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TIDAL CREEKS OF SOUTHWEST FLORIDA:

An Environmental and Aesthetic Assessment

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1977

This senior thesis was submitted on May 24, 1977 in partial fulfillment of the requirements for the Bachelor of Arts Degree. The project was sponsored by Dr. John Morrill, and assisted by grants from the Jesse Noyce Foundation and the Environmental Confederation of Southwest Florida (ECOSWF).

TABLE OF CONTENTS

ACKNOWLEDGEMENTS.....	i
LIST OF FIGURES.....	ii
LIST OF TABLES.....	v
INTRODUCTION.....	1
NATURAL HISTORY.....	5
GEOMORPHOLOGY.....	8
ECOLOGY OF STREAMS AND ESTUARIES.....	11
A. Tidal Creek Habitat.....	17
Bibliography.....	22
HYDROLOGY.....	23
A. Drainage Basins.....	34
Bibliography.....	44
WATER QUALITY.....	45
A. Parameters.....	50
B. Water Quality: An Introduction.....	57
C. Water Quality in Study Creeks.....	60
Bibliography.....	99
BIOLOGICAL VECTORS.....	102
A. Vegetational Communities and Soil Associations.....	103
B. Chlorophyll <u>a</u> and Phytoplankton.....	113
C. Rooted Aquatic Vascular Plants.....	117

TABLE OF CONTENTS...

D. Floating Aquatic Vascular Plants.....	120
Bibliography.....	122
VISUAL QUALITY OF THE TIDAL CREEKS OF SOUTHWEST FLORIDA.....	124
Bibliography.....	143
SUMMARY.....	145
A. Recommendations for Management.....	146
B. Recommendations for Future Research.....	149
C. Recommendations for Preservation.....	150
APPENDIX A: List of Tidal Creeks.....	153
APPENDIX B: Methodologies.....	156
APPENDIX C: Rainfall.....	160
APPENDIX D: Results of April Water Sampling.....	162
APPENDIX E: Soil Associations.....	167
APPENDIX F: Statistical Methods for Aesthetic Analysis.....	177

## Acknowledgements

We are deeply grateful to the many people who have helped us both physically and emotionally during this project. To our friends from Caples and beyond: Lori Hoffman, Helen Hunt, Sandy Morrill, Stan Herwitz, Mark Evans, Ray Gasser, Jack Johnson, Lee Newton, Randy Moon, Jaye Tullai, and Rhonda Evans whose support and assistance kept us sane.

To the agencies and individuals who gave freely of their time and resources: Bill Wilcox and Dr. Maurer of General Development Corporation; Eugene Cabak of Smally, Wellford and Naiven; Charlene Levy and Joe Dalezman of New College; Bob Ratliff of Edison Community College; Horace Sutcliff of USGS; the members of ECOSWF; the Charlotte County Planning Department; and Mansota-88.

And finally, to Dr. John Morrill who instigated this project and followed its meandering course from beginning to end.

## List of Figures

<u>Figure</u>	<u>Page</u>
1 Tidal Creek Study: Regional Map. . . . .	10
2 Biological Spectrum. . . . .	11
3 Nitrogen Cycle. . . . .	14
4 Phosphorus Cycle in the Biosphere. . . . .	16
5 Phosphorus Cycle in a Lake. . . . .	16
6 Idealized streambed slope. . . . .	17
7 Estuarine, Ecotonal, and Lotic Sections of a tidal creek. . . . .	18
8 Salinity changes along a streambed slope. . . . .	20
9 Drainage basin map for Bowlees Creek. . . . .	35
10 Drainage basin map for Whitaker Bayou. . . . .	36
11 Drainage basin map for North and Catfish Creeks. . . . .	37
12 Drainage basin map for South Creek. . . . .	38
13 Drainage basin map for Alligator Creek (Sarasota). . . . .	39
14 Drainage basin map for Alligator Creek (Charlotte). . . . .	40
15 Drainage basin map for Whidden Creek. . . . .	41
16 Drainage basin map for Coral Creek. . . . .	42
17 Drainage basin map for Mullock Creek. . . . .	43
18 The effect of increasing nutrient substances on growth and production. . . . .	47
19 Factors affecting dissolved oxygen levels in an estuary. . . . .	52
20 Key to polygonal graphs showing parameters and concentrations used. . . . .	58
21 Dissolved oxygen and BOD values for study creeks (February 15 - 17). . . . .	67
22 FC/FS ratio expressed as log 10 MPN (February 15 - 17). . . . .	69

<u>Figure</u>	<u>Page</u>
23	Ammonia values for ten study creeks (February 15 - 17) . . . . . 70
24	Total phosphate values for ten study creeks (February 15 - 17). . . . . 70
25	Sample station map and polygonal graphs for Bowlees Creek. . . . . 73
26	Sample station map and polygonal graphs for Whitaker Bayou. . . . . 77
27	Sample station map and polygonal graphs for Catfish and North Creeks. . . . . 80
28	Sample station map and polygonal graphs for South Creek. . . . . 83
29	Sample station map and polygonal graphs for Alligator Creek (Sarasota County). . . . . 86
30	Sample station map and polygonal graphs for Alligator Creek (Charlotte County). . . . . 89
31	Sample station map and polygonal graphs for Whidden Creek. . . . . 92
32	Sample station map and polygonal graphs for Coral Creek. . . . . 95
33	Sample station map and polygonal graphs for Mullock Creek. . . . . 98
34	North Creek vegetation map. . . . . 107a
35	North Creek soil map. . . . . 108
36	Whidden Creek vegetation map. . . . . 108a
37	Chlorophyll <u>a</u> vs. inorganic nitrogen. . . . . 114
38	Chlorophyll <u>a</u> vs. ortho-phosphate. . . . . 115
39	The importance of rooted aquatic vascular plants. . . 118
40	Model of Aesthetic Response. . . . . 126
41	Landscape Components. . . . . 129
42	Representative Landscapes of Southwest Florida. . . . 133

<u>Figure</u>		<u>Page</u>
43	North Creek Basin and proposed greenbelt. . . . .	151
44	Whidden Creek Basin and proposed greenbelt. . . . .	152

List of Tables

<u>Table</u>		<u>Page</u>
1	Classifications of Florida waters, with standards for selected parameters. . . . .	.49
2	Water quality data from February 15 - 17 sample run. . . . .	.62
3	Dissolved oxygen values expressed as percent saturation (February 15 - 17). . . . .	.66:
4	Bacteriological data: FC/FS ratio. . . . .	68
5	Results of Chlorophyll <u>a</u> test (February 15 <sup>th</sup> - 17). . . . .	113
6	Summation of Median Ranks and Scenic Groupings (Q-sort procedure). . . . .	.138
7	Summation of Median Ranks and Scenic Groupings (Likert Interval Scale procedure). . . . .	.138

## Introduction

The need for a study of the tidal creek systems in Southwest Florida is becoming clearer all the time. The phenomenal growth of the state, especially this coast, in recent years has made the need for a supply of potable water quite clear. Existing supplies are adequate, but continued growth at the same rate will soon necessitate the development of new sources of fresh water. Presently, almost all of Florida's drinking water is taken from the ground. However, increased demand due to population growth and a large phosphate mining industry have caused the groundwater flow patterns to change and the potentiometric surface of the groundwater to decline. Not only does this cause a decrease in the amount of water available for use, but the decrease in the "head" of the groundwater entering the Gulf of Mexico is causing saltwater intrusion into the water table, degrading the remaining water supplies. Because of the increasing demand for potable water and the decreasing supply of groundwater, the streams and rivers of Florida are being considered as a source of freshwater, making the maintenance of high water quality in these streams imperative.

