CENTRAL FLORIDA WATER CONSERVATION STUDY

LAKE, POLK AND HIGHLANDS COUNTIES

Prepared By
U.S. DEPARTMENT OF AGRICULTURE
Soil Conservation Service
Gainesville, Florida

In Cooperation With
The Florida Department of Community Affairs
Lake Soil and Water Conservation District
Polk Soil and Water Conservation District
Highlands Soil and Water Conservation District
1987

CENTRAL FLORIDA
WATER CONSERVATION STUDY

for

Lake, Polk and Highlands Counties

Prepared By

USDA Soil Conservation Service

In Cooperation With

Florida Department of Community Affairs

Lake Soil and Water Conservation District

Polk Soil and Water Conservation District

Highlands Soil and Water Conservation District

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I

INTRODUCTION

In the spring of 1984, the soil and water conservation districts of Flagler, Highlands, Lake, Polk, Putnam, and St. Johns Counties requested that the USDA-Soil Conservation Service (SCS) study agricultural water use in their county and ways to use the water more efficiently. Applications for Federal Assistance were made for a Cooperative River Basin Study to be carried out under the authority of section 6, Public Law 83-566, with additional funding from the National Inventory and Monitoring Program. The study was divided into two parts based on geography and land use. Flagler, Putnam, and St. Johns Counties were grouped to make one part of the study; and Highlands, Lake, and Polk Counties were grouped to make a second part. This report details only the procedures and results from Highlands, Lake, and Polk Counties.

Approximately 206,000 acres of agricultural land were inventoried in Highlands, Lake, and Polk Counties to determine specific information on types and operation of irrigation systems. In addition, evaluations were made to gather detailed information on selected irrigation systems. The results of the inventory and evaluations, as well as a description of the study area, a description of the methods used for data collection and analyses, and a summary analyzing the results are presented in this report.

The specific objectives of this study were to:

1. Determine the location of certain lands presently being irrigated.
2. Gather general information on these lands, especially size of area, crop grown, soil phase, water source, and irrigation method used.
3. Perform representative detailed evaluations of systems in order to make irrigation efficiency comparisons.
4. Perform cost analyses on system conversions and upgrading.

The completed report will be made available to landusers, units of government, and regional planning councils. It will also be used by the Soil Conservation Service to schedule future work and to target funding.

Study Area Description

Highlands, Lake and Polk Counties make up the study area. They are located in the central part of peninsular Florida (see map, Appendix A). They have a similar climate and similar trends in the citrus industry and in irrigation of citrus.

The study area has a subtropical climate characterized by long, warm humid summers and by mild, dry winters. The average temperature in summer is 81 degrees Fahrenheit, and the average temperature in winter is 62 degrees Fahrenheit. The average annual rainfall is about 54 inches. In winter, the average daily minimum temperature is 48 degrees Fahrenheit, and the lowest temperature on record is 13 degrees Fahrenheit. In summer, the average daily maximum temperature is 93 degrees Fahrenheit with the highest recorded temperature of 103 degrees Fahrenheit.

Freezing temperatures can occur anytime from mid-November to the end of March with most occurring during late December and January. These freezing temperatures usually occur just before sunrise, and it is very rare when the temperature does not get above 32 degrees during the day. Killing frosts are a problem for the study area, especially in low-lying areas.

Rainfall is seasonally distributed with nearly 60 percent of the average annual total falling during the four-month period of June through September. Rainfall in summer comes mostly in showers and thunderstorms of short duration in the afternoon and early evening hours. Summer showers can be heavy, with two to three inches in a one to two-hour period.

Rains that last all day are rare in the summer; however, when such rains occur, they are usually associated with a tropical storm. Rainfall in winter and early spring is usually less intense than thundershowers but may last 24 hours or longer as the weather during this period is more influenced by frontal weather than convectional weather patterns.

Periods of dry weather can be expected during any season but will most likely occur in winter and spring. Dry periods in April and May are most damaging because of the higher temperatures and the effects these conditions have on cropland and pastureland.

Citrus is an important industry in the study area. Historically, groves are primarily located on the uplands, ridges, and knolls. As urban development competes for these sites, citrus moves into sloughs and flatwoods areas.

The citrus industry in the study area has been hurt in recent years from several hard freezes. These freezes have killed and damaged many acres of citrus. Some of these areas have been replanted to citrus while others have been turned into urban land or left idle.

Presently, the trend in irrigation in the study area is moving from overhead sprinkler irrigation to trickle irrigation on the existing citrus acreage. New irrigation systems being installed are almost entirely trickle systems. Several traveling gun systems are still in existence; however, the number is declining. Under-tree sprinkler irrigation systems have not been widely accepted by citrus producers in the study area, and there have been only a few installed.

The Floridan aquifer is the water source for most irrigation systems in the county which use deep wells. The balance is withdrawn from small surface water lakes. The trend tends to be towards wells due to the wide variation in depths of these lakes during dry years and pressure from regulatory agencies. As urban competition for water increases, producers will have to make more efficient use of the available water supply. Methods to increase water use efficiency are discussed in later sections of this report.

At present, water quantity or quality used for citrus irrigation in the study area is not an extensive problem. Some scattered areas have trouble finding an adequate volume of flow from wells; however, these areas tend to be small. Likewise, quality is a problem in some parts of the study area but it is not widespread. The major problem comes from high sulphur content of the water sources. If not properly treated, sulphur slime bacteria will grow in lateral irrigation lines and hinder or stop flow in trickle emitters.

Highlands County, Florida

Highlands County is the southernmost county in the study area. It is bordered on the north by Polk County, on the east by the Kissimmee River which separates it from Okeechobee County, on the south by Glades County, and on the west by Hardee and Desoto Counties. The county covers 1,029 square miles (Shoemyen, 1985). Approximately 7.3 percent of this area is water.

Among Florida's 67 counties, Highlands County is thirty-fifth in population (Shoemyen, 1985). It accounts for 0.51 percent of Florida's population with 54 persons per square mile, and is the thirty-eighth most densely populated county in Florida. A great deal of growth has taken place in the county since 1940 when the population was 9,340. The 1970 census reported 29,507 persons living in Highlands County. The 1980 census reported an increase to 47,526 persons. This represents an average annual growth rate of 4.88 percent between 1970 to 1980 due primarily to migration. The 1985 population was estimated to be 58,151 persons, an average annual growth rate of 4.12 percent between 1980 and 1985.

The economic base of Highlands County is almost exclusively agriculture or agricultural-related businesses. The county produces significant volumes of citrus fruit, ornamental bulbs, beef cattle, vegetables, and dairy products. During the 1985-1986 growing season, Highlands County ranked fourth in total production of citrus fruit in all of Florida with over 17 million boxes. In earlier growing seasons, Highlands County has been ranked among the top ten citrus-producing counties. In addition, Highlands County is the leading producer of caladium bulbs in the world. Beef and dairy cattle represent other important agricultural products. Some 500,000 acres are devoted to providing pasture for the herds. Vegetable production also adds to the agricultural base in the county with 686 acres devoted to truck farming.

The predominant land use in Highlands County is agriculture, with the largest acreage in pastureland and rangeland. Citrus is the next largest agricultural venture (by land area) in the county, occupying most of the ridge area. Development of residential, commercial, and other

nonagricultural land uses has been increasing in recent years with the influx of retirement-age residents. However, with the recent successive killing freezes in December 1983 and January 1985 occurring in counties to the north of Highlands County (see Figure 4), additional acreage has come into citrus production each year.

The Highlands ridge dominates the topography of Highlands County which ranges in elevation from 100 to 150 feet above National Geodetic Vertical Datum (NGVD) and is 5 to 9 miles wide. The ridge runs in a north-south direction along the western half of the county and covers about 200,000 acres or about 30 percent of the county. On either side of the ridge, the land is flat and is approximately 30 to 70 feet above NGVD. Wetlands comprise 12.3 percent of the county's area and are mainly concentrated to the south of Lake Istokpoga, along the Kissimmee River and along Arbuckle Creek.

Citrus production in Highlands County has been primarily on the soils of the sand ridge area of the county. There are 38,425 acres of citrus or 80 percent of the irrigated acres inventoried on these soils. However, as areas of these soils are being utilized for urban growth and development, new plantings have taken place in other parts of the county. The dominant land forms on which citrus is grown in Highlands County are: uplands and ridges, flatwoods and sloughs, broad low flats, poorly defined drainageways, and marshes and swamps.

Soils of the uplands and ridges include the deep, excessively drained Astatula, Paola and St. Lucie soils, the moderately well drained Archbold, Duette, Daytona, Orsino, and Pomello soils, and the somewhat poorly drained Satellite soils. All of the soils in this group are sandy throughout; they have low to very low available water capacity, rapid permeability, and low natural fertility. Overall, the soils in this group produce good yields, but a well designed and well managed irrigation system that maintains optimum moisture conditions is necessary to assure the best yields.

Soils of the flatwoods, sloughs, broad low flats, and poorly defined drainageways include the poorly drained Basinger, Felda, Immokalee, Myakka, Oldsmar, Pineda, and Smyrna soils, and the very poorly drained Placid soils. The available water capacity of most soils in this group is very low to low in the surface and subsurface layers, moderate in the organic-stained subsoil, and moderate to high in the loamy part of the subsoil. The permeability of these soils is dominantly rapid in the surface and subsurface layers, moderate to moderately rapid in the organic-stained subsoil and moderately slow to slow in the loamy part of the subsoil. These soils have low natural fertility. Less frequent irrigation will be needed in these soils due to a shallow water table. Since citrus tends to be shallow-rooted, care must be taken during dry periods when the water table falls to the extent that it cannot provide moisture to the roots. There are 8,469 acres of citrus or 18 percent of the irrigated acres inventoried on these soils.

Soils of the marshes and swamps include the very poorly drained Hontoon, Kaliga, Tequesta, and Sanibel soils. There are 984 acres of citrus, only 2 percent of the irrigated acres inventoried on these soils. Under natural conditions, these soils are ponded for 6 to 9 months. However, citrus can be grown if a water control system is installed to maintain the water table at a depth of about 4 feet, although it will be shallow-rooted. The natural fertility of these soils is high.

