
48	15.08618080	15.31065932	-0.22447853
49	15.14619516	14.76716843	.37902672
50	13.44962496	13.78505135	-0.33542639
51	14.81146135	14.55267462	.25878673
52	17.05442431	17.48571675	-0.43129244
53	15.22223980	14.84155215	.38068765
54	14.56524135	13.47302025	1.09222110
55	14.56524135	15.48886180	-0.92362044
56	14.29278623	14.50865774	-0.21587151
57	13.48578128	13.36922346	.11655783
58	16.26672685	16.52222654	-0.25549969
59	13.57841088	13.82546089	-0.24705001
60	15.48243211	15.34590526	.13652684
61	13.83052383	14.02252473	-0.19200090
62	14.53994999	14.77102200	-0.23107201
63	14.34071447	14.49860740	-0.15789293
64	15.31296807	15.15313975	.15982832
65	14.85897713	15.03928599	-0.18030886
66	16.49172447	16.70699281	-0.21526834
67	14.02664754	14.07787482	-0.05122729
68	15.68346345	15.44475110	.23871235
69	15.80195092	16.29036687	-0.48841595
DEVIATIONS1111*	9.14561244	9.14561358	-0.00000114

ANALYSIS OF VARIANCE TABLE , REGRESSION COEFFICIENTS , AND STATISTICS OF FIT FOR VARIABLE X 5 WDMODEL

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
REGRESSION	1	92.48169519	92.48169519	556.37222279
DEVIATIONS	67	11.13692115	.16622270	
TOTAL	68	103.61861634		

R-SQUARE = .89252007 SIGMA = .40770419

SOURCE	SS FOR X(I) ADJ	SS IF X(I) LAST	T FOR Ho B(I)=0	B VALUES	STD ERROR B	STD B VALUES
X 0				5.01265813		
X 1	92.48169519	92.48169519	23.58754381	1.01201589	.04290467	.94473281

SET	EXPECTED	OBSERVED	DIFFERENCE
1	14.51818124	14.15198279	.36619844
2	14.16919719	13.77468856	.39450862
3	14.87067315	14.76329996	.10737319
4	15.13160030	15.06254285	.06905745
5	15.85581915	16.38735914	-0.53153999
6	15.21965720	15.55422081	-0.33456361
7	14.80932007	14.22097567	.58834440
8	14.78083961	15.28107810	-0.50023849
9	14.73042175	14.15198279	.57843895
10	13.56957408	13.84506936	-0.27549528
11	16.88974644	16.45955543	.43019101
12	13.92837927	13.81551056	.11286871
13	14.70969715	15.66711003	-0.95741288
14	14.29235642	14.39212392	-0.09976750
15	16.19633440	16.07518815	.12114625
16	15.03514489	15.34373842	-0.30859353
17	14.92851837	14.68261105	.24590733
18	15.20692727	15.76569726	-0.55876999
19	17.39038690	17.57064581	-0.18025891
20	15.47375710	15.54539462	-0.07163752
21	14.10784411	14.23422089	-0.12637679
22	15.30066169	14.98799270	.31266900
23	15.49646354	15.32402255	.17244099
24	14.59918573	14.25376549	.34542024
25	15.47375710	15.33283318	.14092392
26	16.96010792	16.41820024	.54190768
27	14.19273350	13.57978822	.61294528
28	14.90000900	15.45644714	-0.55643814
29	14.59918573	14.54305917	.05612657
30	12.80134760	12.25486281	.54648479
31	16.45689640	16.56470270	-0.10780630
32	11.71227740	12.15477935	-0.44250195
33	14.67418418	14.55744790	.11673627
34	15.30066169	15.36519847	-0.06453678

35	15.30066169	15.36519847	-0.06453678
36	14.06257067	14.15910026	-0.09652959
37	14.63737954	15.03338627	-0.39600673
38	14.28175930	13.21767356	1.06408574
39	14.11427523	14.20077296	-0.08649773
40	16.25409037	15.96377829	.29031208
41	18.82259356	18.99284603	-0.17025246
42	15.17658619	14.69097930	.48560690
43	15.35742512	14.91412285	.44330228
44	12.18792854	12.20607265	-0.01814410
45	14.52657976	14.57631639	-0.04973663
46	16.05890108	16.13298426	-0.07408318
47	16.61201200	16.96310518	-0.35109318
48	14.86470253	15.31065932	-0.44595679
49	14.98323526	14.76716843	.21606682
50	13.52556645	13.78505135	-0.25948490
51	14.67418418	14.55267462	.12150955
52	17.31348796	17.48571675	-0.17222879
53	15.36109851	14.84155215	.51954635
54	14.33366893	13.47302025	.86064868
55	14.33366893	15.48886180	-1.15519287
56	14.05593448	14.50865774	-0.45272326
57	13.63219297	13.36922346	.26296951
58	16.12547932	16.52222654	-0.39674722
59	13.68541736	13.82546089	-0.14004353
60	15.26863195	15.34590526	-0.07727332
61	13.89770977	14.02252473	-0.12481496
62	14.59918573	14.77102200	-0.17183627
63	14.10784411	14.49860740	-0.39076329
64	15.57214911	15.15313975	.41900936
65	14.80932007	15.03928599	-0.22996592
66	16.29748122	16.70699281	-0.40951159
67	14.22704241	14.07787482	.14916759
68	15.85581915	15.44475110	.41106805
69	16.03674558	16.29036687	-0.25362129
DEVIATIONS1111*	11.13692115	11.13692203	-0.00000087

ANALYSIS OF VARIANCE TABLE , REGRESSION COEFFICIENTS , AND STATISTICS OF FIT FOR VARIABLE X 5 WOMODEL

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
REGRESSION	3	32.56577933	10.85525978	62.84224303
DEVIATIONS	25	4.31845652	.17273826	
TOTAL	28	36.88423586		

R-SQUARE =	.88291864	SIGMA =	.41561793	

SOURCE	SS FOR X(I) ADJ	SS IF X(I) LAST	T FOR HO B(I)=0	B VALUES	STD ERROR B	STD B VALUES
X 0				97.66570569		
X 1	31.89119165	32.24518713	13.66275181	.99938803	.07314691	.94389242
X 3	.02064488	.20595522	-1.09192330	-2.84738951	2.60768271	-0.08167190
X 4	.65394280	.65394280	-1.94569879	-8.82741996	4.53688926	-0.14651343

SET	EXPECTED	OBSERVED	DIFFERENCE
1	15.43386297	15.06254285	.37132012
2	16.14904506	16.38735914	-0.23831407
3	15.52082109	15.55422081	-0.03339971
4	15.05087844	15.28107810	-0.23019966
5	13.91323388	13.81551056	.09772332
6	14.98062369	15.66711003	-0.68648634
7	14.27266935	14.39212392	-0.11945457
8	15.46071856	15.34373842	.11698014
9	15.50825001	15.76569726	-0.25744725
10	17.33204283	17.57064581	-0.23860298
11	15.43932860	15.33283318	.10649542
12	16.90713284	16.41820024	.48893260
13	15.16856084	15.45644714	-0.28788630
14	15.60081462	15.36519847	.23561635
15	14.37817261	14.15910026	.21907235
16	14.61338730	15.03338627	-0.41999897
17	19.04219967	18.99284603	.04935365
18	15.14586577	14.69097930	.45488647
19	16.31299235	16.13298426	.18000809
20	16.85920159	16.96310518	-0.10390359
21	15.17029553	15.31065932	-0.14036379
22	14.95492745	14.76716843	.18775902
23	14.94555384	14.55267462	.39287922
24	14.64588812	13.47302025	1.17286787
25	14.64588812	15.48986180	-0.84297367
26	14.37161922	14.50865774	-0.13703851
27	16.08291867	16.52222654	-0.43930786
28	15.56918474	15.34590526	.22327948
29	16.58519611	16.70699281	-0.12179670
DEVIATIONS1111*	4.31845652	4.31848764	-0.00003111