The preservation of "good" water (i.e., aesthetically pleasing and biologically sound) is necessary to the good health of Florida's economy. The beautiful waters of Florida are an attraction to tourists, having many recreational uses such as fishing and swimming. These waters are also necessary for the maintenance of the delicate ecological balance of southwest Florida. The undisturbed creek systems provide natural drainage for the area, and the surrounding wetlands act as a natural filtering mechanism for the water entering the bays. These areas should not be disturbed, as has been already done in many areas, for instance,

by filling them in for development or damming the water further upstream.

These areas, when left relatively undisturbed, provide an environment for many rare and even unique species of animal<sup>s</sup>, such as the bald eagle and the manatee. The vegetation is also quite beautiful, with a great variety of plants. <sup>Since</sup> The varied and unusual vegetational and animal life is another tourist attraction, and it would seem to be in the best interests of the people of Florida to preserve it.

The tourist industry of Florida depends on the maintenance of environmental quality, and the preservation of the high quality of the tidal creeks is necessary for this. Since Florida's economy is based on the tourist industry, it would seem that Florida's economy is dependent upon the maintenance of high quality waters.

A study of the tidal creek system in Southwest Florida may also prove to be of use in the development of water management programs in the <sup>s</sup> area. In Lee County, for instance, it has been said (Water Management in Lee County, A Report for the Board of County Commissioners): "The rapid growth of Lee County has placed it squarely on the threshold of disaster with regard to watershed management...Much of this difficulty can be directly traced to a void of available watershed information and background."

The problems with regard to watershed management are many and varied. In Southwest Florida one of the major problems is flooding. In Sarasota County, Smalley, Welford and Nalven <sup>Engineer</sup> have done extensive work, but much information in the counties to the south remains to be gathered, and existing information needs to be coordinated.

Run-off into the streams and rivers is another problem in this

area. The detrimental effects of excessive runoff have been well documented, and the quality and amount of this runoff is dependent upon the nature of the individual watershed. The increase in sediment load can cause siltation at the mouth and the filling in of the wetland areas when excessive. This has not yet become a major problem in this area. The increase in the amount of nutrients added to the stream<sup>s</sup> especially from agricultural land is a much greater problem here, causing increased entrophication of the streams. In addition, point source discharges of pollutants need to be located and controlled where this has not been already done.

Florida also has the unusual problem of salt water intrusion into both surface and ground water. A detailed analysis of the groundwater problem is not within the scope of this study. However, salt water "intrusion" into the coastal surface waters is. Upstream development and damming of the creeks and rivers causes a reduction in the downstream flow, allowing the salt water to go further upstream. This disturbs the ecological balance, changing the types of plants and animals which inhabit the area. This is not yet a critical problem in Southwest Florida, but "one has only to look at the areas along the Southeast coast of Florida to predict the major problem which will occur when..(an area).. becomes more urbanized." "Water Management in Lee County; A Report to the County Commissioners).

A good water management plan is necessary for a good land use plan. The two are inseparable. It is hoped that this study of the tidal creek systems of Southwest Florida will be useful to the people of the area, providing some of the information necessary (and coordinating much of the existing information) for a better system water management,

and possibly for an overall land use plan. It may also provide valuable information as to the environmental quality of these creeks and the merits of preserving them, both for economic and ecological reasons.

## Natural History

Southwest Florida has a very colorful history. Much of the Florida peninsula was originally inhabited by the Timucan and Caloosa Indians. The people of these Indian tribes no longer exist, but remnants of their civilization, mainly Indian mounds, can still be found all along the coast. Many of these Indian mounds have been dug up, and many pieces of pottery, ornaments, and shells have been destroyed by unknowledgeable, unsupervised people, <sup>Now</sup> and the protection of these mounds is becoming increasingly important.

Pirates are also known to have been quite active along this coast. Many of the islands off the coast are said to have been the hideouts of pirates such as Gasparilla. He is said to have lived in the Ft. Myers area and to have kept a harem on Captiva Island. Whatever the truth of all such stories, they do add color to the history of Southwest Florida.

The flora and fauna of the area are also quite unusual. There are a variety of different vegetational communities in the area. As one moves to the coast from the upland areas, the first community encountered is the pine flatwood and prairie. This system covers a large percentage of the <sup>n</sup> island areas. The canopy consists of slash pine, southern longleaf pine, and sabal palm. Some of the more common understory vegetation is <sup>live oak</sup> live oak, saw palmetto and wax myrtle. Protected vegetation in this community is the bearded grasspink and golden polyploidy. Wildlife in this area is quite varied where the land has not been developed. There are screech owls, great-horned owls, a wide variety of snakes, armadillo, and numerous birds such as turkey, vulture and the burrowing owl which is a threatened species.

In the inland areas, there is also the slough/wet prairie community. This is a "shrubby" area, with wax myrtle and a variety of willows predominating. Other upland vegetational communities are the sand pine scrub and the pine/oak sandhill. Both of these areas are predominantly covered by various pine and oak species such as sand and southern longleaf pine, and turkey and myrtle oak.

All of the above vegetational types exist primarily on the well-drained soil types. As one moves toward the coast, the well drained areas become what is known as the coastal strand. This area is vegetated by Australian pine (an exotic species), seagrape, saw palmetto and sea oats (protected by law), and many other plant species.

In less well drained areas such as along creeks and rivers, hammock vegetational communities and freshwater marshes predominate. *ditto* These are areas of (very thick growth.) Again there is a variety of oak and palm species. In addition there are Southern red cedar, holly, wax myrtle, wild grape, and many types of ferns, including strap fern and shoestring fern which are protected by law.

Closer to the coast, the poorly drained areas become mangrove swamps and saltwater marshes. The vegetation in the mangrove swamps consists mainly of red, white and black mangrove and buttonwood. The marshland vegetation consists of a variety of grasses such as saltgrass and saltmarsh cordgrass, as well as needle rush and saltwort.

