Technical Publication SJ 90-13

Investigation of Potato Water Use in the Tri-County Area of Putnam, St. Johns, and Flagler Counties, Florida

St. Johns River Water Management District

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INVESTIGATION OF POTATO WATER USE IN THE TRI-COUNTY AREA OF PUTNAM, ST. JOHNS, AND FLAGLER COUNTIES, FLORIDA

by

Vincent D. Singleton

St. Johns River Water Management District
Palatka, Florida

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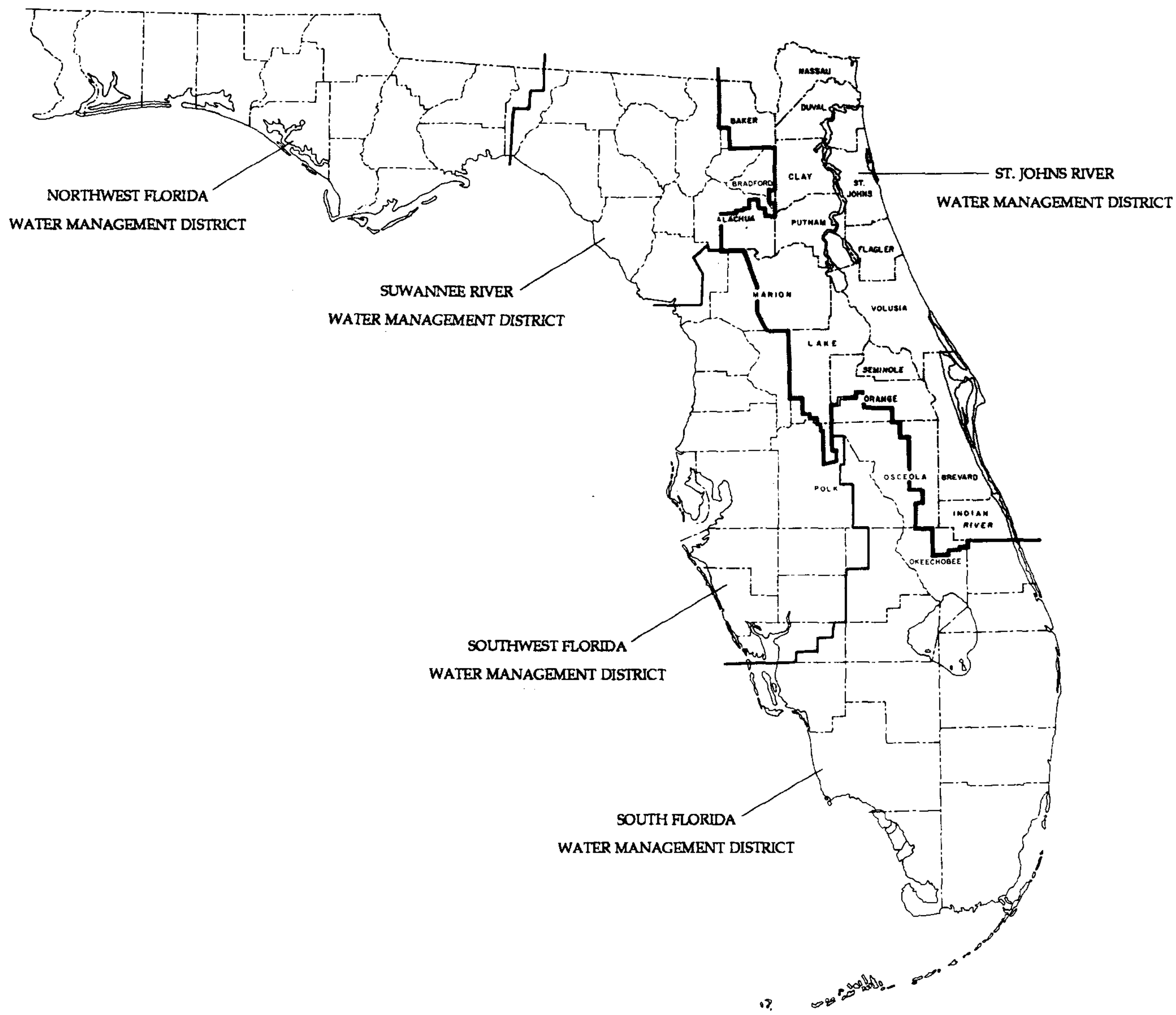

THE ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

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 parts of nineteen counties in northeast Florida. The mission of SJRWMD is to manage water resources to insure 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. Technical reports are published to disseminate information collected by SJRWMD in pursuit of its mission.

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INTRODUCTION

Approximately 94 percent (25,850 acres) of all irrigated potatoes grown in Florida are grown in the tri-county area of Putnam, Flagler, and St. Johns counties.

The tri-county area is located in northeast Florida (Figure 1). In this area, agricultural irrigation is the largest category of ground water use (Marella 1985), and ground water used for potato irrigation is greater than that used for irrigation of any other single crop. Potatoes are a seasonal crop and require irrigation during the spring months.

The St. Johns River Water Management District (SJRWMD) presently uses the modified Blaney-Criddle method of estimating supplemental irrigation requirements (irrigation that supplements rainfall) for various crops, including potatoes. This method is used in areas where few or no direct measurements of supplemental irrigation requirements are available.

PURPOSE AND SCOPE

The purpose of this report is to assess the accuracy of the Blaney-Criddle method of estimating irrigation requirements.

Water use for potatoes was investigated during the 1985-1986 growing season. This study resulted in a determination of the supplemental irrigation requirements for potatoes at selected sites and an estimation of the area-wide quantity of ground water withdrawn for this crop. In addition, estimates of supplemental irrigation requirements collected in the field were compared to estimates derived from the modified Blaney-Criddle model to examine the reliability of the modified Blaney-Criddle model in estimating water use for potato irrigation.

AGRICULTURAL SETTING

In the tri-county area of Putnam, Flagler, and St. Johns counties, potatoes are the major irrigated crop, accounting for 26,000 acres (51.6 percent) of the total acreage in the tri-county area. The