ANALYSIS OF VARIANCE TABLE , REGRESSION COEFFICIENTS , AND STATISTICS OF FIT FOR VARIABLE X F ... MODEL

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
REGRESSION	1	31.89119165	31.89119165	172.45234360
DEVIATIONS	27	4.99304420	.18492756	
TOTAL	28	36.88423586		

R-SQUARE = .86462932 SIGMA = .43003205

SOURCE	SS FOR X(I) ADJ	SS IF X(I) LAST	T FOR H0 B(I)=0	B VALUES	STD ERROR B	STD B VALUES
X 0				5.48488462		
X 1	31.89119165	31.89119165	13.13211116	.98452472	.07497079	.92985446

SET	EXPECTED	OBSERVED	DIFFERENCE
1	15.32894811	15.06254285	.26640526
2	16.03349373	16.38735914	-0.35386541
3	15.41461297	15.55422081	-0.13960784
4	14.98771575	15.28107810	-0.29336235
5	14.15841229	13.81551056	.34290174
6	14.91850586	15.66711003	-0.74860417
7	14.51250209	14.39212392	.12037817
8	15.23511289	15.34373842	-0.10862553
9	15.40222884	15.76569726	-0.36346842
10	17.52637531	17.57064581	-0.04427050
11	15.66181031	15.33283318	.32897712
12	17.10778476	16.41820024	.68958451
13	15.10364793	15.45644714	-0.35279921
14	15.49341599	15.36519847	.12821852
15	14.28895842	14.15910026	.12985816
16	14.84815274	15.03338627	-0.18523352
17	18.91967641	18.99284603	-0.07316961
18	15.37271197	14.69097930	.68173268
19	16.23105899	16.13298426	.09807472
20	16.76914477	16.96310518	-0.19396041
21	15.06930056	15.31065932	-0.24135876
22	15.18461337	14.76716843	.41744494
23	14.88395759	14.55267462	.33128297
24	14.55269236	13.47302025	1.07967211
25	14.55269236	15.48886180	-0.93616944
26	14.28250250	14.50865774	-0.22615524
27	16.29582864	16.52222654	-0.22639789
28	15.46225733	15.34590526	.11635206
29	16.46315815	16.70699281	-0.24383466
DEVIATIONS1111*	4.99304420	4.99304399	.00000021

APPENDIX C

FORM 17-A

BOCA RATON
PUMPAGE IN MILLION GALLONS/MONTH

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1961	89.9	93.3	122.5	128.9	104.2	90.5	132.8	105.1	102.9	88.5	96.1	108.9	1263.60
1962	105.7	114.8	125.9	106.5	153.8	89.6	95.9	109.4	105.4	127.9	111.5	125.2	1371.60
1963	96.0	76.9	131.3	161.2	130.9	96.2	185.0	172.0	95.6	125.7	133.9	132.2	1536.90
1964	106.6	105.4	157.0	187.3	133.9	161.1	164.6	171.7	126.0	136.5	145.6	146.3	1742.00
1965	163.7	123.9	197.4	251.9	257.0	157.8	182.7	185.4	141.5	129.7	130.6	161.9	2083.50
1966	114.3	150.2	182.8	209.6	172.6	92.5	137.2	165.4	120.3	132.7	168.7	172.5	1818.80
1967	151.6	159.1	205.8	289.5	288.8	142.6	221.8	188.3	169.5	150.5	193.7	200.9	2362.10
1968	224.6	207.4	264.4	332.9	188.6	113.1	263.8	270.2	207.2	161.6	240.9	299.8	2774.50
1969	205.0	251.1	223.8	277.7	220.6	207.0	270.4	259.8	191.9	227.0	254.9	250.3	2839.50
1970	270.2	258.6	265.1	440.2	410.0	229.8	306.9	364.1	314.7	317.3	376.0	388.0	3940.90
1971	375.6	323.8	431.7	440.3	308.7	264.6	354.4	341.1	257.2	295.2	290.2	326.8	4009.60
1972	329.9	304.0	427.4	397.7	311.1	232.5	336.8	426.7	352.6	436.8	337.7	340.8	4234.00
1973	382.1	345.3	461.1	509.5	410.3	296.3	240.2	247.7	215.3	249.7	357.0	393.9	4107.90
1974	430.3	457.7	612.0	560.6	575.3	412.5	441.5	384.9	490.5	461.6	446.4	455.8	5729.10
1975	535.7	436.3	596.8	688.7									2257.50
Monthly Avg.	105.3	114.3	128.08	145.17	173.63	151.57	196.84	231.21	236.63	328.41	334.13	352.83	
	342.33	477.43	188.13										

MIAMI-DADE
PUMPAGE IN MILLION GALLONS/DAY

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1960	93.4	93.8	101.4	101.3	97.5	86.4	102.7	91.4	83.5	82.9	88	94.1	1116.4
1961	92.9	99.8	106.6	116.7	105.7	97.5	106.6	107.7	102.2	96.4	93.7	100.2	1226
1962	97.6	113.4	112.4	110.2	122.3	95.1	101.4	104.2	96.0	104.6	95.8	106.0	1259
1963	105.0	105.3	125.5	134.4	119.1	105.3	123.0	120.0	107.0	105.7	111.1	113.6	1375
1964	116.5	118	127.9	135.3	118.5	119.4	127.7	130.1	125.2	117.2	122.4	122.4	1480.6
1965	130.3	130.1	143	161.6	166.1	143.1	145	137	134.2	127.7	129.8	138.1	1686
1966	119.1	132.5	127.7	133.1	135.4	115.3	122.9	127.7	126.8	123.1	124.1	129.4	1759.7
1967	129.5	131.4	140.7	148.9	156.7	124.4	130.4	125.9	135.3	119.4	122.0	133.0	1597.6
1968	130.9	134.7	141.4	166.0	131.3	122.5	138.5	140.0	130.5	125.5	133.8	148.2	1643.3
1969	133.8	142.2	139.2	141.1	134.2	131.3	140.9	140.3	134.9	134.0	133.1	140.3	1645.3
1970	139.2	142.5	144.5	172.3	169.7	144.8	148.6	158.7	152.1	144.8	154.3	164.9	1836.4
1971	165.9	163.4	176.9	185.0	152.9	146.1	159.9	152.1	146.4	150.2	151.2	159.2	1909.2
1972	155.2	155.6	166.8	174.6	158.0	154.6	165.7	173.7	160.4	165.0	160.3	162.0	1951.9
1973	166.6	165.6	180.3	193.3	187.4	178.4	173.3	172.5	172.1	173.3	182.8	180.4	2126
1974	182.7	194.3	202.4	205.0	194.0	181.0	180.5	187.3	186.7	178.5	132.7	180.1	2249.2
Monthly Avg.	93.0	102.1	104.9	114.5	123.3	140.5	146.6	133.1	136.9	137.1	153.0	159.1	
	162.6	177.1	187.4										