The animal life in both the fresh and saltwater marshes, and the mangrove swamps is varied and plentiful. Birds are the most noticeable, <sup>white</sup> and are too numerous even to ~~begin~~ begin to list here. There are a few, ~~however~~, which should be noted: bald eagle (endangered), osprey (threatened), brown pelican (threatened), and <sup>several</sup> many species of herons and egrets.

*also roseate spoonbills (end? or threat?)*

These wetland areas are of special importance to this study. The importance of maintaining this environment in its natural state is clear. Not only do they act as natural drainage for the upland and a filtering area for the eco-system, but they provide a habitat for many species of birds and animals some of which are quite rare. They also provide an environment for many rare plants. This is an economic asset to the people of Florida, providing a unique environment which ~~will~~<sup>will have</sup> attract<sup>ed</sup> tourists.

## Geomorphology

Sixty-three million years ago what is now the Southwest coast of Florida lay under a Paleocene Shallow sea. During the next 50 million years marine sediments and limestone deposits formed the Florida platform, of which the highest areas emerged, in conjunction with gradually regressing sea levels, as dry land.

The newly emergent land was then subjected to the erosive forces of sun, wind and water and the well-defined marine sediment layers became mixed and altered. Sands and clays eroding from the higher portions of the Florida platform were deposited across the Florida Embayment during the Miocene Epoch (25,000,000 years ago) and during the late Miocene and Pliocene (13 million years ago) the emerged land was again subjected to inundation by shallow seas. During these epochs, phosphatic clay sediments formed. Later, in the Pleistocene Epoch, (1 million <sup>years ago</sup>), the fluctuating sea levels deposited several layers of quartz sand across Florida, which form the parent material for many of the soils in Southwest Florida.

Due to the seismic stability of Florida, a surface topography developed with little change in elevation. Elevational changes are a result of marine terracing that took place as the sea levels regressed during the Pleistocene era. The relatively uniform land elevation and slope have resulted in rivers and streams with little gravitational momentum. Such river and stream systems are characterized by slow movement, minor erosional effects, with meandering stream bed patterns and wide flood plains predominating.

## Introduction to Creek Study Areas

In selecting small tidal creeks appropriate for our study, a number of factors were taken into consideration. First of all, because of resource limitations and the general scope of the project, the small creeks in ~~these~~ five counties of the Southwest Florida Region were chosen: Manatee, Sarasota, Charlotte, Lee and Collier Counties. A major consideration for selection was the autonomy of the drainage system of <sup>each</sup> the creek. For instance, we decided not to study creek systems flowing into such major surface water systems as the Manatee, Peace, Myakka or Caloosahatchee Rivers, (nor did we choose creeks that had been studied extensively prior to our study). ~~Choosing~~, Rather, we chose small creeks that flowed into the salt water bay systems.

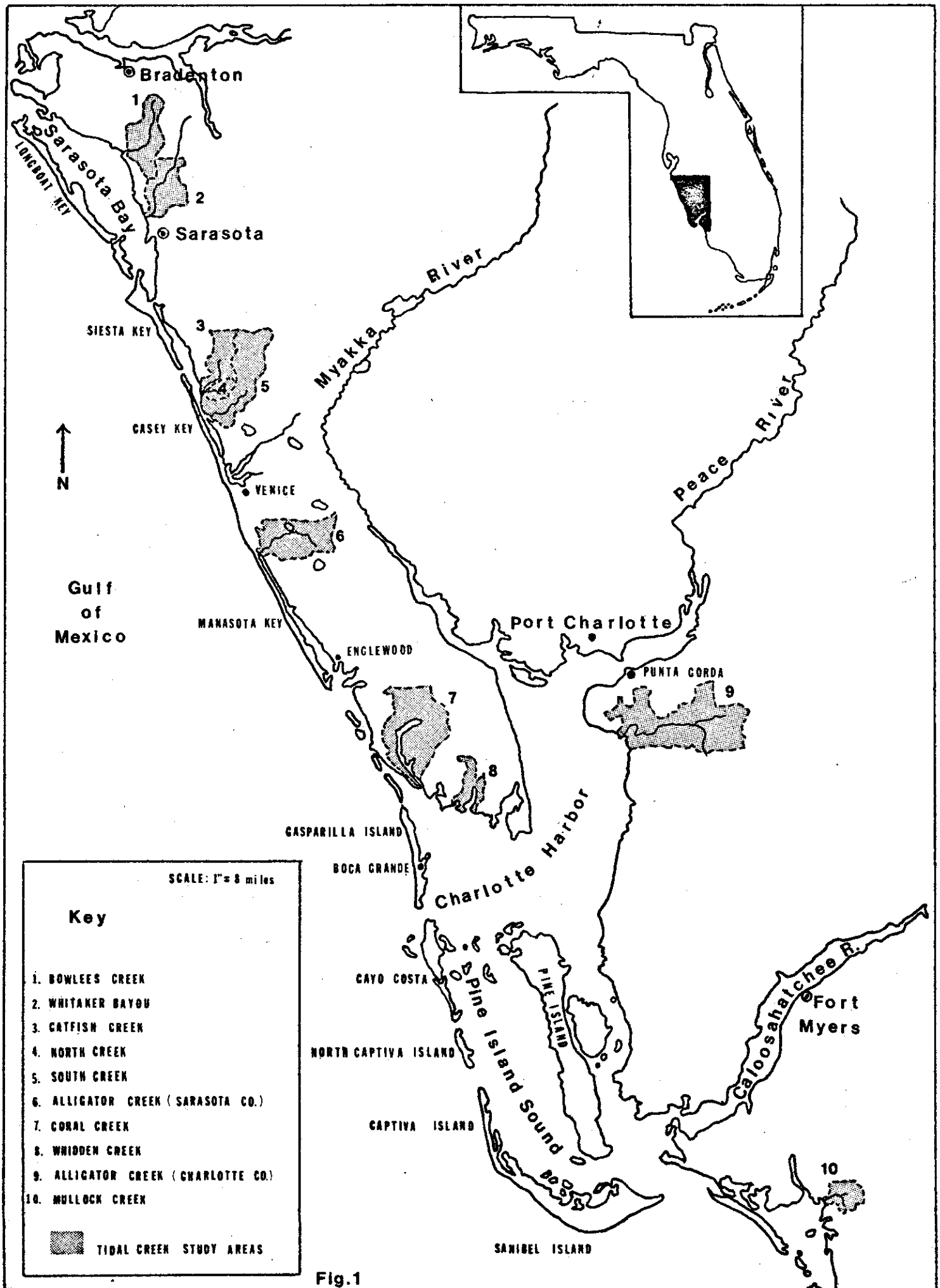
A map of Southwest Florida (Fig 1) shows the locations of the ten study creeks.