Lake County, Florida

Lake County, appropriately named because of its 1,400 named lakes, is located almost in the geographical center of the State. It is the northernmost county in the study area. It is bordered on the north by Marion County, on the east by Volusia, Seminole, and Orange Counties, on the south by Polk County, and on the west by Sumter County. The County covers 954 square miles (Shoemyen, 1985). There are 126,000 acres of lakes and streams.

Among Florida's 67 counties, Lake County is the twenty-first most-populated (Shoemyen, 1985). It accounts for 1.10 percent of Florida's population with 126 persons per square mile, and is the twenty-sixth most-densely populated county in Florida. The county has experienced rapid growth as the population has grown from 69,000 in 1970 to 119,900 in 1984, an average annual growth rate of 4.03 percent. The growth has occurred primarily in the triangle area between Mt. Dora, Eustis and Tavares, and near Leesburg and Clermont which lies about 20 miles west of Orlando.

The economic base of Lake County is primarily agriculture or agricultural-related businesses, as reflected by land use. Tourism, recreation, and light industry also contribute to the economy. As a result of urban growth, a 14 percent decrease in citrus acreage occurred from 1970 to 1980. By 1983, citrus acreage had been reduced to approximately 118,000 acres. In December of 1983 and January of 1985, severe freezes killed 90 percent of the citrus trees in the County. Land values decreased considerably and many acres were developed and planned for development. The outlook for the citrus industry, as predicted by various experts, is for replanting of approximately 50,000-65,000 acres.

The predominant land use in Lake County is agriculture with 15,000 acres of producing and replanted citrus and an additional 87,000 acres of idle citrus (USDA-SCS, 1982), 11,000 acres of vegetables, 60,000 acres of pasture and range, 263,000 acres of forest lands including 88,000 acres of national forest land, and approximately 70,000 acres of urban land.

The topography of Lake County varies from the rolling hills and valleys (characteristics of the central Florida ridge) to the nearly level St. Johns River Basin.

Citrus production in Lake County has been primarily on the soils of the uplands and ridges. There were 26,750 acres of citrus or 86 percent of the inventoried acres on these soils. However, as areas of these soils are being utilized for urban growth and development, new plantings have taken place in other parts of the county. The land forms on which citrus is

grown in Lake County are: sand ridges and uplands; uplands, low knolls and ridges; flatwoods; sloughs and broad low flats; and fill land-loamy materials.

Soils of the sand ridges and uplands range from the deep, excessively drained Astatula soils to the moderately well drained Tavares soils. Most of the soils occurring on this land form are sandy throughout, have low to very low available water capacity, rapid permeability, and low natural fertility. The rolling-topography characteristic of these soils provides some frost protection through air drainage on calm cold nights. Abundant lakes in these areas also help to moderate temperatures. Overall, the soils in this group produce good yields but a well designed and well managed irrigation system that maintains optimum moisture conditions is necessary to assure the best yields.

Soils of the uplands, low uplands, low knolls and ridges include the well drained Orlando and Kendrick soils, the moderately well drained Apopka soils, and the somewhat poorly drained Lochloosa and Sparr soils. The soils in this group are sandy throughout or are sandy and loamy below, have moderate to low available water capacity, are rapidly permeable, are well to somewhat poorly drained, and have medium natural fertility. Overall, the soils in this group are very well suited to citrus production due to their moderate available water capacity and medium natural fertility. There are 4,454 acres of citrus or 14 percent of the inventoried acres on these soils.

Soils of the flatwoods include the poorly drained Immokalee, Myakka, Ona, and Pompano soils. There are only 20 acres of citrus, less than 1 percent of the citrus inventoried on these soils. Page 15 has a description of flatwoods soils. Soils of the sloughs, broad low flats, and poorly defined drainageways include the poorly drained Felda and Emeralda soils. Only five acres of citrus on these soils were inventoried. A description of these soils is on page 8.

Soils of fill land-loamy materials are highly variable within short distances, have moderate to high available water capacity, variable permeability, and moderate to high natural fertility. There are only 25 acres of citrus on these soils.

Polk County, Florida

Polk County is located in the central part of Florida. It is bordered on the north by Sumter and Lake Counties, on the east by Osceola County, on the south by Highlands and Hardee Counties, and on the west by Hillsborough and Pasco Counties. The county covers 1,286,611 acres, or 2,010 square miles (Shoemyen, 1985). The land area covers 1,166,803 acres, or 1,823 square miles. Bodies of water equal to or greater than forty acres cover 119,808 acres or 187 square miles. Approximately 27,566 acres or 44 square miles are federally owned, including parts of the United States Air Force Avon Park Bombing Range.

Among Florida's 66 counties, Polk County is the eighth most populated (Shoemyen, 1985). It accounts for 3.25 percent of Florida's population with 195 persons per square mile, and is the seventeenth most-densely populated county in Florida. The 1970 census reported 228,515 persons living in Polk County. The 1980 census reported 321,652 persons, an average annual growth rate of 3.48 percent between 1970 and 1980 due primarily to migration. The 1984 population was estimated to be 355,413, an average annual growth rate of 2.53 percent between 1980 and 1984.

The economic base of Polk County is primarily agriculture or agricultural-related businesses, phosphate mining and processing, tourism, recreation, and light industry. The agricultural business consists primarily of citrus and citrus production and cattle raising, slaughter and processing. The citrus industry earned 1.5 billion dollars in Polk County in 1987 (Allen, 1987). Polk County was the number one citrus-producing county in the United States with over 125,000 acres planted to citrus in 1984 (Shoemyen, 1985). Light industry includes truss and palate manufacturing.

The predominant land use in Polk County is agriculture with 152,500 acres of cropland, 537,100 acres of pasture and rangeland, 149,000 acres in forest, and 85,000 acres in urban use (USDA-SCS, 1982). Also, there is significant acreage being mined, although much of the land that can be mined for phosphate has been depleted.

Polk County lies within two major land resource areas--southern Florida flatwoods and south-central Florida ridge. Topography is nearly level in the flatwoods and gently sloping in the central Florida ridge.

Citrus crops are grown on a number of different land forms and resulting soil types. The five land forms on which citrus is grown in Polk County are: sand ridges and uplands; uplands, low uplands, low knolls and ridges; flatwoods; sloughs, broad flats, and poorly defined drainageways; and reclaimed mined land.

Soils of the sand ridges and uplands include the deep, excessively drained Candler and Astatula soils, the moderately well drained Tavares soils, and the well drained Apopka soils. The soils in this group are excessively drained to somewhat poorly drained. Most of the soils occurring on this land form are sandy throughout or sandy and loamy, have low to very low available water capacity, rapid permeability, and low natural fertility. The rolling-topography characteristic of these soils provides some frost protection through air drainage on calm cold nights. Abundant lakes in these areas also help to moderate temperatures. Overall, the soils in this group produce good yields, but a well designed and well managed irrigation system that maintains optimum moisture conditions is necessary to assure the best yields. There are 110,634 acres of citrus, or 88 percent of the inventoried acres on these soils.

Soils of the uplands, low uplands, low knolls and ridges include the well drained Fort Meade and Kendrick soils, the moderately well drained Millhopper soils, and the somewhat poorly drained Lochloosa and Narcoossee soils. Some of the soils in this group are sandy throughout or sandy and loamy, have moderate to low available water capacity, are rapidly permeable, are well to somewhat poorly drained, and have medium natural fertility. Overall, the soils in this group are very well suited to citrus production due to their moderate available water capacity and medium

natural fertility. There are 7,592 acres of citrus, or 6 percent of the inventoried acres on these soils.

Soils of the flatwoods include the poorly drained Immokalee, Myakka, Oldsmar, Smyrna, and Wauchula soils. These soils have excessive wetness and low natural fertility. A water control system installed to maintain the water table at a depth of about four feet may be needed. Less frequent irrigation may be needed. Citrus may be shallow-rooted. There are 6,902 acres of citrus, or 6 percent of the inventoried acres on these soils.

Soils of the sloughs, broad low flats, poorly defined drainageways, and depressions have excessive wetness, ponding, and low natural fertility. There are 45 acres of citrus, less than one percent of the inventoried acres on these soils. Soils of the reclaimed mined land consist of overburden or sand tailings. Most of the soils are sandy throughout, have very low available water capacity, very rapid permeability, and low natural fertility. There are 295 acres of citrus, less than one percent of the inventoried acres on these soils.

II

INVENTORY METHODOLOGY

The methods used to collect the data in the field, an explanation of the various irrigation systems inventoried, the procedures used to analyze the inventory data, and the results of the inventory are discussed below.

Data Collection Methods

The collection of the field data was based on a field trip to every grove in each of the three counties. First, the groves were identified on aerial photographs. Then, a field trip to the grove was made to determine if it was or was not irrigated. The irrigated groves were outlined and numbered on aerial photographs. Irrigation data for each grove were recorded on an input data form (Appendix B). The input data form includes county, photo, and field identification numbers, field size, soil type, type of irrigation system(s), method of determining irrigation scheduling, source of water, and citrus status (condition of the trees).

Field visits were used during the inventory to obtain grove information. Field visits were supplemented by interviews with grove owners, grove managers, grove field workers, and others. In addition, many of the grove evaluations were supplemented with data already in SCS files from previous work accomplished in the grove(s).

Irrigation Systems

The irrigation systems inventoried were grouped into four categories and ten sub-categories. Following is a brief description of each system.

Traveling Gun

The traveling gun system is a high capacity irrigator supplied with water through a flexible hose. It is mounted on a self-powered chassis and travels along a straight line while irrigating. The most common traveler has a 500 gpm sprinkler mounted on a chassis and wets a diameter of more than 400 feet. A cable guides the chassis along a straight path as it tows a flexible high pressure hose that is connected to the water supply system. After use, the hose can be drained, flattened, and wound onto a reel. These types of systems were first installed in 1962-1963 because they required less labor and had greater crop returns (Harrison, 1978). According to the National Engineering Handbook, Section 15, Chapter 11 (USDA-SCS, 1983), the probable application efficiency used in design ranges from 55 percent to 67 percent. Jensen (1980) reports that distribution uniformity of 75 percent or higher is common.

Figure 1. A traveling gun sprinkler in a mature grove.