FORM 17-A

WEST PALM BEACH
PUMPAGE IN MILLION GALLONS/MONTH

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1955	300.7	288.3	380	348.9	354.6	271.8	313.4	325.4	371.6	330.0	343.2	269.9	3897.8
1956	315.9	336.1	427.5	395.3	369.5	306.8	319.7	308.8	213.2	268.2	294.9	316.0	3871.9
1957	343.9	291.7	326.0	307.6	292.2	281.2	306.8	266.3	264.6	270.4	316.5	326.3	3593.5
1958	257.5	292.9	308.3	327.9	310.6	330.6	389.4	334.6	288.1	325.3	297.1	281.6	3743.9
1959	305.5	331.2	323.7	383.4	387.3	343.1	364.4	327.2	268.3	296.5	272.1	339.9	3941.6
1960	387.4	305.4	379.4	389.0	446.4	334.3	454.9	393.3	243.2	282.7	315.9	380.1	4311.9
1961	366.2	379.0	459.8	445.9	393.1	385.6	503.1	428.5	458.7	362.8	373.8	404.6	4961.1
1962	405.2	433.5	480.0	422.0	498.2	318.0	337.1	362.5	351.4	361.9	361.6	397.6	4729.0
1963	343.6	297.1	418.3	525.2	415.9	370.4	543.6	445.2	299.4	330.1	360.2	380.9	4629.9
1964	325.0	328.1	455.2	460.0	393.3	408.7	434.3	417.5	327.6	357.6	324.4	330.3	4562.0
1965	380.0	313.9	441.2	545.2	540.8	328.4	437.6	496.7	425.2	359.3	361.9	428.1	5103.2
1966	321.1	364.7	437.5	454.9	453.9	299.7	358.0	323.4	315.1	329.4	396.0	414.4	4468.1
1967	390.8	374.4	487.4	593.1	622.8	384.9	461.6	404.7	389.6	338.6	404.6	470.8	5323.2
1968	451.1	369.1	482.6	560.1	383.9	374.7	466.0	464.9	339.7	265.3	357.2	416.9	4832.0
1969	409.1	435.6	401.1	499.1	395.4	399.9	500	433.7	362.9	369.4	401.4	450.1	5058.6
1970	437.0	399.2	461.8	608.6	642.5	430.7	543.2	594.4	516.9	454.8	535.3	584.6	6209.3
1971	551.6	499.0	642.6	630.1	491.1	408.4	557.8	519.4	417.6	457.9	436.4	489.0	6101.4
1972	487.4	449.4	578.3	507.2	396.9	362.8	515.0	575.7	547.7	566.4	464.5	496.6	5948.2
1973	500	435.8	569.0	626.4	648.5	504.7	498.2	536.5	471.5	496.8	541.5	525.6	6355.0
1974	493.8	534.5	702.1	700.8	661.3	531.6	565.4	567.9	597.1	538.2	559.7	555.8	7008.2
Monthly Avg.	324.8	322.6	299.4	311.9	328.4	359.3	413.4	394.0	385.8	380.1	425.3	372.3	
	443.6	402.7	421.5	517.4	508.4	495.7	529.5	584.0					

FORM 17-A

ESTIMATION OF SEASONAL VARIATION OF MUNICIPAL PUMPAGE IN MILLION GALLONS/MONTH

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1955	77.1	70.7	95.1	84.3	100.1	65.8	87.6	102.1	52.9	82.5	97.1	64.8	980.1
1956	88.0	93.6	117.1	112.4	100.7	107.1	121.3	93.4	35.6	49.2	68.3	83.1	1069.8
1957	93.7	85.1	75.2	73.3	53.6	93.2	76.2	56.9	68.5	62.5	83.2	77.5	898.9
1958	53.5	72.9	67.9	82.4	71.4	140.2	100.1	72.5	80.5	91.2	74.3	47.2	954.0
1959	64.0	69.6	63.0	104.7	103.3	82.9	86.0	85.4	60.2	82.1	61.8	94.9	957.9
1960	100.1	71.8	86.3	91.3	119.9	86.2	117.6	100.2	47.0	46.1	66.7	93.8	1027.0
1961	80.8	99.4	129.6	134.3	109.2	97.7	159.4	133.4	133.0	88.8	88.8	96.3	1350.7
1962	98.6	116.7	134.4	129.7	178.4	81.3	95.3	101.7	91.0	112.2	103.7	103.0	1346.0
1963	76.0	64.4	110.0	128.2	116.5	92.2	158.1	150.8	77.2	91.3	101.3	104.1	1270.1
1964	79.6	86.3	127.8	137.6	96.9	119.2	140.1	136.6	81.8	93.7	105.2	97.3	1302.1
1965	116.7	87.3	141.7	193.1	207.3	107.2	112.4	157.3	96.3	88.3	96.6	116.6	1520.8
1966	78.3	98.5	125.0	138.5	112.0	67.3	92.6	99.0	77.4	88.4	125.8	123.4	1226.2
1967	100.3	117.8	169.6	191.4	208.2	95.7	161.2	114.3	111.1	93.0	134.9	127.5	1625.0
1968	147.9	124.7	156.8	204.6	119.0	68.8	153.0	145.1	101.7	82.3	133.9	154.9	1581.7
1969	112.4	143.9	123.7	148.9	116.0	123.0	159.0	141.7	105.4	118.7	127.3	147.1	1567.1
1970	141.9	128.0	142.7	234.9	232.4	122.6	156.6	181.8	149.1	144.4	157.3	177.8	1969.5
1971	168.6	147.2	206.5	215.1	163.0	134.0	142.2	141.3	123.0	132.1	143.5	172.6	1889.1
1972	173.5	149.9	227.8	228.0	193.6	140.2	177.9	221.7	202.4	264.9	189.9	155.8	2325.6
1973	179.3	153.6	220.8	249.8	241.2	188.4	169.1	173.2	152.5	223.5	282.6	303.7	2537.7
Monthly Avg.	81.6	89.1	74.9	79.5	79.8	85.6	112.5	112.1	105.8	108.5	126.7	102.1	135.4
	131.8	164.1	157.4	193.8	211.5								