Good! Now on what is left of this page let's introduce the reader to what will follow - i.e. an abstract or synopsis of the rationale + thrust of the several sections.

Fig! - is T.S.T.

Need Table for 5-17  
Need pgs 9-17;  
arrange drawings  
2000

✓ I think we need an introductory paragraph that includes  
4) lengths of creeks  
1) total # of tidal creeks in the coastal zone of this region  
2) selection of the 10 creeks as representatives  
3) a general statement about the general picture of transportation of the natural creeks by agr/farmer/recreation/sewage etc activities + ~~etc~~ human attitudes - why in general neglected in the planning process etc.



## Ecology of Streams and Estuaries

Ecology is the study of the relationships between organisms and their environment. The word Oekologie was first used in a scientific sense by the German biologist Ernst Haeckel in a paper published in 1870 (Reid 1961). The word is derived from the Greek roots oikos, "home", and logos, "the study of". Literally, ecology is the study of organisms "at home".

The best way to understand the scope of ecology is to consider it in terms of some principle concepts of organization. The levels or stages of this organization can be imagined as a "biological spectrum" (See Fig 2 ).

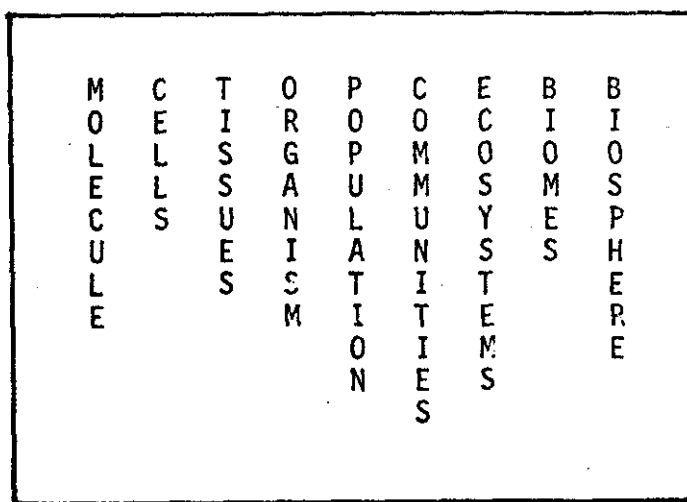


Fig.2 Biological Spectrum (adapted from Odum, 1959)

Ecology is concerned with the right hand side of this spectrum from the organism to the biosphere. Communities and ecosystems are the principle levels of interest <sup>in the present study</sup> to this thesis and are defined as follows:

A community is one or more populations co-occurring in time and space. A community may be defined either geographically or taxonomically. Geographically, a community may include all the populations within a given area. Taxonomically, a community is composed of organisms with similar life habits such as vegetational communities, insect communities, or bird communities.

The ecosystem is the next level of interest in the "biological spectrum" and is considered by many to be the fundamental unit of study in ecology. As first defined by Tansley (Reid 1961), the ecosystem includes "not only the organism-complex, but the whole complex of physical factors forming what we call the environment." This totality is commonly divided into biotic and abiotic components. The biotic component is that segment of the ecosystem that has the attribute of life. The abiotic component consists of all the substances and forces in an ecosystem which affect it but lack the attribute of life.

Two processes are fundamental to the self-perpetuation and self-regulation of an ecosystem. The first, energy flow within an ecosystem, is concerned with the procurement and utilization of food within and from one level of an ecosystem to another (McNaughton and Wolf 1973). In the biosphere almost all usable energy is derived from the sun. Energy is captured in a transferable form by photosynthetic organisms called producers. Producers are grazed upon by herbivores which are in turn eaten by carnivores. All three levels are utilized by

a class of organisms known as decomposers.

These levels of energy utilizations are known as trophic levels and represent different feeding distances from the primary energy source, the sun. Because of thermodynamic constraints and inefficiencies within an ecosystem there are seldom more than four or five trophic levels.

The second fundamental process within an ecosystem is material flow. Energy from the sun is not the only ingredient necessary for the maintenance of an ecosystem; a number of abiotic elements and compounds must also be available. These chemical elements, including all the essential elements of protoplasm, tend to circulate in characteristic flow paths from the environment to organisms and back to the environment. These more or less circular paths are known as biogeochemical cycles (Odum, 1959).

The understanding of biogeochemical cycles has become particularly crucial to man in recent years. The increasing disturbance of natural cycles has made some of these elements scarce and others harmfully abundant. Nitrogen and phosphorous, two of these cyclic elements, are considered macronutrients and are often limiting factors in the productivity of an ecosystem.

Nitrogen plays a fundamental role in the metabolism of organisms. Atmospheric molecular nitrogen is the ultimate source of nitrogen (Hutchinson, 1957), although it is not utilizable in its molecular form. Nitrogen is fixed electrically or photochemically in the atmosphere, by bacteria in the soil, or by blue-green algae in the oceans into biologically utilizable forms (Fig 3 ). Much of the ammonia formed is nitrified, first to nitrite, then to nitrate. All three of these

