

ENGINEERING REPORT

SARASOTA COUNTY COASTAL BASINS
FLOOD CONTROL STUDY

FOR THE
BOARD OF COUNTY COMMISSIONERS
COUNTY OF SARASOTA
FLORIDA

SEPTEMBER, 1961

SMALLY, WELLFORD and NALVEN
CONSULTING ENGINEERS
SARASOTA, FLORIDA

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I. PREFACE

This report is arranged to be essentially self-contained and to serve the needs of various readers. Exhibits bound herein are incorporated for this purpose.

However, the bulk of the engineering involved in the studies authorized by the Board of County Commissioners is represented by the plans which are referenced in the "List of Plans" on the preceding page. These plans are available in bound sets or individual sheets, as suitable for the requirements of the user.

Those who wish to read a summary of the report are directed to the following sections:

II. INTRODUCTION

III. SCOPE

XVI. CONCLUSIONS

XVII. RECOMMENDATIONS

II. INTRODUCTION

The explosive population growth of Sarasota County has magnified and focussed attention on flooding problems which in the past were often ignored. The economic base has simultaneously increased to the point that the maintenance of present and future land values requires measures the costs of which might not have been justified before. The health and welfare of an urbanizing public also demand protection.

The greatest impact naturally has fallen upon those areas with the greatest growth. The Phillippi Creek basin includes the largest urban population outside of the incorporated municipalities, as well as the greatest concentration of improved farm and ranch land. This basin is the subject of an engineering report issued in June of this year to the Board of County Commissioners.

In April 1961 the Board extended the engineering studies to include all of the coastal basins. This report and the separate plans referenced herein are the result.

The basic purpose of this study and report is to establish a frame of reference. Without such a frame of reference the course of events cannot be analyzed properly, and statistical data bewilders instead of guides; the pressures for actions by conflicting interests cannot be resolved into the best solutions in the public interest; premature steps may be taken which could create more ultimate harm than good, and future generations may be mortgaged with excessively high costs of correction; orderly and desirable community growth may be temporarily or permanently injured.

There is probably not a single aspect of water management from flood control to esthetics that will not come back to real property values in the long run. Thus the entire community has an economic stake, in addition to all of the other public and private rewards involved in preservation of water resources and foresighted water management.

Man's relationship to his water environment may be broken into two classifications, water resources and water management. "Water resources" basically refers to water as man finds it in nature, as rainfall, surface water, and ground water. "Water management" may be defined as what man does about water, and thus includes flood control, drainage, conservation, usage and the results of usage, and in general, artificial water-related forces and effects.

When mankind was small in number and his works puny, the natural forces behind water resources dwarfed the significance of water management. Now the works of man have achieved massive "feedback" effects to the point that this natural resource is endangered.

Considering this present interrelationship, the term "water management" is used generally in the report where a blanket term will simplify the text. Where peculiarly applicable, the term "water resources" is applied. These definitions should also help to explain the use of these terms in other references, and in acts of Congress and the state legislature. For example, the U. S. Geological Survey will tend to speak of water resources, whereas the U. S. Army Corps of Engineers in terms of control because of primary interests of these agencies lie in these respective fields.

Sarasota County is already suffering from an acute problem in the Phillippi Creek basin. The county has the opportunity to proceed with vigor, tempered with caution, toward solution of its problems in other basins before they become oppressive.

III. SCOPE

A. General

The scope of this study may be classified as follows:

- A. Overall hydrology of each basin and the hydraulics of the existing and proposed major drainageways therein.
- B. Insofar as available topographic data permits, the delineation of flood hazard areas that now exist, and corresponding minimum building elevations for new construction.

The intensity of the investigation has been of a preliminary nature, as set out in the authorization. It establishes a frame of reference which reveals the most important elements and provides a basis for charting further steps.

B. Right-of-way for Drainageways

The first important goal has been achieved, which is the establishment of the right-of-way requirements for major drainageways, which will permit legal and other steps to avoid encroachment by construction and subdivision platting. The requirements of bridges and culverts for highway crossings may be pre-planned, of which the State Road Departments improvements of S. R. 45 (U.S. Route 41) are of immediate urgency.

C. Topographic Data

The key to complete basin analysis is reliable topographic data. Preliminary topographic data may be used for preliminary purposes, and more refined data may be obtained and applied to succeeding stages of study and construction. Unfortunately only limited topographic data is available in most of these basins. The present U. S. Geological Survey maps delineate contours at 20 foot intervals, which is

hardly sufficient for any purposes in land as flat as these basins. We have assembled data from all available sources, but much more will be needed in the future.

For the major drainageways we have completed field surveys as needed for the hydraulic analyses reported herein. However, delineation of flood hazard areas has been severely handicapped by lack of sufficient topographic data in many areas.

D. Previous Studies and Reports

Previous engineering studies and reports have been reviewed and correlated to the degree that they are applicable to the scope and criteria of this study. The Phillippi Creek basin has previously been studied by this firm, and the crossing at U.S. Route 41 by J. E. Greiner Company. The preliminary report by the U. S. Soil Conservation Service on the project in Cowpen Slough and Shakett Creek, officially designated "Sarasota West Coast Watershed," has been analyzed, and modifications are proposed herein which would be of considerable benefit. Other reports are referred to in the text and are referenced in an appendix.

E. Boundary Survey

Although the hydraulic analysis of the channels reveals the future right-of-way that should be reserved, the exact location of this right-of-way requires boundary surveys. To complete such surveys for all basins would be very costly. This cost would be justified if there were no other way to protect the right-of-way from the effects of even more costly encroachment, but for most of the basin delineation of future right-of-ways, under a master drainage plan, may be sufficient for the present time, provided it is legally protected. Land developers may be expected to allow for this right-of-way as part of their plans, in the same manner in which they incorporate segments of the comprehensive road plan. This procedure is beneficial to the developer, because it provides drainage for his subdivision.

On the other hand, this procedure may be too late for certain "hot spots" where widening of drainageways presents a costly problem not only as to construction but also as to acquisition of valuable right-of-way, for which a certain number of dwellings must be removed or demolished. For this reason, the Board of County Commissioners might later authorize certain alignment studies and localized boundary surveys in keeping with the hydraulic requirements of the channels.

F. Limitations to Scope

This report is limited to major basins and drainageways. Localized coastal terrain and the offshore keys are not included in this classification. Their areas, relief feature and proximity to the bays are such that minor basins and drainageways will apply. The term "minor" refers to size, and not to the seriousness of any local problems that may exist.

G. Other Aspects

The scope of this study and report is specifically related to problems resulting from flood control and drainage in the basins. Surface water runoff is not the only aspect of water management of importance in this area. Ground water conservation, including resistance to salt water intrusion, and other aspects of water management are touched upon herein, but the emphasis is basically on surface runoff.

IV. GENERAL ASPECTS OF SARASOTA COUNTY

A. General

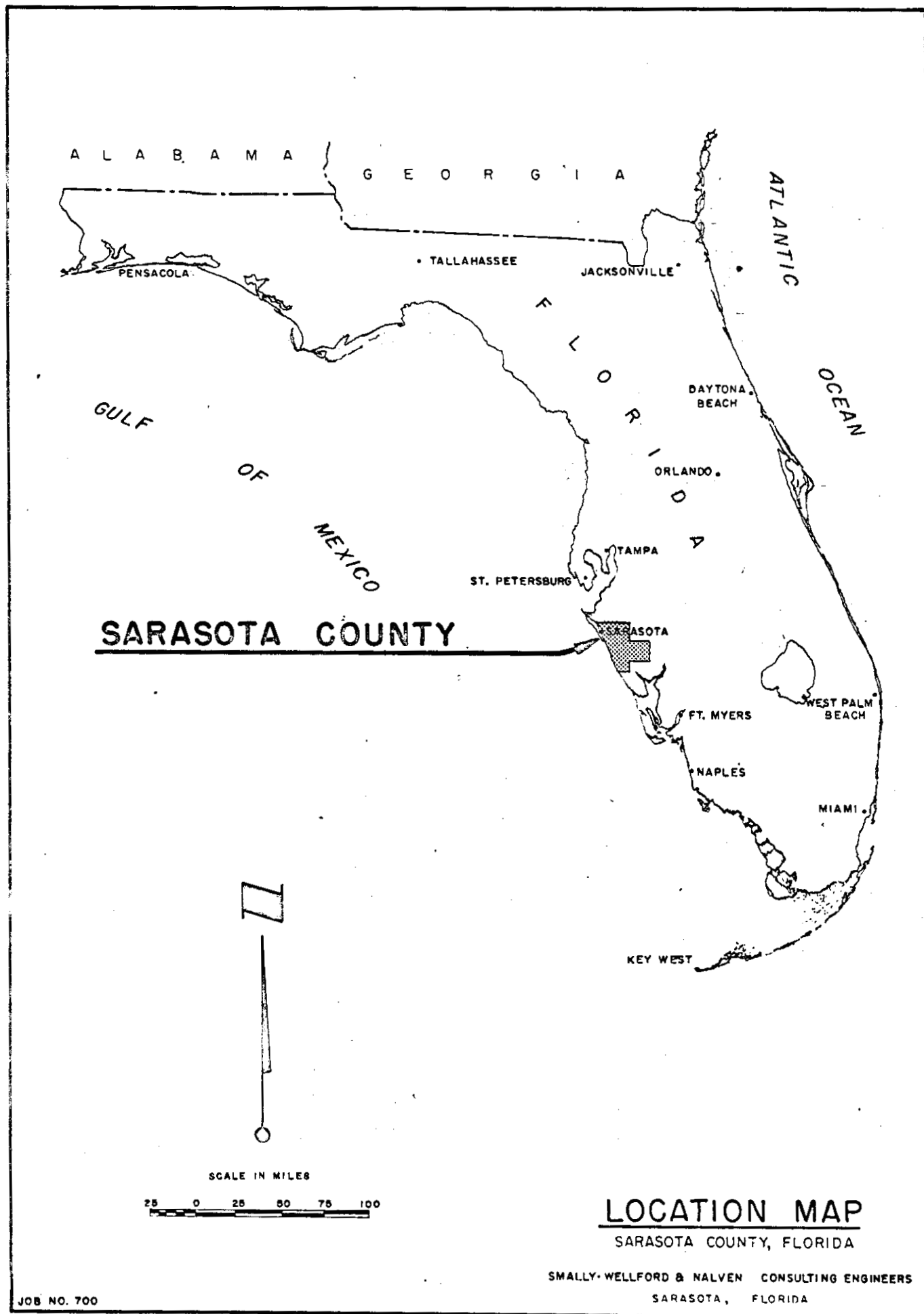
Sarasota County is located below Tampa Bay on the west coast of peninsular Florida, as shown on Exhibit "A" on the following page. Enjoying 30 miles of sandy beaches on the Gulf of Mexico, the total land area of the county is 586 square miles. Population centers have developed along the coast and will ultimately present an unbroken metropolitan strip, with future growth then moving inland.

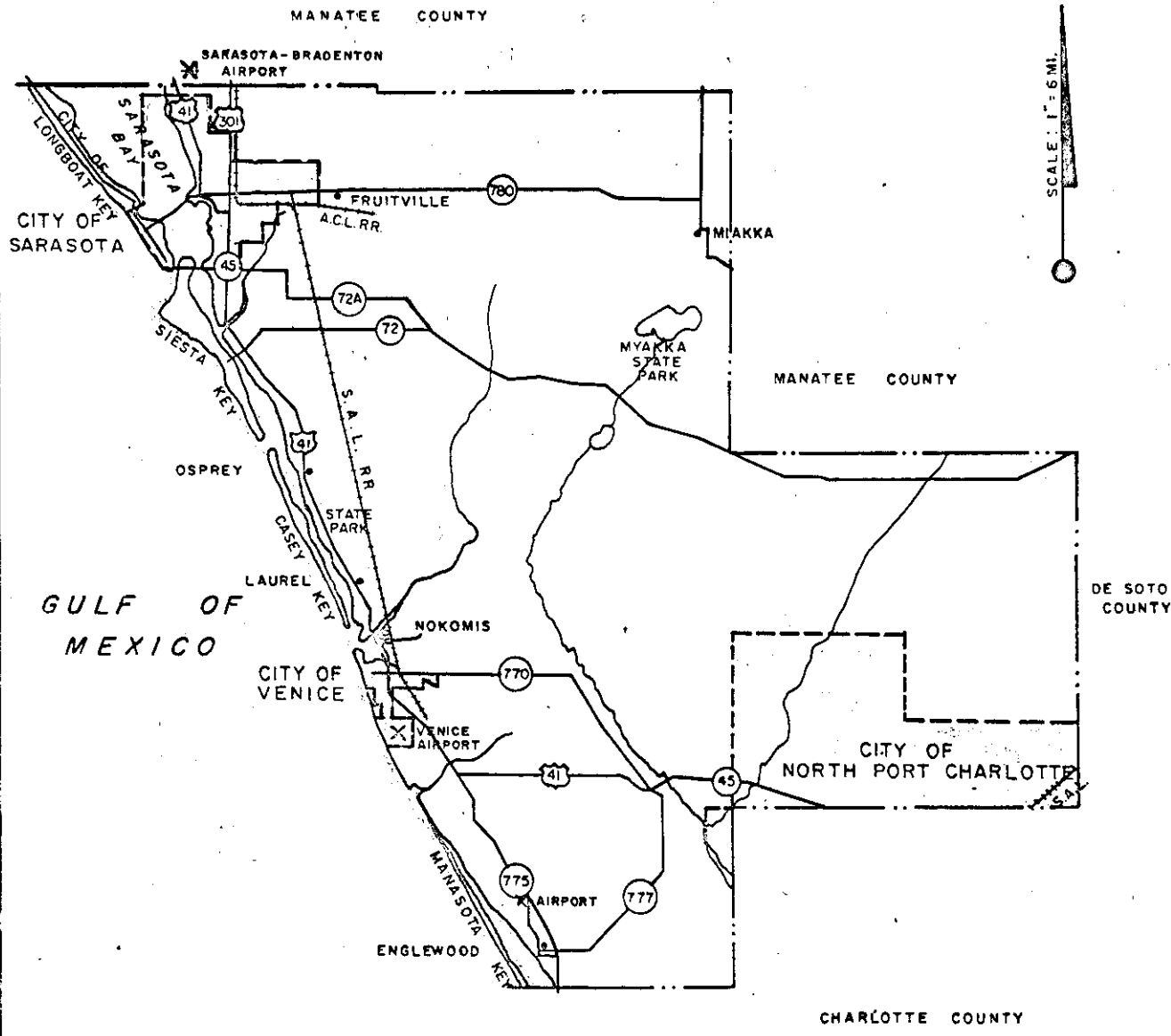
Exhibit "B," following Exhibit "A," maps the county outlines and principal cultural features. The main city is the City of Sarasota, which is also the county seat, with almost half the present population. The City is fifty miles south of the major twin cities of Tampa and St. Petersburg. The City of Venice, seventeen miles further south, which was founded as a model retirement community about 30 years ago, is also growing rapidly.

Sarasota County is served by a full range of public and civic services, such as a modern county school system, hospitals, churches and civic clubs. There are extensive recreational and sports facilities. The cultural environment is reflected in community concerts, professional and amateur theaters, a public library, newspapers and radio stations. Sarasota is the winter home of the Chicago White Sox baseball club.

B. History

Sarasota County was carved out of Manatee County in 1921. Long a sleepy farm community, with some commercial fishing and a modest resort activity, the area experienced the best and worst of the boom of the 1920's. Permanent assets derived from this period were transportation facilities which made further development inevitable.





SARASOTA COUNTY

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The following years saw Sarasota with a healthy, permanent growth in the direction of a resort community and a simultaneous increase in the retirement population. During World War II period, Sarasota became an Air Corps training base, which created a number of direct and indirect stimulations.

After the war Sarasota climbed rapidly. Although the resort activities hold the popular attention, the quiet growth of the stable permanent population actually is more impressive. Sarasota is now more than a resort and retirement community. It is also a center of art and culture, with a healthy commerce of retail trade, light industry and specialized agriculture. Many people who retain business connections up north make Sarasota their permanent home. Others who thought to retire have resumed active work and have started new businesses in Sarasota.

C. Transportation

Transportation facilities of almost every type are available, Sarasota being served by land, sea and air.

Two federal highways pass through Sarasota. U. S. Route 41, the well-known Tamiami Trail runs north and south, terminating at its southern end in Miami. U. S. Route 301 has its southern terminus in Sarasota. These highways are supplemented by state, county, and city roads. Efforts are being made to have road improvement keep pace with the increasing residential population, as well as the great tourist influx. The federal routes are being four-laned by stages.

Rail transportation is furnished by two major railroads, Seaboard Airline and Atlantic Coast Line, with full passenger and freight facilities. Bus lines and motor freight lines are also well established, with modern terminals.

The great deep-water port of Tampa is only fifty miles to the north. Sarasota is bordered by part of the inland waterway system, and is served by boat and barge

traffic of limited draft. Improvement and deepening of the channel is now underway under the federally supported Gulf Coast Intracoastal Waterway Project which ultimately will traverse the entire Gulf Coast, and will link up with other waterway systems.

Sarasota inherited two large airports from the wartime Air Corps, both of which are in active civil use. The main airport, Sarasota-Bradenton Airport is served by National and Eastern Airlines. In addition to the airline passenger and freight traffic, both airports handle a large volume of commercial and private airplane movements.

D. Economy of County

The county economy is not only a matter of local commerce and industry, but is rooted also in the independent income and wealth of the population.

Starting from an agricultural base the economy has become resort-oriented. Growth of a permanent population, at first strongly represented by retired persons, has spread information as to Sarasota's natural advantages, and new industry has been established at a quickening rate. The growth of population has of itself developed industry and services to supply local demands.

The building construction industry is naturally the largest because it reflects directly the growth of the area. Industries include building products, electronics, plastic and rubber products, chemicals, wire products, boats and accessories, fishing equipment, trailers and accessories, dairy and other consumer products, furniture, and others.

Agriculture has a long established background, having been for many years the original backbone of the economy. In general, agriculture is prosperous, subject to setbacks due to bad weather conditions, and is relatively stable in size.

V. POPULATION GROWTH

A. General

Knowledge of the population characteristics and its past trends will assist in analyzing present problems and in planning for the future. Although exact population statistics are not of critical importance to water management, as they would be for public utilities, it should be recognized that without people there would be no water problem.