The two subcategories associated with this system are the buried main and the portable pipe. The former is used when the flexible hose is connected to the buried main water supply. The latter method is used when the flexible pipe is connected to a portable pipe which, in turn, is connected to the water supply. These irrigation systems are thought to be the most expensive to operate (Harrison, 1978). Traveling sprinklers require the highest pressures of any system. In addition to the 80 to 100 psi required at the sprinkler nozzles, hose friction losses add another 20 to 40 psi to the required system pressure (USDA-SCS, 1982). Therefore, traveling guns are best suited for supplemental irrigation where seasonal irrigation requirements are small, thus mitigating the high power costs associated with operating pressures.

Solid Set Sprinkler

Another category of irrigation systems is the solid set sprinkler systems. This system distributes the irrigation water to the field through pipelines and applies water to the soil through sprinkler nozzles. One very common sprinkler sub-category is the overhead system. Buried laterals are placed 18 to 30 inches below the ground with a riser pipe going vertically up from the lateral above the mature citrus trees where the sprinkler distributes the water in a circular path. Koo (1985) showed in a study at the Lake Alfred Citrus Research and Education Center that overhead sprinkler-irrigated trees had the highest fruit production when compared to both spray jet and drip trickle irrigation systems. The higher fruit production is attributed to the greater amount of ground area covered by overhead sprinklers. The overhead sprinklers used more water than either of the two types of trickle systems. Other studies concur that sprinkler-irrigated

trees are larger in size, have denser foliage, larger leaves, and produce more boxes of fruit than those irrigated with trickle systems due to the larger wetted area (Koo, 1978; Koo, 1984; Sites, 1986). As the tree density in a grove increases, and there are more trickle emitters per acre, trickle irrigation becomes similar to overhead sprinkler irrigation both in the quantity of water used and in the health and vigor of the tree due to the increased wetted area (Koo, 1985). Application efficiency with overhead systems can be very high, approaching 85 percent according to Jensen (1980) which is higher than can be achieved by most irrigation methods. Harrison (1978) estimates application efficiencies for overhead systems to vary from 70 to 90 percent. According to the Florida Irrigation Guide (USDA-SCS, 1982), probable application efficiency used in design ranges from 70 percent for daytime operation to 80 percent for nighttime operation and higher efficiencies under certain conditions.

Other solid set sprinkler systems include under-tree sprinklers. Under-tree sprinklers are similar to overhead sprinklers, except that the riser pipe only extends a couple of feet above the ground and wets a smaller area. The last subcategory of solid set sprinklers is the portable lateral sprinklers that are left in place during the growing season. This hand-moved system is composed of either portable or buried mainline pipe with valve outlets at various spacings for the portable laterals. These laterals are of aluminum tubing with quick couplers and have either center-mounted or end-mounted riser pipes with sprinkler heads. Advantages to this system are that you can put the water where you want it and irrigate more area than any other system. Unfortunately, there is a high labor requirement (USDA-SCS, 1982).

Figure 2. An under-tree sprinkler in a mature grove.

Figure 3. An overhead sprinkler in a grove which was frozen, then replanted.

Trickle Systems

The third category is comprised of the trickle systems. In the last ten years, the use of trickle irrigation has increased rapidly because of lower initial and operating costs as compared with other types of systems (Harrison, 1983). Trickle systems run at lower pressures and use less water than other irrigation systems (Harrison, 1983; Koo, 1985; USDA-SCS, 1982). In addition, many farmers apply fertilizer through the trickle systems.

The two subcategories of trickle irrigation include the spray jet and the drip systems. Both types of emitters are placed along small diameter laterals operated under low pressure. However, the spray jets provide a larger wetted pattern, normally 10-20 feet in diameter requiring fewer emitters per canopy area. This type of system is better suited for the dry sandy soils associated with most of the area involved in this study. Koo (1985) showed in a study at the Lake Alfred Citrus Research and Education Center that spray jet irrigation produced 46 boxes of fruit per acre for every inch of water applied over no-irrigation control as compared to 29 boxes for overhead sprinkler and 24 boxes for drip irrigation. There was a greater increase in fruit production when irrigating with overhead sprinklers over the nonirrigated control. The increase with overhead sprinklers was 71.7 percent compared to 20.3 percent with spray jet and 7.7 percent with drip. The greater production with the increased water applied for overhead sprinklers was due to the advantage of the larger wetted area. Drip irrigation uses flow rates of 1/2 to 2 gph as compared to the 8 to 40 gph rates for spray jets. Unfortunately, with drip systems the water tends

Figure 4. Overhead sprinklers being used for freeze control in the winter of 1982.

Figure 5. Spray jet trickle irrigation in a grove replanted after a freeze killed the mature trees.

to percolate straight down on the sandy soils resulting in small wetted diameters. Therefore, more emitters are needed to cover the canopy area. There is more lateral movement of the water on finer textured soils using drip systems resulting in larger wetted diameters.

Harrison (1978) estimates application efficiency for drip systems to vary from 80 to 90 percent. Jensen (1980) reports emission uniformity of new installations as high as 90 percent, with 80 percent a more typical value. According to the Florida Irrigation Guide (USDA-SCS, 1982) potential application efficiency for design purposes should not exceed 90 percent. In a study conducted by the SCS in several citrus producing counties on Florida's east coast, the application efficiency of trickle spray jet irrigation was estimated to be 78 percent (USDA-SCS, 1984). The same study reports emission uniformity to range from 81 to 97 percent with the average for the systems studied being 92 percent.

Subirrigation

The last category in this study is the subirrigation systems which are used to supply water to the root zone of the crop and to control the water table (natural or artificial). There are very few of these systems used to irrigate citrus in these three counties because conditions needed are not present in most of the soils where citrus is grown. These conditions include a naturally high water table or a very slowly permeable soil layer below the root zone on which an artificially elevated water table can be maintained without excessive losses through deep percolation.

One of the subcategories is the open subirrigation method. The water is supplied to a main supply ditch at the highest point of the field on an area to be irrigated. The water is conveyed by gravity through the entire field area with lateral ditches. Structures are used to restage the water at intervals so that water will back into the laterals and move laterally to raise the water table.

The second subirrigation method is similar to the open subirrigation method except that the main supply ditch is replaced with a pipeline distribution system. The irrigation water flows out of the pipe in small ditches or furrows at a controlled rate so that the depth of flow is very shallow. When water reaches the other end, it is designed so that the water table of the field is uniform and located fairly precisely at the same depth as the small ditches.

The third subirrigation system is the underground conduit method. Lateral ditches are replaced by underground lateral pipelines which are usually perforated corrugated plastic tubing. The water table is regulated by water flowing through the tubing. The water table is usually held just below the root zone where capillary movement brings the water into the root zone for use.

Analysis of Inventory Data

The data collected in the field represented 871 fields consisting of 49,327 acres in Highlands County, 542 fields consisting of 31,254 acres in Lake County, and 4,999 fields consisting of 125,488 acres in Polk County. These data were sorted and grouped by irrigation systems, water source, and method of irrigation scheduling. Additionally, the irrigation systems were further grouped by citrus status and soils.

The soils were grouped into three dominant land forms for Highlands County. They are: (1) uplands and ridges; (2) flatwoods, sloughs, broad low flats, and poorly defined drainageways; and (3) marshes and swamps. Each of these land forms is described in detail in Chapter 1. In Lake County, there are five groups: (1) sand ridges and uplands; (2) uplands, low uplands, low knolls, and ridges; (3) flatwoods; (4) sloughs, broad low flats, and poorly defined drainageways; and (5) fill land, loamy materials. In Polk County, there are six groups. The first four are the same as Lake County, the fifth is reclaimed mined land, and the sixth is depressional and ponded.

The data analyses were performed on an AT&T-6300 personal computer using UNIX data base software. The results are presented in Appendix B.

Among the 47,878 irrigated acres inventoried in Highlands County, 42 percent are using an overhead sprinkler system, 57 percent are using trickle irrigation, and 2 percent are using traveling guns. Of the trickle systems, 60 percent are using a spray jet system and 40 percent are using a drip system. The majority of the citrus was alive and healthy.

Among the 31,254 irrigated acres in Lake County, 51 percent are using an overhead sprinkler system, 27 percent are using a trickle system with a spray jet, 22 percent are using a traveling gun with a buried mainline pipe, and the remaining 5 percent are using other systems. The majority of the citrus was frozen, and future plans for the grove are unknown.

Among the 125,488 irrigated acres in Polk County, 48 percent are using an overhead sprinkler system, 33 percent are using a trickle system with a spray jet, 17 percent are using a traveling gun with portable pipe, 8 percent are using under-tree sprinklers, and the remaining 6 percent are using other systems. The majority of the citrus was alive and healthy.

Table 1. Inventory Overview

County	Irrigated Citrus	Traveling Guns	Solid Set Sprinklers	Trickle Systems	Subirrigation	Other
	acres					
Highlands	47,878	397	19,964	27,517	0	0
Lake	31,254	6,841	15,801	8,612	0	0
Polk	125,488	20,958	59,890	41,683	30	2,927

III

IRRIGATION SYSTEM EVALUATION

Irrigation systems were evaluated as a part of this study in an attempt to determine how efficient the systems operated. The data collected were studied to determine the major consistent problems associated with the various systems. The systems evaluated included 30 trickle irrigation systems, 17 permanent solid-set systems, and 5 traveling gun irrigation systems.

Methodology

Evaluations of the irrigation systems were performed by the respective field office staffs. The irrigation systems evaluated were chosen to be representative of the various systems described in Chapter II. The system evaluations were performed as normally operated by the landowner. The evaluation procedure consisted of gathering such information as sprinkler or emitter discharges and pressures, depth of water applied, rated sprinkler or emitter pressure and discharges, soil type, etc. A detailed description of the procedures to evaluate irrigation systems is included in the Florida Irrigation Guide.

General Efficiency from Test Results

The results of the evaluations are summarized below.

Trickle Irrigation Systems

The evaluation of the trickle irrigation systems showed that the emission uniformity (EU) for 33 percent of the systems was excellent (EU greater than 90 percent); 47 percent was good (EU 81-90 percent); 10 percent was fair (EU 70-80 percent); and 10 percent was poor (EU less than 70 percent) (USDA-SCS, 1983). The systems with low EU's are the result of two main problems: poor design and poor maintenance. The poor designs are mainly on systems where the topography was not taken into account resulting in a greater pressure variation and, therefore, a greater flow rate variation than is acceptable. Poor maintenance is mainly due to clogged emitters and to the mixing of emitters of varying flow characteristics after the systems were installed.