FORM 17-A

CITY OF BELLE GLADE
ESTIMATION OF SEASONAL VARIATION OF MUNICIPAL PUMPAGE IN MILLION GALLONS/MONTH

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1967	65.6	63.2	71.2	58.4	67.4	51.6	49.5	42.3	30.8	33.5	53.7	82.3	669.5
1968	92.6	83.8	88.1	73.8	72.2	65.1	48.7	52.7	46.7	57.3	67.3	90.8	8 9.1
1969	97.0	91.9	89.7	84.7	72.8	58.8	56.4	54.9	46.9	56.5	67.6	97.9	875.1
1970	108.1	98.3	102.8	98.6	106.4	91.1	0.0	58.9	56.8	67.3	95.1	108.7	1052.2
1971	111.3	100.0	102.6	103.3	103.5	92.6	63.5	63.0	63.6	94.1	100.4	103.8	1101.7
1972	107.8	100.4	114.0	101.7	113.3	109.4	110.0	95.4	65.7	97.1	107.6	107.6	1230.0
1973	104.9	100.8	115.9	113.1	119.9	106.3	103.2	99.9	78.6	113.3	104.5	108.1	1268.5
1974	107.6	98.9	119.3	116.5	109.4	94.3	105.3	107.0	96.8	90.9	105.2	109.6	1260.8
Monthly Avg.	55.7	69.9	72.9	87.6	91.8	102.5	105.7	105.0					
1967	1.18	1.13	1.28	1.05	1.21	.93	.89	.76	.55	.60	.96	1.48	
1968	1.32	1.20	1.26	1.06	1.03	.93	.70	.75	.67	.82	.96	1.30	
1969	1.33	1.26	1.23	1.16	1.00	.81	.77	.75	.64	.78	.93	1.34	
1970	1.23	1.12	1.17	1.13	1.21	1.04	.68	.67	.65	.77	1.09	1.24	
1971	1.21	1.09	1.12	1.13	1.13	1.01	.69	.69	.69	1.03	1.09	1.13	
1972	1.05	.98	1.11	.99	1.11	1.07	1.07	.93	.64	.95	1.05	1.05	
1973	.99	.95	1.10	1.07	1.13	1.01	.98	.95	.74	1.07	.99	1.02	
1974	1.02	.94	1.14	1.11	1.04	.90	1.00	1.02	.92	.87	1.00	1.04	
Average	1.17	1.08	1.18	1.09	1.11	.96	.85	.82	.69	.86	1.01	1.20	12.02

DELRAY BEACH
MONTHLY PERCENTAGE
MONTHLY VALUES/MONTHLY AVERAGE

FORM 17-A

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MONTHLY AVERAGE
1955	.94	.87	1.17	1.03	1.23	.81	1.07	1.25	.65	1.01	1.19	.79	81.6
1956	.99	1.05	1.32	1.26	1.13	1.20	1.37	1.05	.40	.55	.77	.93	89.1
1957	1.25	1.14	1.00	.98	.72	1.24	1.02	.76	.91	.83	1.11	1.03	74.9
1958	.67	.92	.85	1.04	.90	1.76	1.26	.91	1.01	1.15	.93	.59	79.5
1959	.80	.87	.79	1.31	1.29	1.04	1.09	1.07	.75	1.03	.77	1.19	79.8
1960	1.17	.84	1.01	1.07	1.40	1.01	1.37	1.17	.55	.54	.78	1.10	85.6
1961	.72	.88	1.15	1.19	.97	.87	1.42	1.19	1.18	.79	.79	.86	112.5
1962	.88	1.04	1.20	1.16	1.59	.73	.85	.91	.81	1.00	.93	.92	112.1
1963	.72	.61	1.04	1.21	1.10	.87	1.49	1.43	.73	.86	.96	.98	105.8
1964	.73	.79	1.18	1.27	.89	1.10	1.29	1.26	.75	.86	.97	.90	108.5
1965	.92	.67	1.12	1.52	1.64	.85	.89	1.24	.76	.70	.76	.92	126.7
1966	.77	.96	1.22	1.36	1.10	.66	.91	.97	.76	.87	1.23	1.21	102.1
1967	.74	.87	1.25	1.41	1.54	.71	1.19	.84	.82	.69	1.00	.94	135.4
1968	1.12	.95	1.19	1.55	.90	.52	1.16	1.10	.77	.62	.93	1.18	131.8
1969	.86	1.10	.95	1.14	.89	.94	1.22	1.09	.81	.91	.98	1.13	130.5
1970	.86	.78	.87	1.43	1.42	.75	.95	1.11	.91	.88	.96	1.08	164.1
1971	1.07	.94	1.31	1.37	1.04	.85	.90	.90	.78	.84	.91	1.10	157.4
1972	.90	.77	1.18	1.18	1.00	.72	.92	1.14	1.04	1.37	.98	.80	193.8
1973	.85	.73	1.04	1.18	1.14	.89	.80	.82	.72	1.06	1.34	1.44	211.5
	.89	.88	1.10	1.25	1.15	.92	1.11	1.06	.80	.87	.96	1.00	11.99

APPENDIX D

FORM 17-A

BOCA RATON
MONTHLY PERCENTAGE
MONTHLY VALUES/MONTHLY AVERAGE

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1961	0.85	0.89	1.16	1.22	0.99	0.86	1.26	1.00	0.98	0.84	0.91	1.03
1962	0.92	1.00	1.10	0.93	1.35	0.78	0.84	0.96	0.92	1.12	0.98	1.10
1963	0.79	0.60	1.03	1.26	1.02	.75	1.44	1.34	0.75	0.98	1.05	1.03
1964	0.73	0.73	1.08	1.29	0.92	1.11	1.13	1.18	0.87	0.94	1.00	1.01
1965	0.94	0.71	1.13	1.45	1.48	.90	1.05	1.06	.81	.74	.75	.93
1966	.75	.99	1.20	1.38	1.13	.61	.90	1.09	.79	.87	1.11	1.13
1967	.77	.80	1.04	1.47	1.46	.72	1.12	.95	.86	.76	.98	1.02
1968	.97	.89	1.14	1.43	.81	.49	1.14	1.16	.89	.69	1.04	1.29
1969	.86	1.06	.94	1.17	.93	.87	1.14	1.09	.81	.95	1.07	1.05
1970	.82	.79	.81	1.34	1.25	.70	.93	1.11	.96	.97	1.14	1.18
1971	1.12	.97	1.29	1.31	.92	.79	1.06	1.02	1.07	.88	.87	.98
1972	.93	.86	1.21	1.13	.88	.66	.95	1.21	1.00	1.24	.96	.96
1973	1.12	1.00	1.35	1.49	1.20	.86	.70	.72	.63	.73	1.04	1.15
1974	.90	.96	1.28	1.17	1.20	.86	.92	.80	1.03	.97	.93	.95
	.89	.88	1.13	1.29	1.11	.78	1.04	1.05	.88	.90	.99	1.06

MONTHLY PERCENTAGE

MONTHLY VALUES/MONTHLY AVERAGE

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1960	1.00	1.00	1.09	1.09	1.05	.93	1.10	.98	.89	.89	.95	1.01
1961	.91	.98	1.04	1.14	1.03	.95	1.04	1.05	1.00	.94	.92	.98
1962	.93	1.08	1.07	1.05	1.16	.91	.97	.99	.92	.97	.91	1.01
1963	.92	.92	1.09	1.17	1.04	.92	1.07	1.05	.93	.92	.99	.99
1964	.94	.96	1.04	1.10	.96	.97	1.03	1.05	1.01	.95	.99	.99
1965	.93	.92	1.01	1.15	1.18	1.02	1.03	.97	.95	.91	.92	.98
1966	.81	.90	.87	.91	.92	.79	.84	.87	.86	.84	.85	.88
1967	.97	.99	1.05	1.11	1.17	.93	.98	.94	1.01	.89	.92	1.00
1968	.96	.98	1.03	1.21	.96	.89	1.01	1.02	.95	.92	.98	1.08
1969	.97	1.04	1.01	1.03	.98	.96	1.03	1.02	.98	.98	.97	1.02
1970	.91	.93	.94	1.13	1.11	.95	.97	1.03	.99	.95	1.00	1.08
1971	1.04	1.02	1.11	1.16	.96	.92	1.00	.96	.92	.94	.95	1.00
1972	.95	.96	1.02	1.07	.97	.95	1.01	1.06	.99	1.01	.98	1.00
1973	.94	.93	1.02	1.09	1.06	1.00	.98	.97	.97	.98	1.03	1.01
1974	.97	1.03	1.08	1.09	1.03	.96	.96	1.00	1.00	.95	.97	.96
	.94	.98	1.03	1.10	.97	.94	1.00	1.06	.96	.94	.95	.93
	.96	1.00	1.05	1. 2	.99	.96	1.02	1.08	.98	.96	.97	.95