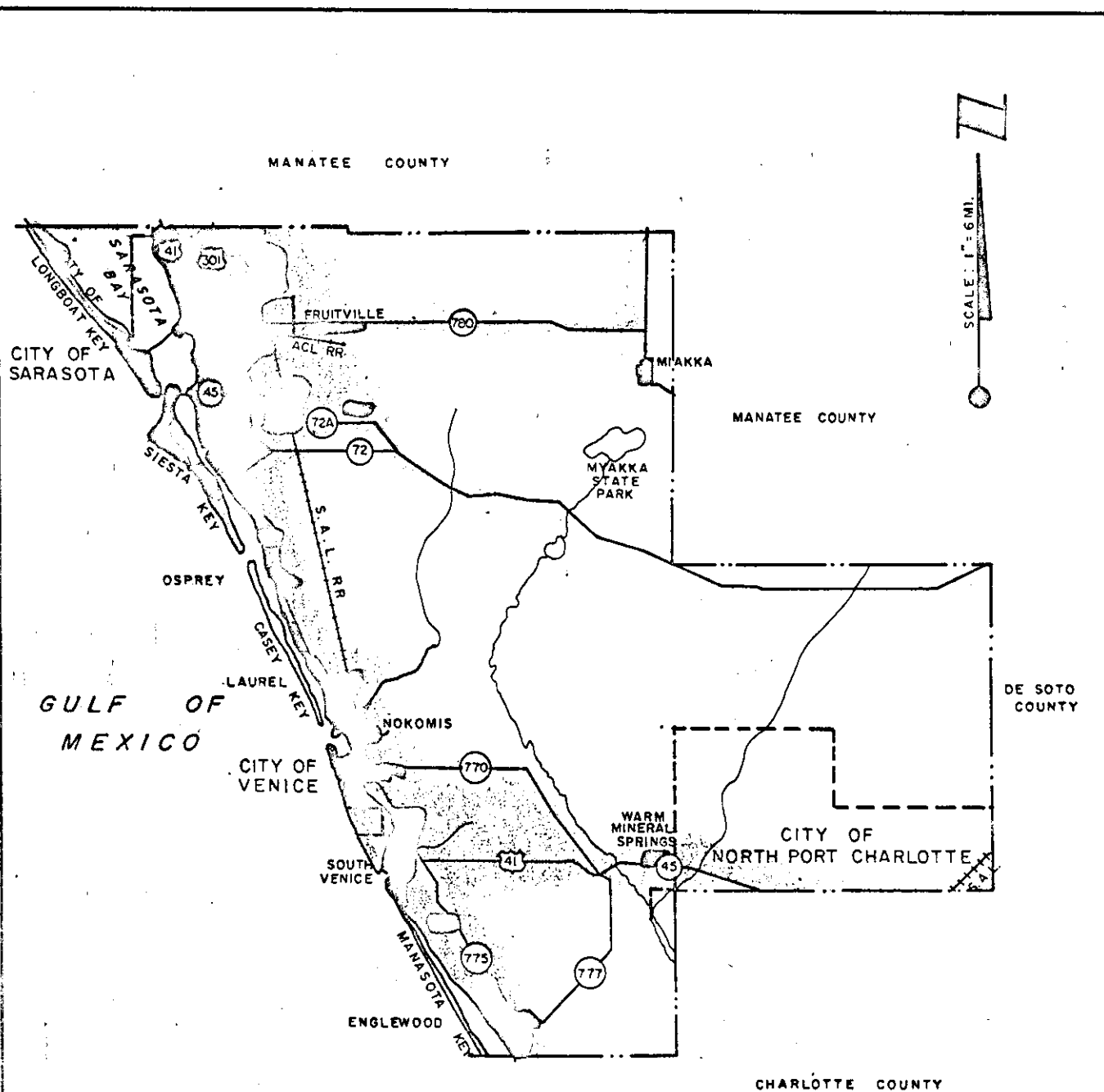
Exhibit "C," on the following page, portrays graphically the populated areas of Sarasota County and the trends that appear likely for the future. All of the established communities are shown, of which the following are incorporated cities:

Sarasota
Venice
Longboat Key
North Port Charlotte

The City of North Port Charlotte covers the largest area, a huge 55.5 square miles, but had a population in 1960 of only 178 persons. The area relates to the subdivision holdings of the development corporation, rather than the natural result of urbanization.

The U. S. Bureau of the Census made its latest decennial count in 1960, which means that recent data is available. This information is usually accurate. However, it is often overlooked that the purpose of the Census Bureau is not always identical with the requirements of others.

The Census Bureau must count the nation only once. Therefore they do not credit an area with the population which has its "usual" domiciles elsewhere. Yet people who are in fact, if not officially, residents of an area for many months of the year, occupy dwellings, support the economy, make use of public services and pay taxes. Surely these people must be considered in connection with community water resources.



LEGEND

- PRESENT POPULATED AREAS
- POPULATION TREND

POPULATED AREAS AND POPULATION TRENDS

SARASOTA COUNTY, FLORIDA

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In other parts of the nation this factor is usually minor and may be neglected. However, there is no question that in Sarasota County the effective population is far greater than the official census count. There are methods for evaluating this factor statistically and weighing its effects. Such an analysis is beyond the needs and scope of this report. Therefore 1960 census data will be noted herein, but with the caution that these figures underrate the real picture:

1960 RESIDENT POPULATION

	<u>Number of Persons</u>	<u>Percent of Total</u>
City of Sarasota	34,083	44.5
City of Venice	3,444	4.5
Englewood	2,877	3.7
Balance of County	<u>36,491</u>	<u>47.3</u>
Sarasota County (Total)	76,895	100.0

The trend to outside the City of Sarasota is revealed by the above 44.5 percent in the city in 1960 as compared to 66.2 percent in 1950.

B. Growth Rates

The rates of population growth of the county from 1930 to 1960 are shown on Exhibit "D" on the next page. In addition, a number of significant growth rates for the past ten years have been tabulated below, for comparative purposes:

POPULATION GROWTH RATES 1950 to 1960

	<u>Annual Rate of Increase</u>
Sarasota County -- Overall	10.3
Unincorporated Sarasota County	15.6
City of Sarasota	6.1
City of Venice	16.9
Dade County	6.1
State of Florida	6.0
United States	2.3

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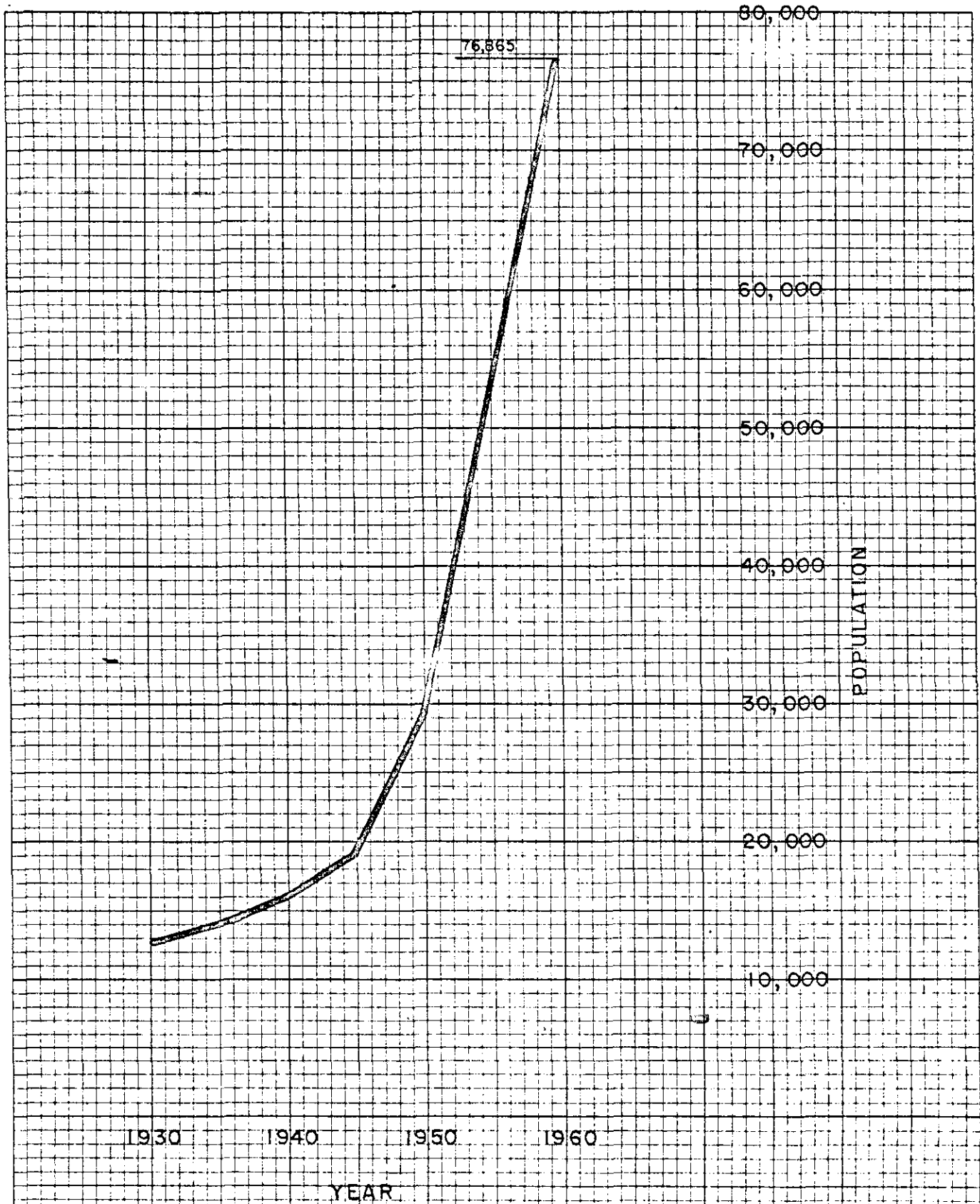


EXHIBIT 'D'

POPULATION GROWTH

SARASOTA COUNTY, FLORIDA

SEPTEMBER 1961

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At the 1950-1960 growth rate, the population of the county would double in seven years. The Sarasota County growth rate is impressive by any standard, and ranks fourteenth of all the counties in the United States for this period. This growth reflects the explosive trend of the coastal areas of peninsular Florida. Waterfront, white sandy beaches and a favorable climate have proven to be a magnetic combination, and the available raw supply is rapidly dwindling. To this is added a way of life favored by many and the growing power of a regional commercial and industrial hub.

The overall growth characteristic for a large urban area is actually a summation of many different growth factors, which have distinctive features of their own. These may be described as follows:

1. Expansion of metropolitan areas.
2. Establishment of subdivisions some distance from metropolitan areas, the large subdivisions usually being farther away because of land costs and the need for virgin tracts.
3. Small satellite subdivisions near or in between metropolitan areas and large subdivisions.
4. Gradual filling-in of the open areas between metropolitan areas and all of the other subdivisions.
5. Settlement on or near desirable land features, especially coasts, bayous, rivers and lakes.
6. Growth along major highways, such as U. S. 41.

The most unpredictable factor is the growth of large subdivisions. Unlike the established communities, whether incorporated or unincorporated, which have a history and will grow naturally, the large subdivisions have a kind of forced growth that is fertilized by advertising, promotion and the inducements of pre-planned facilities which ordinarily would follow growth instead of leading it.

If a long national recession does not intervene and the developers maintain their momentum they will have a tremendous total impact on the area population. On the other hand, if either condition is reversed, there could be a leveling off.

Whether any subdivision development will be an asset or a liability to the county depends on many factors. Control and guidance may be provided by county planning, subdivision regulations, zoning and other tools and approaches. The overall public interest is not served solely by land development, but also by ultimate land use for many purposes, including those of the public at large.

Another factor that can have a potential effect on development is the extent and locations of large land holdings that are kept off the market. Whether these holdings will have a restraining influence will depend on future policies and events.

It is not surprising that the urban areas outside the boundaries of the City of Sarasota are increasing in population faster than the city itself. The classic pattern is that a young suburban community, considered separately from its urban core, will grow rapidly until it too becomes mature and begins to approach saturation.

C. Projections

There is little about the history of Florida's post-World War II growth to inhibit optimism, and many studies continue to reflect high growth rates. However, a certain amount of caution should be injected as to future projections.

Florida's phenomenal growth has leaned heavily on migration. Even if this migration should continue at a constant high level, each year's influx will become a smaller percentage of the larger existing population. In addition, it is well to assume that the migration wave itself will reach a peak and gradually decline, reaching a steady level at some future date.

In addition, the limitations of saturation will itself tend to reduce the rate of increase in future years. The pattern in California, which Florida seems to be following, is a good example. Despite Los Angeles' great numerical increase since 1950, the annual rate of increase of this city has been only about 2.5% since 1950. On the other hand, it can be assumed that in the residential suburbs of the California cities the growth rates have been much greater, as they are for suburbs of Florida cities.

For these reasons long-range projections should be tempered with conservatism, to avoid planning for events that might not transpire. Growth rates for the distant future must ultimately taper off toward the national projection which is only 1.5% per year.

D. Relationship to Water Management

The population trends in the county have effects on water management in many ways. The rapidity of surface runoff is itself directly affected by built-up areas, and Exhibit "I" of the projected population densities appears later in the report to support the computations of drainage basins.

VI. LAND USE

A. Present Land Use

Land use is the culmination of the relationship of man to nature. The ultimate meaning of this study will be its value for this purpose. There is hardly an event taking place in the county that does not have some bearing on it.

A generalized land use map of Sarasota County appears on the following page, as Exhibit "E." This map relates to existing conditions and is confined to major features. It is suitable for the purposes of an overall examination of water management.

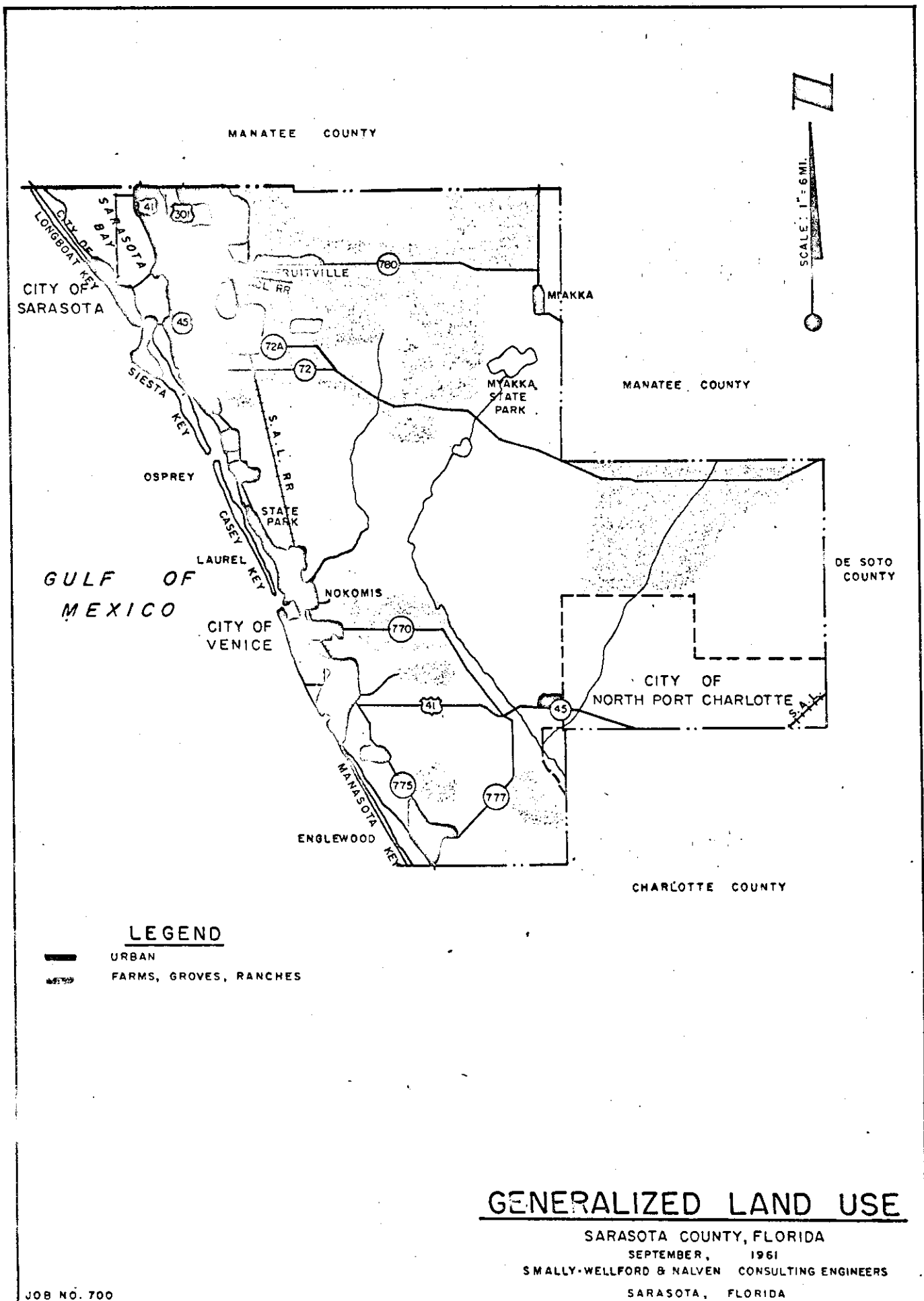
The major land uses may be summarized as follows:

1. Urban
2. Agricultural: farms and ranches
3. Undeveloped: forests, prairies, swamps and marshes.

The present urban and agricultural areas are outlined on the map. The urban communities are reviewed in the previous section of the report on population growth. Agricultural areas indicated are approximate, and serve the purpose of showing their relationships to the rest of the county.

Much of the farmland can be drained and its water table controlled by natural or artificial means. Guidance and even financial assistance are available for progressive practices under the Sarasota Soil Conservation District and related federal, state and local governmental programs.

Much of the presently undeveloped land, which covers a major portion of the county, contains numerous shallow wet-weather ponds. It is believed that ranching will gradually move into these areas, rather than crop types of agriculture.