Permanent Solid-Set Irrigation Systems

A complete system evaluation of the solid-set systems could not be made due to the difficulty in gathering accurate catch-can data. This is due to the canopy of the trees. However, the evaluation of the permanent solid-set irrigation systems showed that at least 53 percent exceeded the SCS standard for sprinkler spacing. The data also showed that at least an additional 17 percent of these systems had too much pressure variation which would adversely affect system distribution uniformity.

Traveling Gun Irrigation Systems

The evaluations were incomplete; therefore, no summary of the irrigation efficiency or distribution uniformity could be made of the systems.

IV

SUMMARY

It is obvious that within the next few years agricultural water users will be faced with important decisions regarding irrigation potential. According to census statistics, the State's population is growing by more than 780 permanent residents per day. With the statewide average water use per day per capita being 175 gpd (Fernald, 1984), the yearly increase in population alone represents a 49.8 million gallon increase in water use. The question facing state and local officials is--how many years will it be before the demand exceeds the supply of fresh ground and surface waters? In some coastal areas, salt water intrusion has already moved inland.

The amount of freshwater withdrawn for irrigation purposes in 1980 accounted for 41 percent of all water used. This places crop irrigation as the single major water use in the State (Fernald, 1984). For this reason, public pressures are increasing on the agricultural water users to become efficient and conservative in their water use.

While public opinion tends to stereotype the farmer as a person who believes that there is an inexhaustible supply of water just for him, the facts indicate that all water users share the same concerns regarding water quality and quantity. Irrigation costs are increasing and water for the grower is too expensive to wantonly waste.

This study has identified, in the three major citrus-producing counties of the State, a variety of irrigation systems being used with a range of irrigation efficiencies. The objective of all of these systems is to obtain

maximum fruit production with the least quantity of water. There are three factors that must be considered in dealing with irrigation problems in these three counties:

First, the type of irrigation system being used. While this study has inventoried all of them, there are only three main types used in these counties--traveling gun, permanent solid-set sprinklers, and trickle. By design, these systems have different potential application efficiencies. The potential application efficiency will depend upon the system's age, system maintenance, and design. For these reasons, system efficiency cannot be assumed. It is quite clear, however, that there is a substantial potential for conserving water and energy by using the systems with the highest potential efficiency. However, other items such as potential production, system cost, and system maintenance should be considered in the selection of a system.

The second major factor is system design. As indicated in the system evaluations, one of the major causes for poor uniformities is improper design. The areas where this is most prevalent is where the land has changing topography. While designs are critical to all systems, they are most important when dealing with trickle systems as they have much lower flow rates and with small fluctuations result in poor emission uniformities. As a result of poor emission uniformities, some areas can receive substantially more water than necessary while others do not receive enough. Not only can this problem result in ineffective water use, but it can also result in potential production losses to the grower as nutrients are leached from some trees while others may experience stress from lack of

sufficient moisture. While these losses may not be significant or obvious, the grower should be aware of this.

With the trend in the study area moving towards trickle systems, it is extremely important that they are designed properly. Currently, the Florida Irrigation Society and the SCS both have specifications for irrigation systems that, if followed, will provide irrigation systems that will be designed to meet the needs of the crop and maximize water and energy use.

Detailed evaluations will identify those systems with design problems and determine what is needed to overcome the system problems. In some cases, modifications such as replacing nozzles or emitters and/or adjusting pump discharge pressure can be made that will improve the system efficiency. In some situations, the system may be beyond simple system modifications and the landowner will have to consider other alternatives, such as converting the system. While the initial cost of the conversion to another system is expensive there are other factors which, over time, may outweigh the cost. The Ratio Comparison Tables in Appendix C provide comparative cost analyses for various irrigation systems. These tables can be used as a tool to assist in making decisions regarding comparison or conversion of an existing system.

Third, and most important, is how the systems are operated and maintained. The operation of a system will determine largely which systems are wasting water and energy and which ones are conserving through maximizing use. A substantial amount of water can be wasted by the individual who has a well-designed, well-maintained system and operates it

improperly regardless of the type of system. There are some growers using trickle systems which use more water per irrigated acre than others using traveling gun or sprinkler type as a result of mismanagement.

There are a number of methods available for making decisions on when to irrigate and how much water to apply. When these methods are properly utilized, optimum water use will result. The problem, however, exists when only a few landusers have the information or tools necessary to properly schedule irrigation. Also, there are some who would be able to improve their system efficiency if they knew the application rates of their systems, the rooting depth of their crop, the water-holding capacity of the soil, and the consumptive use of the crop. Irrigation water management is becoming increasingly important as more and more growers seek assistance.

The most economical method that can be used by the grower to conserve water is through irrigation water management. It will take some time to learn the methods and evaluate the system to find out its capabilities. This practice is one which will serve to maximize water utilization for any type of system.

This study has served to identify the extent of irrigated acres and variability of systems within three citrus-producing counties in Florida. The evidence emphasizes the importance of assisting those with irrigation systems to: more effectively operate what they have, reorganize existing systems to improve efficiency, consider converting inefficient systems to alternative ones, and to provide irrigation education and information to all irrigators. Time is of the essence in Florida, and through a

through a cooperative effort by individuals, universities, state, local, and federal agencies, we can address this issue before it becomes a critical problem.

LITERATURE CITED

Allen, Harvey, Lakeland Ledger Fact Book, Lakeland, Florida, 1987.

Fernald, Edward A., Atlas of Florida, The Florida State University Foundation, Inc., Tallahassee, Florida, 1984.

Harrison, D. S., A. G. Smajstrla, and F. S. Zuzueta, An Economic Analysis of Irrigation Systems for Production of Citrus in Florida, Florida Agricultural Experiment Stations Journal, Series No. 5118, University of Florida, Gainesville, Florida, 1983.

Harrison, Dalton S., Irrigation Efficiencies, Agricultural Engineering Fact Sheet, University of Florida, Gainesville, Florida, 1978.

Jensen, M. G., Design and Operation of Farm Irrigation Systems, American Society of Agricultural Engineers, St. Joseph, Michigan, 1980.

Koo, R. C. J., Response of Marsh Grapefruit Trees to Drip, Under Tree Spray and Sprinkler Irrigation, Proc. Fla. State Hort. Soc. 98:29-32,1985.

Koo, R. C. J., Response of Densely Planted "Hamlin" Orange on Two Rootstocks to Low Volume Irrigation, Proc. Fla. State Hort. Soc. 91:8-10, Florida Agricultural Exp. Station's Journal Series No. 1497, 1978.

Koo, R. C. J. and A. G. Smajstrla, Effects of Trickle Irrigation and Fertigation on Fruit Production and Juice Quality of "Valencia" Orange, Proc. Fla. State Hort. Soc. 97:8-10, Florida Agricultural Exp. Station's Journal Series No. 5974, 1984.

Shoemyen, Anne H., Susan S. Floyd, and Amy T. Banta, Florida Statistical Abstract, The University Presser of Florida, Gainesville, Florida, 1985.

Sites, J. W., H.J. Rentz and E. J. Deszyck, 1951, Some Results with Irrigation Research with Florida Citrus, Proc. Fla. State Hort. Soc., 64:71-79, IN: Koo, R. C. J., Response of Marsh Grapefruit Trees to Drip, Under Tree Spray and Sprinkler Irrigation, Citrus and Vegetable Magazine, August 1986.

USDA-SCS, Florida Irrigation Guide, Gainesville, Florida, 1982.

______, Irrigation Evaluation Report, Florida Targeted Water Conservation Studies, Gainesville, Florida, 1984.

______, National Engineering Handbook, Gainesille, Florida, 1983, Sec. 15.

USDA-SCS-Soil Science Staff, 1982 National Resource Inventory Report Gainesville, Florida, 1982.

OTHER RELATED LITERATURE

Harrison, D. S., A. G. Smajstrla, and F. S. Zazueta, Irrigation Systems and Cost Estimates for Row Crop Production in Florida, IFAS Bulletin 216, University of Florida, Gainesville, Florida, 1985.

_____, Sprinkler, Trickle and Other Irrigation Systems: Cost Estimates for Citrus and Orchard Crops, IFAS Bulletin 197, University of Florida, Gainesville, Florida, 1983.

Harrison, D. S. and R. C. J. Koo, Irrigation Methods and Equipment for Production of Citrus in Florida, IFAS WRC-10, University of Florida, Gainesville, Florida, 1978.

Merriam, John L., and Jack Keller, Farm Irrigation System Evaluation: A Guide for Management, Utah State University, Logan, Utah, 1978, pp 22-28, 66-70, 99-104, 130-136.

Smajstrla, Allen G., and Dalton S. Harrison, Considerations in Converting from High Pressure (Permanent Overhead and Traveling Guns) to Low Measure (Trickle) Irrigation Systems for Citrus, Florida Cooperative Extension Service, IFAS, Department of Agricultural Engineering, University of Florida, Gainesville, Florida, 1982, mimeo rep 82-8, 4 pp.

Smajstrla, Allen G., Dalton S. Harrison, and Fedro S. Zazueta, Field Evaluation of Trickle Irrigation Systems: Uniformity of Water Application, Bulletin 195 of Florida Cooperative Extension Service, IFAS, University of Florida, Gainesville, Florida, 1984, pp 4-8.

Smajstrla, Allen G., Dalton S. Harrison, and J. M. Stanley, Irrigation Pumping Efficiences, Agricultural Engineering Fact Sheet AE-22, Florida Cooperative Extension Service, IFAS, Department of Agricultural Engineering, University of Florida, Gainesville, Florida, 1980, 4 pp.

Smajstrla, Allen G., Dalton S. Harrison, and G. A. Clark, Irrigation Scheduling with Drip and Spray Jet Trickle Irrigation Systems: I. Durations of Water Applications, Florida Cooperative Extension Service, IFAS, Department of Agricultural Engineering, University of Florida, Gainesville, Florida, 1983, mimeo rep 82-9.