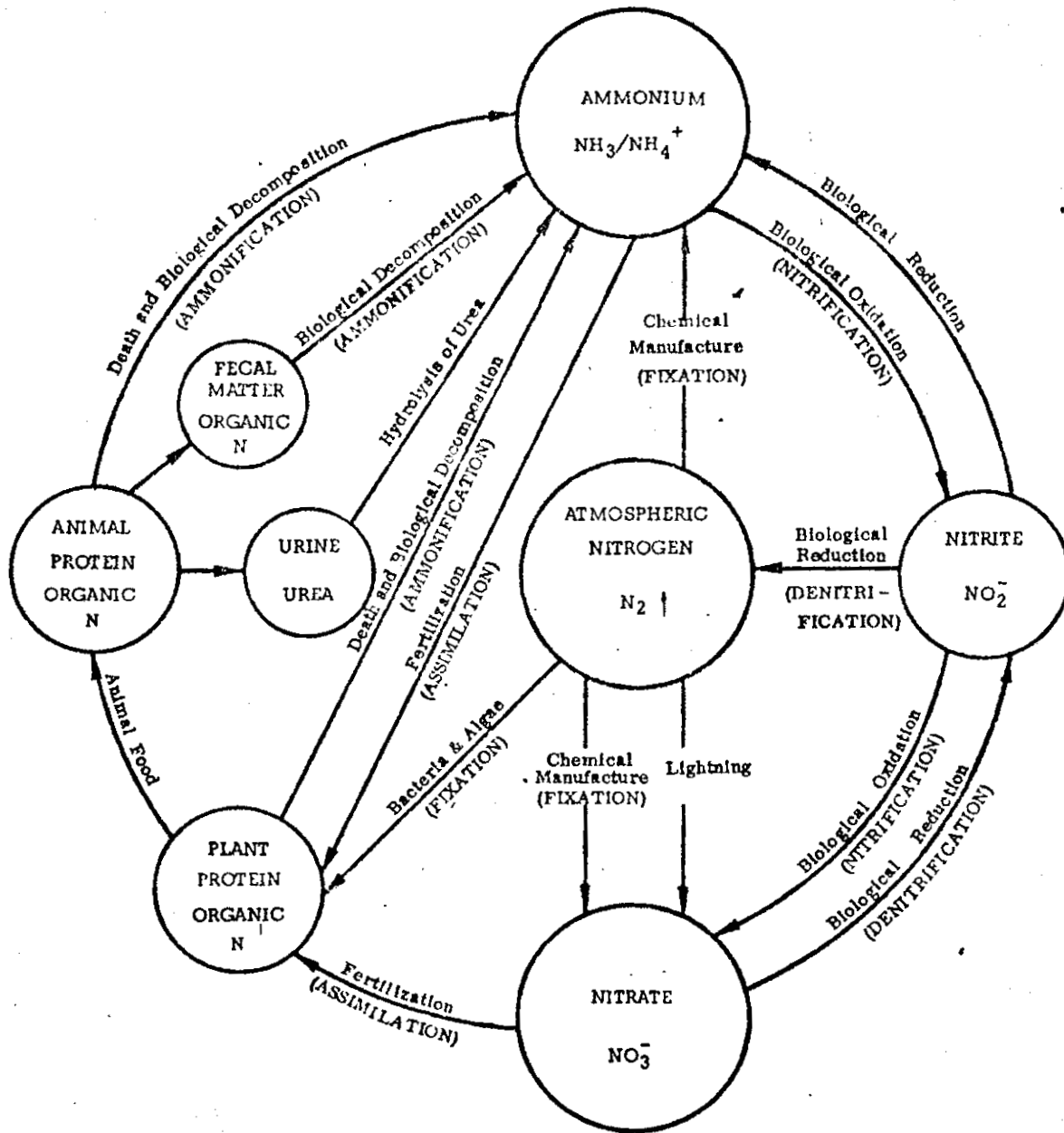


Fig. 3 Nitrogen Cycle (from Horstkottle et. al., 1974)

forms are utilized biologically. The reverse process, nitrate reduction to  $N_2$ , is known as denitrification. It usually occurs when bacteria utilize nitrate as a hydrogen acceptor in place of oxygen thereby reducing nitrate concentrations (Hutchinson 1957). There are three theoretical sources of nitrogen compounds in natural waters: 1) influents such as ground water and sewage; 2) precipitation, and 3) fixation in water and sediments (Hutchinson 1957).

In the estuarine waters of the southeastern United States nitrogen is often the limiting nutrient for the productivity of an ecosystem (Williams 1972). The open ocean ratio of 15 moles of nitrogen to 1 mole of phosphorous does not hold true for coastal and estuarine waters (Williams 1972). This is particularly true in Southwest Florida where the natural deposits of phosphorous are high.

Phosphorous is the second major element considered a macro-nutrient and a limiting factor in the productivity of an ecosystem. The concentration of total exchangeable phosphorous in natural waters is determined primarily by 1) basin morphology as it relates to volume and dilution; 2) chemical composition of the geological formations of the area; 3) drainage basin features in relation to organic runoff; 4) organic metabolism within the body of water; and 5) the rate at which phosphorous is lost to sediments (Reid 1961). Kramer (1962) estimates that up to 70% of the phosphorous in natural waters is the result of agricultural runoff and detergents; but in southwest Florida the high geological concentrations are equally important. Figures ( 4 ) and ( 5 ) illustrate the phosphorous cycle in the biosphere and in the closed system of a lake.

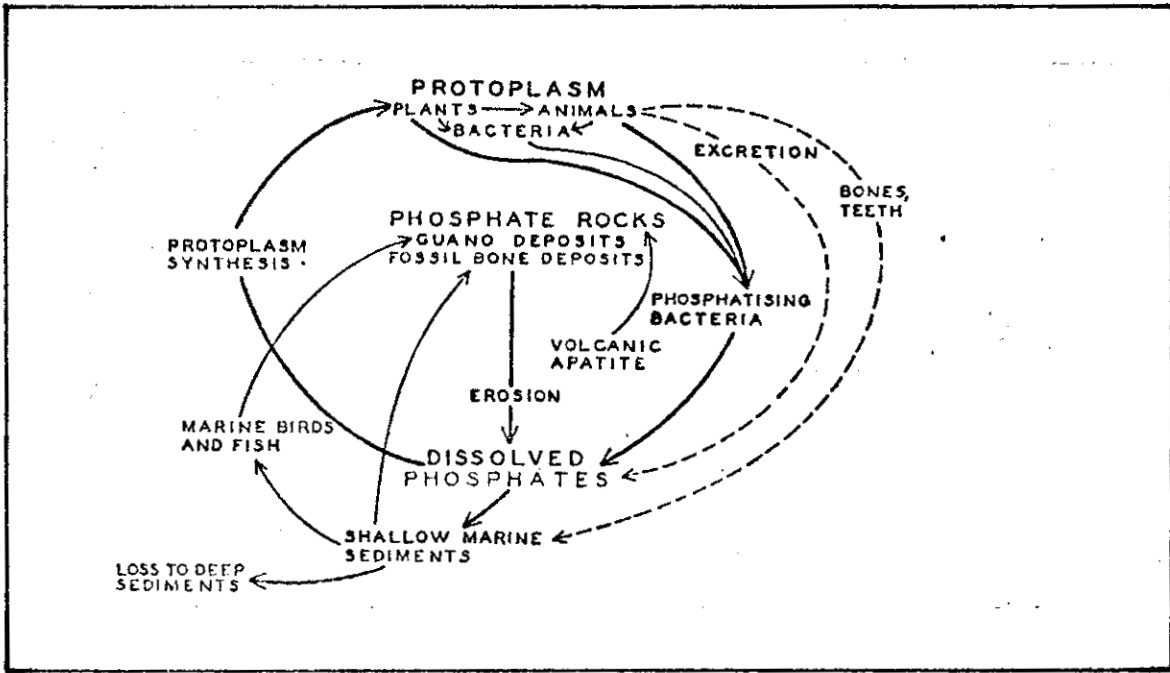


Fig. 4 Phosphorous Cycle in the Biosphere (from Odum, 1959)