B. Community Goals

The goals of the community are the prerogative of the public, not of the engineer or planner, who can, however, use his skills to call attention to needs, alternatives, and experiences elsewhere, to clarify the problems and thus assist in the decisions taken. A factor that is often neglected in a rapidly growing area is that the public itself will change, and that some attempt should be made to evaluate probable adjustments to orientation of the community. This kind of planning will tend to minimize future friction and gain public support, without which vital programs are rejected constantly to the detriment of many communities in Florida.

The history of past land usage and the needs of the present can be reviewed intensively. Corrections of existing problems follow without undue difficulty. The future cannot be predicted accurately, but intelligent projections can be made based on the current state of knowledge, and these can be continually adjusted as necessary.

In terms of market value the classification of land starting with the lowest and proceeding upward is generally as follows:

1. Wilderness, swamp, and other raw land.
2. Woodland
3. Pastured Woodland
4. Pasture
5. Pastured cropland
6. Cropland
7. Groveland
8. Commercial and Industrial
9. Urban

Because financial pressures usually guide events in our economy, when not controlled otherwise, the sequence of usage usually moves toward the higher dollar

values. For instance, today's farms and groves adjacent to urban areas will give way to tomorrow's urban development, when the demand arises.

Freedom to grow in this manner stems from the rights of people in this country to use their property as they see fit. In many respects it is a self-regulating system that amalgamates a number of strong forces. On the other hand, completely haphazard growth is not always in the public interest, and many methods have been established to control the features deemed important. Road right-of-way and public parks are examples of the many interests of the public that have been recognized and have been upheld by the courts provided proper procedures are followed. Planning and zoning are modern tools to lend an organized approach to these community needs.

The public interests in water management have not been fully recognized, because only recently have the population density, agricultural usage, industrial demand and other factors created an awareness of the complete picture. Many of the newly studied aspects of water management have been brought into the open so recently that they have not been covered adequately by legislation nor tested in the courts. It is inevitable that water management needs will be recognized by the public and by the courts. Recent history is proving this.

C. Planning

The land use requirements relating to water management that should be incorporated in future planning include the following:

1. Major flood routing areas
2. Water impoundment and ground water recharge areas
3. Conservation and recreation areas.
4. Multi-purpose areas, incorporating the above and other aspects.
5. Road right-of-way
6. Canal right-of-way

7. Water control structures

8. Other needs of water management that may be developed.

It is recommended that continued intensive study be made of land use in Sarasota County and of the needs and goals of the future, leading to public support of policies that are necessary to avoid the penalties of delay until the problems become unbearably difficult and costly.

VII. INTRODUCTION TO WATER MANAGEMENT

Water management may be defined as including the water resources endowed by nature, their usage by man and effects upon him, and the controls imposed on these resources. The concentration of an expanding population and industry exposes far greater economic and human values to risk, especially where development moves into marginal land that is subject to flooding, water consumption promises to reach staggering proportions.

Controls now available are so potent that, with related effects, man's works can impose significant forces on the natural resources. The former unplanned and sometimes haphazard approach to water management is a luxury that can no longer be afforded, as these trends continue and perhaps accelerate. Economic well being and public health are now at stake.

In Florida the history of water use was long affected by a sparse population and a water surplus. Removal of the surplus surface water was the problem that was obvious, and the first efforts turned to drainage and flood handling. Among the foreseen results was overdrainage in dry times, creating new problems. Conservation then became recognized.

Other water problems made themselves evident. Salt water intruded into well aquifers. Erosion of channels and beaches, damage from hurricane floods, needs of agricultural irrigation, navigation, and recreation thrust themselves upon a rapidly growing state. Pollution of wells and rivers by sewage and industrial wastes became a problem that could no longer be ignored.

The public interests in water management have not been fully recognized, because the population density, agricultural usage, industrial demand and other factors only recently have created an awareness of the complete picture. Many of the

newly studied aspects of water management have been brought into the open so recently that they have not been covered adequately by legislation nor tested in the courts. It is inevitable that water management needs will be recognized by the public and by the courts, and recent history is proving this.

Water Management encompasses the following aspects of significance to Sarasota County, many of which are overlapping in complex ways:

Weather (rainfall, etc.)

Evaporation from land and water surfaces

Transpiration from plants

Natural environment

Topography

Geology

Soils

Vegetation

Surface Water

Overland runoff

Runoff through natural and improved channels

Impoundment

Ground Water

Shallow aquifers

Artesian aquifers

Water table conservation

Salt water intrusion

Flooding

From rainstorms runoff

From storm tides

Land Conservation

Soil conservation

Beach and channel erosion control

Quality of Fresh Water

Public water supply (health)

Recreation (health, fish, etc.)

Irrigation

Industrial requirements

Quality of Salt Water

- Recreation (health)
- Fishing, commercial and sport

Fish and Wildlife Conservation

Cultural Usage and Values

- Land use
- Public water supply
- Sewage and waste disposal
- Urban needs and protection
- Agriculture and forestry
- Commerce and industry
- Navigation
- Recreation
- Land values
- Esthetics, natural and artificial

Organizations and Interests

- Federal agencies
- State agencies
- Counties
- Municipalities
- Other public agencies
- Universities, institutes and foundations
- Public interest associations (e.g., Audubon Society)
- Professional and technical associations
- Commercial and industrial associations
- Miscellaneous organizations of many kinds
- Civic and other local associations
- Unorganized commercial and industrial interests
- Unorganized individual interests

VIII. PHYSICAL FEATURES OF SARASOTA COUNTY

A. Geology

The peninsula of Florida lying above sea level rests upon a much wider continental peninsula rising from the depths of the Gulf of Mexico and the Atlantic Ocean, known as the Floridian Plateau. Geological investigations reveal that at times far more of this plateau has been exposed, whereas at other times the sea covered most of the present state area. About half of this plateau is now covered by relatively shallow waters.

Peninsular Florida has a number of basic geological formations. Lying upon the deepest core rocks are thick sedimentary limestone formations, which have been labeled the Ocala Group, and the Suwanee and Tampa formations. Some of these formations crop out above ground in the central areas of the state, but they dip greatly as they move southward. The top of the Tampa formation occurs about 300 to 600 feet below the surface in Sarasota County. These limestones are highly permeable, but are highly mineralized except in the northeastern part of the county.

The Hawthorne formation overlies the limestones. It consists of deposits of various clays, marls, shells, limestones and sands. This unhomogeneous formation amounts to a relatively impervious layer confining the water in the limestone aquifer beneath. The Hawthorne aquifer is correspondingly variable, but supplies much of the presently acceptable well water.

The upper formations lying above the Hawthorne which are classified as surface materials, consist mainly of sand and shells with some clay. They range in thickness from 5 to as much as 100 feet. This layer produces the least mineralized water in the county, being recharged by local rainfall.

B. Topography

Sarasota County is made up of parts of several marine terraces that were constructed by ocean waters during the Pleistocene epoch. Different invasions of marine seas left successive shores over the coastal lowlands of Sarasota County at elevations of approximately 70, 42, and 25 feet. The terraces corresponding to these several inundations, have been named, respectively, Penholoway, Talbot and Pamlico. The Pamlico terrace is the most extensive in the county. Changes from one marine terrace level to another, for the most part, are indefinite and poorly defined. The most apparent terrace escarpments are in the northeastern part of the county.

Changes in elevation are very gradual, and the rise is barely perceptible over long stretches of landscape. A few localities have small, narrow, low ridges with nearly flat tops that are a few feet above the surrounding terrain.

Elevations in the county range from sea level to about 95 feet. The highest points are in the northeast, several miles north of Old Myakka. The highest measured elevation, 95.5 feet, is near the Manatee County line, a short distance south of Verna. Other elevations are Bee Ridge, 36 feet; Laurel, 13 feet; Osprey, 17 feet; Sarasota, about 10 to 31 feet, and Venice, about 7 to 15 feet.

Numerous slight depressions of shallow wet areas and sloughs about one to three feet deep are common. They range from less than an acre to many acres in size, but their total area is considerable. The water levels in these depressions fluctuate significantly. In the rainy season, they are a few feet higher than in dry periods. Many of the depressions are shallow intermittent ponds without natural outlets.

Surface runoff in the flatlands is characterized by shallow, indistinctly defined drainageways with sluggish flows. Heavy rainfall tends to become impounded in sheets which move overland slowly along the flat slopes, impeded by the

frictional resistance of land and vegetation, until they gradually work their way into the drainageways or else remain impounded in the wet weather ponds and other natural depressions.

Tidewaters extend inland for several miles into some of the embayments, lagoons, and streams along the coastal section and up the Myakka River to a point east of Venice. The change from salt to fresh water is gradual and is usually accompanied by changes in the kinds of vegetation.

The plans supplementing this report incorporate topographic data for the basins studied, assembled from available sources, supplemented by field surveys in the vicinity of the drainageway within the basins. The ridges defining basins within the watersheds are shown on the exhibits at the end of the report.

In land as flat as much of Sarasota County, relatively small adjustments in elevations may shift contours and ridge lines considerable distances, and man-made structures such as built-up roadways may superimpose new ridges. For these reasons it may be anticipated that the future will reveal corrections as refined data is accumulated and construction changes the landscape.

C. Soils and Vegetation

Most of the county has a mantle of marine quartz sand deposited during sea stages of the ice age. Details relative to the surface soils and their characteristics are covered comprehensively in the excellent "Soil Survey of Sarasota County" issued in 1959 by the U. S. Department of Agriculture in cooperation with the University of Florida Agricultural Experiment Stations.

Except for certain mucklands, most of the soils are low in natural fertility. Their agricultural value lies in their susceptibility to specialized soil and water management, and their location in an area favored by climate for the winter market.

The sub-tropical climate favors a great variety of natural vegetation of tropical and temperate species. Although land elevations are relatively flat, minor differentials, such as pine islands as compared to swamps and sloughs, provide sufficient variation in soil moisture and aeration for the root structures of many kinds of plants.

IX. HYDROLOGY

A. The Hydrologic Cycle

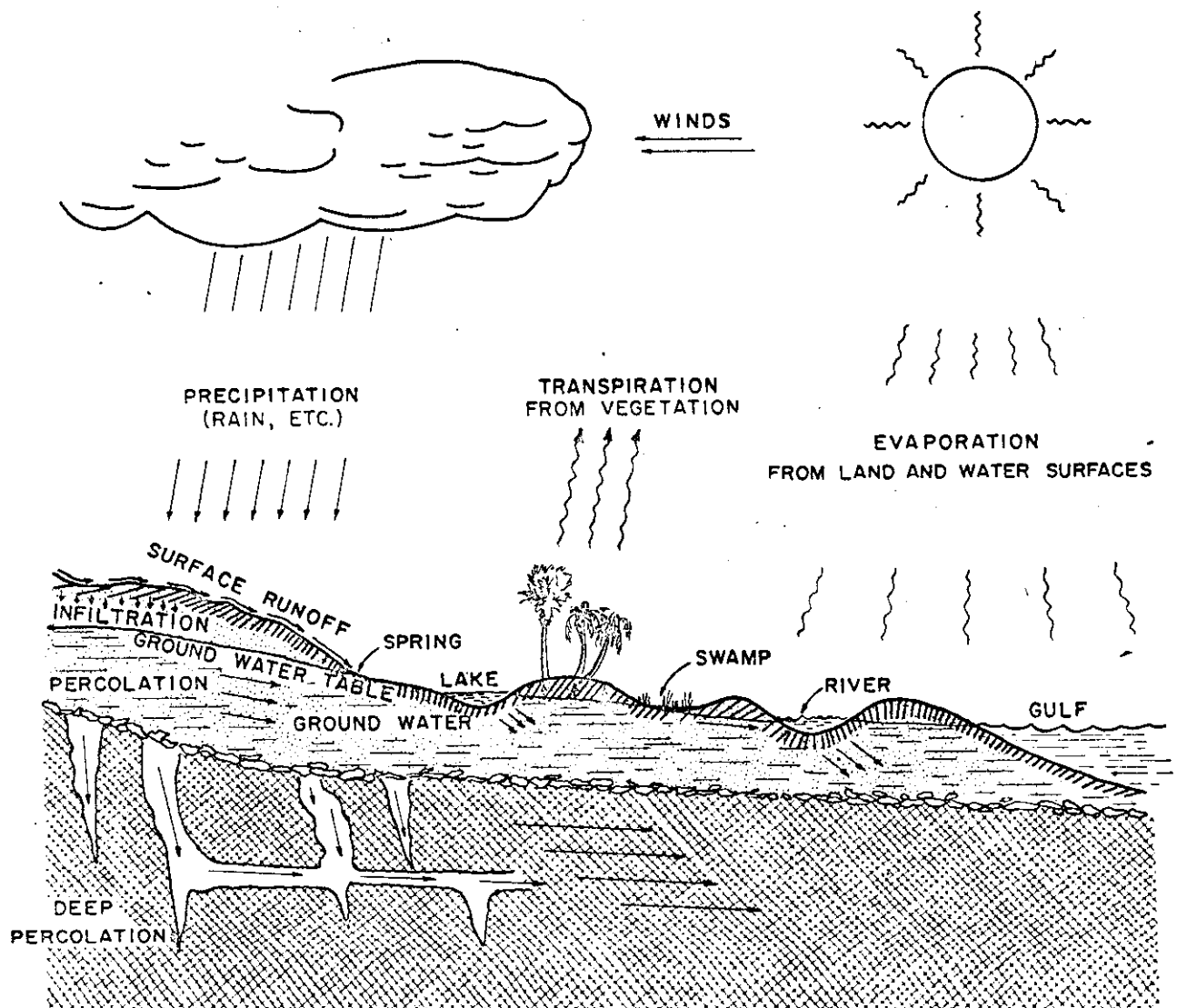
The behavior of water as it relates to the earth is encompassed by the science of hydrology. Nature's unending re-use of water is termed the hydrologic cycle. This cycle is pictured on the following page, as Exhibit "F."

Water condenses from the moisture in the atmosphere and falls as rain. Then it moves over and beneath the land surface to the sea. This cycle is completed by returning moisture to the atmosphere through evaporation, from the oceans, from the lands, and from vegetation. Much of the rainfall falls on the seas, abbreviating its span in the hydrological cycle.

Evaporation from surface water and wet soil, with transpiration from the foliage of plants returns the greater proportion of the total rainfall to the air. The amount of water infiltrating directly into the ground is limited. Underground lateral movement is slow, and after the water table rises during the wet season surplus water will lie upon the surface or evaporate.

The amount that remains after evaporation and infiltration will be surface water. This will approximate 20 percent of rainfall in Sarasota County, and represents the water potentially available for additional use.

The foregoing is a simplified description of an exceedingly complex, inter-related and variable series of processes. To complicate matters, the works of man are now beginning to exert influence in many ways. Urbanization reduces infiltration and accelerates surface runoff. Drainage and flood control improvements collect sheet surface water into channels. Pumping water out of the ground affects the movement, quantity and quality of the ground water storage. Effects on evaporation and transpiration result from land use for agriculture. All of these effects are inter-related.



THE HYDROLOGIC CYCLE

SMALLY-WELLFORD & NALVEN CONSULTING ENGINEERS
SARASOTA, FLORIDA

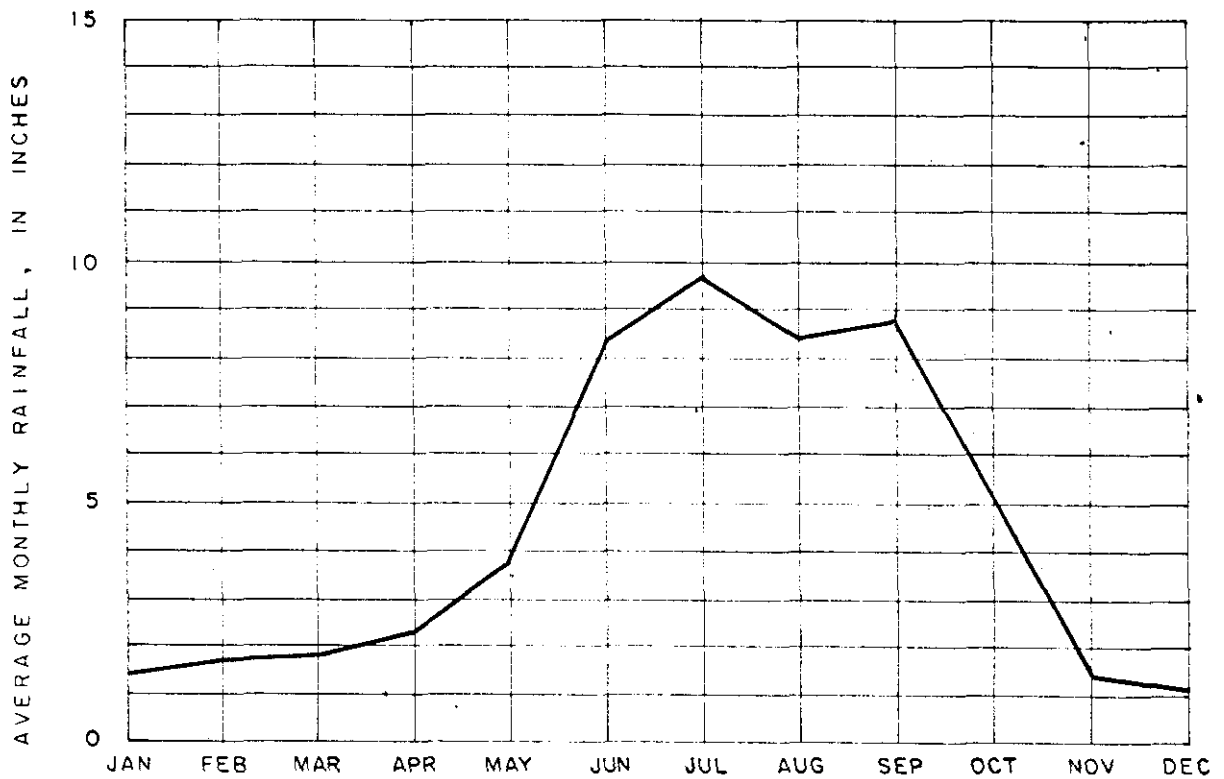
B. Hydrological Data

Southern Florida lies nearer to the equator than any other part of continental United States and is surrounded on three sides by great seas. These, together with other factors, create a unique climate characterized by warm weather, usually ample rainfall, and normally light and persistent winds. The climate may be termed a state resource, in that it attracts residents and tourists, permits growing of off-season crops, encourages certain industries and military installations, and in many other ways offers advantages found nowhere else in the nation to the same degree.