Smajstrla, Allen G., Problems Associated with Poorly Designed Low-volume Irrigation Systems for Citrus, IFAS, Florida Cooperative Extension Service, IFAS, Department of Agricultural Engineering, University of Florida, Gainesville, Florida, rep 80-8.

USDA-SCS, Irrigation Water Requirements, Gainesville, Florida, 1981, TR-21 User's Manual, Draft, Eng File, 31 pp.

GLOSSARY

Application Efficiency - Ratio of the average depth of irrigation water stored in the root zone to the average depth of water applied expressed as a percent.

Application Rate - The rate at which water is applied to the crop by the sprinklers in pattern.

Aquifer - A geologic formation, group of formations, or part of a formation that contains sufficient saturated, permeable material to be able to yield significant quantities of water to wells or springs.

Available Water Holding Capacity (AWC) - Available water holding capacity is the amount of water the soil will hold between field capacity and the permanent wilting point.

Carryover Soil Moisture - Moisture stored in soils within root zone depths during the winter, at times when the crop is dormant or before the crop is planted. This moisture is available to help meet the consumptive water needs of the crop.

Emission Uniformity - The emitter flow variation along a drip line.

Emitter - A device which meters water flow from the laterals to the soil in low volume systems.

Flow Restrictions - Physical restrictions in the line of water flow. They can be preplanned, such as gate valves, pressure regulators, etc., or unplanned, such as corrosion, clogging, etc.

Friction Loss - The loss incurred when water is moving through an enclosure. Reflects smoothness of pipe, length of pipe, orifice sizes in components, mechanical restrictions and volume of water being moved.

gpm - Abbreviation for gallons per minute, the standard flow measurement of water in irrigation design.

gph - Abbreviation for gallons per hour usually used in design of low volume systems.

gpd - Abbreviation for gallons per day commonly used in reference to per capita water use.

Ground Water - All subsurface water that is in zones of saturation.

Infiltration - The downward entry of water into the immediate surface of soil or other material.

Irrigation Efficiency - The percentage of applied irrigation water that is stored in the soil and available for consumptive use by the crop. When the water is measured at the farm headgate, it is called farm-irrigation efficiency; when measured at the field, it is designated as field-irrigation efficiency; and when measured at the point of diversion, it may be called project-efficiency.

Irrigation Frequency - Refers to the allowable number of days between irrigations. It depends on the consumptive-use rate of a crop and on the amount of available moisture in the root zone (moisture extraction depth) between field capacity and the starting moisture level for irrigation.

Irrigation Period - Irrigation period refers to the number of days a system--of given capacity--takes to irrigate the design area. Irrigation period should always be equal to or less than irrigation frequency.

Lateral - A pipeline branching off from the main and distributing water to the nozzles, emitter, or other device used to apply irrigation water.

Main - A large pipeline sized to carry the water for the irrigation system from the water source to the point of distribution to laterals. Usually sprinklers are not connected directly to the main.

Nozzle - A device which allows water to flow from the riser to the crop in a sprinkler system.

Operating Cost - The cost of operating a system which includes water costs, pumping costs, repair costs, and labor costs.

Operating Pressure - The pressure at which a system or sprinkler operates. Static pressure less pressure losses. Usually indicated at the base of a sprinkler.

Permeability - The quality of the soil that enables water to move downward through the profile.

psi - Abbreviation for pounds per square inch, the standard pressure measurement of water in irrigation design.

Riser - The pipe where the emitter or nozzle is attached to the lateral.

Spacing - The distance between sprinkler heads or emitters along the lateral and the spacing between laterals.

Sprinkler Irrigation - Sprinkler irrigation is a system in which the irrigation water is distributed to the field through pipelines and applied to the soil by spraying with sprinkler nozzles or perforations operated under pressure.

Supply (Water Source) - The origin of the water used in the irrigation system.

Surface Water - All water on the surface of the ground, including water in natural and man-made boundaries as well as diffused water.

System Distribution Uniformity - (DU) is the ratio of the average low quarterly depth (1/4 of the catchcans containing the lowest volume of water) caught to the average depth expressed as a percent.

Trickle Irrigation - Trickle irrigation is a system for efficient slow application of water for irrigation directly to the crop root zone area. The water is applied on or below the soil surface through emitters or applicators placed along small diameter laterals operated under pressure. Common types of emitters include orifices, micro tubes, sprayers, porous or perforated tubing and bubblers.

Uniformity of Application - A general term designating how uniform the application of the sprinkler or emitter is over the area it is covering while in pattern.

Water Pressure - Pressure which water exerts as measured in pounds per square inch or in foot-head.

Water Table - The level below which the ground is saturated with water. This level can be very near the surface of the ground or many feet below it.

OR

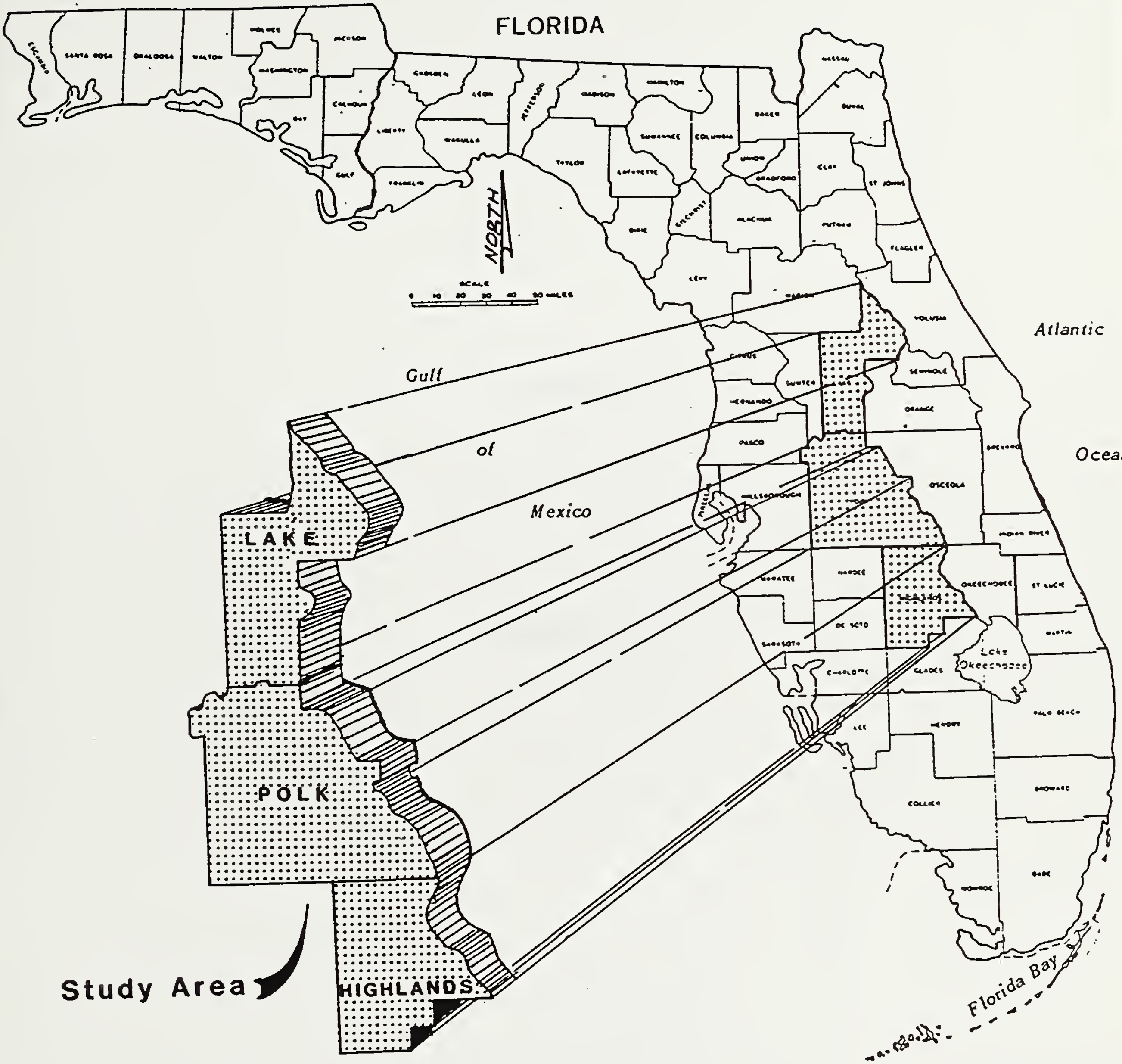
The upper limit of the soil or underlying rock material that is wholly saturated with water.

Water Table, Apparent - A thick zone of free water in the soil. An apparent water table is indicated by the level at which water stands in an uncased borehole after adequate time has been allowed for adjustment in the surrounding soil.

Water Table, Perched -A water table standing above an unsaturated zone. In places an upper or perched water table is separated from a lower one by a dry zone.

APPENDIX A

MAP OF STUDY AREA



U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
LAKE, POLK & HIGHLANDS COUNTIES

CENTRAL FLORIDA WATER CONSERVATION STUDY

STUDY AREA LOCATION MAP

Figure 6

APPENDIX B

INVENTORY DATA

Central Florida Water Conservation Study

INPUT DATA FORM FOR CITRUS AREA

Date of Inventory________________ Name of Person Doing Inventory________________

Area [__] 1

1=Citrus
2=Tri-County

County [__] 2

1=Lake
2=Polk
3=Highlands
4=St. Johns
5=Flagler
6=Eastern Putnam

Photo No.[__][__][__][__] 3 4 5 6

Field No. [__][__][__][__][__] 7 8 9 10 11

Soil [__][__][__][__] 12 13 14 15

Field Size [__][__][__][__] 16 17 18 19

Irrigation Systems [__][__] 20 21

Traveling Gun	1	
Buried main		1
Portable Pipe		2
Sprinkler	2	
Overhead		1
Under tree		2
Portable Laterals		3
Trickle	3	
Spray Jet		1
Drip		2
Subirrigation	4	
Open		1
Open with pipeline		2
Underground		3
Other	5	

Method [__] 22

1=Feel & Appearance
2=Accounting Method
3=Tensiometers
4=Observation wells
5=Crop Appearance
6=Other

Source [__] 23

1=Well
2=Surface
3=Other

Crop [__] 24

1=Citrus
2=Nursery
3=Vegetable
4=Other

Citrus Status [__] 25

1=Frozen, replant probable
2=Frozen, abandon
3=Frozen,future unknown
4=Young reset
5=Alive healthy
6=Alive, freeze damaged (pruned)
7=Alive, freeze damage
8=Alive, other
9=Other

Is this grove being evaluated?[__] 26

1=Yes
2=No

Comments [__] 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46

[__] 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68

[__][__][__][__][__][__][__][__][__][__][__][__] 69 70 71 72 73 74 75 76 77 78 79 80

Note: When recording comment use question number first when possible.