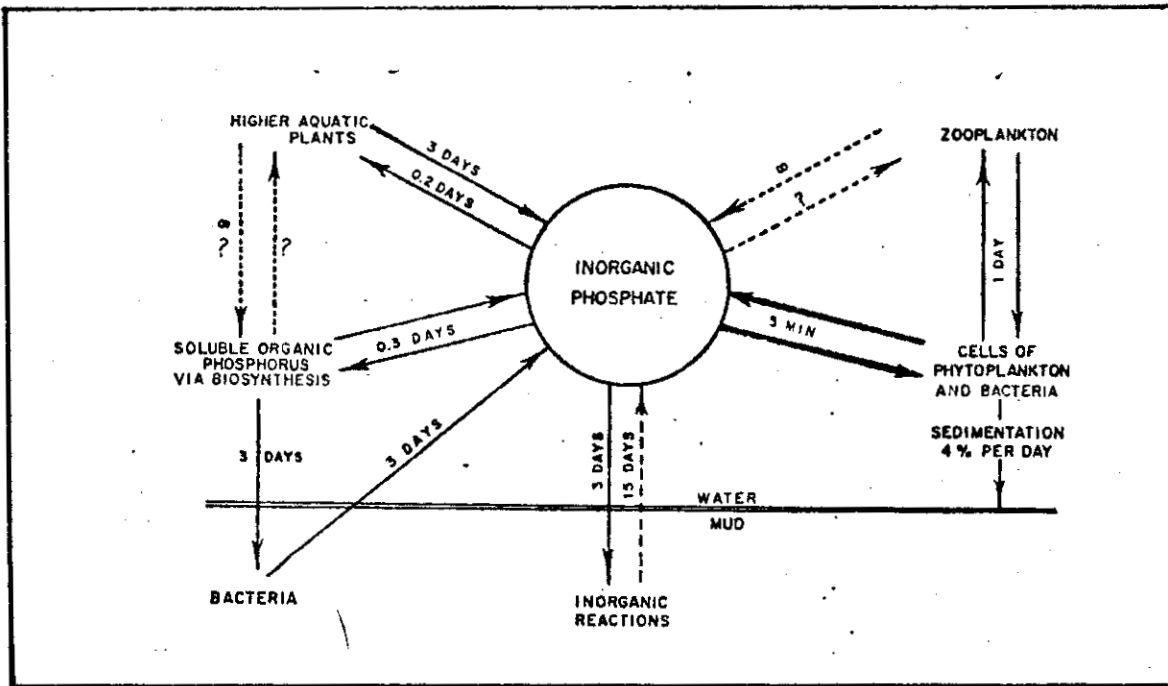


Fig. 5 Phosphorous Cycle and Turnover time in a Lake (from Reid, 1962)

### A. The Tidal Creek Habitat

As a working definition a tidal creek is a body of water draining uplands and forming a microestuary at its mouth. The proportion of a creek influenced by tidal flux varies according to the slope of streambed. This is the most important factor that distinguishes the tidal creeks in our study. For example North Creek has a significant lotic (flowing freshwater) component because of a relatively steep, sloping streambed (see Fig 6 ). In contrast Whidden Creek has no significant slope to its streambed and is completely estuarine.

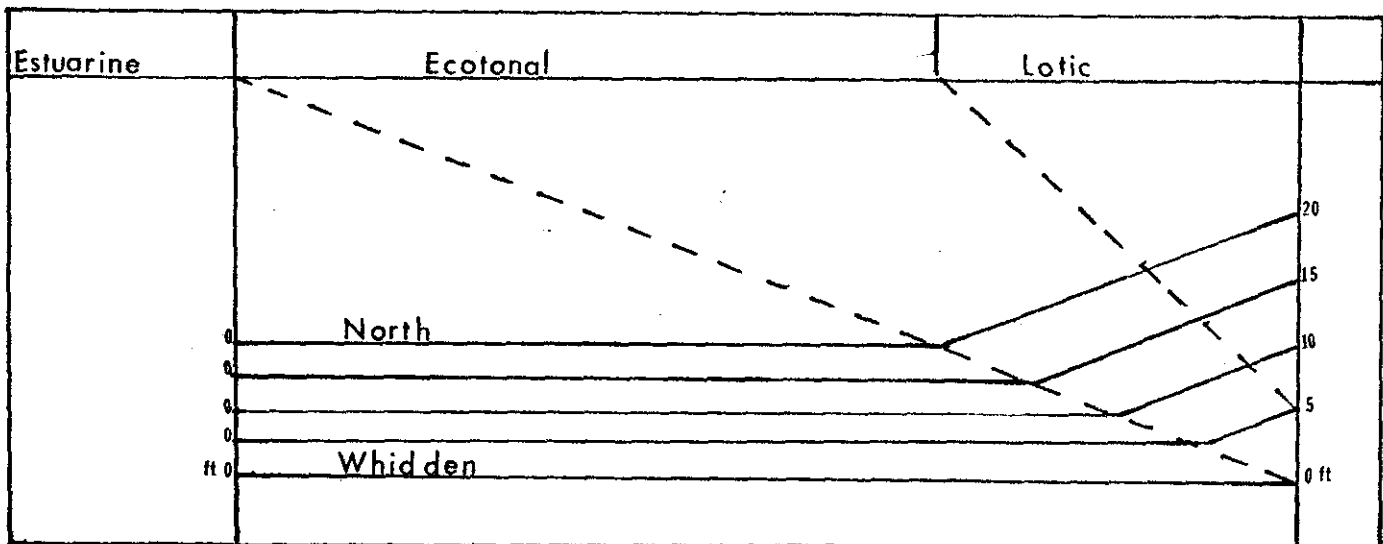


Fig. 6 Idealized Scale of Streambed Slope

A major result of streambed slope is the location of the salt water-fresh water interface. This interface or ecotone marks the transition from a lotic to an estuarine ecosystem (Fig 7 ).