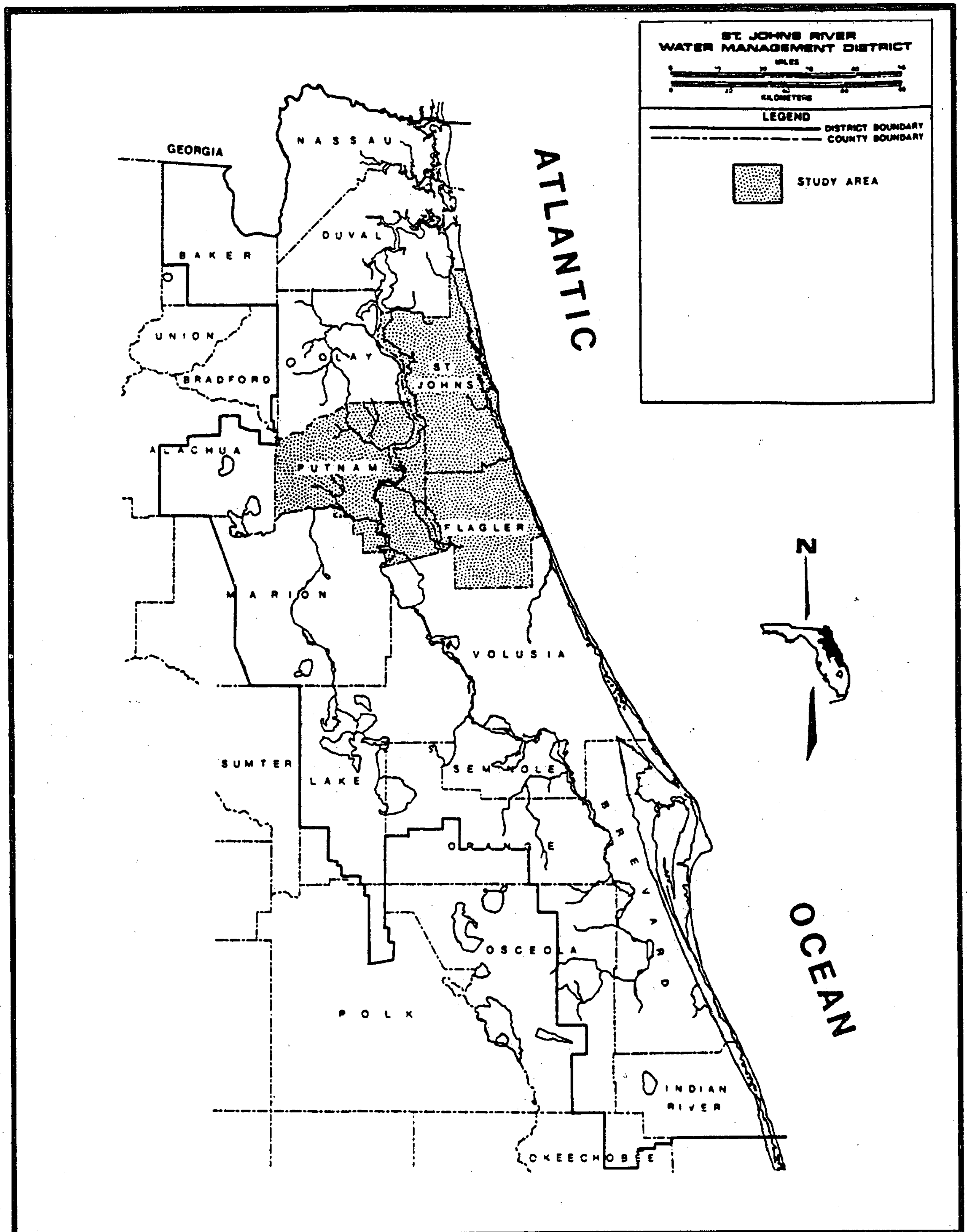

Figure 1. Delineation of the tri-county area in the St. Johns River Water Management District

primary production areas are Federal Point, East Palatka, and Orange Mills in Putnam County; Hastings, Elkton, and Tocoi in St. Johns County; and Bunnell in Flagler County (Figure 2). St. Johns County has the largest acreage of potatoes, accounting for 18,500 acres, with Putnam and Flagler counties having 4,500 and 3,000 acres, respectively.

The soils in the study area are generally described as poorly drained, nearly level, on low broad flats. However, due to a limited soil moisture holding capacity and uneven distribution of rainfall events, supplemental irrigation is required. Potatoes are grown from January through May, but the irrigation season is generally concentrated from February through May.

IRRIGATION METHODS

Before the mid-1960s, the open-ditch seepage irrigation system was generally used for potato irrigation. Water was pumped into a large open ditch, which delivered water to V-shaped furrows in the field. The open ditch method is not very efficient because water is lost to evaporation from the large surface area of the ditch, and because before each rainfall, water stored in the ditch is released to prevent floods.

However, since the mid-1960s, the semi-closed (pipeline) seepage system has replaced the open ditch. The pipeline system has eliminated the loss of water from the delivery system and has increased the potential for water use management.

In the semi-closed (pipeline) seepage irrigation system (Figure 3), water withdrawn from deep confined aquifers is pumped into underground polyvinyl chloride (PVC) pipe and delivered directly to each open V-shaped water furrow in the field through a valve which can be adjusted to increase or decrease the quantity of flow. These furrows are 60 ft apart. Water seeps from the furrow laterally underground to the planted areas. Seepage systems irrigate potatoes by raising the water table to just below the crop root zone. The water moves up through the soil to the root by capillarity. Semi-closed seepage irrigation systems are only 30-70 percent efficient (Smajstrla and others 1988). However, because they are inexpensive to install and operate compared to other types of systems (i.e., overhead sprinklers, center pivot, drip), they are quite popular.

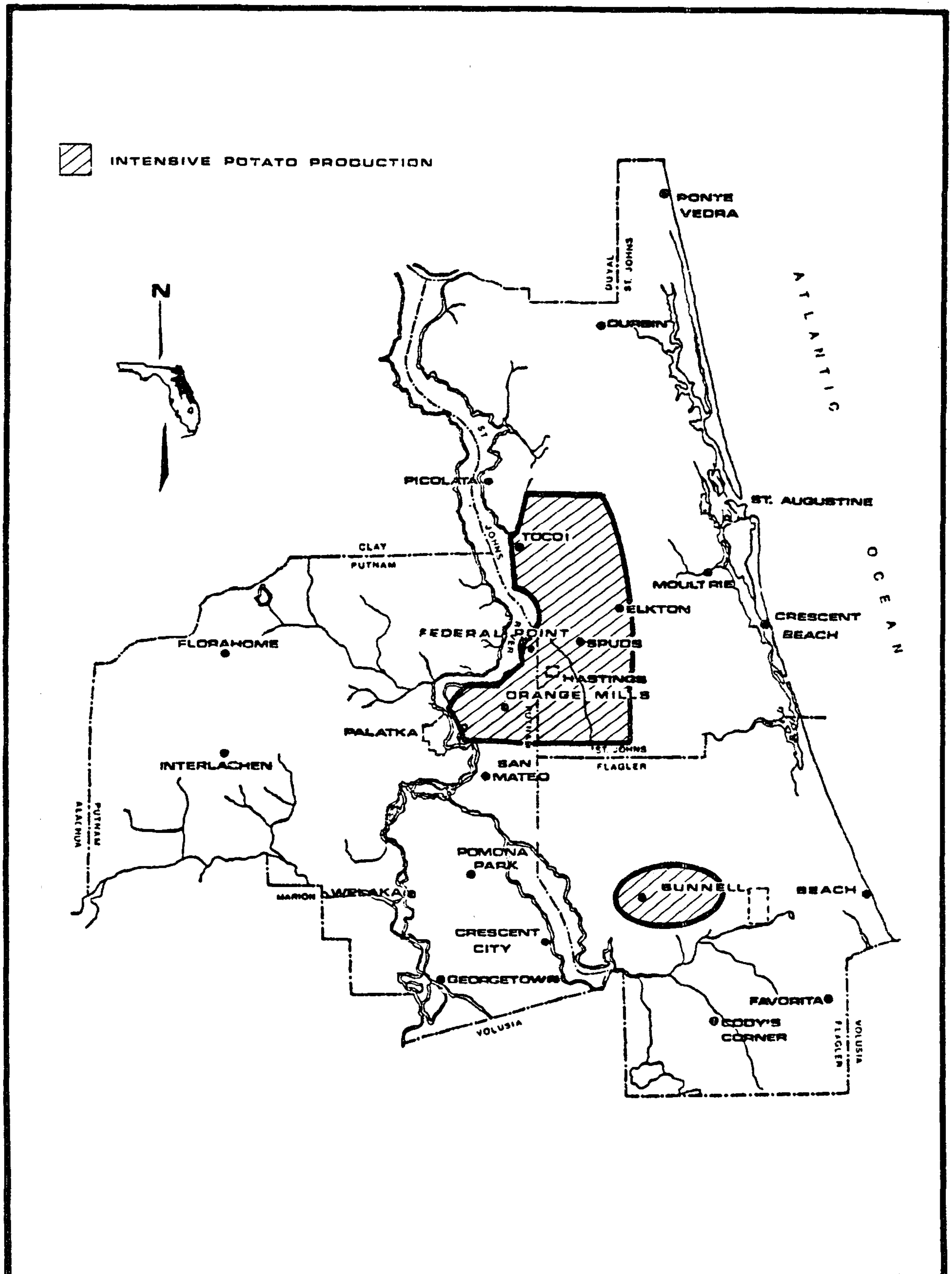

Figure 2. Location of intensive potato production in the tri-county area.