HIGHLANDS COUNTY INVENTORY DATA

49,327 total acres (1,449 acres non-irrigated)

Table 2. Highlands County Irrigation Systems

SYSTEM	ACRES
Traveling Gun-Buried Main (11)	156
Traveling Gun-Portable Pipe (12)	241
Sprinkler-Overhead (21)	19,454
Sprinkler-Under tree (22)	510
Sprinkler-Portable laterals (23)	0
Trickle-Spray jet (31)	16,704
Trickle-Drip (32)	10,813
Subirrigation-Open (41)	0
Subirrigation-Open w/pipeline (42)	0
Subirrigation-Underground (43)	0
Other (5)	0
TOTAL	47,878

Table 3. Highlands County Water Source

SOURCE	ACRES
Well (1)	37,760
Surface (2)	10,073
Other (3)	45
TOTAL	47,878

Table 4. Highlands County - Method of Scheduling

METHOD	ACRES
Feel and appearance (1)	21,332
Accounting method (2)	22,040
Tensiometers (3)	99
Observation wells (4)	0
Crop appearance (5)	4,198
Other (6)	209
TOTAL	47,878

Table 5. Highlands County Citrus Status (By Systems)

Traveling Gun-Buried Main (11)

STATUS	ACRES
Frozen, replant probable (1)	0
Frozen, abandon (2)	0
Frozen, future unknown (3)	0
Young reset (4)	0
Alive healthy (5)	156
Alive, freeze damage (pruned) (6)	0
Alive, freeze damage (7)	0
Alive, other (8)	0
Other (9)	0
TOTAL	156

Traveling Gun-Portable Pipe (12)

STATUS	ACRES
Frozen, replant probable (1)	0
Frozen, abandon (2)	0
Frozen, future unknown (3)	0
Young reset (4)	0
Alive healthy (5)	0
Alive, freeze damage (pruned) (6)	0
Alive, freeze damage (7)	241
Alive, other (8)	0
Other (9)	0
TOTAL	241

Sprinkler-Overhead (21)

STATUS	ACRES
Frozen, replant probable (1)	35
Frozen, abandon (2)	107
Frozen, future unknown (3)	32
Young reset (4)	0
Alive healthy (5)	17,920
Alive, freeze damage (pruned) (6)	62
Alive, freeze damage (7)	1,261
Alive, other (8)	0
Other (9)	37
TOTAL	19,454

Table 5. Highlands County-Citrus Status (By Systems) (continued)

Sprinkler-Under tree (22)

STATUS	ACRES
Frozen, replant probable (1)	0
Frozen, abandon (2)	0
Frozen, future unknown (3)	0
Young reset (4)	0
Alive healthy (5)	425
Alive, freeze damage (pruned) (6)	0
Alive, freeze damage (7)	0
Alive, other (8)	0
Other (9)	45
TOTAL	470

Sprinkler-Portable Laterals (23)

STATUS	ACRES
Frozen, replant probable (1)	0
Frozen, abandon (2)	0
Frozen, future unknown (3)	0
Young reset (4)	0
Alive healthy (5)	0
Alive, freeze damage (pruned) (6)	0
Alive, freeze damage (7)	0
Alive, other (8)	0
Other (9)	0
TOTAL	0

Trickle-Spray Jet (31)

STATUS	ACRES
Frozen, replant probable (1)	10
Frozen, abandon (2)	0
Frozen, future unknown (3)	0
Young reset (4)	80
Alive healthy (5)	15,512
Alive, freeze damage (pruned) (6)	19
Alive, freeze damage (7)	1,083
Alive, other (8)	0
Other (9)	0
TOTAL	16,704

Table 5. Highlands County-Citrus Status (By Systems) (continued)

Trickle-Drip (32)

STATUS	ACRES
Frozen, replant probable (1)	0
Frozen, abandon (2)	0
Frozen, future unknown (3)	44
Young reset (4)	0
Alive healthy (5)	10,243
Alive, freeze damage (pruned) (6)	38
Alive, freeze damage (7)	488
Alive, other (8)	0
Other (9)	0
TOTAL	10,813

Table 6. Highlands County - Crop

Crop	
Citrus (1)	49,057
Nursery (3)	145
Other (4)	125
	49,327

Table 7. Highlands County - Soils (By Systems)

Uplands and Ridges

SYSTEM	ACRES
Traveling Gun-Buried Main (11)	156
Traveling Gun-Portable Pipe (12)	241
Sprinkler-Overhead (21)	19,278
Sprinkler-Under tree (22)	510
Trickle-Spray jet (31)	14,195
Trickle-Drip (32)	4,045
TOTAL	38,425

Flatwoods, Sloughs, Broad Low Flats, and Poorly Defined Drainageways

SYSTEM	ACRES
Sprinkler-Overhead (21)	176
Trickle-Spray jet (31)	2,509
Trickle-Drip (32)	5,784
TOTAL	8,469

Table 7. Highlands County - Soils (By Systems) (continued)

Marshes and Swamps

SYSTEM	ACRES
Trickle-Drip (32)	984

LAKE COUNTY INVENTORY DATA

31,254 total acres

Table 8. Lake County-Irrigation Systems

SYSTEM	ACRES
Traveling Gun-Buried Main (11)	6,451
Traveling Gun-Portable Pipe (12)	390
Sprinkler-Overhead (21)	14,786
Sprinkler-Under tree (22)	1,003
Sprinkler-Portable laterals (23)	12
Trickle-Spray jet (31)	8,562
Trickle-Drip (32)	50
Subirrigation-Open (41)	0
Subirrigation-Open w/pipeline (42)	0
Subirrigation-Underground (43)	0
Other (5)	0
TOTAL	31,254

Table 9. Lake County-Water Source

SOURCE	ACRES
Well (1)	30,984
Surface (2)	270
Other (3)	0
TOTAL	31,254

Table 10. Lake County- Method of Scheduling

METHOD	ACRES
Feel and appearance (1)	22,708
Accounting method (2)	598
Tensiometers (3)	0
Observation wells (4)	0
Crop appearance (5)	8,448
Other (6)	0
TOTAL	31,254

Table 11. Lake County-Citrus Status (By Systems)

Traveling Gun-Buried Main (11)

STATUS	ACRES
Frozen, replant probable (1)	397
Frozen, abandon (2)	150
Frozen, future unknown (3)	5,234
Young reset (4)	60
Alive healthy (5)	70
Alive, freeze damage (pruned) (6)	440
Alive, freeze damage (7)	100
Alive, other (8)	0
Other (9)	0
TOTAL	6,451

Traveling Gun-Portable Pipe (12)

STATUS	ACRES
Frozen, replant probable (1)	0
Frozen, abandon (2)	0
Frozen, future unknown (3)	338
Young reset (4)	0
Alive healthy (5)	0
Alive, freeze damage (pruned) (6)	0
Alive, freeze damage (7)	0
Alive, other (8)	0
Other (9)	52
TOTAL	390

Sprinkler-Overhead (21)

STATUS	ACRES
Frozen, replant probable (1)	1,513
Frozen, abandon (2)	230
Frozen, future unknown (3)	10,334
Young reset (4)	915
Alive healthy (5)	645
Alive, freeze damage (pruned) (6)	520
Alive, freeze damage (7)	579
Alive, other (8)	0
Other (9)	50
TOTAL	14,786

Table 11. Lake County-Citrus Status (By Systems) (continued)

Sprinkler-Under tree (22)

STATUS	ACRES
Frozen, replant probable (1)	170
Frozen, abandon (2)	0
Frozen, future unknown (3)	335
Young reset (4)	120
Alive healthy (5)	0
Alive, freeze damage (pruned) (6)	0
Alive, freeze damage (7)	0
Alive, other (8)	90
Other (9)	288
TOTAL	1,003

Sprinkler-Portable Laterals (23)

STATUS	ACRES
Frozen, replant probable (1)	0
Frozen, abandon (2)	0
Frozen, future unknown (3)	0
Young reset (4)	0
Alive healthy (5)	0
Alive, freeze damage (pruned) (6)	0
Alive, freeze damage (7)	0
Alive, other (8)	12
Other (9)	0
TOTAL	12

Trickle-Spray Jet (31)

STATUS	ACRES
Frozen, replant probable (1)	2,202
Frozen, abandon (2)	180
Frozen, future unknown (3)	2,916
Young reset (4)	2,077
Alive healthy (5)	175
Alive, freeze damage (pruned) (6)	505
Alive, freeze damage (7)	495
Alive, other (8)	0
Other (9)	12
TOTAL	8,562

Table 11. Lake County-Citrus Status (By Systems) (continued)

Trickle-Drip (32)

STATUS	ACRES
Frozen, replant probable (1)	0
Frozen, abandon (2)	0
Frozen, future unknown (3)	0
Young reset (4)	0
Alive healthy (5)	50
Alive, freeze damage (pruned) (6)	0
Alive, freeze damage (7)	0
Alive, other (8)	0
Other (9)	0
TOTAL	50

Table 12. Lake County-Soils (By Systems)

Sand Ridges and Uplands

SYSTEM	ACRES
Traveling Gun-Buried Main (11)	5,678
Traveling Gun-Portable Pipe (12)	390
Sprinkler-Overhead (21)	12,149
Sprinkler-Under tree (22)	833
Trickle-Spray jet (31)	7,650
Trickle-Drip (32)	50
TOTAL	26,750

Uplands, Low Uplands, Low Knolls, and Ridges

SYSTEM	ACRES
Traveling Gun-Buried Main (11)	758
Sprinkler-Overhead (21)	2,607
Sprinkler-Under tree (22)	165
Sprinkler-Portable laterals (23)	12
Trickle-Spray jet (31)	912
TOTAL	4,454

Table 12. Lake County-Soils (By Systems) (continued)