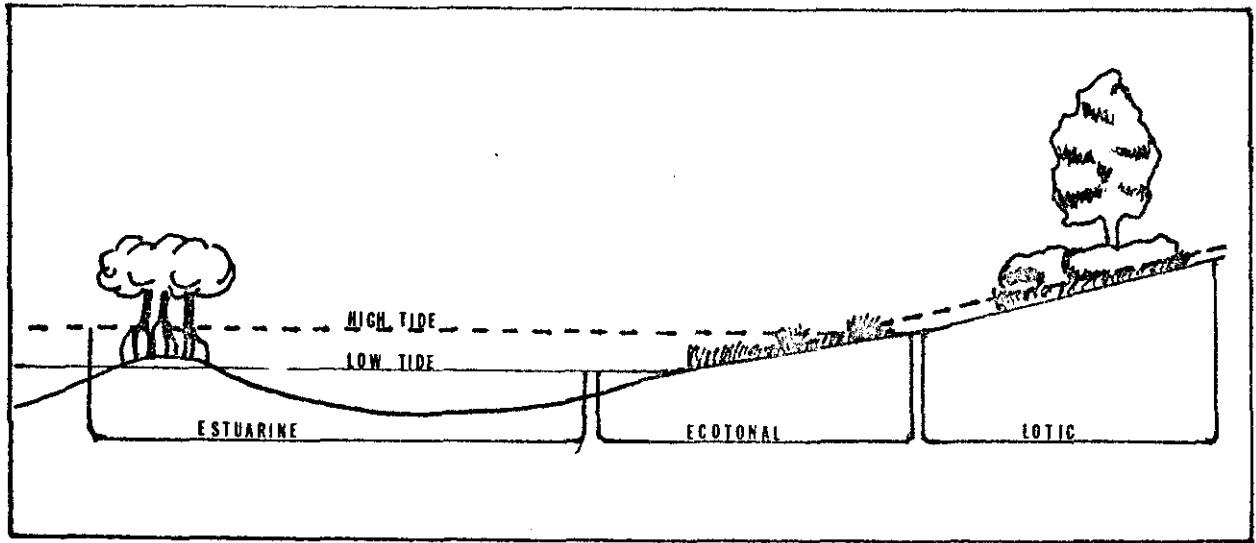


Fig.7 Estuarine, Ecotonal, and Lotic Sections of a Tidal Creek

*T  
wetland  
+ transitional  
wetland*

In general an ecotone is a transitional zone between two or more diverse communities and is a junctional or tensional zone connecting these communities (Odum 1969). A common characteristic of an ecotone is the edge effect. This is a tendency toward increased variety and density of species because of the fact that ecotones are occupied by members of both adjoining ecosystems as well as by a set of species unique to the ecotone.

The lack of streambed slope in Coral and Whidden Creeks may

result in a hypersaline region instead of a lotic region near the headwaters. The salinity of these creeks increases as the distance from the mouth increases (Fig. 9). This is the result of evapotranspiration and the lack of freshwater inflow and complete tidal flushing.

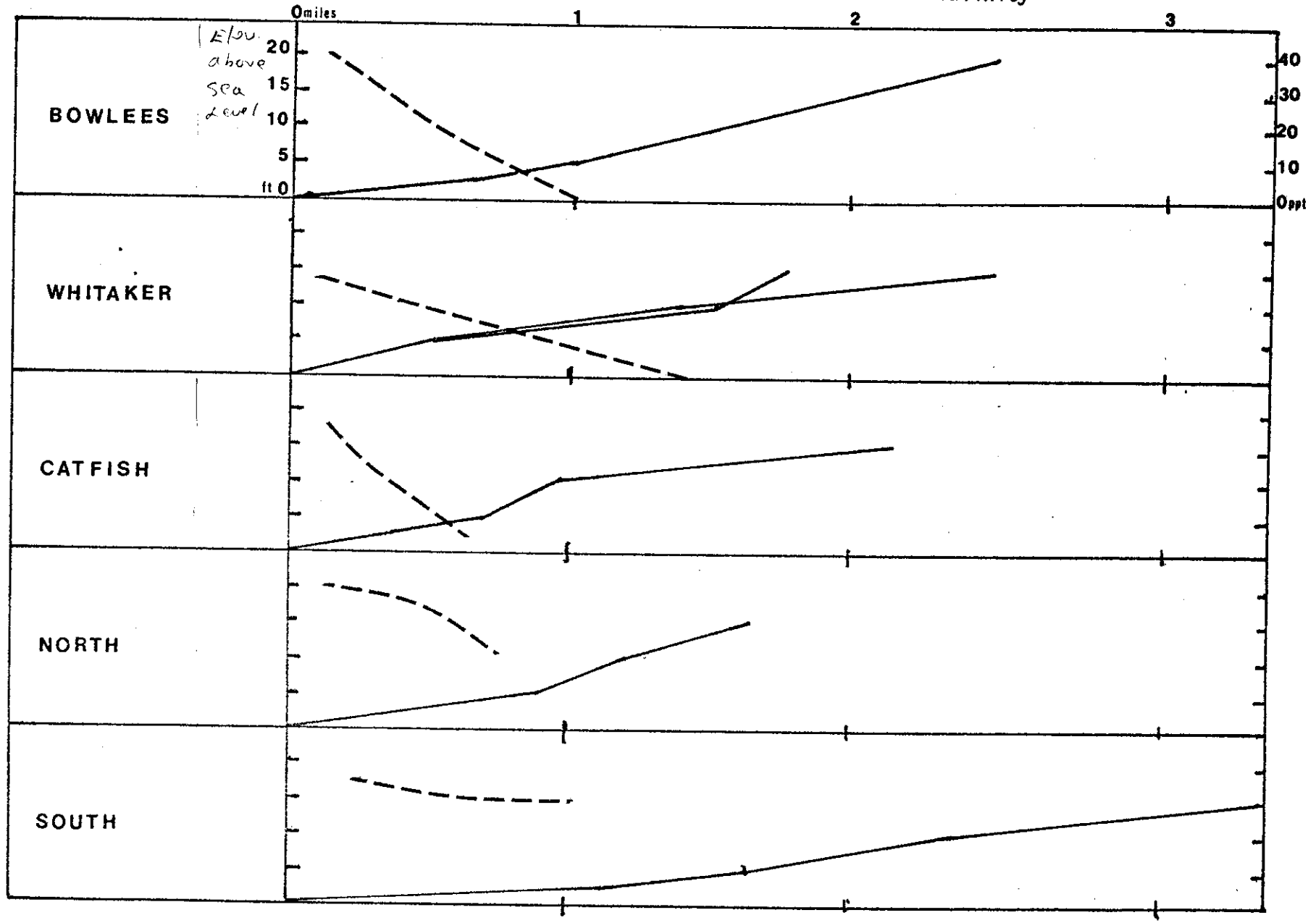
The combined factors of streambed slope and salinity gradients make it apparent that North Creek and Whidden Creek represent extreme points on a continuum. As when defining vegetational communities, distinguishing two different ecosystems is always somewhat arbitrary. But the establishment of two ecosystems characterized by North and Whidden Creeks seems a logical and useful categorization. Bowlees, Whitaker, Catfish, North, Alligator (Sarasota), Mullock, and Alligator (Charlotte) fall in the North Creek category. Coral and Whidden fall in the Whidden Creek category.

Scott - I'm not certain if "ecotonal" <sup>rel. to</sup> in the ecological diversity applies to the stream proper. But I see your point.

At the same time you have a second ecotonal system as you move from the center or edge of stream up the stream bank. Here, too, the slope of the bank relative to horizontal dist. is reflected in streamside diversity - with say North Creek and Whidden Creeks at the opposite ends of the spectrum. At the same time in each creek system this vertical diversity changes as you move up stream from the mouth until a certain point and the lower ecotonal or lotic end when stream width or flood plain width ~~passes~~ narrows beyond a certain critical stream/flood plain width/bank slope/ht. ratios.