The temperatures are less extreme than most other parts of the United States, both in winter and summer. Frosts are infrequent in winter, which is the key factor in the winter agriculture. Although summer days are almost uniformly hot, with highs in the low 90's, peak "heat-waves" are absent.

Tropical storms up to hurricane intensity are most likely to occur during the late summer and fall, but are fortunately infrequent. These storms may be accompanied by torrential downpours covering tremendous areas. The highest winds, approximately 100 mph, are particularly dangerous to coastal areas, where they cause high storm tides.

The total annual rainfall upon Sarasota County averages 54 inches per year. There are two striking aspects to this rainfall. First is the fixed seasonal pattern; more than half of the total falls in the four to five month summer period, as shown on Exhibit "G" on the following page. Second is the uneven geographical distribution of local rainfall, for the reason that summer rains, unlike the rains in the dry season are produced by local heavy rainshowers. A striking example of this uneven distribution is offered by Miami's three stations, within 10 miles of each other, which report average annual rainfalls of 42.9, 47.2 and 56.4 inches; monthly totals have been known to differ by more than 11 inches.



Average total annual rainfall = 54"

Source: U. S. Weather Bureau

SARASOTA COUNTY
AVERAGE MONTHLY RAINFALL

Sarasota County lacks long-term data sufficient for its ultimate engineering needs, although much useful data is available. Action now to broaden the data collection program of the various agencies involved will provide data in keeping with the limited needs of the present, and will accumulate in time-value in parallel with the more ambitious requirements that the future is certain to impose on the county.

In Sarasota, our "Local weatherman," Hollis Bacon, has been collecting rainfall, temperature and related data for over twelve years. Considering the variations in geographic distribution of rainfall, a single station may prove inadequate. This deficiency has been partly ameliorated by correlation with data from outside the county, particularly the Tampa station, which has records covering 45 years.

Recognizing the factor of geographical distribution of rainfall records, the County Engineer recently placed a number of rain gages in various parts of the county for volunteers to help record data.

The most serious deficiency for present purposes is the lack of stream gages and water level recording stations. The Myakka River stream gage is the only record of any length within the County. Recently stream gages were placed on Phillippi Creek for a short duration. The only water level recording station in existence for any length of time is Myakka Lake. No stations within Sarasota County collect evaporation data.

C. Engineering Computations

The rainfall factors most useful for engineering computations are not taken directly from the raw data records, but from curves that are developed from such data, to show the relationship between rainfall intensity, duration and frequency for applicable geographical areas. Such curves have been developed more reliably in the Tampa area because of a longer history of complete data. The Tampa and

Sarasota County Rainfall-Intensity - Duration Curves based on Isohyetal maps of Florida by Yarnell appear to coincide.

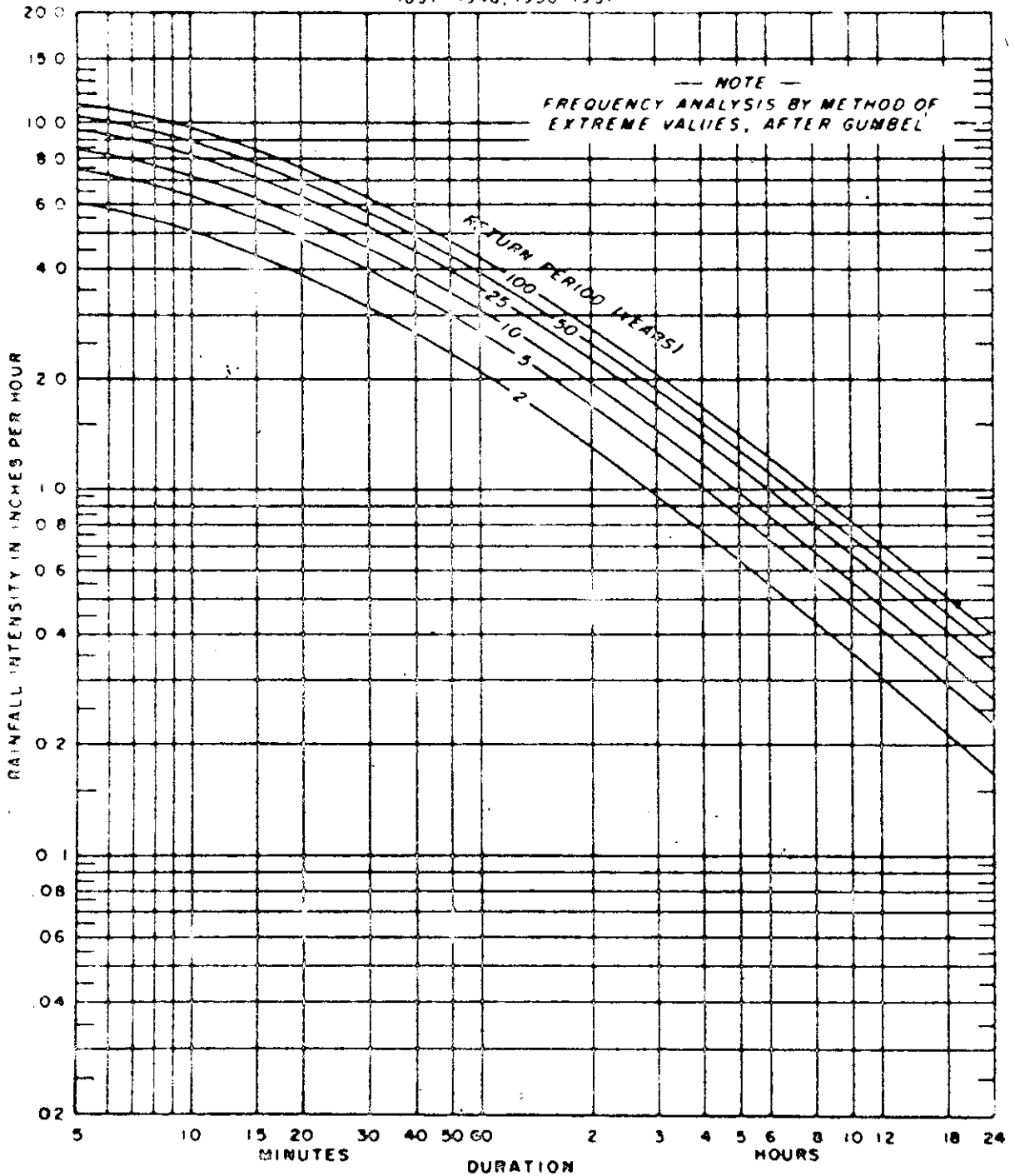
Exhibit "H" on the following page shows the Rainfall Intensity - Duration - Frequency curves used for runoff computations in the report.

RAINFALL INTENSITY - DURATION - FREQUENCY CURVES

U.S. DEPARTMENT OF COMMERCE WEATHER RECORDS, TECHNICAL PAPER NO. 25

TAMPA, FLORIDA*

1897-1948, 1950-1951



* THE TAMPA AND SARASOTA COUNTY RAINFALL INTENSITY - DURATION CURVES, BASED ON ISOHYETAL MAPS OF FLORIDA BY YARNELL, APPEAR TO COINCIDE.

SMALLY WELLFORD & NALVEN CONSULTING ENGINEERS
SARASOTA, FLORIDA

JOB NO. 700

X. SURFACE WATER

A. General

The surface water aspects of the coastal basins, representing the most pressing current problems, have received the most intensive study in connection with the report. This section reviews the general aspects of the subject, and a separate section following is devoted to the specifics of the basins and their drainageways.

Surface water is the water that lies or moves above the ground. Surface and ground water are especially interrelated in the low, flat relief and porous soils of Florida, and water may change its habitat, so to speak, several times before reaching the sea or evaporating into the air.

Out of annual rainfalls of about 45 to 65 inches only about 8 to 10 inches may be defined as surface runoff. Most of the difference passes to the air as evaporation and plant transpiration. If the sum of ground water movement, evaporation and transpiration remain fairly constant, the surface water runoff represents the water potentially available for additional use. It is the reserve that may be drawn upon.

This runoff is a tremendous total quantity. Totals and averages, however, are misleading. The problem is that there is too much of it when not needed, and too little when needed. Geographical distribution even in the wet season may be a local problem because of the point nature of the summer rainstorms which supply most of the water. Conservation practices will help to offset these distribution problems of time-cycle and geography.

Surface waters within the county arising from the general rainfall distribution have superimposed upon them the flow of water from higher elevations. Nature does not recognize political boundaries. Exhibit "O" at the end of the report,

outlines graphically the areas where some degree of jurisdiction overlaps. None of the basins in this report extend beyond the county line except for the mouth of Godfrey Creek. Other county basins not studied include areas of Manatee, Charlotte and DeSoto Counties.

B. Characteristics Within County

Sarasota County is a flatlands area, where overland flow generally moves sluggishly through ill-defined drainageways. A number of streams, all of them relatively short except for the Myakka River, may be called rivers and creeks. These are supplemented by canals in certain areas. Ridge lines are low and may even be temporarily submerged by flood runoff. This terrain means that man's works, such as a built-up roadway, may readily modify nature's basins. This characteristic can be used to advantage, but causes problems where construction ignores it.

Although relatively flat, the gradual land slopes would permit flood runoff in most areas by natural means, through adequate channels. In rural areas pasture grasslands might need no further protection than open drainage systems, but vegetable crops and citrus cannot tolerate long submergence, and may require water table control in certain areas beyond the economic feasibility of such a system. It is anticipated that, where needed, the practice of diking and pumping of farms will be applied. However, ultimate concentration of agricultural acreage will demand rural canal systems to supplement the major drainageways which are delineated in the plans which supplement this report.

Farmers have participated in the U. S. Agricultural Conservation Program, for which grants up to 50 percent of construction cost are available. The projects involve disposing of excess water through ditches and canals, and are subject to technical control of the Soil Conservation Service, which maintains an office in Sarasota County.

The major drainageways through the unincorporated urban communities within the coastal basins have been studied, but detailed investigation of local problems is beyond the scope of the report. Supplementary studies of the established and growing urban areas like Osprey and Englewood would be advisable. Old subdivisions may also require investigation, but it is assumed that new ones are being internally engineered for drainage. By means of suitable county regulations all future subdivisions are required to comply with suitable minimum standards.

Although the wet-weather ponds and other natural depressions impound or attenuate a considerable volume of surface water in the wet season, these generally dry up during the dry season, and there are no deep lakes to provide year-round storage. Neither does the ground water supply sufficient lateral seepage into the rivers to maintain significant flow during the dry season. Past flow and level records of most of the existing creeks and canals all indicate extended periods of little or no flow.

During low stages these drainageways are also subject to salt water encroachment by tidal action. This threat may be controlled by the placement of suitable salinity dams, but the lack of fresh water flow still precludes the use of these sources for either urban water supply or rural irrigation, especially considering that the demand for both is at a peak during the period of lowest flows. The river valleys are too limited to provide large storage capacities by the use of dams. Any significant impoundment possibilities appear to be limited to the more remote flatlands. These may need protection as recharge areas and may be suitable for more ambitious projects as the economics of the future warrants.

C. Water Management of Surface Water

Water management of surface water must solve problems of routing and distribution of surplus runoff, yet allow for conservation of ground water during the dry season. A master plan must establish the major drainage basins and define

drainageways. Sizes and cross-sections of channels, bridges and culverts must be determined for present and ultimate usage. Weirs must be sized and set for both wet and dry weather purposes. The next section sets out such a master plan.

The key to a successful water management program is to work with nature, not to fight it. This approach will also help preserve the natural resources which lend character to the county and are necessary for its development.

Changes and improvements must be analyzed carefully to be sure that new problems are not simultaneously created. Drainage attempts have led to such problems in other parts of Florida. These have been accentuated during cycles of wet and dry years. To obtain relief from the unusual flooding in successive wet years, major drainage canals have been excavated. When normal or dry years return the area may be overdrained, lowering the water table at the expense of the ground water.

This produces many unhappy results. The parched land fails to support vegetation and may become, relatively, a seasonal desert. Forest fires destroy timber stands and may endanger homes. Wild animals and fish perish. Lowering of the water table invites salt water intrusion near the coast, and over-pumping for irrigation may contaminate aquifers.

After a number of abnormally dry years, people have been known to start building homes, and farmers to improve lands which normally were reserved for impoundment of surface water. When normal or wet years return, these improved areas will be submerged. The investment thus threatened may lead to the type of excessive drainage above described, only more aggravated because the measures to solve the problems may be more desperate and perhaps so ambitious that the assistance of public agencies may be enlisted.

The impoundment and natural conservation features of the undeveloped remote flatlands deserve more detailed study. Most of the huge amount of water lost to

evaporation was once surface water, and consideration might well be given to saving some of the riches for a dry day. Future huge dry weather demands may force the issue.

For this purpose impoundment of surplus surface water for release as needed may be a solution. Impoundment areas would have to be selected. Diking, control devices and dry-weather pumping would be some of the elements of the system. There are many complex factors to be investigated. Impoundment depths, evaporation rates to the air and infiltration rates into a floor of marl of possibly permeable rock are examples. In the end, economics will govern, because benefits will have to exceed the high costs.

Road design in general should fit the overall drainage plans for the county, whether designed by the county or the State Road Department. Under certain conditions a roadside canal may permanently lower the water table. Conversely, an elevated roadway may act as a levee, forcing surface water and the water table to rise and adversely affect large areas.

The surface water drainage of urban areas is also a matter of growing importance to the county. Existing problems are mainly the result of uncontrolled and uncoordinated development. The best tool to apply is a set of subdivision regulations that incorporate drainage requirements in accordance with consistent policy, and require plan approval by the County Engineer before platting or construction is authorized.

XI BASINS AND DRAINAGEWAYS

A. General

Exhibit "P," at the end of the report, is a graphic index of the basins included in this flood control study. For convenient reference the following numbers and names have been applied to these basins:

<u>Basin No.</u>	<u>Name</u>
1	Phillippi Creek Basin
2	Elligraw Bayou Basin
3	Catfish Creek Basin
4	North Creek Basin
5	South Creek Basin
6	Shakett Creek Basin
7	Curry Creek Basin
8	Hatchett Creek Basin
9	Alligator Creek Basin
10	Forked Creek Basin
11	Godfrey Creek Basin

The basins are defined by ridge lines from which water flows downhill to major drainageways. Although these are the coastal basins, much of the terrain is an irregular narrow strip along the coast, which itself is not included because the drainage from these coastal areas will be through minor local channels that are outside the scope of this study.

The Whitaker Bayou Basin is not included because its major drainageway lies within the boundaries of the City of Sarasota. Unincorporated areas of the county drain into this drainageway through upstream canals.

The City of Sarasota straddles the westerly ridge lines of the Phillippi Creek Basin. The city area to the west is outside the scope of the study. The city area to the east is included in the study of Phillippi Creek Basin, a report on which has been submitted to the Board of County Commissioners earlier this year.

Part of the City of Venice lies within the Hatchett Creek Basin, and has been included as to total runoff, but not as to minor internal drainage. Segments of major drainageways pass through the city.

Shakett Creek basin derives its name from its main outlet. Most of this basin, and parts of adjoining basins, lie within the tentative area now being processed by the U. S. Soil Conservation Service under their designation "Sarasota West Coast Watershed" as a P.L. 566 program. This basin has also been called after Cowpen Slough, which is the main drainageway in the upper reaches. Runoff computations have been made for the entire basin, but only the lower portion has been assumed to be urbanized.

B. Design Criteria

A single main channel through each major basin provides the most economical and effective flood drainageway solution, unless there are special qualifying circumstances. This channel should be sized to carry ultimate expected runoff within its banks at velocities not exceeding three feet per second. Suitably designed bridges, culverts, weirs and spillways will be required in the channel. Minor canals will drain into the major channels.

The drainageway requirements for the various coastal basins in Sarasota County have been computed on the basis of future requirements, and not present needs. Even if a channel is excavated by stages and will not reach its designed cross-section for some years, it is urgent that the right of way for this channel be reserved beforehand, to avoid prohibitive costs and other problems. Similarly, drainage

structures should be designed with an eye to the future, even if they may be built by stages. In instances the incremental cost might be small enough to warrant construction of the final design.

A certain frequency of occurrence of a "Design Flood" must be assumed for practical purposes, because it would be uneconomical to design a system that would be overtaxed only once in, say, 100 years. In flat coastal areas loss of life is not a likely result of floods, and intervals of occurrence have generally ranged between 10 and 50 years for reasonable design practice. The "Phillippi Creek Basin Flood Control Study" was based on a twenty-five year frequency.

For this and other reasons a twenty-five year frequency has been applied for the basins throughout the county. Although this means an average of four floods a century, the floods will not be evenly spaced, and conceivably two occur consecutively. Past history is applied for these projections, and can never predict the future with total accuracy, although it provides the best clues known at this time.

Computed surface water discharge reflects two related events. First is overland runoff into distinct channels, and second is the characteristics of the receiving channel. The "rational method" is recommended by most competent authorities as the best practice for areas up to 100 square miles. The quantities of discharge at various points of concentration of the channels were computed, with the area above these points determined from the basin ridge maps.

It was noted in Section VI of the report that land use has great effects on water management. One of these relates to runoff, and is reflected in the "rational method" by a coefficient. Runoff from roof tops and paved areas obviously will be greater than for natural vegetation, and improved farmland will carry off water faster than a flat wilderness. The runoff coefficient depends on the type of surface its porosity and roughness, and takes into consideration interception, detention, evapo-transpiration, and accretion to ground storage.