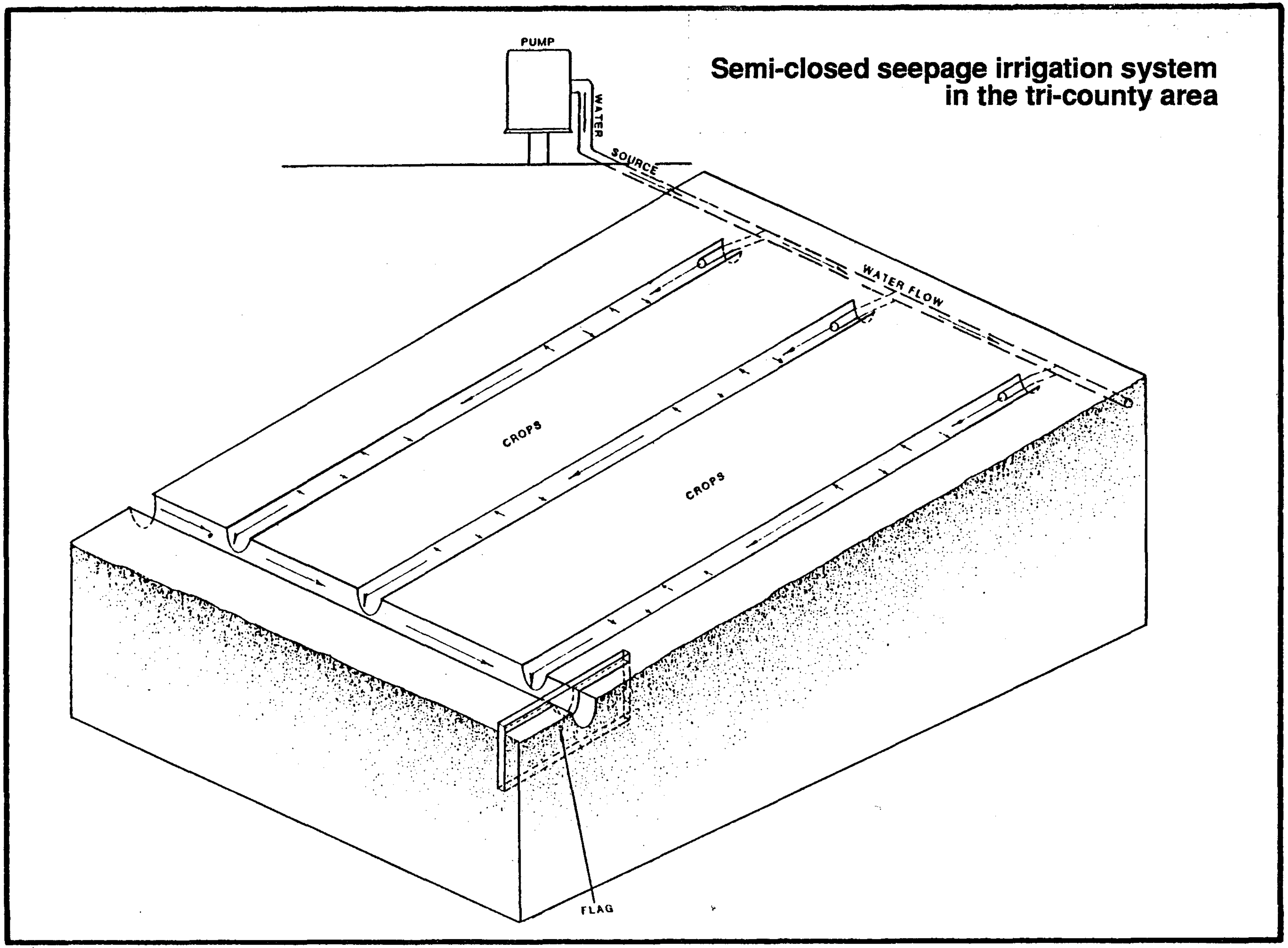

Figure 3. Typical profile of a semi-closed seepage irrigation system

WATER USE DETERMINATION

FIELD MEASUREMENTS

During fiscal year 1981-82, an agricultural irrigation monitoring program called "Benchmark Farms" was initiated by SJRWMD. This program established a monitoring network of agricultural water users throughout the district, in lieu of metering all individual agricultural water users. The purpose of this program was to collect actual field-measured data by which to evaluate agricultural water use.

POTATO IRRIGATION STUDY

For this study of potato irrigation, monitoring sites were established at 31 randomly chosen potato farms in the study area (Figure 4). Grower participation in this program was voluntary. The monitoring network consists of 17 farms in St. Johns County, 12 in Putnam County, and 2 in Flagler County. Each site was established after an on-site interview with the farm manager to determine the general characteristics of the site.

Farms in the study area all have the same type of irrigation system (the semi-closed seepage system). Although individual site sizes range from 15 to 125 acres, most average about 40 acres. The potato irrigation monitoring sites were selected to represent both ends of the scale of farm size, with a majority of sites being in the range of 30-40 acres.

After sites were selected for this study, an ultrasonic flow meter was attached to the system's piping, establishing the flow rate in gallons per minute (gpm). Although the flow rate is subject to change in response to changes in the potentiometric surface, this study assumed that the flow rate remained fairly constant throughout the season. Electrically powered pumps were used by all irrigators in this study. In order to determine the duration of the pumping, an electric hour meter was also installed on the irrigation pumps. Pumping duration data were collected monthly, and converted to gallons pumped monthly. This information was stored in a computer data base. The computer file for each site consisted of the site number, the acres irrigated, pumping rates (gpm) measured by a flow meter, and the duration of pumping monthly.

Water use was determined for 23 of the 31 monitored potato farms during the 1985 and 1986 growing seasons. Data from eight of the monitored sites are not reported due to equipment failure during both of the two years. The water use data from the remaining 23 sites are assumed to be representative of farms in the tri-county area. Average water used for both years was determined by weighted averages: total irrigation (acre-inches) for all operating sites was summed, then divided by the total acres irrigated for those sites. Data show that the average amount of irrigation water withdrawn for the potato farms monitored in the tri-county area was 19.48 inches in 1985 and 19.71 in 1986 (Table 1). On the monitored sites, the range in water use was 10.24 to 39.28 inches in 1985 and 8.80 to 29.43 inches in 1986. The wide range of use is due to varying soil types, differing farm management practices, and the different quantities of water use during different periods (early, middle, or late) of the crop growing season. Crops planted later generally used more water than the crops planted earlier. This was expected because crop water requirements or evapotranspiration (ET) increase as temperature and length of daylight hours increase.

Irrigation water use for the 1985 and 1986 growing seasons is very similar in total quantity, in view of the average application rate and irrigated acres. During the 1985 growing season, approximately 13.75 billion gallons of water (37.68 mgd averaged over the whole year) were used for irrigation, and during the 1986 season, approximately 13.92 billion gallons of water (38.12 mgd averaged over the year) were used (Figure 5). However, the time and intensity of use differs somewhat due to rainfall. Water use for potato irrigation generally took place over a four-month period, though the reported water use per day (mgd) figure is an average for 12 months.

The average monthly irrigation (inches) added to monthly rainfall totals (inches) from the Federal Point rainfall station gives the total inches of water applied to the farms (Figure 6) per month. These totals do not necessarily apply to the entire 26,000 acres of planted acreage in the study, due to the staggered planting schedule. For example, in January 1985, an average irrigation of 2.25 inches was applied (Figure 6) to potato farms irrigating during that month. However, only about 2,600 acres, or 10 percent of the farms in the area, were actually irrigated that month. On the other hand, the April 1985 figure applies to the entire 26,000 acres grown, as April is the peak of the growing season, when all farms are irrigated.