Flatwoods

SYSTEM	ACRES
Traveling Gun-Buried Main (11)	0
Traveling Gun-Portable Pipe (12)	0
Sprinkler-Overhead (21)	20
Sprinkler-Under tree (22)	0
Sprinkler-Portable laterals (23)	0
Trickle-Spray jet (31)	0
Trickle-Drip (32)	0
TOTAL	20

Sloughs, Broad Low Flats, and Poorly Defined Drainageways

SYSTEM	ACRES
Sprinkler-Under Tree (22)	5

Fill Land - Loamy Materials

SYSTEM	ACRES
Traveling Gun-Buried Main (11)	15
Sprinkler-Overhead (21)	10
Total	25

POLK COUNTY INVENTORY DATA

125,488 total acres inventoried

Table 13. Polk County- Irrigation Systems

SYSTEM	ACRES
Traveling Gun-Buried Main (11)	2,071
Traveling Gun-Portable Pipe (12)	18,887
Sprinkler-Overhead (21)	49,439
Sprinkler-Under tree (22)	10,326
Sprinkler-Portable laterals (23)	125
Trickle-Spray jet (31)	40,502
Trickle-Drip (32)	1,181
Subirrigation-Open (41)	30
Subirrigation-Open w/pipeline (42)	0
Subirrigation-Underground (43)	0
Other (5)	2,927
TOTAL	125,488

Table 14. Polk County- Water Source

SOURCE	ACRES
Well (1)	122,772
Surface (2)	509
Other (3)	2,207
TOTAL	125,488

Table 15. Polk County-Method of Scheduling

METHOD	ACRES
Feel and appearance (1)	4,434
Accounting method (2)	527
Tensiometers (3)	0
Observation wells (4)	20
Crop appearance (5)	117,846
Other (6)	2,661
TOTAL	125,488

Table 16. Polk County-Citrus Status (By Systems) (continued)

Traveling Gun-Buried Main (11)

STATUS	ACRES
Frozen, replant probable (1)	0
Frozen, abandon (2)	132
Frozen, future unknown (3)	328
Young reset (4)	0
Alive healthy (5)	1,022
Alive, freeze damage (pruned) (6)	85
Alive, freeze damage (7)	504
Alive, other (8)	0
Other (9)	0
TOTAL	2,071

Traveling Gun-Portable Pipe (12)

STATUS	ACRES	
Frozen, replant probable (1)	0	
Frozen, abandon (2)	2,063	
Frozen, future unknown (3)	1,829	
Young reset (4)	428	
Alive healthy (5)	9,143	
Alive, freeze damage (pruned) (6)	758	
Alive, freeze damage (7)	4,653	
Alive, other (8)	0	
Other (9)	0	
TOTAL	18,874	(13 acres not reporting status)

Sprinkler-Overhead (21)

STATUS	ACRES
Frozen, replant probable (1)	0
Frozen, abandon (2)	1,412
Frozen, future unknown (3)	1,788
Young reset (4)	1,275
Alive healthy (5)	30,372
Alive, freeze damage (pruned) (6)	2,076
Alive, freeze damage (7)	10,996
Alive, other (8)	70
Other (9)	1,450
TOTAL	49,439

Table 16. Polk County-Citrus Status (By System) (continued)

Sprinkler-Under tree (22)

STATUS	ACRES	
Frozen, replant probable (1)	0	
Frozen, abandon (2)	361	
Frozen, future unknown (3)	526	
Young reset (4)	319	
Alive healthy (5)	4,754	
Alive, freeze damage (pruned) (6)	765	
Alive, freeze damage (7)	3,389	
Alive, other (8)	0	
Other (9)	120	
TOTAL	10,234	(92 acres not reporting status)

Sprinkler-Portable Laterals (23)

STATUS	ACRES
Frozen, replant probable (1)	0
Frozen, abandon (2)	0
Frozen, future unknown (3)	0
Young reset (4)	0
Alive healthy (5)	0
Alive, freeze damage (pruned) (6)	125
Alive, freeze damage (7)	0
Alive, other (8)	0
Other (9)	0
TOTAL	125

Trickle-Spray Jet (31)

STATUS	ACRES	
Frozen, replant probable (1)	10	
Frozen, abandon (2)	479	
Frozen, future unknown (3)	579	
Young reset (4)	5,045	
Alive healthy (5)	25,234	
Alive, freeze damage (pruned) (6)	1,348	
Alive, freeze damage (7)	7,557	
Alive, other (8)	36	
Other (9)	169	
TOTAL	40,457	(45 acres not reporting status)

Table 16. Polk County-Citrus Status (By System) (continued)

Trickle-Drip (32)

STATUS	ACRES
Frozen, replant probable (1)	0
Frozen, abandon (2)	0
Frozen, future unknown (3)	0
Young reset (4)	201
Alive healthy (5)	900
Alive, freeze damage (pruned) (6)	0
Alive, freeze damage (7)	80
Alive, other (8)	0
Other (9)	0
TOTAL	1,181

Subirrigation-Open (41)

STATUS	ACRES
Frozen, replant probable (1)	0
Frozen, abandon (2)	0
Frozen, future unknown (3)	0
Young reset (4)	0
Alive healthy (5)	30
Alive, freeze damage (pruned) (6)	0
Alive, freeze damage (7)	0
Alive, other (8)	0
Other (9)	0
TOTAL	30

No system 42 or 43.

Table 16. Polk County-Citrus Status (By System) (continued)

Other (51)

STATUS	ACRES	
Frozen, replant probable (1)	0	
Frozen, abandon (2)	503	
Frozen, future unknown (3)	157	
Young reset (4)	30	
Alive healthy (5)	195	
Alive, freeze damage (pruned) (6)	237	
Alive, freeze damage (7)	1,755	
Alive, other (8)	0	
Other (9)	10	
TOTAL	2,887	(40 acres not reporting status)

Table 17. Polk County-Crop

Crop	
Citrus (1)	125,448 acres
Nursery (2)	10 acres
Vegetables (3)	30 acres
Other (4)	0 acres
	125,488

Table 18. Polk County-Soils

Sand Ridges and Uplands

SYSTEM	ACRES
Traveling Gun-Buried Main (11)	1,484
Traveling Gun-Portable Pipe (12)	16,875
Sprinkler-Overhead (21)	45,592
Sprinkler-Under tree (22)	9,033
Sprinkler-Portable laterals (23)	80
Trickle-Spray jet (31)	33,720
Trickle-Drip (32)	1,161
Other (5)	2,689
TOTAL	110,634

Table 18. Polk County-Soils (continued)

Uplands, Low Uplands, Low Knolls, and Ridges

SYSTEM	ACRES
Traveling Gun-Buried Main (11)	361
Traveling Gun-Portable Pipe (12)	1,151
Sprinkler-Overhead (21)	2,061
Sprinkler-Under tree (22)	815
Trickle-Spray jet (31)	3,036
Other (5)	168
TOTAL	7,592

Flatwoods

SYSTEM	ACRES
Traveling Gun-Buried Main (11)	206
Traveling Gun-Portable Pipe (12)	851
Sprinkler-Overhead (21)	1,768
Sprinkler-Under tree (22)	443
Sprinkler-Portable laterals (23)	45
Trickle-Spray jet (31)	3,511
Subirrigation-Open (41)	30
Other (5)	48
TOTAL	6,902

Sloughs, Broad Low Flats, and Poorly Defined Drainageways

SYSTEM	ACRES
Traveling Gun-Portable Pipe (12)	10
Sprinkler-Overhead (21)	10
Trickle-Spray jet (31)	25
TOTAL	45

Reclaimed Mined Land

SYSTEM	ACRES
Traveling Gun-Buried Main (11)	20
Sprinkler-Overhead (21)	8
Sprinkler-Under tree (22)	35
Trickle-Spray Jet (31)	210
Other (5)	22
TOTAL	295

Table 18. Polk County-Soils (continued)

Depressional/Ponded SYSTEM	ACRES
Trickle-Drip (32)	20
TOTAL	20

APPENDIX C

RATIO COMPARISON TABLES

EXPLANATION OF RATIO COMPARISON TABLES

Initially, data were gathered from specialists at the University of Florida who work in economics, engineering, and extension service, and from ASCS and SCS personnel. Also, a survey was made of pertinent publications from governmental and university sectors.

Of the many publications reviewed, the most helpful were: "Factors to Consider in Determining the Profitability of Sprinkler Irrigation" by Golden, Maddox, Walch, and Davis; "Sprinkler, Trickle, and Other Irrigation Systems: Cost Estimates for Citrus and Orchard Crops" by Harrison, Smajstrla, and Zazueta; "Irrigation Systems and Cost Estimates for Row Crop Production in Florida" by Harrison, Smajstrla, and Zazueta; "Inputs and Costs of Selected Sprinkler Irrigation Systems for Citrus in Central Florida" by Reuss and Harrison; "Irrigation Systems for Crop Production in Florida" by Harrison; and "Irrigation Methods and Equipment for Production of Citrus in Florida" by Harrison and Koo.

The data are well fitted for ratio comparison. Tables have been constructed with each system assuming the part of the "base system" allowing the other systems to be compared in relation to it.

There are six ratio comparison tables:

1. Table 19 compares "traveling gun-buried main" to the remaining systems.

2. Table 20 compares "traveling gun-portable pipe" to the remaining systems.

3. Table 21 compares "sprinkler-overhead" to the remaining systems.

4. Table 22 compares "sprinkler-under tree" to the remaining systems.

5. Table 23 compares "trickle-spray jet" to the remaining systems.

6. Table 24 compares "trickle-drip" to the remaining systems.

These systems relate to survey data and irrigation conditions monitored in the survey area.

Please refer to "Table 19, Ratio Comparison by System-Base System-Traveling Gun (Buried Main)" when reading the following paragraphs.

The basis of ratio tables is to offer overall average comparisons between the various systems. Therefore, when another system registers a greater cost than the base system, it will list a number greater than 1.0, and when another system registers a smaller cost than the base system, it will list a number less than 1.0.

Therefore, a number listed in a column as 0.90 may be interpreted one of two ways. First, this particular item could be expressed as being 90 percent of the base item. Second, this particular item could be expressed as being 10 percent less than the base item.