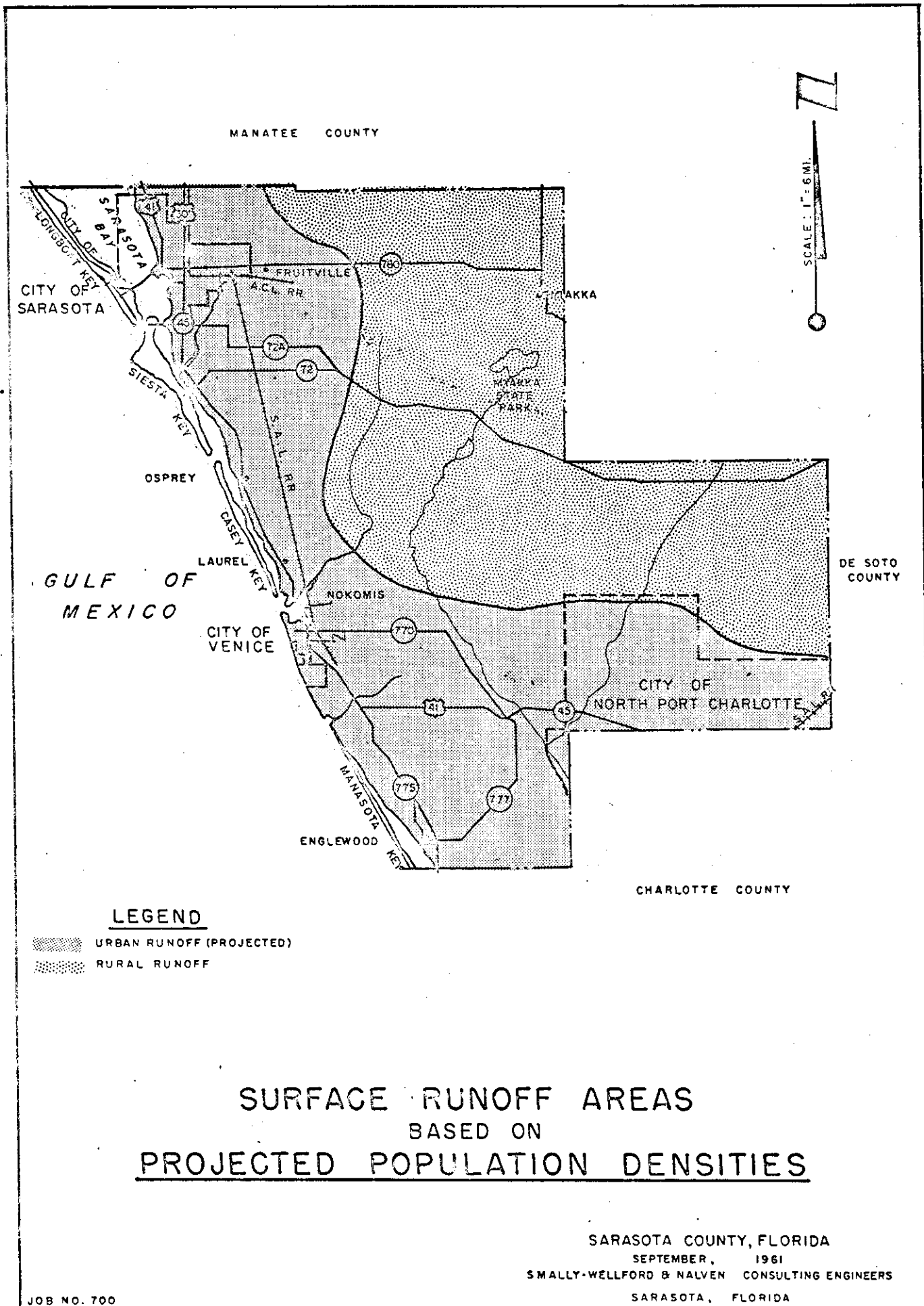
Because the purpose of the computations is to establish the future needs for the basins, it was necessary to establish a projection of land use. Exhibit "I," on the following page, outlines the boundaries of these projections, and is based on the consideration of population growth and land use reviewed in previous sections. Because the future cannot be predicted with total accuracy, it may be advisable to review these assumptions from time to time.

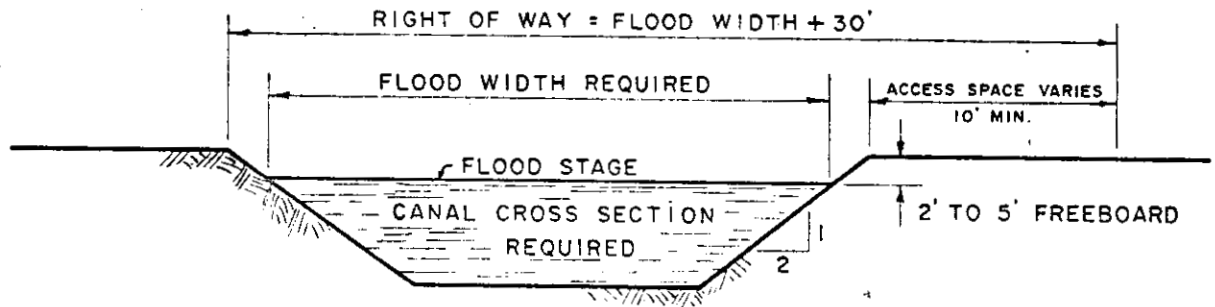
For present and future urban areas, a weighted runoff coefficient of 0.35 was established for this study, and reflects the miscellaneous types of construction in such areas. For rural runoff, a coefficient of 0.20 was applied, based on improved practice rather than impoundment, since for conservatism it should be assumed that the future will ultimately progress in this direction. Both of these coefficients have been proven reasonable by past events in southern Florida, and are in keeping with hydrological methods applied by agencies with Florida experience.

The intensity in rainfall in inches per hour is related to the time of concentration. The rainfall intensity-duration-frequency curves which appear as Exhibit "H" in Section IX have been applied for this purpose, as discussed previously.

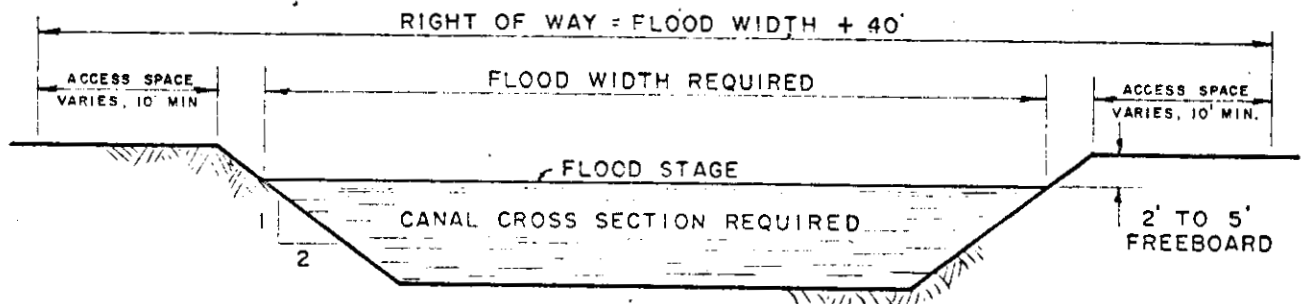
The time of concentration is not constant for any particular drainage area, and will not only be affected by overland flow but by the channel flow length and velocity. Channel hydraulics are based on Kutter's formula, using $n=0.0275$. A maximum permissible velocity of 3 feet per second was applied which allows maximum discharge, considering the types of soils in this area, without undue scouring.

Criteria for canal cross-sections are graphically presented by Exhibit "J," following Exhibit "I." Provisions must be made for access to maintain canals, and the limitations of equipment are such that access is needed on both sides for wider canals. These features are also incorporated in Exhibit "J."





RIGHTS OF WAY UP TO 120'



RIGHTS OF WAY OVER 120'

PROPOSED CRITERIA FOR CANAL RIGHTS OF WAY

C. Major Drainageways and Structures -- General

The master drainage plans which supplement the report are listed in the forepart of the text. These include the major coastal drainage basins in Sarasota County. At least one main drainageway is established for each of these basins.

The drainageways have been located where they are most suitable for natural conditions, except that advantage has been taken of major man-made works of the past. Minor adjustments as to alignment have been made to avoid known built-up areas but radical shifting of a major stream, or development of alternate outlets, are considerations that would be premature for a study of this type.

Knowledge of the most logical solution from a hydrological viewpoint must be developed before weighing any possibilities for such radical departures, which would involve special problems in each case, necessitating an intensive study.

The alignments of the drainageways are shown in their approximate locations, and before actual land acquisition more detailed surveys should be applied to delineate the exact alignments. These refinements could be made in many instances by the engineers for subdivisions and other private interests, which would minimize expense to the county. In such cases the portions of the drainageways engineered should be in compliance with the county master drainage plan, and subject to the approval of the county engineer to verify this condition, as well as to avoid the possibility of discontinuity at the upstream and downstream connections. Provided these requirements are met, a certain amount of realignment for legitimate private objectives could be accepted in land as flat as most of Sarasota County. In keeping with this flexible approach major alternatives could also be considered, provided it was demonstrated by engineering data adhering to the county criteria that equivalent results would be achieved.

Every major coastal drainage structure in the county has been measured approximately, and is shown on the drainage plans. These drainage structures include various types of bridges, culverts and weirs.

The plans also show the drainage structures proposed for ultimate requirements, on the basis outlined previously. Where existing structures are adequate they are so indicated, but in many places they must be replaced. Although a number of structures should be installed as soon as feasible because of known flooding, most of the structures, as well as the widening of the drainageways, are a matter of orderly staging for future needs.

Weirs have been located tentatively in the various drainageways, to make full use of the channel cross-sections and to avoid velocities which cause scouring and silting. The approximate locations depend on the design flood profile and the existing slope of the ground, to permit a minimum freeboard of 2 feet and a maximum of 5 feet. The design should be such that a minimum water depth of 4 feet is pooled during low flow periods, in order to maintain a head of fresh water for conservation and beauty and reduce vegetation control problems. The exact locations of the weirs would be adjusted in accordance with final engineering design for construction.

For drainageways discharging into tidewater, the final weir downstream will also act as a salinity dam to prevent salt water intrusion by tidal action. The head of fresh water behind the weir will assist in this purpose. Before actual installation of these terminal weirs, a detailed investigation of local ground water should be made, and if the tentative location is too far upstream to protect good quality wells, the weir should be moved further downstream.

D. Review of Coastal Basins

No. 1 Phillippi Creek Basin

A separate report has been issued to the Board of County Commissioners under date of June, 1961, covering a study of the 58 square mile Phillippi Creek Basin. Because of the critical flood problems which has caused halting of the platting of new subdivisions, on the one hand, and the availability of extensive topographic data on the other, a more detailed study was completed than of the other basins reported on herein.

The plans referenced in this report show the relationship of Phillippi Creek Basin to the other coastal basins. For further details, reference should be made to the Phillippi Creek Basin report and plans.

No. 2 Elligraw Bayou Basin

The Elligraw Bayou Basin actually is four small sub-basins grouped together in this study because of their physical similarities and for clarity of presentation. Bounded on the north by the Phillippi Creek Basin which extends roughly to Clark Road, on the east by the Seaboard Airline Railroad, on the south by Catfish Creek Basin, these basins discharge into Little Sarasota Bay.

The terrain rises from Little Sarasota Bay to approximately elevation 10 to 14 MSL at U.S. 41 and gradually rises to the northeast with scattered depressions of typical wet weather ponds.

Of the four sub-basins, the Matheny Creek and Elligraw Bayou sub-basins drain a majority of the area, and are presently of critical importance due to subdividing and construction in process. The Matheny Creek Basin drains 1,640 acres of land about a third of which is already developed for residential and commercial purposes and another third in the planning stage. At present the structures at U.S. 41 and

at Bispham Road are undersized, as are the main drainageways. If development continues without improvement to the existing structures and main outlet of this creek, serious flooding will occur in the Bispham Road and nearby areas.

Stage construction of a subdivision requires staged improvements downstream. Since this basin is presently being developed, it is suggested that the recommended right-of-way width be dedicated to the county by the subdivider now, with proper alignment in keeping with recommended engineering practices, and that staged improvements to the drainageways be constructed to meet the increased needs. The existing structure at Beneva Road is a temporary one and is adequate for the present.

Sub-basin 2-B (Elligraw Bayou) is presently undeveloped but approximately a sixth of this area is in the planning stage for Gulf Gate Subdivision, with future development close at hand. This drainageway is inadequate, and almost invisible at U. S. 41. The structure at U. S. 41 is presently undersized and development will cause difficulty unless adequate drainage is provided. The structure at Beneva Road is temporary and adequate for the present undeveloped condition.

Holiday Bayou Basin also has an outlet problem at U.S. 41. The channel upstream from U. S. 41 has recently been improved, including temporary structures at Beneva Road which are adequate for now. These improvements, although benefitting the eastern portion of the basin, will aggravate the problem at U. S. 41.

Clower Creek Basin has recently been improved by the Sarasota County Public Works Department to provide an outlet for the trapped water in the Vamo Road area and east. These improvements will suffice until further development.

Because of the location of U. S. 41 in relation to the topography of the land it is proposed to place weirs just west of the highway to control discharge velocities and salt water intrusion, allowing small boat access up to U. S. 41.

In summary for these four sub-basins, they all are in a critical area, being just south of the Phillippi Creek Basin where subdividing has been stopped, and thereby diverted to this area. The Tamiami Trail at present is one of the worst drainage barriers, and unless drainage is improved simultaneously the situation may rapidly become almost prohibitively difficult and costly to correct. A repetition of subdivision prohibition might result.

No. 3 Catfish Creek

The major area drained by Catfish Creek is east of Elligraw Bayou Basin, south of Phillippi Creek Basin, west of South Creek Basin and North of North Creek Basin, with only a very small portion of this basin actually adjacent to Little Sarasota Bay. At present approximately 7,200 acres are drained by this creek. From Little Sarasota Bay to U. S. 41 the ground rises to approximately elevation 10 MSL, and then to the northeast and north very gradually with numerous wet weather ponds. The largest area of inundation is in the southeast corner of the basin. Under extreme flooding this low area submerges the basin ridges, thereby draining into Catfish, North and South Creeks.

The drainageway needs general improvement throughout. The creek is undersized, the Vamo Way bridge is undersized, and the weir west of U. S. 41 needs widening; at present it is partially washed out. The bridge at U. S. 41 is undersized and the roadway is low; records show that floods have over-topped the road recently and undoubtedly will again. Alignment at present and in the future will be a particular problem in this entire basin and it is recommended that right-of-way be obtained now, at least in the U. S. 41 area, with possibilities of realignment considered.

At present the Soil Conservation Service is proposing to construct a relief channel in the eastern portion of this basin with its outlet at Cowpen Slough in the Shakett Creek Basin. With additional minor drainageways this channel would

reduce the 7,200 acres presently drained by Catfish Creek to 4,680 acres, more than a third of the area thus being diverted to Cowpen Slough. This plan is beneficial in that it takes a great deal of runoff away from the urbanizing and already overburdened Catfish Creek Basin and adds only 5 percent to the acreage drained by Cowpen Slough. Because this outlet in Cowpen Slough is considerably south in the Shakett Creek Basin the effect on the "critical" storm is even less than 5 percent.

This plan is definitely recommended and the rights-of-way and structures on Catfish Creek have been sized for only 4,680 acres. Future rights-of-way for the relief channel are shown on the plans. The outlet is shown in the plan for South Creek.

At the present time there exists a drainage canal running north-south, along the future extension of McIntosh Road, that has been instrumental in relieving wet areas and aiding mosquito control. In addition, the canal has acted as an overflow "valve" for the three basins within which it lies, Elligraw, Catfish and North Creeks, thus helping to relieve more serious flooding in one particular basin. It is recommended that this canal remain in service until the improvements outlined on the plans are begun. Then the canal could be used for minor drainage within the basin.

It might also be noted that if it were found economically feasible, drainage-ways in the Catfish Creek Basin could be extended northward to help relieve some of the Phillippi Creek Basin and open up new areas for development in that basin.

No. 4 North Creek Basin

North Creek Basin drains 2,130 acres, and is a relatively small basin south of Catfish Creek and west of South Creek Basin. The ground rises very gradually east of U. S. 41 from approximately elevation 10 MSL to 15 MSL at the Seaboard Air-line Railroad. Several wet weather ponds exist in this basin, but of particular

importance is the need for minor drainage improvements to the Osprey area. Osprey is a "hot spot" with problems of right-of-way and structures that should be studied before corrections become more costly.

As to North Creek itself, the existing structures are adequate but weirs are needed to control velocities and prevent erosion and siltation, along with salt water intrusion. After construction of the weirs, the creek can be widened and straightened when the need arises. The first weir or salinity dam, should be placed in the vicinity of U. S. 41 to minimize the right-of-way required to avoid deep channel cuts and also to protect wells in the Osprey area.

No. 5 South Creek Basin

South Creek, draining into Dryman Bay just north of Sorrento Shores, presently drains approximately 8,250 acres that lie between Shakett Creek Basin on the east and North and Catfish Creeks on the west. The ground rises very slowly to the north-northeast with numerous wet weather ponds.

As in the case of Catfish Creek, the Soil Conservation Service is proposing to construct a relief channel in the northeast portion of this basin with its outlet in Cowpen Slough, in the Shakett Creek Basin.

This new channel would relieve 3,500 acres from the South Creek Basin, more than a 40 percent reduction in area drained. This plan is so highly recommended that it should be carried through by the county if necessary. The resulting relief to South Creek would make all the existing structures adequate for future urbanization of this basin.

The existing drainageway should be straightened, particularly the removal of the loop just south of the state park area. More detailed planning of this should be done in cooperation with the State Park Commission.

It should be mentioned that improvements to South Creek may be made as outlined, before the Soil Conservation Services lateral is constructed, without overtaxing South Creek. This is possible because of the presently undeveloped and poorly drained nature of the upper reaches of this basin, which tend to impound runoff.

The most north and easterly canal planned in South Creek Basin, with 110 ft. right-of-way will also drain into Cowpen Slough. The need for this canal was discussed with local representatives of the Soil Conservation Service, and it was agreed that the need for a canal in this location exists but has not been previously planned by the Soil Conservation Service because of right-of-way problems.

Another existing problem area in this basin is the area south of South Creek and west of the SAL Railroad. Two minor sub-basins in the North Laurel area drain into Blackburn Bay and need additional studies for right-of-way and structures. In order to relieve some of the load on these basins a canal running parallel to the railroad north to South Creek has been proposed.

In need of immediate improvement is the very overgrown and undersized drainageway running south to South Creek just east of U. S. 41. Staged construction, beginning with cleaning and opening up of this drainageway would at least provide an outlet for some of the water now trapped to the north.

For proper development of this large basin, plans should be prepared now, reviewing alignment and location of the salinity dam with the State Park Commission in order that they may develop their park program in conjunction with future drainage plans.