The growing/irrigation period for any selected field is about three months. Therefore, the monthly water requirement on a selected farm should be determined based on the growth period for that farm site.

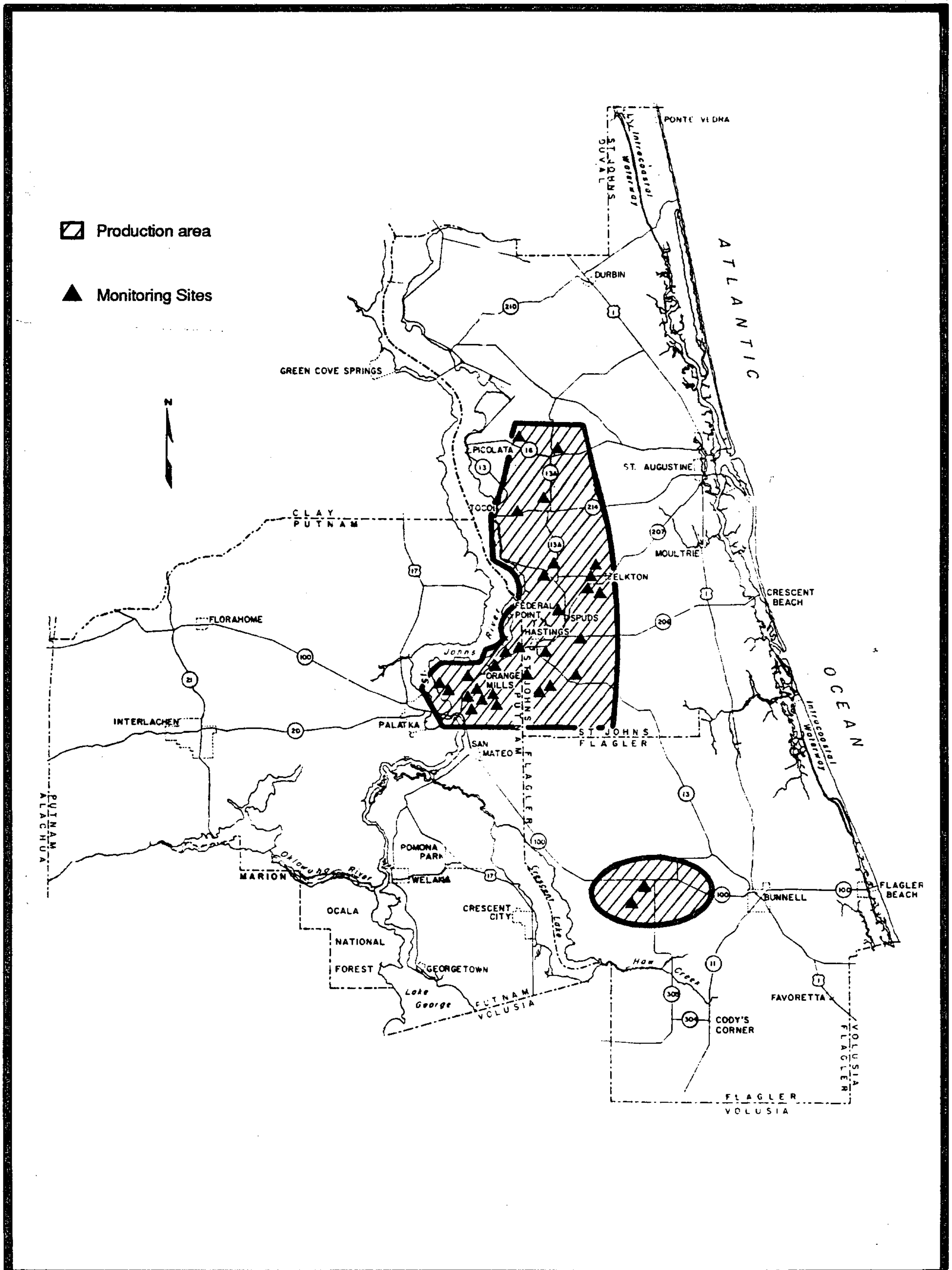

Figure 4. Location of the monitored sites in the potato production area

Table 1. Water used on monitored sites, 1985 and 1986, listed by number of acres irrigated

Site Number	Acres Irrigated	1985 Irrigation Per Acre (inches)	1986 Irrigation Per Acre (inches)	1985 Total Irrigation (acre-inches)	1986 Total Irrigation (acre-inches)
01	16	***	22.05	***	352.80
39	20	30.55	***	611.00	***
58	30	15.55	***	469.80	***
65	30	11.13	8.83	333.90	264.90
71	30	15.81	18.54	474.30	556.20
26	35	***	12.31	***	430.85
72	35	***	17.76	***	621.60
42	35	24.18	26.54	846.30	928.90
59	40	20.33	***	813.20	***
60	40	23.74	12.44	949.60	497.60
61	40	13.70	***	548.00	***
31	40	26.85	26.65	1074.00	1066.00
48	40	15.24	***	609.60	***
49	40	10.24	8.80	409.60	352.00
62	50	17.59	19.58	879.50	979.00
47	60	39.28	29.43	2356.80	1765.80
51	60	21.06	19.98	1263.60	1198.80
69	64	18.12	***	1159.68	***
70	68	20.56	***	1398.08	***
02	70	12.42	11.89	869.40	832.30
66	80	***	24.53	***	1962.40
36	120	18.33	14.51	2199.60	1741.20
27	125	18.06	28.12	2257.50	3515.00