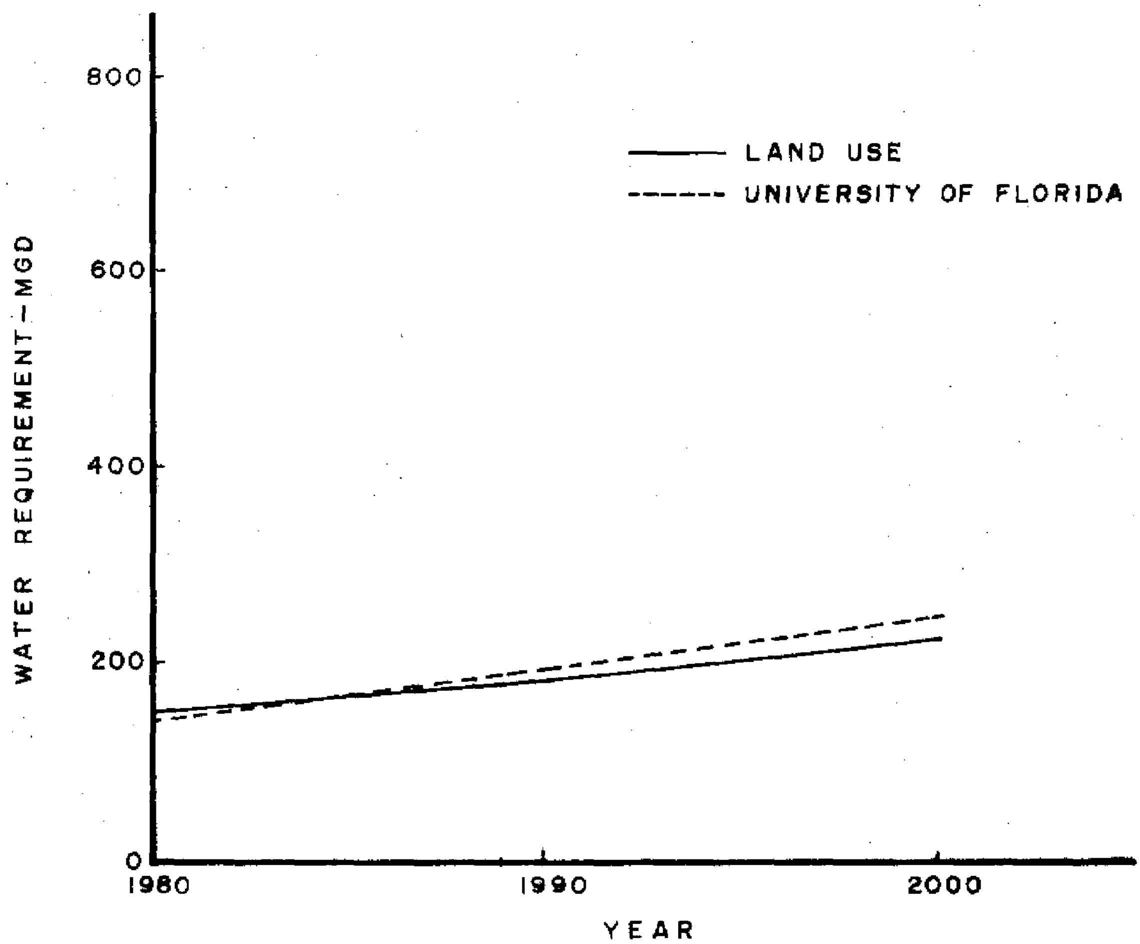
WEST PALM BEACH

MONTHLY PERCENTAGE

MONTHLY VALUES/MONTHLY AVERAGE

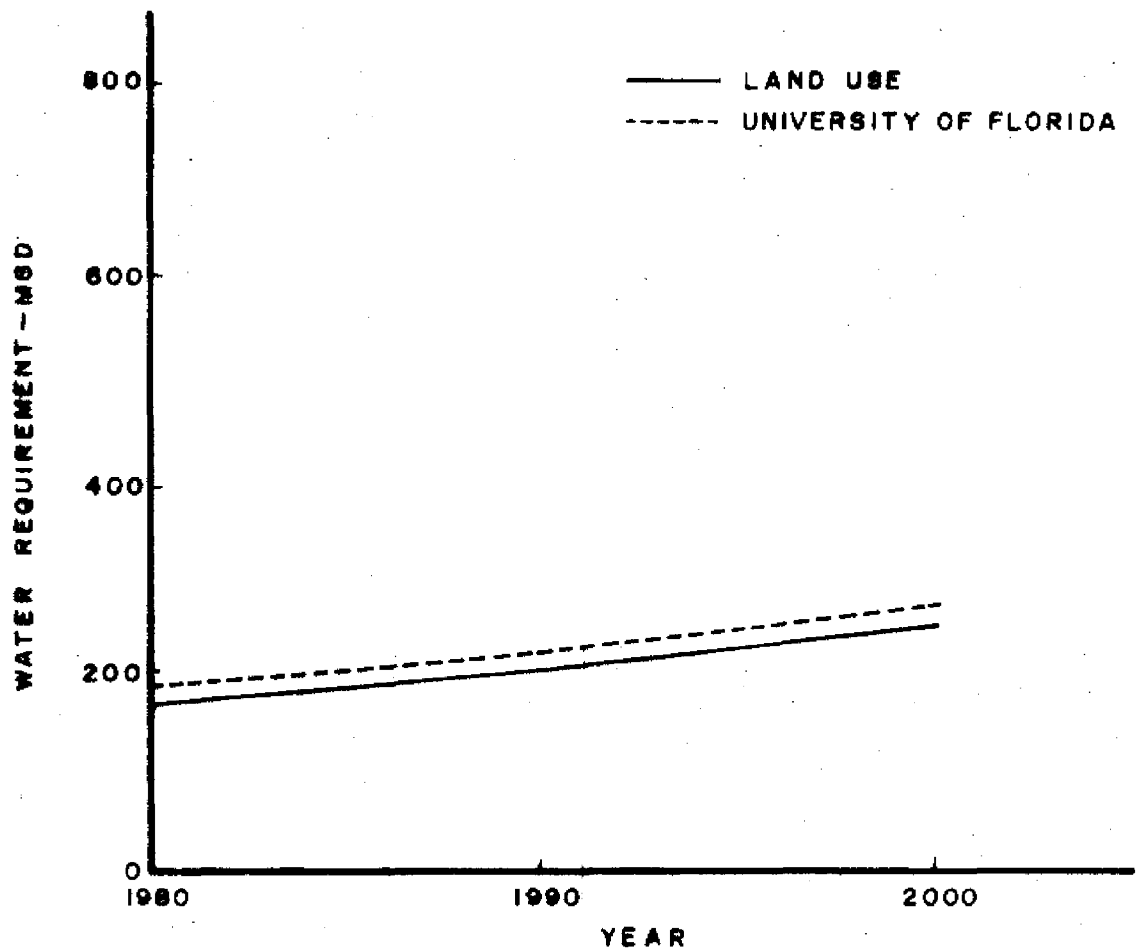
FORM 17-A

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1955	.92	.98	1.17	1.07	1.09	.84	.96	1.00	1.14	1.02	1.06	.83
1956	.98	1.04	1.32	1.22	1.14	.95	.99	.96	.66	.83	.91	.98
1957	1.15	.97	1.09	1.03	.97	.94	1.02	.89	.88	.90	1.06	1.09
1958	.82	.94	.99	1.05	.99	1.06	1.25	1.07	.92	1.04	.95	.90
1959	.93	1.01	.98	1.17	1.18	1.04	1.11	.99	.82	.90	.83	1.03
1960	1.08	.85	1.05	1.08	1.24	.93	1.27	1.09	.68	.79	.88	1.06
1961	.88	.92	1.11	1.08	.95	.93	1.22	1.04	1.11	.88	.90	.98
1962	1.03	1.10	1.22	1.07	1.26	.81	.85	.92	.89	.92	.92	1.01
1963	.89	.77	1.08	1.36	1.08	.96	1.41	1.15	.78	.85	.93	.99
1964	.85	.86	1.11	1.21	1.03	1.07	1.14	1.10	.86	.94	.85	.87
1965	.89	.74	1.04	1.28	1.27	.89	1.03	1.16	1.00	.84	.85	1.00
1966	.86	.98	1.17	1.22	1.22	.80	.96	.87	.85	.88	1.06	1.11
1967	.88	.84	1.09	1.34	1.40	.87	1.04	.91	.88	.76	.91	1.06
1968	1.12	.92	1.19	1.39	.95	.93	1.16	1.15	.84	.66	.89	1.03
1969	.97	1.03	.95	1.18	.94	.95	1.19	1.03	.86	.88	.95	1.07
1970	.84	.77	.89	1.18	1.24	.83	1.05	1.15	1.00	.88	1.03	1.13
1971	1.08	.98	1.26	1.24	.96	.80	1.10	1.02	.82	.90	.86	.96
1972	.98	.91	1.17	1.02	.80	.73	1.04	1.16	1.10	1.14	.94	1.00
1973	.94	.82	1.07	1.18	1.22	.95	.94	1.01	.89	.94	1.02	.99
1974	.84	.91	1.20	1.20	1.13	.91	.97	.97	1.02	.92	.96	.95
	.95	.91	1.11	1.18	1.10	.91	1.08	1.03	.90	.89	.94	1.00