No. 6. Shakett Creek Basin

Shakett Creek, draining Fox Creek and Salt Creek, which is the lower portion of Cowpen Slough, is a large basin of over 90 square miles that in its upper reaches drains a small portion of Manatee County. This basin has been studied on a

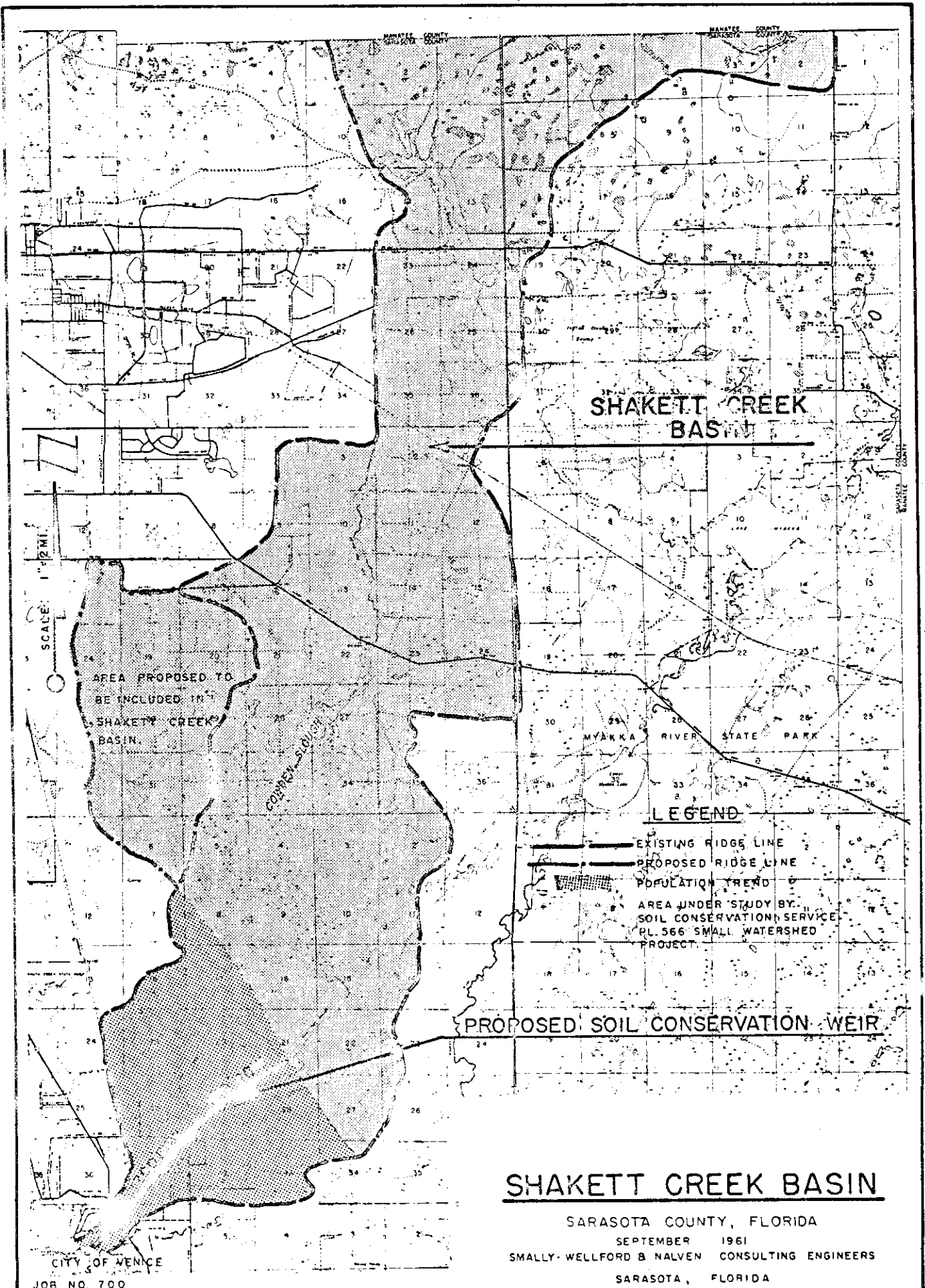
preliminary basis by the Soil Conservation Service in order to obtain federal aid under P. L. 566 for development of agricultural drainage. Now that Congressional approval appears definite, the Soil Conservation Service is planning more detailed surveys and final design of their drainageways.

The area under study by the Soil Conservation Service and its relation to the basin outline is shown on Exhibit "K," on the following page. Also shown on this exhibit is the population growth trend that has previously been reviewed in the report. At present the Soil Conservation Service is planning improvements from Laurel Road northward.

It is apparent that part of this agricultural land will develop into urban areas, roughly upstream to the beginning of Cowpen Slough itself. In order to allow for this future development we have reviewed the preliminary Soil Conservation Report and find that from Laurel Road northward a top of bank width of 150 ft. is planned and is adequate.

Since right-of-way has not yet been obtained in this area, it is recommended that additional width be obtained for proper maintenance. Reliance on local property owners to permit access is not sufficient for long-range planning. In this instance, a total right-of-way of 190 ft. is recommended. The Soil Conservation Service may not provide sufficient excavated channel for ultimate needs, but the right-of-way would be available under this recommendation.

South of Laurel Road to Donna Bay a minimum right-of-way of 200 ft. is required. This also is shown on Exhibit "K." The Soil Conservation Service shows a salinity dam tentatively located one mile northeast of Laurel Road. Unless serious well-water problems arise in the Laurel area from salt water intrusion, no weir should be needed south of the Soil Conservation structure.



No. 7 Curry Creek Basin

South of the Shakett Creek Basin and west of the Myakka River Basin, the Curry Creek Basin drains into Roberts Bay just north of Venice. This basin drains 5,640 acres of gradually sloping land that has been fairly well drained for farming and is slowly beginning to develop further. The north branch of Curry Creek was extended recently eastward to the Myakka River. This cut-through, sometimes referred to as the "Blackburn Canal," was created by private interests as a relief for flooding on the Myakka River.

A designed maximum discharge of 800 cubic feet per second through the canal was proposed by DeLeuw, Cather and Brill, engineers for the private interests. The existing structures are adequate on the north branch and the lower creek. The weir specified in the vicinity of Venice By-Way by DeLeuw, Cather and Brill has never been constructed and definitely should be, as a salinity barrier.

On the south branch of Curry Creek the existing 5 ft. culvert structures are undersized, causing scouring now and probably worse conditions later. When improvements are made to the canal a weir will be required east of the canal junction with Curry Creek.

No. 8 Hatchett Creek Basin

South of Curry Creek Basin, east of Venice and north of Center Road is Hatchett Creek Basin. Draining 2,400 acres of developed and semi-improved land this basin is unusual in that it drains in a northwest direction and is of particular importance because of its location, past development and future.

Because of the present inadequate right-of-way through East Venice Subdivision and the possibly excessive cost of widening the existing drainageway, two alternate by-passes have been proposed. These by-passes are intended to protect

the existing drainageway from excessive velocities, overtopping of banks and undue maintenance, by providing a diversion canal with a weir over which flood waters will pass when a certain flood stage is reached.

The preferred by-pass is shown as alternate "A" on the plans. This should be the routing if the Intracoastal Waterway is constructed along their route designated "C-1." Its benefit is an existing drainageway through low lying lands, and requires a 70 ft. right-of-way if Alternate "B" is used, and only a small increase in size to 90 ft. right-of-way for alternate "A." Also in favor of the "A" routing is its short length, less maintenance, and the lending of greater potential as an industrial site with direct water and rail access.

Alternate "B" would be necessary should the Intracoastal Waterway be constructed elsewhere. This route crosses a minor ridge near Venice Farm Road, but the additional discharge into Hatchett Creek can be handled by the existing structures.

As is the case with other coastal basins, a salinity dam is necessary in addition to other weirs which control discharge velocities. A preliminary location for a salinity dam is west of Venice-By-Way. Other weirs will be necessary to control flood waters in the by-pass.

Further development in the eastern portion of this basin will require staged construction of drainageways. As noted on the plans, in the future all drainage from Venice Gardens should flow southward to Alligator Creek as initially planned by the subdivision engineers.

No. 9 Alligator Creek

Draining approximately 6,350 acres, or about 10 square miles, Alligator Creek discharges into Lemon Bay in South Venice Subdivision. The area drained is of great importance due to its rapid growth and presence of three existing subdivisions,

Venice Gardens, South Venice, and Venice East. In 1960 the Board of County Commissioners authorized a study of this basin by another engineering firm.

These plans have been reviewed by us for consistency with the purposes of this study. The 150 ft. right-of-way specified will be adequate, as will most of the alignment. Realignment locally at U. S. 41 is recommended however, for better approach and discharge through the structure.

In the plans referenced herein we propose that right-of-way requirements be continued eastward of U. S. 41. A more detailed study should be made to establish the exact location of a salinity dam, tentatively west of U. S. 41.

Because of insufficient topographic data, safe building elevations could not be accurately determined. We have ascertained that building elevations proposed by the above mentioned earlier study of this basin must be adjusted in certain areas, but otherwise may be applicable.

No. 10 Forked Creek Basin

Forked Creek drains a fairly large area of 5,930 acres that lies south of U. S. 41 along State Road 775. At Lemon Bay, where the creek discharges, the ground rises relatively rapidly to elevation 10 to 15 MSL, then dips and rises again slowly toward the northeast, with numerous wet weather ponds. This configuration of the lands results in three major drainageways within the one basin. In the upper reaches these drainageways are unimproved sloughs that flood in the rainy season. The outlet west of S. R. 775 is through Overbrook Subdivision and at present is adequate in this area, but once development is begun east of S. R. 775, which will accelerate with the rebuilding of S. R. 775, conditions will become more serious.

This lower creek area eventually should be straightened, widened and deepened. For the present, alignment should be studied and the 220 ft. right-of-way obtained before house construction makes land acquisition a very costly matter.

Presently the structures on S. R. 775 are adequate but will need replacement for future development. The north branch box culvert at S. R. 775 acts as a weir, but when the structure is replaced a separate weir should be constructed here. The south branch box culvert at S. R. 775 permits tidal flow east of the road and does not act as a weir. Therefore constant silting action will take place in the Creek just west of S. R. 775, requiring continued maintenance until a weir is constructed in this area.

North of Overbrook Road, nearest the western portion of this basin, there is a 460 acre sub-basin that has no definite drainageway. Before any development can proceed in this area a canal will have to be cut and an adequate structure at Overbrook Road constructed. In a sub-basin of this small size, it would not be advisable to stage this construction but rather complete the work when development begins.

Also north of Overbrook Road, just west of S. R. 775, the existing drainageway is in very bad shape. When improvements are made to this section, the Overbrook Road bridge should also be widened or replaced.

With fairly good topographic data covering a majority of this basin, preliminary flood hazard and minimum building elevations were established east of S. R. 775. A small additional amount of field work would permit completion of contours north of Forked Creek and west of S. R. 775, and then flood hazard areas and minimum building elevations could be determined in the more important area of Overbrook Subdivision.

No. 11 Godfrey Creek Basin

The Godfrey Creek Basin, sometimes referred to as Deer Creek, Gottfried Creek or Rock Creek, drains over 12 square miles, and is the most southerly Sarasota County coastal basin. Its outlet is into Lemon Bay, in Charlotte County, at New Point Comfort.

A coastal "bluff" at elevation 10 to 12 MSL lies on the western border of this basin, being less than one-half mile from Lemon Bay and running through the center of Englewood. The basin consists mainly of fairly flat lands with wet weather ponds, elevation 10 to 15 MSL north of S. R. 777. The majority of this land is owned by Venetia, Inc. and was completely surveyed by others for previous development plans.

The main problem area in this basin is north of Englewood where a low area runs in a northwest direction away from S. R. 777. In the design of S. R. 775 the State Road Department used this existing low area for detention of water, carrying roughly half of the overflow northeast under S. R. 775 and the remainder southeast under S. R. 775 and along the north right-of-way of S. R. 777 to Godfrey Creek.

Master planning requires looking ahead far enough to see the future development of this north Englewood area, and the need to control runoff within definite canal banks and permit maximum use of land for urbanization. It is therefore planned to drain this critical area all to the north and relieve the already inadequate ditch along S. R. 777 of a large portion of the load now imposed on this very overgrown outlet.

In routing this water to the north an open canal with a minimum of four feet of water maintained by a weir north of Artists Avenue and a minimum of 30 ft. of width at the water line, will provide an attractive fresh water canal that will help keep the ground water table high, provide excellent drainage for the area, and make a great deal more land usable. It should be noted that the 70 ft. right-of-way is a minimum, and should private interests desire to widen this or develop fresh water lakes in this vicinity, it would benefit the area.

Also considered was the possibility of taking this drainage directly to the west for a more direct outlet to Lemon Bay. Although this would relieve some of the burden on Godfrey Creek, because of the weir and detention in the canal, the

actual relief is not great enough to warrant the considerable costs for right-of-way to the coast, canal construction through a ridge and an outlet structure on the bay. Natural drainageways are by far preferred to most of man's costly attempts to overcome nature.

The second major problem in this basin is that of a salinity dam on Godfrey Creek. At present tidal flow extends well above S. R. 777, and almost definitely is contributing to salt water intrusion into local well supplies. Because of the existing water supply problem in this and nearby areas, a water district has been formed to construct a central water system. If salt water intrusion into well aquifers thus ceases to be a problem, continued tidal flow north of S. R. 777 would be beneficial in permitting boat access to the bay for a large area north of this road, increasing land values.

However, if good drinking water is not thus made available from another source, a low salinity dam should be placed in the S. R. 777 area to help the ground water situation. Such a dam would prevent some presently marginal land from being developed because of occasional flooding.

Englewood has numerous minor drainage problems, outside the scope of this report that should be studied by the county to prevent haphazard drainage that is costly to correct.

XII. GROUND WATER

A. General

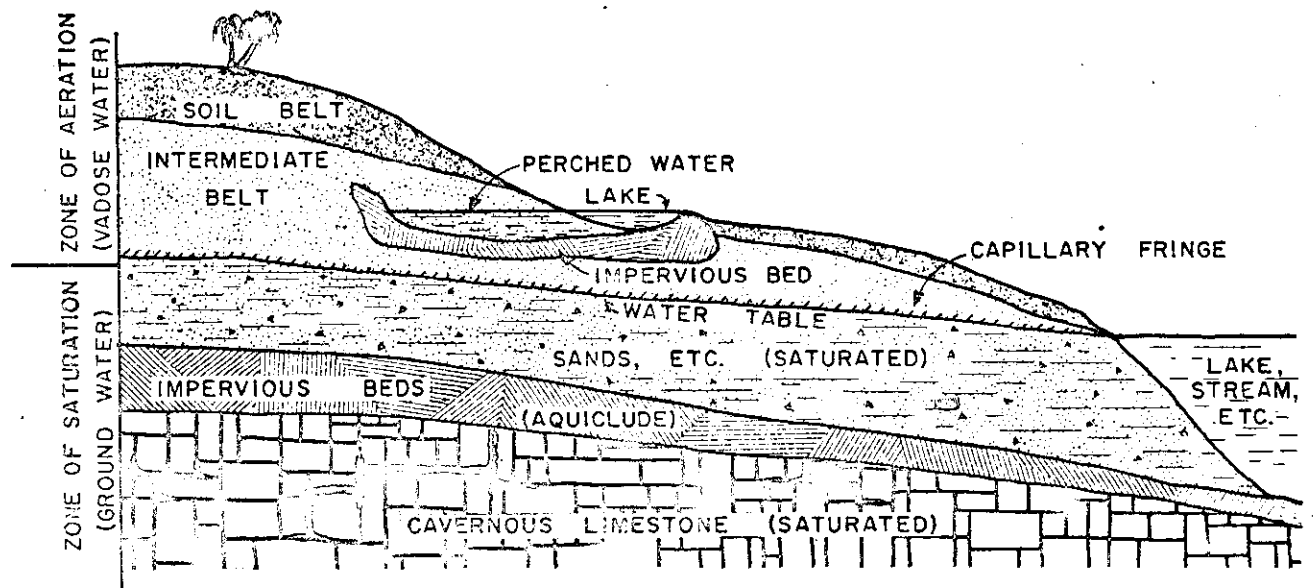
The classifications of water lying beneath the surface of the ground are illustrated by the sketch on the next page, Exhibit "L." There are two major zones. The term "ground water" applies to the lower levels which are saturated, the water table being the upper surface of the ground water. Moisture above the water table is in the "zone of aeration," part or all of which is available to the roots of plants.

Sometimes saturated water is held above the overall water table by local impervious beds of rock or hardpan. This localized ground water is known as "perched water," and may be of considerable importance to certain areas.

Ground water is stored in the openings available, which may range from tiny voids between soil particles to large cavities in rocks. The ability to absorb water "porosity," is not identical with the property of transmission, "permeability." Clay is highly porous and yet low in permeability; therefore it yields low flows to wells. The limestones, sands and shells of Florida are generally highly permeable and are therefore favored as high-volume aquifers where they are not excessively mineralized.

Ground water may be viewed as a huge covered water reservoir. The total amount in storage is tremendous. It is covered by the upper soil layer, which in dry weather retards evaporation, a feature that surface water storage lacks. This reservoir may be tapped as needed, but replenishment must ultimately balance use or the deficit will cause major problems, and in extreme instances could lead to a kind of bankruptcy.

Rainfall replenishes the ground water. It may infiltrate directly into the soil it falls upon, or indirectly from surface runoff flowing from higher elevations overland or through channels.



CLASSIFICATION OF SUBSURFACE WATER

ADAPTED FROM VERNON

JOB NO. 700

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SARASOTA, FLORIDA

Rainfall infiltrating into one area may recharge ground water elsewhere by percolating laterally through the ground. The water table is a hidden hydraulic gradient which is a measure of the gravity force that powers this underground flow. Lateral percolation of ground water is a slow movement that originates at higher elevations and continues to the sea, where it seeps out and is lost.

Ground water may seep out of as well as into streams and lakes, before reaching the sea. Drainage and irrigation canals are examples of water table control exercised by farmers. Wells tap the ground water reservoir for drinking and irrigation water. Plants pump out huge quantities as part of their transpiration process.

The quality of the ground water is also of importance, and need not be the same for all purposes. Drinking water standards are not identical with agricultural specifications. Budgeting of the available supply may take this into consideration when a shortage arises.