1985 Average Irrigation Per Acre = 19.48 inches
1986 Average Irrigation Per Acre = 19.71 inches

*** = No data

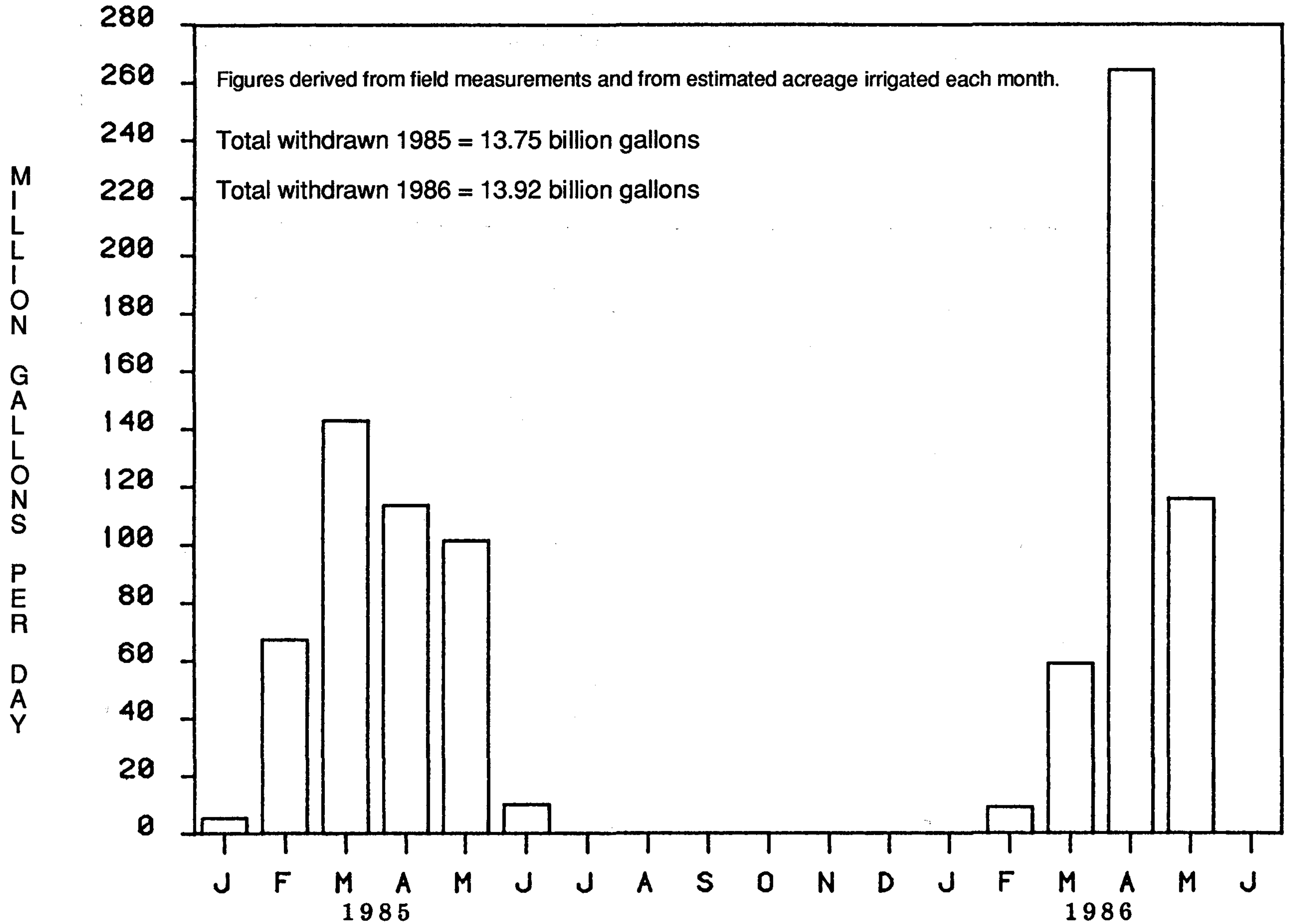

Figure 5. Total water withdrawals (mgd) by month for potato irrigation in the tri-county area, 1985 and 1986 growing seasons

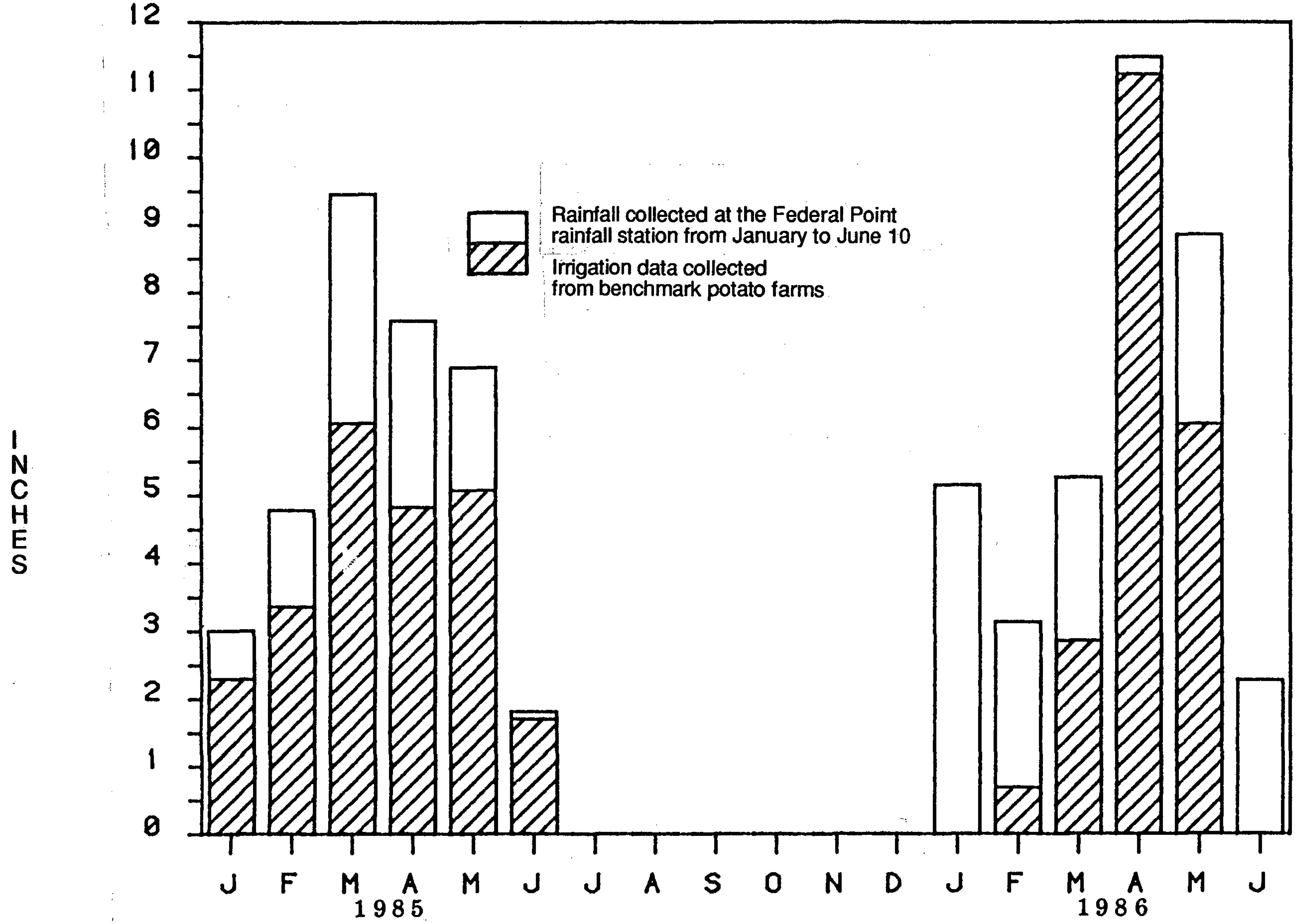

Figure 6. Average monthly water applications (inches) in tri-county potato farms, 1985 and 1986 growing seasons

THE MODIFIED BLANEY-CRIDDLE MODEL

Blaney and Criddle (SCS 1970) determined that the amount of water required by crops during a normal growing season closely correlated with mean monthly temperatures and daylight hours. They developed coefficients (for stage of growth, area daylight hours, and climate) which could be used in a mathematical expression to determine crop water requirements (ET) in areas where only climatological data were available. The crop water requirement or evapotranspiration (ET) includes water transpired by the plant and evaporated from the soil surface around the plant. The Blaney-Criddle model estimates crop water requirements (ET) using climate coefficients, as in the following equation:

Equation 1: $ET = KF$, where

ET = Evapotranspiration (crop water requirement)

K = Empirical consumptive use crop coefficient for the growing season. (This coefficient varies with the different crops being irrigated.)
- $K = Kt \times Kc$, where
- Kt = A climatic coefficient which is related to the mean monthly air temperature (t). Values of Kt are based on the formula, $Kt = .0173t - .314$.
- Kc = A coefficient reflecting the growth stage of the crop. Values are obtained from crop growth stage coefficient curves.

F = Sum of the monthly consumptive-use factors for the growing season (sum of product of mean monthly temperature and monthly percentage of daylight hours of the year).
- $F = (t \times p)100$, where
- t = Mean monthly air temperatures in degrees Fahrenheit
- p = Monthly percentage of daylight hours in the year

The Soil Conservation Service (SCS) modified the Blaney-Criddle model to take account of the fact that only some rainfall is available for crop use. SCS called the rainfall actually available for use effective rainfall. Effective rainfall is estimated as a function of total rainfall, the crop water requirement (ET), and the soil storage capacity. Higher crop water requirements and soil storage capacities result in higher effective rainfall for a given total rainfall. To estimate effective rainfall, the SCS analyzed 50 years of rainfall records from 22 National Oceanic and Atmospheric Administration (NOAA) weather stations throughout the United States in order to obtain soil moisture balances (SCS 1970). From their analysis, the SCS determined that average effective rainfall (RE) can be estimated by the formula below. The SCS modified the Blaney-Criddle formula (Equation 1) to account for estimated average effective rainfall.