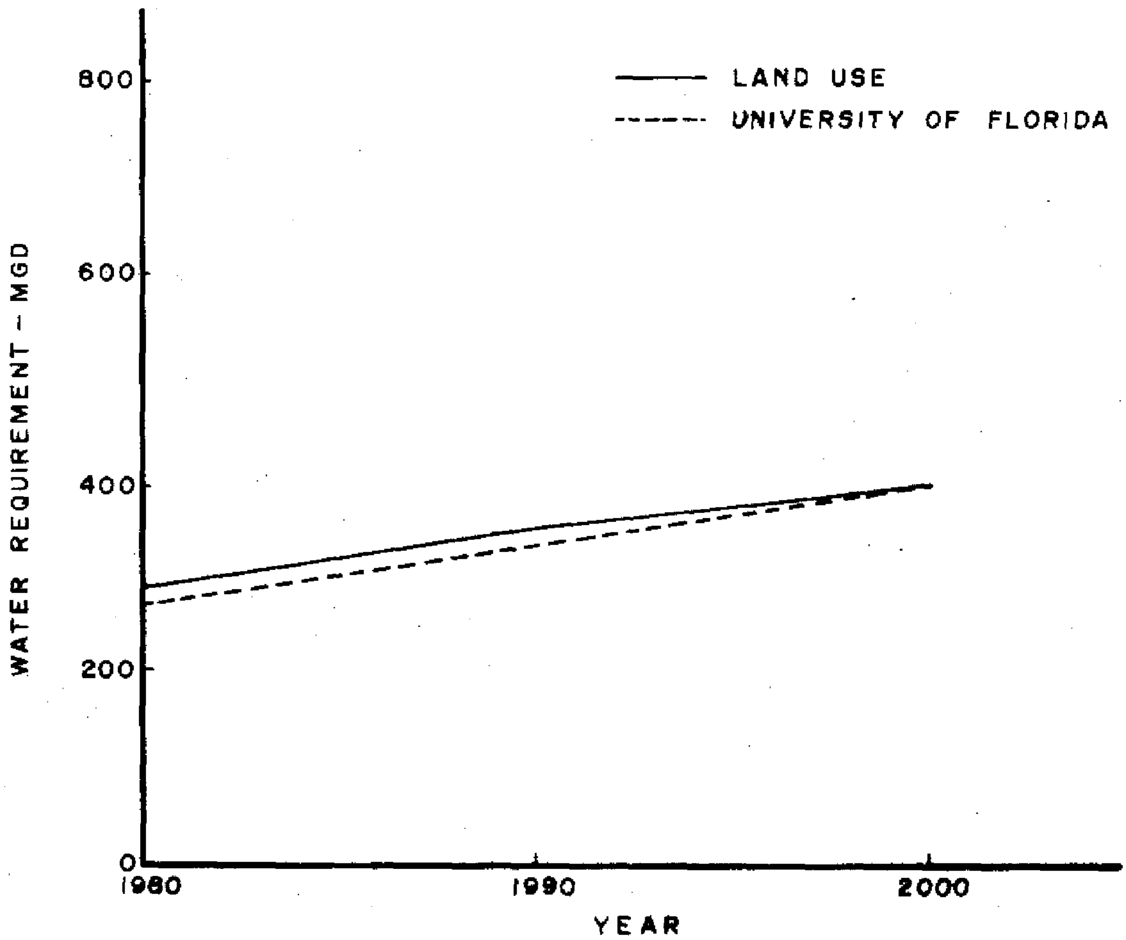
PROJECTED WATER REQUIREMENT
PALM BEACH COUNTY

FIGURE 3



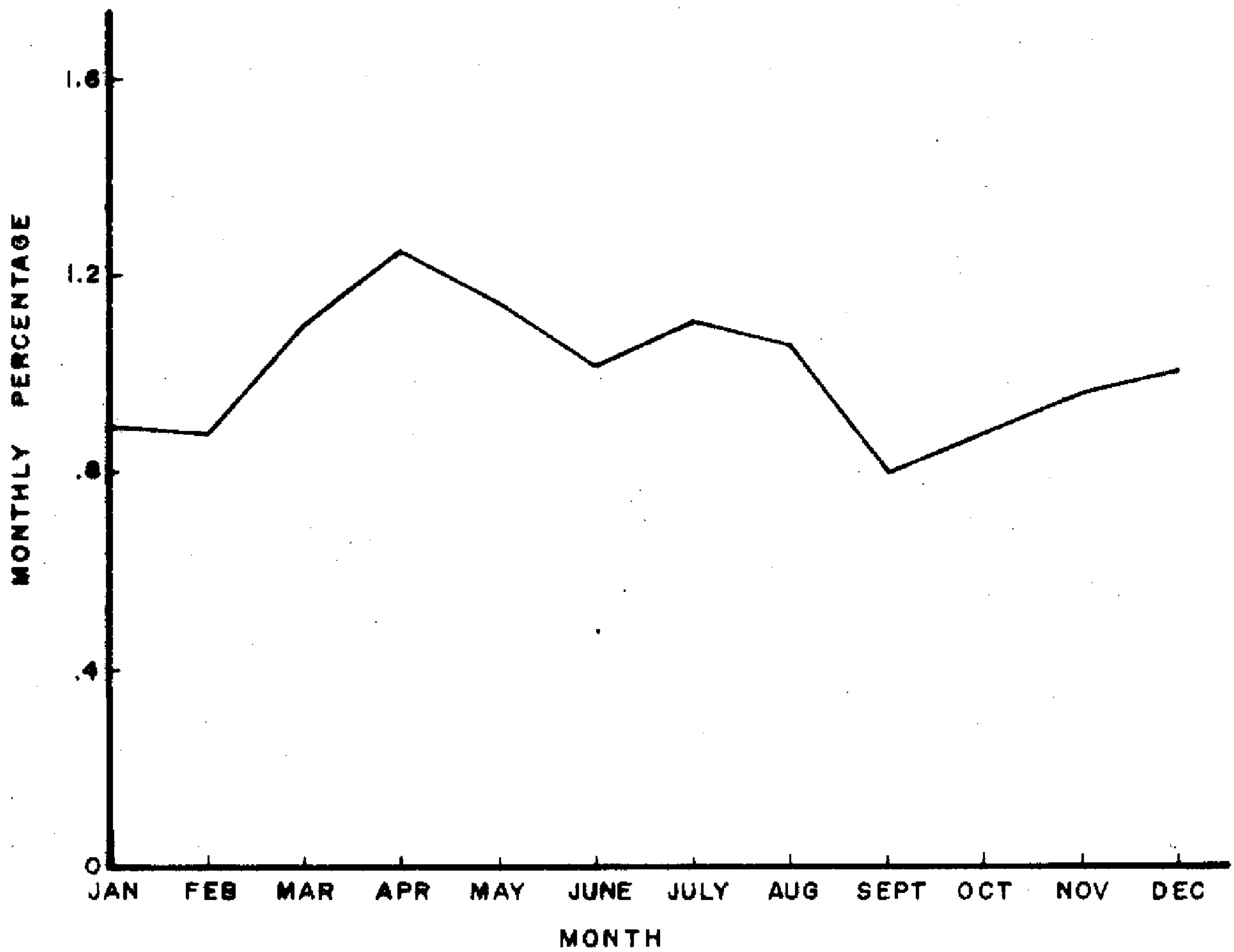
PROJECTED WATER REQUIREMENT
BROWARD COUNTY