During former invasions of the sea over southern Florida, salty water permeated the limestone formations. Saline residues remained after the sea retreated. Fresh water from rainfall has been diluting and flushing out the ancient salts for some 10,000 years, but in many areas like Sarasota County, the process is still incomplete.

B. Sarasota County Resources

A number of investigations have been made of the ground water resources of Sarasota County. The most intensive is V. T. Stringfellow's 1933 report which covers investigations made in 1930 by the U. S. Geological Survey in cooperation with the Florida Geological Survey. The Board of County Commissioners engaged E. W. Bishop to make a supplementary investigation, the report on which was issued in 1960. Other data sources are listed in the appendix, and no purpose would be served by burdening a report of this type with material and tabulations that are readily available for reference.

Although much information is thus at hand, there is need for further investigation, especially because of the pressures for increasing supply and the changes since Stringfellow's work of 30 years ago. The City of Sarasota is investigating the feasibility of replacing its present well supply with better water to the east. The report prepared in 1958 by this firm for the County on a proposed Lower Phillippi Creek Utility District reviews certain aspects of the water supply situation.

C. Ground Water Consumption

The loss of ground water directly to the sea is probably not a major factor in Sarasota County, because of the flatness of the water table gradient which reflects the low land slope, and the impermeable formations at or close to the surface.

Of more significance to the county is seepage out of the ground into lakes, streams and canals. This becomes surface water, most of which is lost by evaporation or runoff. Deep channels of this nature without weirs may lower the water table, with dangerous consequences.

Direct consumption of ground water is the main demand on this resource, and both nature and man are involved. Transpiration from plants is nature's main use of ground water. If the water table falls below the level to which the roots of various plants can reach, transpiration may be reduced. This happens especially in locally overdrained areas. There are seasonal changes in transpiration resulting from plant life cycles.

Transpiration from crops will become an increasingly large consumer of ground water, especially with expanded irrigation practices. Competent authorities estimate that for the entire state, agricultural water consumption is now reaching about half of the total for all uses, and by 1970 the proportion will reach 70 percent.

This is even more staggering considering that the per capita usage of water for all other purposes is also increasing rapidly. In Sarasota County the dry weather demand coincides with the peak of the crop growth in the winter season.

When it is realized that all estimates for the future must also supply tremendous increases for urban and industrial consumption, the impact is evident. Ground water will supply perhaps 90 percent of the demand, and measures should be considered for conservation of this resource. Impoundment of surplus surface water for release and recharge of the ground water when needed is one possibility that Sarasota County may ultimately benefit from.

Fire hazards may be reduced if the water table is maintained at reasonable levels in dry weather. On the other hand, prolonged flooding will kill or weaken both hardwoods and softwoods.

The spring of 1961 revealed acute problems in various areas of Sarasota County from a prolonged dry spell and increased consumption.

D. Salt Water Intrusion

Salt water not only meets fresh water at the coast and tidal inlets, but also underlies much of the county. The salt water near the coast is modern sea water whereas inland the salt water beneath the fresh water represents the residues from ancient ice-age seas which have never been flushed out.

Fresh water is slightly lighter than sea water and will tend to float upon it. Near the coast the theoretical Ghyben-Herzberg principle generally applies, which is that for every foot of fresh water above sea level there will be about 40 feet below. It is analogous to an iceberg, most of which lies below the water surface.

The significance of the water table immediately becomes evident; if the water table is, say, 5 feet above sea level, fresh water will extend about 200 feet below,

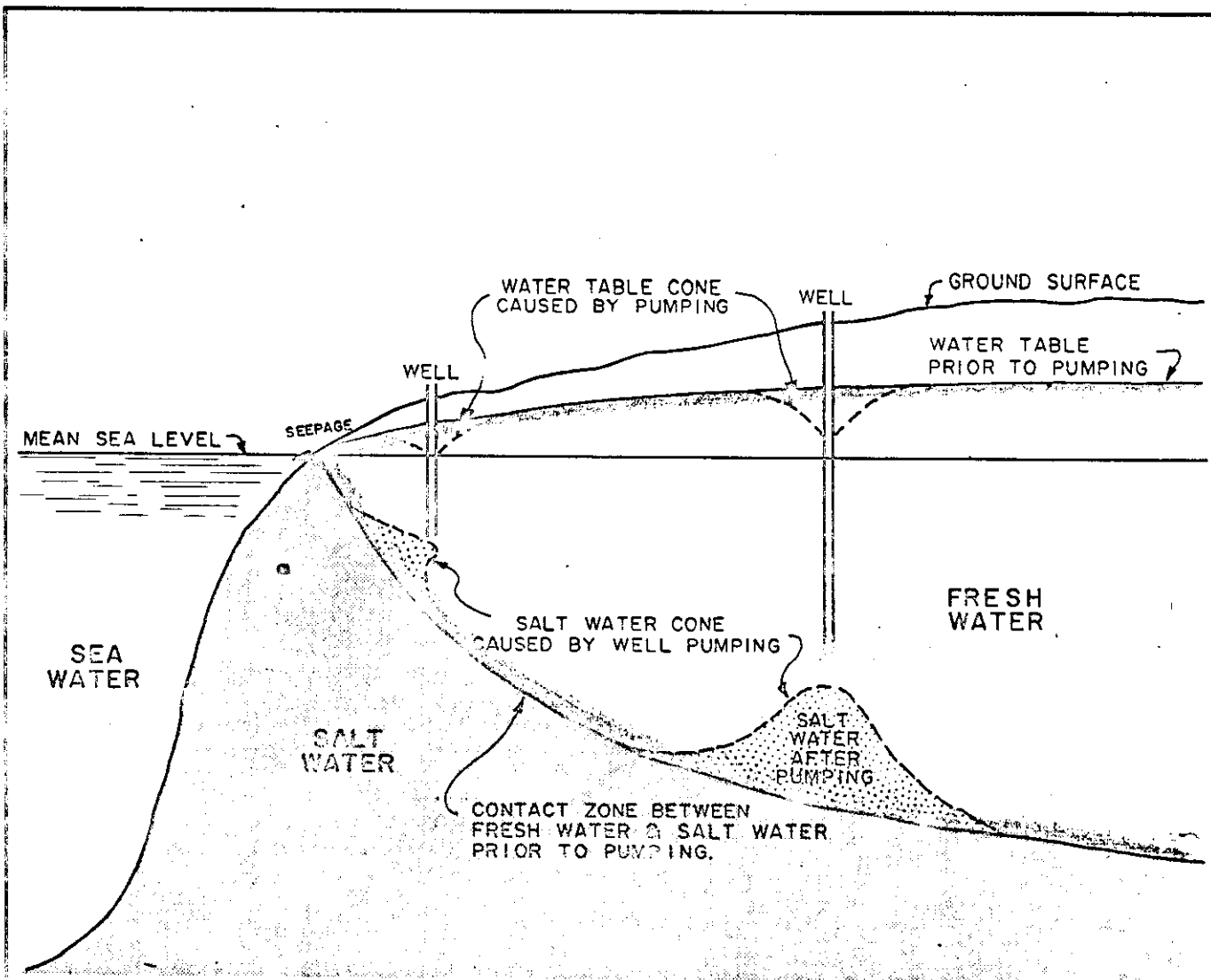
and a well tapping this zone will, at least initially, obtain fresh water. The actual shape of the zone of contact is a curve, as shown on Exhibit "M," on the following page. This exhibit illustrates the classical principles, and also the effects of pumping.

The relationship shown on Exhibit "M" is for shallow non-artesian wells in a permeable aquifer. This description fits the main source of fresh ground water in coastal Sarasota County, and salty shallow wells near the coast such as in Englewood, appear to confirm the condition.

Salt water intrusion immediately adjacent to land may move laterally inland, as well as vertically upward. A "salinity" dam placed in tidewater channels helps resist salt water intrusion by barring tidal flow inland, as well as by pooling fresh water above it.

The 40 to 1 ratio principle does not apply inland, for various reasons, but the basic situation is similar in that a head of fresh water floats on an irregular bed of salty water. At deeper levels the shallow surface soils, the pressure effects of artesian aquifers and the influence of the impervious layers that confine these aquifers alter the relationship.

The placement, construction and operation of wells have a great influence on contamination of the fresh water aquifers. Drawdown of the well by pumping lowers the water table locally, as an inverted cone, which in turn permits the underlying salt water to move upward in an opposite cone effect. Where the wells are close to the coast, the bottom cone may be warped sideways toward the sea, with consequent movement of sea water laterally toward the well. In either case, contamination from salt water may result. The harder the pumping and the closer the spacing of the well field, the greater will be the potential intrusion.



GENERAL RELATION OF FRESH WATER TO SEA WATER IN COASTAL AREAS

NOTE: Above schematic illustration shows shallow non-artesian wells in permeable aquifer. Sketch not to scale.

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JOB NO. 700

The complex factors relating to wells, their placement and construction, and their function as the means of tapping the ground water resources of the county call for a public policy related to well drilling. A well drillers code should be considered as a first step. Other regulations may be necessary in the future.

Uncapped artesian wells also can create problems. Where the local underground piezometric pressure exceeds the ground elevation, water will flow freely, or "wild," out of an open well that taps the artesian aquifer. Capped wells that have corroded casings can be contaminating adjacent shallow aquifers unseen. For the latter reason, capping is insufficient and may even accelerate hidden underground contamination. Plugging of the wells is the best solution.

The wildly flowing well problem is so common in Florida that a special inventory was published by the Florida Geological Survey in 1957. The State Division of Water Resources and Conservation has initiated a plugging program.

E. Other Contamination

There are other sources of ground water contamination in Sarasota County. Irrigation water, unlike rainfall, contains dissolved salts. The quantity may be minor enough for ordinary usage, but may build up over a period of time. Sea spray and unusually high tides add to the problem in coastal areas. Where natural rainfall flushes out these salts, the problem may be transferred to the lower areas of the basin. The importance of agriculture and the value of irrigation to Sarasota County is such that this aspect merits further study to preclude or minimize the problem, rather than attempt to solve it after it might reach major proportions.

Outside of the cities of Sarasota and Venice, there are a limited number of central water supply and sanitary sewerage systems. The county franchise regulations are a potent tool in encouraging and controlling these systems.

Overall, a majority of the population outside of the cities use private wells for water supply, and septic tanks with drainfields for sewage disposal. Failures of septic tank systems are widespread when the water table rises to the ground level, and the County Health Department reports that many complaints are received of sewage standing in yards and open ditches.

Pollution by industrial wastes will become a problem as the county attracts more industry, unless suitable treatment is required. Such treatment has been installed at the local EMR plant. Nature may also add undesirable pollutants at times.

A long range program for water management should incorporate procedures for coping with pollution before it becomes a hazard or excessively costly to correct after the fact. Sarasota County has already taken important steps in this direction.

XIII. COASTAL ASPECTS

A number of aspects of water management relate to the coasts of Sarasota County, including the tidal banks of the various creeks. Salt water intrusion into the ground water has been discussed previously.

Surface water runoff of lands along the coast can make effective use of the proximity of the sea as a receiver. Natural coastal streams and existing canals require improvement, and new canals will be required. Weirs rising with land contours will minimize channel scouring and consequent silting of the coastal outlets.

Coastal areas feel the brunt of storm tides, which reach great proportions during hurricanes. Flooding from storm tides may be compounded by superimposed wave action and by simultaneous rainstorm flooding. Bay and estuary configuration influences the effects of entering tides. The following table is based on information made available to us by the Coastal Engineering Laboratory of the University of Florida:

TIDE ELEVATIONS AT SARASOTA (Not including wave action)

<u>Average Frequency</u> (once every)	<u>Elevations above Mean Sea Level, in Feet</u>
100 years	9.1
50 years	7.0
20 years	4.5
10 years	3.5
5 years	3.2
2 years	2.7

The vulnerability of much of the low coastal and river areas to these storm tides is evident. Control of building elevations in flood hazard zones would provide a measure of protection to the public and would serve as a useful guide to builders and developers.

The beaches, islands, inlets and bays are valuable assets which lend character to the county. They provide the basis for the important resort economy and for public recreation. Property values are threatened where erosion takes place.

Fundamentally, a beach is not a stable piece of land. In a way it is almost alive, the sand grains constantly churning up and shifting. The sand mantle covering Florida itself originated far to the north. Nature's shifting of the shoreline meant little until population pressures sent land values soaring. Contending with the great sea and wind forces of nature is a task that can be very expensive, and may only be justified in many cases by correspondingly greater values of the land to be protected. In addition to the beaches, bays, inlets and channels are subject to erosion and silting, generally due to currents rather than wave action.

Because of the importance of the coastal resources to the state, the Coastal Engineering Laboratory has been set up at the University of Florida to perform research on this still inexact science, and to advise and work with various state and local agencies. Much remains to be done in this field.

Navigation in general is a matter of federal jurisdiction, the channels being under the administration of the Corps of Engineers. For projects which qualify under the benefit-cost formulas, assistance may be obtained through funds appropriated by Congress. Combination with flood control projects is possible under certain conditions.

The Intracoastal Waterway, now under construction, is a Corps of Engineers project. A protected channel 9 feet deep and 100 feet wide will extend ultimately along the entire U.S. coast on the Gulf of Mexico, and will link up to other waterway systems. Various passes are also being studied by the Corps of Engineers.

Pollution of salt water is a danger to health, recreation and fishing. Through these it can menace the resort economy and commercial fishery. This problem can be avoided by proper controls and construction of sewage treatment plants which provide for complete treatment of sewage from urban communities.

Other agencies interested in coastal aspects are listed in Exhibit "N." (Pg. 77)

XIV. AGENCIES IN WATER MANAGEMENT

A. General

The ramifications of water management are so broad and far-reaching that an almost bewildering array of agencies are involved in one way or another. This would have happened under any circumstances, even if arranged carefully at one time according to a master plan of agency interest and responsibility.

The actual situation is that involvements of these agencies developed over a long period of time, and followed the impact of increasing problems and awareness of the needs, not only in this state but throughout the entire nation. Congressional and state statutes have multiplied and changed, and areas of agency responsibility have shifted constantly. Bureaus have grown broader and narrower, have had their responsibilities added to or split off, and have even ceased altogether. Many of these agencies are interrelated with each other and with various local interests, and the patterns of these relationships are likewise complex and shifting constantly. The intermingling of water management relationships appear at first glance to be a structure grown to confusing complexity.

Yet this edifice is not a meaningless tower of Babel. Granted that it grew this way without overall direction from above, it has been guided largely by dedicated persons who have pitted their intelligence and cooperation against staggering variations and complexities.

In order to present the general picture in an orderly manner, a classification system similar to one established by the Florida Resource Study Commission (Report of December 1960) has been applied, expanded and related to the situation affecting Sarasota County. A chart appearing on the following page as Exhibit "N" is the result. A certain amount of simplification was necessary in preparing a chart of this type, because these agencies are interrelated in many ways.

F U N C T I O N S A N D
M A J O R I N T E R E S T S

[illegible]

THE PURPOSE OF THIS CHART IS TO SHOW THE OVERALL CHARACTERIZATION OF FWS: AGENCY INVOLVEMENT IN WATER MANAGEMENT. THE DEPTHS OF INTERESTS OF THESE AGENCIES VARY GREATLY, AND THE INTERNAL ORGANIZATIONS OF THE AGENCIES AND THEIR FUNCTIONS ARE OFTEN COMPLEX. FOR CLARITY OF PRESENTATION REASONABLE JUDGMENT HAS BEEN APPLIED IN ASSIGNING THE FUNCTIONS AND MAJOR INTERESTS. THE FUTURE WILL ALTER SOME OF THESE.

PREPARED BY
SMALLY, WELLFORD & HALVEN - CONSULTING ENGINEERS
SARASOTA, FLORIDA
MAY, 1961

PUBLIC AGENCIES IN WATER MANAGEMENT

EXHIBIT "N"

The agencies shown are the most important which are now or may be potentially related to water management in the Sarasota County area. Some agencies listed are subsidiary to others also listed, but have been separated because of the importance of their specialized functions. It would be impossible to list herein all of the agencies which at some time or other might touch upon these matters to minor degrees.

Subsequent to the printing of Exhibit "N" it has been announced that the State Board of Conservation has been reorganized, with minor changes in titles of the various divisions, and strengthening of administrative structure.

B. Functions

The functions of these agencies include collection of basic data, analysis and research; regulation of water use and pollution, approaches to the development of water supplies, irrigation and recreational facilities; and water management aspects of soil and water conservation, flood control, drainage, insect and weed control, navigation, beach and channel erosion, and fire protection.

A total potential of the agencies is highly important. Not every avenue will be suitable for Sarasota County, but selective use may be applied as part of the county's water management program. The county may encourage and participate in certain operations of these agencies.

Certain agencies are permitted to make grants or loans related to water management. Some of these programs are designed for individual farmers and groups which form districts.

The agencies most deeply concerned with drainage and flood control, as presently or potentially related to Sarasota County, are the following:

1. Soil Conservation Service of U. S. Department of Agriculture
2. U. S. Army Corps of Engineers

3. State Road Department
4. State Division of Water Resources and Conservation
5. County of Sarasota
6. Adjacent Counties (Manatee, Charlotte, DeSoto)
7. Cities of Sarasota, Venice and North Port Charlotte
8. Sarasota Soil Conservation District
9. Manatee, Charlotte and Peace River Soil Conservation Districts
10. Hyde Park Drainage District
11. Various Road and Bridge Districts

C. Federal Aid for Drainage and Flood Control

The Small Watershed Act, Public Law 566 establishes direct participation in planning and construction of small watershed improvements, provided the benefits derived therefrom justify the expenditures. The benefits are computed according to procedures established by law, and basically are agricultural, the act itself being administered by the Soil Conservation Service, U. S. Department of Agriculture. Application for assistance must originate locally and be approved by the State Conservation Board.

The Cowpen Slough plan in the Shakett Creek Basin, designated by the Soil Conservation Service as the "Sarasota West Coast Watershed," is such a project, and is in its final planning stage. An application is now in process for a proposed "Big Slough" project covering much of the county area east of the Myakka River Basin, and extending into adjacent counties. The Boards of County Commissioners and Conservation Districts of the counties involved have endorsed the application.