Equation 2:

$$RE = (0.70917rt^{0.82416} - 0.11556)\ (10)^{0.02426u}(f)$$

RE = effective rainfall
rt = total monthly rainfall
u = monthly consumptive use (ET)
f = soil water storage factor. The soil water storage factor (f) is related to usable soil water storage D (in), by the relationships:

$$f = (0.531747 + 0.295164D - 0.0567D^2 + 0.003804D^3)$$

A soil water storage factor D = 2 in. is used for this study and is generally accepted as average for soils in the tri-county area (J. S. Rogers pers. com. 1987).

The SCS modified Blaney-Criddle technique is used by SJRWMD to estimate the gross irrigation requirements (GIR) of crops. GIR is calculated by subtracting the rainfall available for crop use (RE) from the crop water requirement (ET) and dividing that difference by the efficiency of the irrigation system. For this study, an average efficiency of 50 percent (Smajstrla and others 1988) was assigned to the seepage irrigation method.

This study compares the modified Blaney-Criddle estimate of GIR to field data collected as part of the Benchmark Farms Program. Climatological (rainfall and temperature) data needed as input into the modified Blaney-Criddle model are from the NOAA station at Federal Point in the study area. For this study, rainfall during the 30 year period, 1951-80, is used. The modified Blaney-Criddle model as presently used by SJRWMD is based on the same 30 years of rainfall data. Although the rainfall station at Federal Point has 98 years of data recorded, this report accounts for only 30 years of data in order to compare with current SJRWMD practice.

The area's production season, which starts in January and ends in June, was divided into three growth periods. The farmers in the area generally plan an early, mid-season, and late planting. The modified Blaney-Criddle model was used to determine the GIR for the following growth periods: (1) January 10 to April 25; (2) February 1 to May 15; and (3) March 1 to June 10. Although the beginning and ending of each of the three growth periods overlap, the crops in each are in differing stages of growth, thus the water requirements vary. Growth period divisions provide for a more realistic view of overall GIR as calculated by the modified Blaney-Criddle program for the entire production time.

The modified Blaney-Criddle method used by SJRWMD for estimating GIR uses monthly average temperature and rainfall from 30 years of data (1951-1980). SJRWMD allocates the GIR for potatoes at a rate which it is assumed will satisfy the irrigation requirement 80 percent of the time (the other 20 percent of the time the allocated amount is not adequate). Table 2 shows the modified Blaney-Criddle results for a supply assumed adequate 80 percent of the time, tabulated for the three growth periods. The average seasonal crop water requirement (ET) and gross irrigation requirement (GIR) are 14.05 and 16.66 inches, respectively. These results were derived by averaging the calculations for the three periods. The resulting GIR of 16.66 inches is assumed adequate 80 percent of the time (i.e., in 2 out of 10 years, the GIR would be expected to exceed this maximum allowed value).

Table 2. Summary of modified Blaney-Criddle water use estimate presently used by SJRWMD

Season	Month	Temp	Lite	Rt	F	Kt	Kc	ET*	RE	NIR	GIR
early season	Jan 1	57.00	7.32	2.95	2.83	0.67	0.41	0.71	0.61	0.10	0.20
	Feb	54.40	7.03	3.61	3.82	0.63	0.81	1.79	1.53	0.26	0.52
	Mar	65.20	8.37	3.46	5.46	0.81	1.30	5.29	1.98	3.31	6.62
	Apr 25	67.00	8.70	2.43	4.86	0.85	1.31	4.93	1.25	3.68	7.36
					TOTALS:			12.72	5.37	7.35	**14.70**
mid-season	Feb 1	54.40	7.03	3.61	3.69	0.63	0.45	0.87	0.74	0.13	0.26
	Mar	65.20	8.37	3.46	5.46	0.81	0.99	3.70	1.81	1.88	3.76
	Apr	67.00	8.70	2.43	5.83	0.85	1.35	5.59	1.48	4.11	8.22
	May 15	75.10	9.53	4.09	3.46	0.99	1.28	3.67	1.26	2.41	4.82
					TOTALS:			13.83	5.29	8.53	**17.06**
late season	Mar 1	65.20	8.37	3.46	5.28	0.81	0.47	1.58	1.35	0.23	0.46
	Apr	67.00	8.70	2.43	5.83	0.85	1.06	4.04	1.35	2.69	5.38
	May	79.60	9.48	5.91	2.51	1.06	1.26	7.36	2.57	4.79	9.58
	Jun 10	79.60	9.48	5.91	2.51	1.06	1.26	2.61	1.21	1.40	2.80
					TOTALS:			15.59	6.48	9.11	**18.22**

Average (overall) ET = 14.05 inches
Average (overall) RE = 5.72 inches
Average (overall) GIR = **16.66** inches

*Monthly totals of ET values differ slightly from overall seasonal values. These monthly values were adjusted to reflect seasonal total ET.

Temp = Temperature
Lite = Hours of daylight
Rt = Total rainfall
F = Consumptive use factors
Kt = Climatic coefficient
Kc = Growth stage coefficient
ET = Evapotranspiration
RE = Effective rainfall
NIR = Net irrigation requirement
GIR = Gross irrigation requirement

EVALUATION OF THE MODIFIED BLANEY-CRIDDLE TECHNIQUE

This study showed that the 1985 and 1986 field-measured gross irrigation requirements (GIR) for potatoes were 19.48 and 19.71 inches, respectively. Yet the average estimate derived from use of the modified Blaney-Criddle model for the three growth periods selected is 16.66 inches, for an 80 percent adequate irrigation water supply.

By definition, GIR is the difference between the crop water requirement (ET) and the effective rainfall (RE), divided by the efficiency of the irrigation system. Since the crop water requirement (ET) and the system efficiency vary little from year to year, this suggests the effective rainfall amount is the variable which could cause significant differences in GIR.

The modified Blaney-Criddle estimate (16.66 inches) is assumed adequate 8 out of 10 years or at a frequency of 80 percent. Therefore, in order to compare the modified Blaney-Criddle results with the field data collected, it is necessary to establish the frequency of the effective seasonal rainfall data represented for those two years (1985 and 1986 growing seasons). Records of effective seasonal rainfall are not available; therefore, total seasonal rainfall records must be used to estimate the frequency of effective seasonal rainfall amounts.

FREQUENCY OF EFFECTIVE RAINFALL

The procedure for determining the frequency of effective rainfall is based on the assumption that for any fixed period or growing season, other factors being equal, effective rainfall will vary from year to year in direct proportion to the variance in total rainfall. Thus, the frequency distribution of total seasonal rainfall may be used as a measure of the frequency distribution of effective seasonal rainfall.

It is generally accepted that climatological data for 25 years or longer can be used to determine the frequency or probability of occurrence of total seasonal rainfall. The procedure involves ranking the growing-season rainfall for each year in order of magnitude and plotting the data on log-normal probability paper.

Figure 7 shows the probability plot of 30 years of rainfall data (1951-1980, February to May totals) for the tri-county area. A best fit line for all the plotted points is drawn to establish the frequency distribution of the total growing-season rainfall (February to May). In the tri-county area, the mean irrigation-season rainfall for this period (30 years) was 13.54 inches (using Federal Point rainfall station). Rainfall for the 1985 and 1986 irrigation seasons is shown on the 30-year probability line (Figure 7). Rainfall totals for February through May 1985 and 1986 were 9.38 and 7.91 inches, respectively. These totals correspond to 80 and 89.5 percent probability, respectively.

The recurrence interval (T) of rainfall is represented by the following equation:

<u>Equation 3</u>: $$T = \frac{1}{(1 - P/100)}$$

P = Probability percent (%)

Thus, the recurrence interval (T) is 5, or 1 in 5 years for 1985 data, and 9.5, or 1 in 9.5 years, for 1986 rainfall data. For the purpose of this study, it is assumed that 1 in 5 year occurrence is equivalent to a 2 in 10 year occurrence.