FIGURE 4



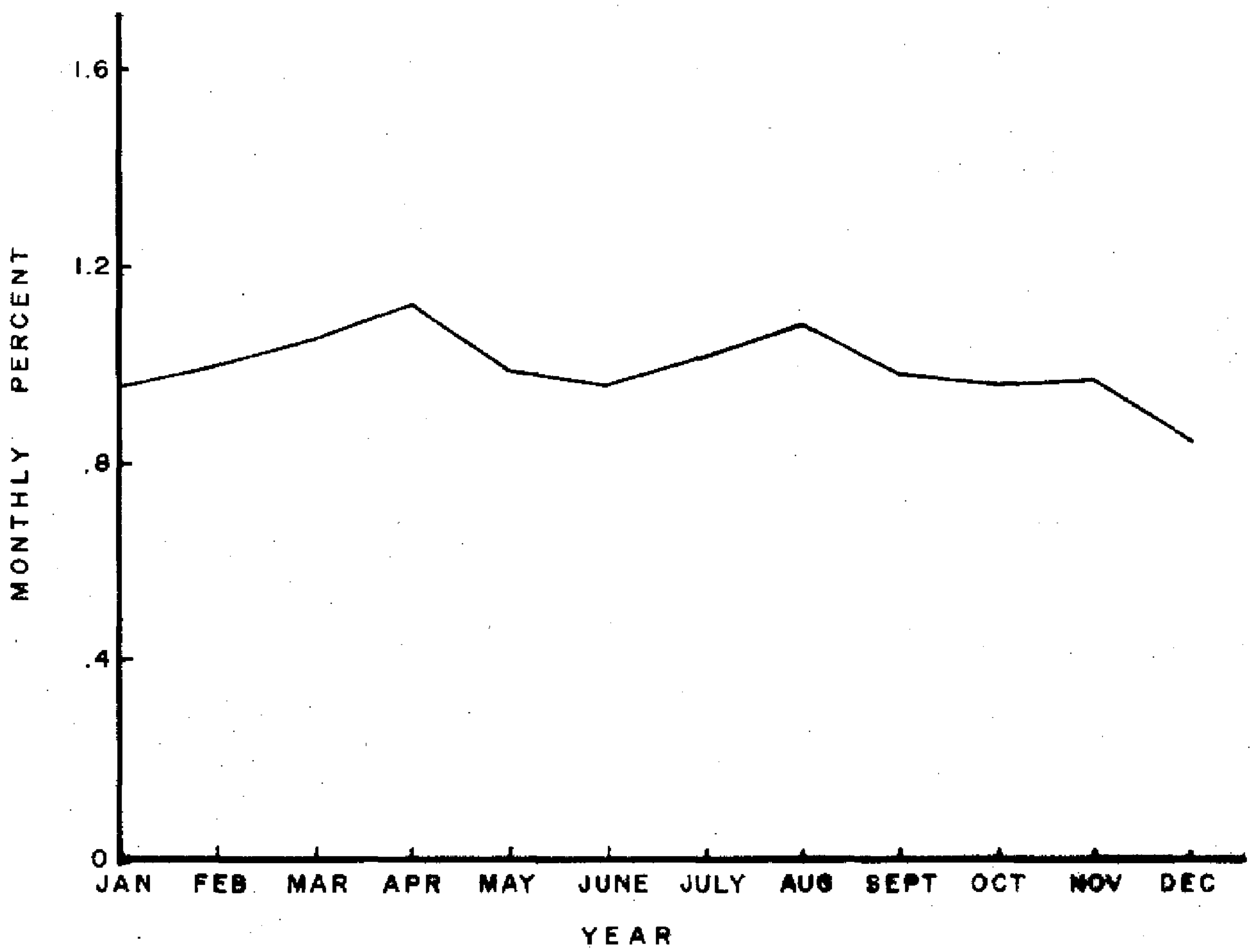
PROJECTED WATER REQUIREMENT
DADE COUNTY

FIGURE 5



SEASONAL PUMPAGE VARIATIONS
CITY OF DELRAY BEACH

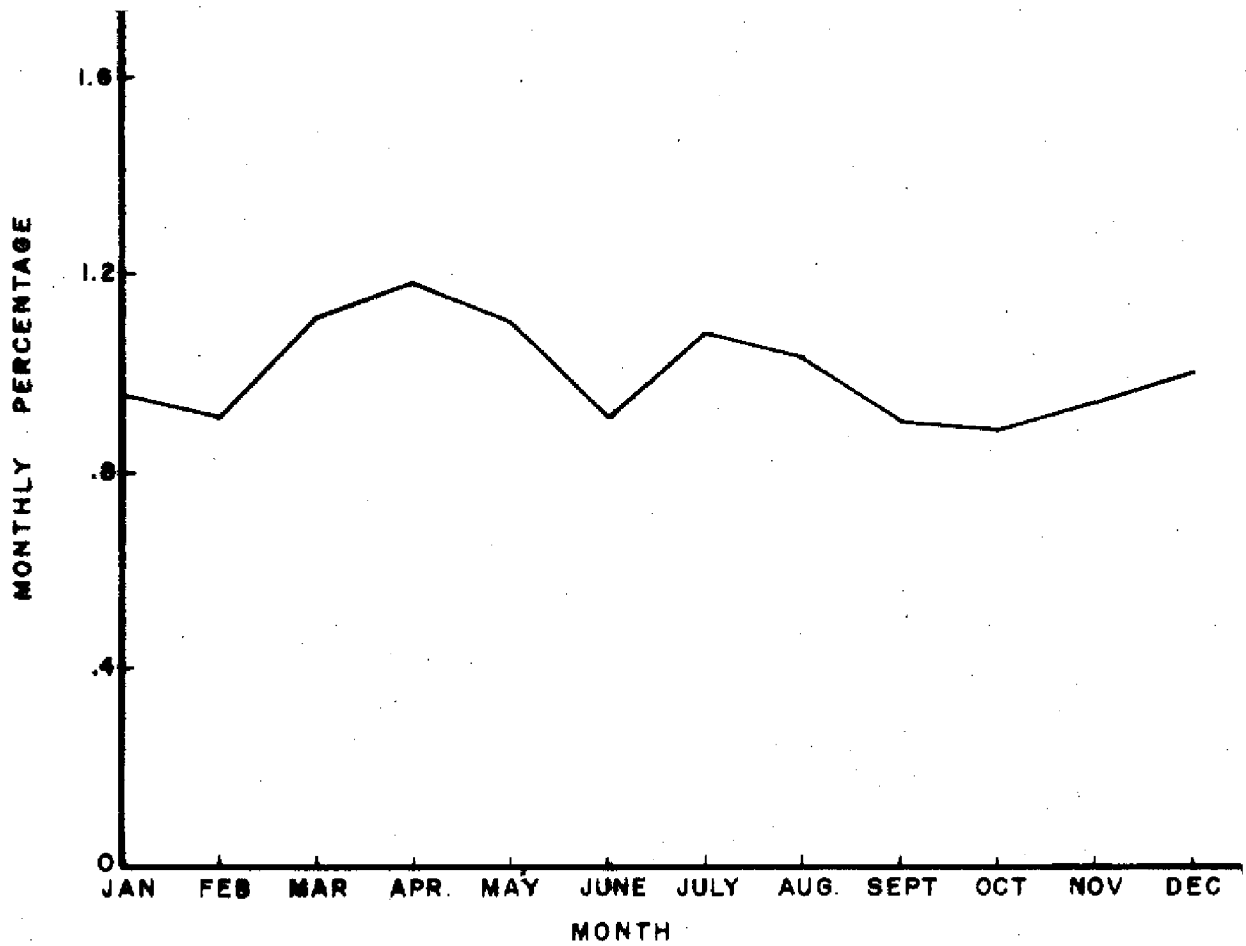
FIGURE 6



SEASONAL PUMPAGE VARIATIONS