The U. S. Army Corps of Engineers processes major flood control and navigation projects. Justification must qualify under federal statute, but secondary benefits may be included. Urban flood control aid is under the jurisdiction of this agency,

and in 1960 Congress authorized a Phillippi Creek project. However authorization is only the first step, and no work on a major project can be carried forward without funds specifically appropriated by Congress. This year, for the second time, an appropriation for a study was deleted, although by such a narrow margin that perhaps another well-supported effort might succeed next year.

Loans for planning of public works are processed by the Housing and Home Finance Agency on an interest-free basis, which are repayable when the project goes to construction. The same agency sometimes processes long-term loans for actual construction, at reasonable interest rates. However, it has been more difficult for a county to obtain such loans than for a city.

D. State Road Department

The State Road Department's interest is basically confined to road structures affected by drainage, runoff, and navigation. The most critical highway in the basins studied is State Road 45 (U. S. 41) which is being four-laned by stages.

Ultimately the State Road Department will be interested in and possibly involved with various structures on other state roads which pass through the basins. This agency should be furnished with copies of the county plans.

E. Incorporated Municipalities

In general, cities exercise jurisdiction over their own water management. Since water naturally runs downhill the agencies sharing a basin must cope with mutual problems, or alter nature, with all the new problems which that step would create.

Copies of the county master drainage plans should be furnished to the cities affected, as a preliminary to establishing mutual responsibilities. Although minor drainage features are primarily a matter of local jurisdiction, they should be suitably related to the major drainageways and coordinated at political boundaries. Cooperation should result in the best solutions at the least cost to the public.

XV. WATER MANAGEMENT DISTRICTS

A. General

The formation of a legal district is a device that has been found suitable in Florida and elsewhere where a specialized function presents difficulties to the established local governing bodies. Districts commonly stem out of one or more of the following situations:

1. The geographical boundaries of the area involved differ greatly from local political boundaries.
2. The function of the district benefits only a limited part of the population.
3. The constitutional or statutory powers of the established governmental body are not suited, broad or flexible enough to fit the functions of the district, its financing, administration, or its relationship to other local, state and federal agencies.
4. The framework of assessment and taxation available to the established body does not permit special levying of costs against the interests that derive the most benefits.

A district may be larger or smaller than a county, or may coincide with county boundaries. A district might be sponsored through local, county or state action, and might involve participation or cooperation at all levels including the federal government. The broad powers commonly granted to incorporated cities because of their concentrated intra-relationship often permits them to assume the functions of districts. Examples of these situations exist today in Sarasota County.

The following types of districts are most intimately concerned with aspects of water management:

1. Water Management Districts, also called Water Conservation, Flood Control or Drainage Districts.

2. Road & Bridge Districts
3. Sanitary Sewerage Districts (generally combined with water supply)
4. Water Supply Districts
5. Soil Conservation Districts

This list by no means exhausts the possible types of districts, because the essence of the district concept is its flexibility, which may be tailored to fit the needs by a special act of the legislature. Nor does this list exclude the universal impact of water resources and management on practically any other type of district, even though its responsibilities and powers lie elsewhere.

B. County Water Conservation Districts

Sarasota County has two special acts which enable the formation of water conservation districts with broad powers and flexible financing. These were enacted in 1959 as 59-1849 and 59-1850. The term "water conservation district" appears in these acts, but their effect is identical to a water management district.

59-1849 covers formation of a district at the initiative of electors within the district area, whereas 59-1850 provides for creation of a district by the Board of County Commissioners. Neither act has been applied to date.

Financing is subject to public action and other legal safeguards. Issuance of general obligation bonds requires the approval of freeholders within the district. Prior to issuing "assessment bonds," payable from assessments against benefited lands, public hearings are required, and recourse to the courts is provided for. Legal determination is necessary as to an election in connection with assessment bonds.

In an assessable district only those lands receiving benefits from the improvements are assessed, and in proportion to the benefits received. No formula for

benefits is spelled out, the Board of County Commissioners having discretion over the fixing of a fair and equitable basis. The Board may permit payment of assessments over a period up to 20 years. Interest must not exceed 8 percent per year.

A district may cover a local area or the entire county. The first action by the Board of County Commissioners under these acts will be of the utmost importance in establishing fundamental policy as to local vs. county-wide approach, because a precedent thus set would be difficult to change.

A county-wide district would be a simpler device than a multiplicity of separate districts. The Board of County Commissioners may take the initiative, with suitable public support, and the relatively complicated and time-consuming steps may be taken care of once, instead of many times. In general the application of funds would follow the growth of population, which would provide a measure of benefit going to those who would pay the most district taxes. Ultimately improvements would be required over the entire county. This arrangement would be flexible in that actions could be scheduled as needed anywhere in the county.

The disadvantage of a county-wide district is that necessarily step-wise improvements might create opposition from those taxpayers receiving no immediate direct benefits. Local districts, on the other hand, would tend to raise funds and apply them for specific projects in behalf of those taxed.

In either event, there are certain costs which will apply to the entire county, such as master planning and engineering, like this study and report. In the case of the county-wide district this is less of a problem, but where smaller districts are concerned it is not logical to assess costs to one such district for the overall plan into which this district would fit.

There would also be legal, election, and other expenses involved in creating such districts. Any procedures set up should provide that preliminary expenses of

this nature in behalf of a proposed district be payable from the general funds of the county, but should be reimbursable expenses which would be repaid from the proceeds of bonds or other obligations or assessments issued or collected by the district to accomplish the purposes.

It may be noted that the county is now faced with urgent problems. Immediate improvements out of county budget funds prior to major project operations is a procedure in keeping with past and present county functions.

C. Existing Drainage District

The old Hyde Park Drainage District covers about four square miles southwest of the former Sarasota-Fruitville Drainage District. It straddles a portion of Phillippi Creek.

Most of the Hyde Park Drainage District lies within the county, and logically should be taken in by the county. A small area in the northwest corner is outside the Phillippi Creek Basin, and lies within the City of Sarasota, the ridge line almost coinciding with the city boundaries in this location. Consideration might be given to the city absorbing this small portion of the Hyde Park District.

In 1924 the Sarasota-Fruitville Drainage District was established, the boundaries of which cover the major areas of Phillippi Creek Basin. This district was absorbed by the County of Sarasota on June 30, 1961.

D. Road and Bridge Districts

Existing general statutes permit the formation of Road and Bridge Districts. Drainage improvements incidental to the construction and protection of roads and bridges are permitted.

A number of such districts have been set up in Sarasota County, such as South Venice, Sarasota Springs and Golden Beach. Internal drainage has been improved greatly thereby.

Consideration may be given to utilization of other Road and Bridge Districts where drainage problems for relatively minor areas are involved.

XVI. CONCLUSIONS

A. General

Water Management is important to any community. The water on, under, and around the county is as much a part of its natural resources as is the land itself.

For Sarasota County the matter is of especial significance, because of the water orientation of commerce, industry, and the public, and the phenomenally rapid population growth. The unincorporated areas are growing more rapidly than the City of Sarasota, and now contain more than half the residents.

Land use is the culmination of the relationship of man to nature, and water management must be guided by it. Long-range plans must incorporate the effects of such usage. The community, through its elected public officials, should set the goals.

The land use requirements relating to water management that should be incorporated in future planning include the following:

1. Major flood routing
2. Water impoundment and re-charge areas
3. Conservation and recreation areas
4. Areas subject to flood hazard (flood plains).
5. Multi-purpose areas, incorporating the above and other aspects
6. Road right-of-way
7. Drainageway right-of-way
8. Water control structures
9. Other needs of water management that may be developed

B. Coastal Basins

The surface water aspects of Sarasota County represent the most pressing current problem within the coastal basins, which have enjoyed the greatest population

growth. Flood runoff computations have been made based on a magnitude recurring at intervals averaging 25 years. The runoff factors apply to ultimate, not existing land use, for which projections and assumptions had to be applied.

The requirements of major drainageways and drainage structures have thus been established, with their corresponding right-of-way needs. Although many years will elapse before it is necessary to complete this program, steps may be planned to provide for orderly implementation, as needed, by successive stages. Each stage of construction may be related to the next stage. Perhaps most important, reservation of right-of-way may be accomplished, and encroachments therein prevented, so that prohibitive costs may be avoided when this right-of-way is needed for construction.

Although detailed investigation of each basin is beyond the scope of the study, a basin-by-basin review has been incorporated in the report, which takes note of the most immediate problems. In general, limited actions are required now as to major structures (bridges, culverts, and weirs), but judicious improvements to selected channels will provide relief to many wet areas. Ultimately, developers may excavate at least parts of some channels.

C. Application of Basin Plans

The limitations should also be understood. This is a preliminary study, and subject to future refinement prior to construction. The most natural existing way out for each drainageway has been applied, based on hydraulic considerations. Where localized problems, such as cost factors due to existing urbanization, may so justify, alternate flood routing may be considered. Ridge lines which define the basins may be shifted in land as flat as most of Sarasota County.

For these reasons, adjustments to the master drainage plans may be considered, provided they are based on equivalent criteria. However, allowance for future

flexibility should not delay the adoption of the plans as official county policy. Even the most refined and exact plans will always be subject to change.

It is anticipated that the exact location of the required right-of-way will be established as the lands are improved and subdivided, using the plans referenced herein as a guide. Supplementary alignment and boundary studies may be advisable in certain "hot spots" from time to time. A number of these appear in the review of the coastal basins, as well as in the separate report on the Phillippi Creek Basin.

D. Flood Hazard Areas

Unfortunately, available topographic data, even when supplemented by field surveys in the vicinity of the main drainageways, is sufficient to delineate flood hazard areas and corresponding minimum building elevations in only three of the eleven coastal basins.

It may be noted that a considerable amount of intermittent elevations in non-contiguous areas have been accumulated in the course of this study, but are not complete enough for plotting of topographic contours. Selective surveying to supplement this data would permit delineation of additional flood hazard areas.

Considering the present and prospective population growth in all of these coastal basins, completion of sufficient topographic mapping for the purpose of controlling building construction is an immediate need.

E. Minor Sub-Basins

Minor sub-basins and localized problems areas are not within the scope of this report. The term "minor" applies to areas and sizes of drainageways, and not to the seriousness of any local problem that may exist. There are urbanized areas, such as Englewood, that are now in need of detailed study.

The process of community development is continuous, and corresponding vigilance is essential to insure that subsidiary measures fit the overall picture, and that succeeding steps are taken when the time is ripe but not too late.

In this connection, particular emphasis is placed upon the need for the county to exercise control over minor drainageways, where such exist, to provide for their improvement, and to arrange for new minor drainageways as necessary. Much of this can be handled in the processing of new subdivisions, but engineering reviews of localized areas will be necessary to be sure of ultimate coordination in the public interest.

F. Other Agencies

The broad field of water management enlists the services and involves the jurisdictions of many agencies, local, state, and federal. The functions of these agencies are noted in the report.

Cooperation between all agencies involved should provide the best and least costly solutions, in the public interest. Of particular significance to the coastal basins studied in this report are the local municipalities, State Road Department, U. S. Soil Conservation Service, and U. S. Army Corps of Engineers. Imminent reconstruction of segments of S. R. 45 (U. S. 41) emphasizes the urgency of advising the State Road Department as to the needs of the drainageway structures, to avoid a repetition of the existing problem at the Phillippi Creek crossing.

G. County Areas Not Studied

Exhibit "O," at the end of the report, covers the entire county, and shows the areas studied to date, as well as the areas under some degree of drainage jurisdiction of other agencies.

Although ultimately these agencies and perhaps others might assume all or some of the responsibilities in certain areas not studied under county authorization, consideration should be given to the possibility of exploratory engineering review of all areas of the county, so that the entire picture will come into focus. This review would assist the Board of County Commissioners in determining policy based on public necessity, and a knowledge of present and future responsibilities.

H. Principle of Staging

The principle of proceeding by stages should apply to all future steps, whether detailed studies, designs or construction of improvements. Staging permits budgeting of funds in an orderly manner, and assignment of priorities to the most pressing problems. Each step reveals more clearly the next steps of most importance. Adjustments may be incorporated as future events occur and more refined knowledge becomes available, resulting in superior solutions at less cost.

Duplication of effort may be minimized, where federal aid or subdivisions may provide engineering and construction, at consequent cost savings to the county. Improvements geared to the pace of higher land uses will be economically justified and in effect financed by increases in the property values that they enhance.

A problem may merit preliminary investigation, leading in turn to a detailed study, then preparation of final plans, and finally construction. On the other hand, where delay is hazardous, immediate final design and construction may be justified. Each problem or project should be judged on its own merits. In order to avoid misunderstanding, the public should be made aware that successive steps are not repetitive, but are economical and insure continuing policy control by the Board of County Commissioners.

Ultimately hundreds of millions of dollars in property values will develop within the coastal basins alone. Scheduling of engineering and planning ahead of time, at relatively small cost, will save countless thousands, perhaps millions, of county funds later. Unpleasant future problems, blighted areas and other difficulties may be minimized.

XVII. RECOMMENDATIONS

A. Immediate Program

There are a number of drainage and flooding problems which may be deemed to be of sufficient urgency to justify immediate corrective actions, perhaps out of general county funds. The existing problems of the coastal basins and drainageways have been reviewed in the report, in Section XI, but assignment of priorities would be a prerogative of the Board of County Commissioners, as a matter of public policy.

Localized drainage problems also exist within the basins. Although these are beyond the scope of this study, some of them may be considered to be urgent by the Board.

B. Long-Range Program

The following steps should be initiated, in keeping with the long-range water management needs of Sarasota County. Many of these should be taken by stages.

1. Formulate community goals related to land use, utilizing the services of the County Planning Commission. Establish public policy on the improvement of marginal land in flood plains for urban subdivisions.
2. Adopt the master drainage plans as official public policy.
3. Protect the right-of-way needed for ultimate drainageways, by suitable legal means. Prevent encroachment by building construction or subdivision platting. Encourage voluntary deedding or dedication of this right-of-way.
4. Make alignment surveys prior to purchase of right-of-way in areas already built-up before the cost spirals still higher. Where especially high costs or other handicaps apply, detailed studies of alternatives may be justified.
5. Continue to delineate areas subject to flood hazard, utilizing supplementary topographic surveys, starting with existing urban areas and proceeding in advance of the expansion of residential subdivisions. Establish minimum building elevations in these flood hazard areas.

6. Schedule detailed engineering of minor drainage areas at a pace that keeps ahead of the problems of expanding urbanization.
7. Develop an approach toward rural canal systems which would connect to the major drainageways.
8. Continue to develop the legal and administrative framework for guidance and enforcement of water management policies. Zoning, subdivision regulations, and permit systems for channel and building construction are among the existing and potential tools for this purpose.
9. Review with the County Attorney the scope of actions and alternatives under Special Acts 59-1849 and 59-1850, relating to creation of water conservation districts. In this connection determine county policy as to a county-wide or district basis for financing projects. Consider also, for minor drainage, the use of road and bridge districts.
10. Schedule construction of improvements by stages, as the needs manifest themselves and financing permits. Review the discussion of these basins in Section VI in this connection.
11. Review the master drainage plans periodically, and revise them in keeping with changing conditions. Add drainage plans that will become available, such as tributary canal systems, whether engineered by the county or other interests.
12. Review the county road program, including state and federal highways, against the background of the master drainage plans, to the degree that they are interrelated. The State Road Department should be furnished with copies of the county plans.
13. Develop policies and measures toward protecting the ground water supply from salt intrusion and pollution. These would include implementation of a well drilling code and a "wild-well" plugging program in cooperation with the State Division of Water Resources and Conservation.

14. Establish liaison and cooperation with other agencies having jurisdiction over water management in the Sarasota County area. Copies of the master drainage plans should be furnished to certain of these agencies.
15. Continue to explore the possibilities of major federal aid, especially under Public Law 566 for agricultural basins and under the various laws administered by the U. S. Army Corps of Engineers relating to flood control and navigation projects, possibly in combination. Provide for continuous follow-up, in order to maintain or improve county priorities.
16. Sponsor and encourage broadened data collection and studies by a number of agencies. A study of ground water and geology by the U. S. Geological Survey would be valuable, especially if the delineations and functions of impoundment and recharge areas were explored. Another study that one of these or another federal agency might be persuaded to undertake would be of the build-up of salts in the soil from irrigation, sea spray and other sources.
17. Authorize such additional studies as the Board of County Commissioners may deem advisable. A number of possibly fruitful investigations are referred to in the text of the report, notably of exploratory basin studies in the balance of the county.
18. Consider other recommendations of lesser immediate importance that appear throughout the report.
19. Before taking any action on any water management problem, consider the potential impact on aspects other than the one at hand. Flood control measures, for instance, should not deplete the ground water in dry weather.
20. Refer also to the specific recommendations as to Phillippi Creek Basin incorporated in our report of June, 1961, and the report of the J. E. Greiner Company of August, 1961.

APPENDIX A

Reference Maps and Aerial Photos of Sarasota County

Section Maps, Official Sarasota County Atlas

Topographic Maps, 1944-1956 U. S. Geological Survey

Miscellaneous Topographic Maps, Florida State Road Department
Sarasota County Public Works Department
Smally, Wellford and Malven
Various other consulting engineers

Aerial Photos, 1960 Official Sarasota County

Aerial Photos, 1958 Smedley Atlas

APPENDIX B

General References

The following references are a selected list that apply, directly or indirectly to water management in Sarasota County. Many other references not listed also bear on this subject to some degree. Standard engineering reference works are not included.

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1939 - Geology of Florida, F.G.S. Bulletin No. 29

Davis

1943 - The Natural Features of Southern Florida, F.G.S. Bulletin No. 25

Parker and Cooke

1944 - Late Cenozoic Geology of Southern Florida, with a Discussion of the Ground Water. F.G.S. Bulletin No. 27

Peek

1958 - Ground-Water Resources of Manatee County, Florida, F.G.S. Report of Investigations No. 18

Peek

1958 - Record of Wells in Manatee County, Florida, F.G.S. Information Circular No. 19

Schroeder, Klein and Hoy

1958 - Biscayne Aquifer of Dade and Broward Counties, F.G.S. Report of Investigations No. 17

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JOB NO. 700

GENERAL MAP OF SARASOTA COUNTY DRAINAGE AREAS

SCALE 1" = 2 MILES

SEPTEMBER 1961
SMALLEY WELFORD & NALVEN CONSULTING ENGINEERS
SARASOTA, FLORIDA

C-700-41