Additionally, a number listed in a column as 1.20 may be interpreted as being 120 percent of the base item. Last, this particular item could be expressed as being 20 percent greater than the base item.

For example, in Table 19, gross irrigation inches required for "Traveling Gun-Portable Pipe" system has a value of 1.12. This means that, on the average, a "Traveling Gun-Portable Pipe" system should use 12 percent more water than the base system of "Traveling Gun-Buried Main" uses.

It should be remembered that these tables are guides and represent a set of average conditions which will probably not exist exactly in real life. However, they should provide direction in evaluating potential irrigation system choices for an individual irrigation operation.

Conversion

Information pertaining to conversion from one system to another system was very limited. A major cost factor related to converting systems is whether a pump and well are in place. If present, experience has shown that the existing well and pump would be tied into the new system. This is usually done without regard to the possibility that the existing well and pumping system might not provide the pressure and gpm needed to properly operate the new system. If a well and pumping unit were in place, it is estimated that installation costs (fixed costs) could be reduced by 50 percent.

The survey indicated that major improvements in irrigation efficiency could be achieved by using better management in the operation of the systems in place. Closer monitoring and scheduling of irrigation periods need greater attention. It was indicated that this is the single most important factor in increasing irrigation efficiency in the survey area.

Finally, equipment adjustments aimed toward SCS irrigation guidelines are strongly recommended. Presently, many systems do not meet these specifications. Mainly, the adjustments would revolve around changing the pump discharge pressure and sprinkler head nozzles.

Summary

There are many variables which contribute to an operational cost per acre. In the first set of comparisons, variable costs seem to be the least for "Drip" irrigation systems. However, each situation in which it is used should be individually evaluated. For example, installing a drip irrigation system on a deep sandy ridge soil may not provide adequate moisture during drought periods, resulting in low yields. Additionally, some systems such as subirrigation require relatively level landscapes to be operational. Therefore, an irrigation system may not be feasible in all situations.

The various systems can be adapted singly or in combination to fit an individual farming situation. However, no one system may be applicable to all situations. Therefore, it should be stressed that these tables are "guides for comparison" and should be thought of as an "initial first step" in the formulation of an irrigation water management plan.

TABLE 19

RATIO COMPARISON BY SYSTEM - BASE SYSTEM - TRAVELING GUN (BURIED MAIN)

SYSTEM	GROSS IRRIGATION INCHES/REQ.	POTENTIAL SYSTEM EFFICIENCY	VARIABLE COST/RATIOS PER ACRE/YEAR			COST/RATIOS PER ACRE/YEAR		
			SYSTEM CHECK	OPERATION	MAINTENANCE	VARIABLE	FIXED	TOTAL
BASE SYSTEM TRAVELING GUN BURIED MAIN	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00
TRAVELING GUN								
PORTABLE PIPE	1.12	0.90	NA	1.12	1.68	1.16	0.70	1.10
SPRINKLER								
OVERHEAD	0.79	1.27	3.36	0.45	1.10	0.52	1.19	0.60
UNDER TREE	0.79	1.27	11.85	0.40	0.95	0.48	1.13	0.56
TRICKLE								
SPRAY JET	0.79	1.27	11.85	0.25	1.15	0.36	1.13	0.46
DRIP	0.74	1.34	9.48	0.20	0.62	0.26	0.90	0.34

Gross irrigation based on net estimated requirement of 15.1 inches and adjusted for potential efficiency.
Variable expenses include items such as: fuel, oil, repairs, maintenance, labor and overhead.
Fixed expenses include system installation/depreciation over estimated life.

Table 20

RATIO COMPARISON BY SYSTEM - BASE SYSTEM - TRAVELING GUN (PORTABLE PIPE)

SYSTEM	GROSS IRRIGATION INCHES/REQ.	POTENTIAL SYSTEM EFFICIENCY	VARIABLE COST/RATIOS PER ACRE/YEAR			COST/RATIOS PER ACRE/YEAR		
			SYSTEM CHECK	OPERATION	MAINTENANCE	VARIABLE	FIXED	TOTAL
BASE SYSTEM TRAVELING GUN PORTABLE PIPE	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00
TRAVELING GUN								
BURIED MAIN	0.90	1.12	NA	0.90	0.60	0.86	1.43	0.91
SPRINKLER								
OVERHEAD	0.71	1.42	NA	0.41	0.66	0.44	1.70	0.55
UNDER TREE	0.71	1.42	NA	0.36	0.57	0.41	1.62	0.51
TRICKLE								
SPRAY JET	0.71	1.42	NA	0.22	0.69	0.31	1.62	0.41
DRIP	0.67	1.50	NA	0.18	0.37	0.23	1.29	0.31

Gross irrigation based on net estimated requirement of 15.1 inches and adjusted for potential efficiency.
Variable expenses include items such as: fuel, oil, repairs, maintenance, labor and overhead.
Fixed expenses include system installation/depreciation over estimated life.

Table 21

RATIO COMPARISON BY SYSTEM - BASE SYSTEM - SPRINKLER (OVERHEAD)

SYSTEM	GROSS IRRIGATION INCHES/REQ.	POTENTIAL SYSTEM EFFICIENCY	VARIABLE COST/RATIOS PER ACRE/YEAR			COST/RATIOS PER ACRE/YEAR		
			SYSTEM CHECK	OPERATION	MAINTENANCE	VARIABLE	FIXED	TOTAL
BASE SYSTEM SPRINKLER OVERHEAD	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00
TRAVELING GUN								
BURIED MAIN	1.27	0.79	NA	2.20	0.91	1.94	0.84	1.66
PORTABLE PIPE	1.42	0.71	NA	2.45	1.52	2.25	0.59	1.83
SPRINKLER								
UNDER TREE	1.00	1.00	3.52	0.88	0.86	0.93	0.95	0.94
TRICKLE								
SPRAY JET	1.00	1.00	3.52	0.55	1.05	0.69	0.95	0.76
DRIP	0.94	1.06	2.82	0.44	0.57	0.51	0.76	0.57

Gross irrigation based on net estimated requirement of 15.1 inches and adjusted for potential efficiency.
Variable expenses include items such as: fuel, oil, repairs, maintenance, labor and overhead.
Fixed expenses include system installation/depreciation over estimated life.

Table 22

RATIO COMPARISON BY SYSTEM - BASE SYSTEM - SPRINKLER (UNDER TREE)

SYSTEM	GROSS IRRIGATION INCHES/REQ.	POTENTIAL SYSTEM EFFICIENCY	VARIABLE COST/RATIOS PER ACRE/YEAR			COST/RATIOS PER ACRE/YEAR		
			SYSTEM CHECK	OPERATION	MAINTENANCE	VARIABLE	FIXED	TOTAL
BASE SYSTEM SPRINKLER UNDER TREE	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00
TRAVELING GUN								
BURIED MAIN	1.27	0.79	NA	2.49	1.05	2.08	0.88	1.77
PORTABLE PIPE	1.42	0.71	NA	2.78	1.77	2.42	0.62	1.95
SPRINKLER								
OVERHEAD	1.00	1.00	0.28	1.13	1.16	1.07	1.05	1.07
TRICKLE								
SPRAY JET	1.00	1.00	1.00	0.62	1.22	0.74	1.00	0.81
DRIP	0.94	1.06	0.80	0.50	0.66	0.55	0.80	0.61

Gross irrigation based on net estimated requirement of 15.1 inches and adjusted for potential efficiency.
Variable expenses include items such as: fuel, oil, repairs, maintenance, labor and overhead.
Fixed expenses include system installation/depreciation over estimated life.

Table 23

RATIO COMPARISON BY SYSTEM - BASE SYSTEM - TRICKLE (SPRAY JET)

SYSTEM	GROSS IRRIGATION INCHES/REQ.	POTENTIAL SYSTEM EFFICIENCY	VARIABLE COST/RATIOS PER ACRE/YEAR			COST/RATIOS PER ACRE/YEAR		
			SYSTEM CHECK	OPERATION	MAINTENANCE	VARIABLE	FIXED	TOTAL
BASE SYSTEM TRICKLE SPRAY JET	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00
TRAVELING GUN								
BURIED MAIN	1.27	0.79	NA	3.99	0.87	2.81	0.88	2.19
PORTABLE PIPE	1.42	0.71	NA	4.45	1.45	3.26	0.62	2.41
SPRINKLER								
OVERHEAD	1.00	1.00	0.28	1.81	0.95	1.45	1.05	1.32
UNDER TREE	1.00	1.00	1.00	1.60	0.82	1.35	1.00	1.24
TRICKLE								
DRIP	0.94	1.06	0.80	0.80	0.54	0.73	0.80	0.76

Gross irrigation based on net estimated requirement of 15.1 inches and adjusted for potential efficiency.
Variable expenses include items such as: fuel, oil, repairs, maintenance, labor and overhead.
Fixed expenses include system installation/depreciation over estimated life.

Table 24

RATIO COMPARISON BY SYSTEM - BASE SYSTEM - TRICKLE (DRIP)

SYSTEM	GROSS IRRIGATION INCHES/REQ.	POTENTIAL SYSTEM EFFICIENCY	VARIABLE COST/RATIOS PER ACRE/YEAR			COST/RATIOS PER ACRE/YEAR		
			SYSTEM CHECK	OPERATION	MAINTENANCE	VARIABLE	FIXED	TOTAL
BASE SYSTEM TRICKLE DRIP	1.00	1.00	NA	1.00	1.00	1.00	1.00	1.00
TRAVELING GUN								
BURIED MAIN	1.34	0.74	NA	4.98	1.60	3.82	1.11	2.90
PORTABLE PIPE	1.50	0.67	NA	5.57	2.68	4.43	0.77	3.19
SPRINKLER								
OVERHEAD	1.06	0.94	0.35	2.27	1.76	1.97	1.32	1.75
UNDER TREE	1.06	0.94	1.25	2.00	1.52	1.83	1.25	1.64
TRICKLE								
SPRAY JET	1.06	0.94	1.25	1.25	1.85	1.36	1.25	1.32

Gross irrigation based on net estimated requirement of 15.1 inches and adjusted for potential efficiency.
Variable expenses include items such as: fuel, oil, repairs, maintenance, labor and overhead.
Fixed expenses include system installation/depreciation over estimated life.