Therefore, the 1985 effective rainfall data have a probability of occurrence of 80 percent and represent the same frequency (80 percent frequency) that the modified Blaney-Criddle formula uses to estimate the gross irrigation requirement. Therefore, it would be expected that the 1985 field-measured results and the modified Blaney-Criddle results should be similar. Yet the actual average irrigation application (field-measured) for 1985 was 19.47 inches, which is about 17 percent higher than the modified Blaney-Criddle result of 16.66 inches.

Thus far, the following have been established:

1. The effective rainfall is the variable causing a significant difference between the GIR measured in the field and that estimated by the modified Blaney-Criddle model.

2. The effective and total rainfall for the 1985 growing season is equivalent to the frequency (80 percent) which the modified Blaney-Criddle model uses to determine the gross irrigation requirement. Yet a significant difference exists between the 1985 field measured result and the modified Blaney-Criddle estimate.

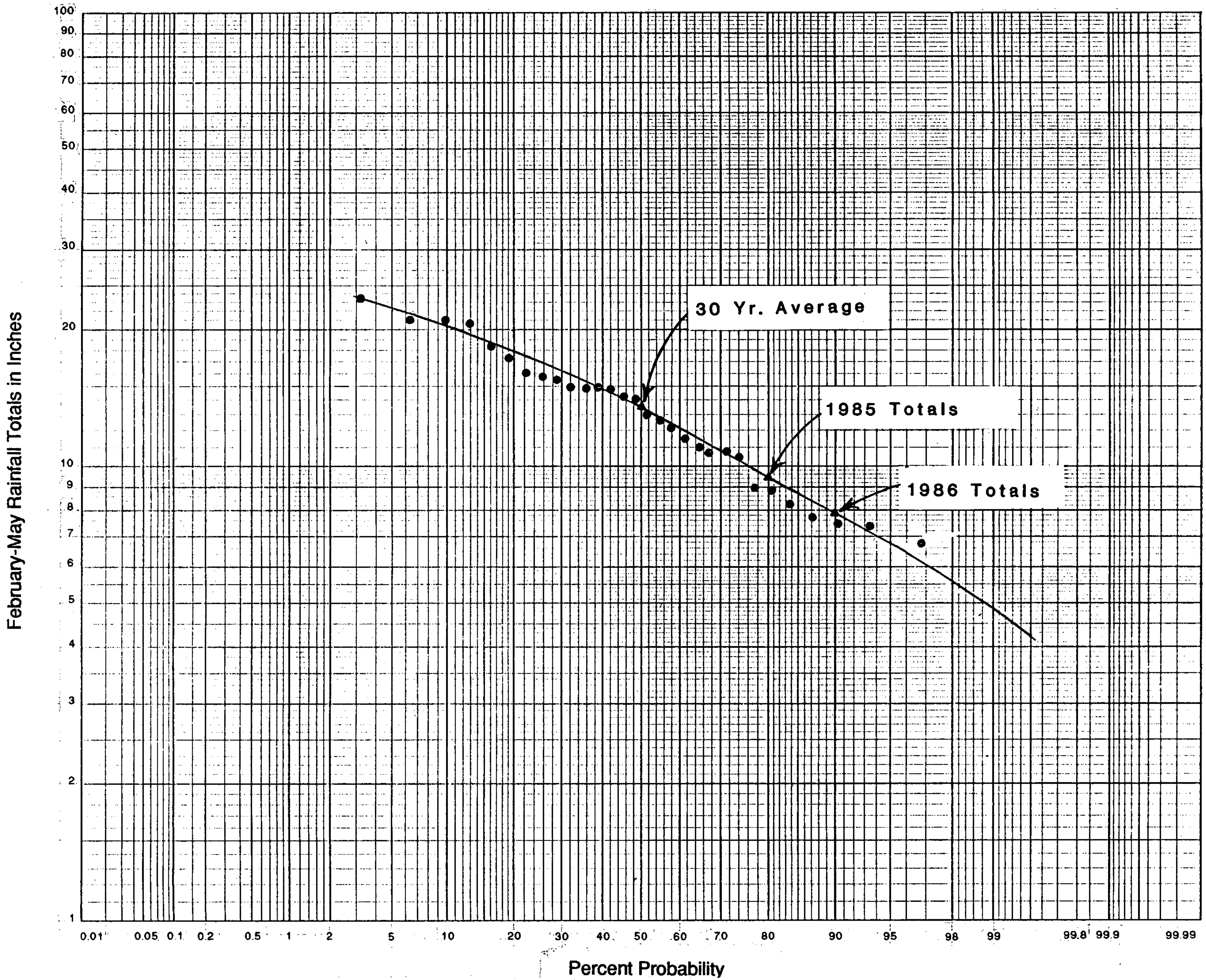

Figure 7. Probability plot for rainfall data, 1951 to 1980, from the rainfall gauge at Federal Point, Florida

EVALUATION OF EFFECTIVE RAINFALL

SCS modified the Blaney-Criddle technique in order to account for effective rainfall. SCS presents two methods that can be used to evaluate effective rainfall (SCS 1970). The first method uses ratios calculated by SCS based on rainfall data collected throughout the United States (Table 3). The average effective rainfall is multiplied by the ratio to determine effective rainfall at a certain probability of occurrence. SCS suggests using the ratio table for determining effective rainfall at a desired percent chance of occurrence "when the degree of accuracy desired does not warrant the time required to plot a growing-season rainfall frequency distribution curve for each crop under consideration." The second method involves plotting a rainfall frequency curve for a specific study area. The ratio table employed in the modified Blaney-Criddle model is used by SJRWMD.

To use the first method, a mathematic mean of the growing-season rainfall for at least 25 years must be determined for the crop under consideration. The growing season for a crop is the production period during which the crop is potentially irrigated. Crops such as citrus, fern, or blueberries are potentially irrigated year-round. Therefore, when considering these crops, the growing-season rainfall is the annual rainfall. Potatoes, in contrast, are normally irrigated in the study area from February through May; therefore, the growing-season rainfall is the February through May rainfall.

The ratio is selected by using average growing-season rainfall and the desired percent chance of occurrence (Table 3). The product of the SCS ratios (Table 3) and the average effective rainfall (from Equation 2) is the effective rainfall at the desired probability of occurrence. The average annual rainfall for the tri-county study area (using Federal Point rainfall station) is 52 inches, which in Table 3 corresponds to a ratio of .854, at 80 percent chance of occurrence. Using this ratio in the model results in a GIR of 16.66 inches.

The modified Blaney-Criddle computer program used by SJRWMD asks the user to input "average annual rainfall" for a study area. This has resulted in an error in the district's analysis of the irrigation requirement of potatoes, because with a short season crop such as potatoes, the average growing season rainfall should be used. Using annual rainfall rather than seasonal rainfall causes the model to overestimate the effective rainfall on potatoes at 80 percent chance of occurrence and thus underestimate the gross irrigation requirement (GIR). This error has resulted in an overall GIR of 16.66 inches (Table 2), which is less than the field-measured estimate.