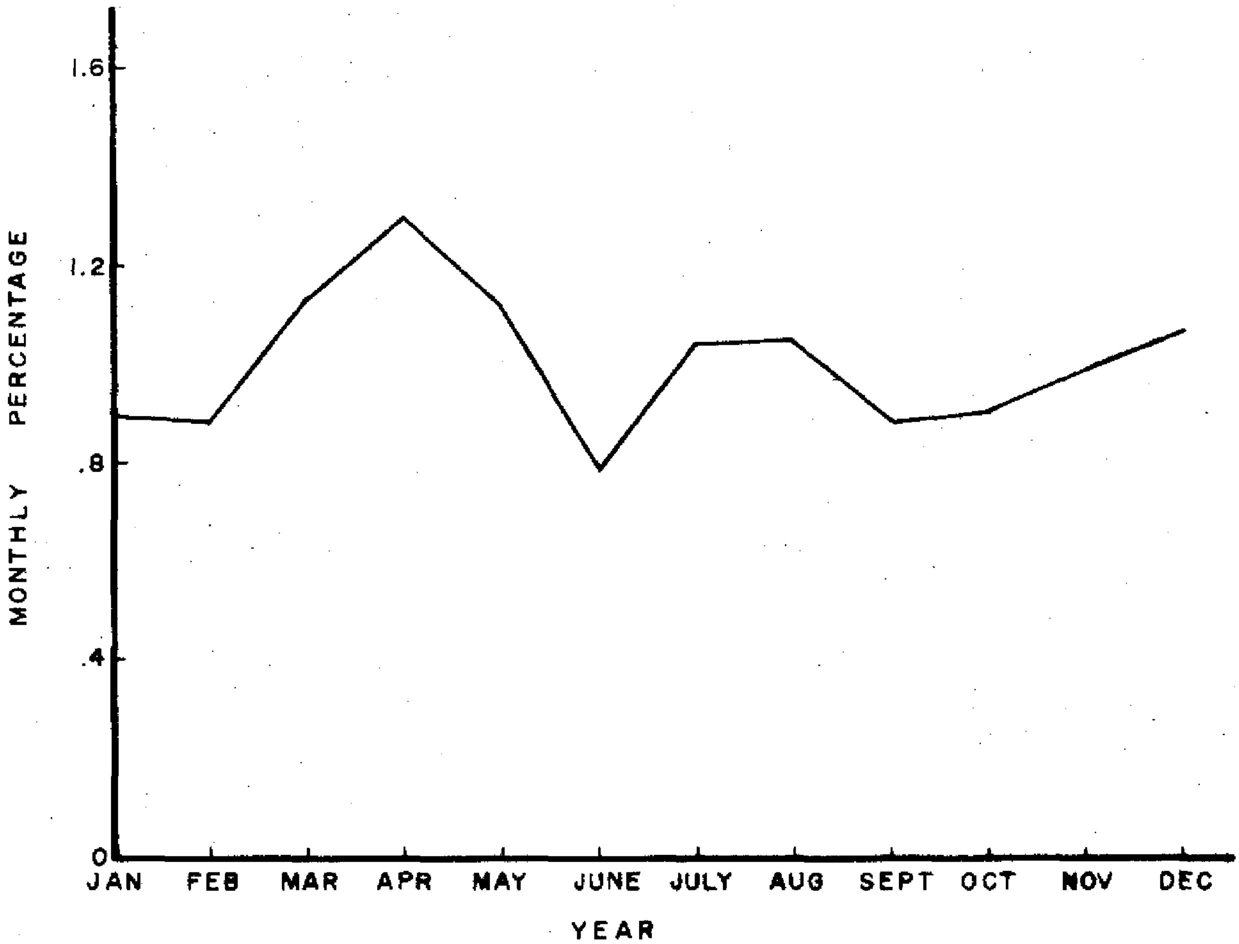
MIAMI-DADE SEWER & WATER AUTHORITY

FIGURE 7



SEASONAL PUMPAGE VARIATIONS
CITY OF WEST PALM BEACH

FIGURE 8



SEASONAL PUMPAGE VARIATIONS
CITY OF BOCA RATON

FIGURE 9