Potatoes are generally irrigated from February through May. The average seasonal (February to May) rainfall from 1951 through 1980 (30 years) within the study area is 13.5 inches, which corresponds to a ratio of .705 at 80 percent chance of occurrence (Table 3). The product of this ratio (.705) and the average effective rainfall from

Table 3. Ratios for determining probability of occurrence for effective rainfall

Average Seasonal Rainfall (inches)	Percent Chance of Occurrence 50	60	70	80	90
3	0.80	0.68	0.56	0.45	0.33
4	0.84	0.72	0.61	0.50	0.38
5	0.87	0.76	0.65	0.54	0.42
6	0.88	0.78	0.68	0.57	0.45
7	0.89	0.79	0.69	0.60	0.48
8	0.90	0.81	0.71	0.62	0.51
9	0.91	0.82	0.73	0.63	0.53
10	0.92	0.83	0.75	0.65	0.55
12	0.93	0.85	0.78	0.69	0.58
14	0.94	0.86	0.79	0.71	0.61
16	0.95	0.88	0.81	0.73	0.63
18	0.95	0.89	0.82	0.74	0.65
20	0.96	0.90	0.83	0.75	0.67
22	0.96	0.90	0.84	0.77	0.69
24	0.97	0.91	0.84	0.78	0.70
26	0.97	0.92	0.85	0.79	0.71
28	0.97	0.93	0.86	0.80	0.72
30	0.97	0.93	0.87	0.81	0.73
35	0.98	0.93	0.88	0.82	0.75
40	0.98	0.94	0.89	0.83	0.77
45	0.98	0.94	0.90	0.84	0.78
50	0.98	0.95	0.91	0.85	0.79
55	0.99	0.95	0.91	0.86	0.80
60	0.99	0.95	0.91	0.87	0.81
70	0.99	0.95	0.92	0.88	0.83
80	0.99	0.95	0.93	0.90	0.86

Equation 2 will result in a truer GIR and effective rainfall at 80 percent chance of occurrence. Using the ratio .705 and the same climatological data used in Table 2, the result is an overall GIR of 18.65 inches, which is only 3 percent less than the field-measured estimate (Table 4).

The second method the SCS uses for determining effective rainfall at a desired percent chance of occurrence involves plotting a growing-season rainfall frequency distribution curve for at least 25 years of data (Figure 7). This method assumes effective rainfall varies from year to year in direct proportion to the variance in total rainfall. Therefore, the frequency distribution of total rainfall can be used as a measure of the frequency distribution of effective rainfall. From this curve, a ratio can be determined between average seasonal rainfall and seasonal rainfall at 80 percent chance of occurrence. For example, 9.3 inches of rainfall has an 80 percent chance of occurrence, according to the probability plot of 30 years of data (Figure 7). The average seasonal rainfall at 80 percent probability of occurrence, 9.3 inches, divided by average seasonal rainfall, 13.5 inches, is 0.69. The product of this ratio and the average effective rainfall (from Equation 2) is the effective rainfall at 80 percent chance of occurrence. The ratio derived by this method is expected to be more accurate than the ratios on Table 3 since the rainfall data is more site specific. However, the ratio derived by this method (0.69) is very close to the ratio (0.705) derived from Table 3. For practical purposes, the resulting GIR will be the same.

For seasonal crops, average seasonal rainfall rather than annual rainfall should be used in the modified Blaney-Criddle model for estimating GIR. The modified Blaney-Criddle model used by SJRWMD can be a very useful technique when field measurements are not available. However, to attain accurate results, it must be adjusted for each crop's growing season as it relates to rainfall.

Table 4. Summary of modified Blaney-Criddle water use estimate after applying seasonal rainfall

Season	Month	Temp	Lite	Rt	F	Kt	Kc	ET*	RE	NIR	GIR
early season	Jan 1	57.00	7.32	2.95	2.83	0.67	0.41	0.71	0.49	0.22	0.44
	Feb	54.40	7.03	3.61	3.82	0.63	0.81	1.79	1.23	0.56	1.12
	Mar	65.20	8.37	3.46	5.46	0.81	1.30	5.29	1.60	3.69	7.38
	Apr 25	67.00	8.70	2.43	4.86	0.85	1.31	4.93	1.01	3.92	7.84
					TOTALS:			12.72	4.33	8.39	**16.78**
mid-season	Feb 1	54.40	7.03	3.61	3.69	0.63	0.45	0.87	0.60	0.27	0.54
	Mar	65.20	8.37	3.46	5.46	0.81	0.99	3.70	1.47	2.23	4.46
	Apr	67.00	8.70	2.43	5.83	0.85	1.35	5.59	1.19	4.40	8.80
	May 15	75.10	9.53	4.09	3.46	0.99	1.28	3.67	1.02	2.65	5.30
					TOTALS:			13.83	4.28	9.55	**19.10**
late season	Mar 1	65.20	8.37	3.46	5.28	0.81	0.47	1.58	1.09	0.49	0.98
	Apr	67.00	8.70	2.43	5.83	0.85	1.06	4.04	1.09	2.95	5.90
	May	75.10	9.53	4.09	7.16	0.99	1.35	7.36	2.08	5.28	10.56
	Jun 10	79.60	9.48	5.91	2.51	1.06	1.26	2.61	0.98	1.63	3.26
					TOTALS:			15.59	5.24	10.35	**20.70**

Average (overall) ET = 14.05 inches
Average (overall) RE = 4.62 inches
Average (overall) GIR = **18.86** inches

*Monthly totals of ET values differ slightly from overall seasonal values. These monthly values were adjusted to reflect seasonal total ET.

Temp = Temperature
Lite = Hours of daylight
Rt = Total rainfall
F = Consumptive use factors
Kt = Climatic coefficient
Kc = Growth stage coefficient
ET = Evapotranspiration
RE = Effective rainfall
NIR = Net irrigation requirement
GIR = Gross irrigation requirement

SUMMARY OF FINDINGS

Irrigation of potatoes in the tri-county area was monitored during the 1985 and 1986 growing seasons. Data collected from 23 farms in the area were used to determine the irrigation requirements during both years and to evaluate the accuracy of the modified Blaney-Criddle model of irrigation requirements used by SJRWMD. The results of this study are listed below.

1. According to measured Benchmark Farms field data, the average application of water on potatoes was 19.48 inches in 1985 and 19.71 inches in 1986. In view of the average application rate and the total irrigated acres (26,000 acres), the total water used in the area was approximately 13.75 billion gallons in 1985 (37.68 mgd per year average) and approximately 13.92 billion gallons in 1986 (38.12 mgd per year average).

2. The field-measured gross irrigation requirement (GIR), representing an 80 percent probability of occurrence (19.47 inches), is 17 percent higher than the estimate (16.66 inches) of the modified Blaney-Criddle model as used by SJRWMD.

3. The modified Blaney-Criddle model used by SJRWMD misrepresented the effective rainfall at the desired percent chance of occurrence because the format of the model required average annual rainfall rather than average seasonal rainfall for determining the ratio between average effective rainfall and effective rainfall at the 80 percent probability frequency. Potatoes are a seasonal crop. Application of effective seasonal rainfall, rather than annual rainfall, resulted in the modified Blaney-Criddle estimate being only 3.1 percent less than the field-measured estimate.

4. When properly used, the modified Blaney-Criddle model can be a useful tool for estimating irrigation requirements when field measurements are not available.

REFERENCES

Jenab, S. A., D. V. Rao, and D. Clapp. 1986. Rainfall analysis for northeast Florida. Technical Publication SJ 86-4, Palatka, Fla.: St. Johns River Water Management District.

Marella, R. L. 1986. Annual water use survey: 1985. Technical Publication SJ 86-5. Palatka, Fla.: St. Johns River Water Management District.

Rogers, J. S. and J. F. Batholic. 1975. Estimated evapotranspiration and irrigation requirements for citrus. Soil and Crop Science Society of Florida Proceedings, vol. 35.

Smajstrla, A. G., B. J. Boman, G. A. Clark, D. Z. Haman, D. S. Harrison, F. T. Izuno, and F. S. Zazueta. 1988. Efficiencies of Florida Agricultural Irrigation Systems. Bulletin 247, Institute of Food and Agricultural Sciences. Gainesville, Fla.: University of Florida.

United States Department of Agriculture. 1970. Irrigation Water Requirements. Soil Conservation Service Technical Report No. 21. Washington, D. C.

St. Johns River Water Management District
P. O. Box 1429
Palatka, Florida 32178-1429
(904) 328-8321