F/ 9 Salinity Changes along Streambed Slope ( ————— Streambed Slope

----- Salinity

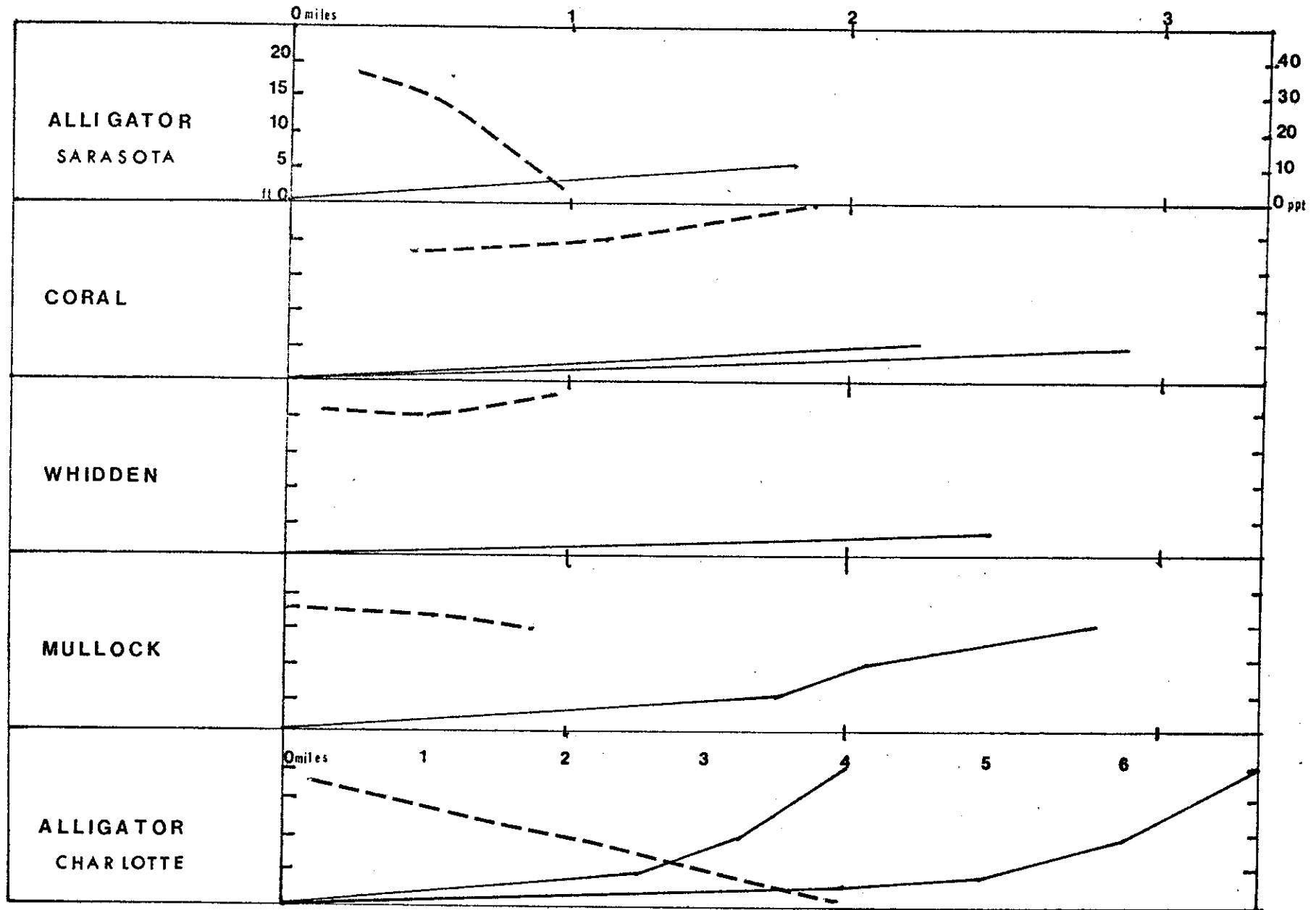


Distance from mouth of creek in miles

oe

F. 9 Salinity Changes along Streambed Slope

———— Streambed Slope  
 - - - - Salinity



*Distance from mouth of creek*

1-8

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## Hydrology

Hydrology can be defined as the science that deals with the depletion and replenishment of the earth's water resources. It is concerned with the transportation of water through the air, over the ground and through the strata of the earth. Hydrologic considerations relating to the tidal creeks of Southwest Florida will be primarily concerned with transportation of water over the ground, (i.e. surface runoff). Surface water hydrology is an immense factor in the ecological functioning of Southwest Florida. The topography of Southwest Florida is a direct result of the historic surface water hydrology whose main component is runoff.

Factors controlling runoff can be divided into two major groups, 1) climatic effects relating to precipitation and 2) physical characteristics of drainage basins.

### Climatic Effects Relating to Runoff:

1. type of precipitation
2. rainfall intensity
3. duration of rainfall
4. distribution of rainfall within drainage basin
5. direction of storm movement
6. antecedent precipitation and soil mixture
7. climatic conditions affecting evaporation and transpiration

### Physical Characteristics of Drainage Basins

1. land use
2. soil type
3. slope
4. type of drainage net

## Notes

### Hydrology

1.) You have two fig 9's

2.) Your drainage basin maps have notes to them in hydrology section I think they are worth spending at least a page or more of text

#### For notes:

1.) Explanation - of lines on figs

2.) a Table showing

a) historical creek lengths + network

b) Present length of macro network -

c) peculiarities of some drainage patterns - i.e. urban vs agricultural

all of this to be related to impact on the creek and the bay area at mouth of creek.

also point out - of 10 creeks no hydrological - stream flow records available

Maybe even a paragraph of kinds of info that are needed for future planning + management

Physical Characteristics of Drainage Basins (cont.)

5. extent of indirect drainage
6. artificial drainage

Climatic Effects Relating to Precipitation

1. Type of Precipitation: In Southwest Florida, rainfall is the only significant form of precipitation, and it profoundly affects runoff. Southwest Florida annual rainfall ranges from 50 - 60 inches of which 60% falls during the summer months generally as a result of frequent thunderstorm activity. The winter months are relatively dry with the bulk of the rainfall generally occurring on one or two days.
2. Rainfall Intensity: Rainfall intensity is important in relation to runoff. When rainfall intensity exceeds the infiltration capacity of the sub-surface, runoff will occur and will increase rapidly with further increases in rainfall intensity. In Southwest Florida, severe cyclonic storms (hurricanes) have been known to drop 10 - 12 inches of rain in a single 24 hour period. Thunderstorms are known to drop 3 - 4 inches of rain in a 24 hour period.
3. Duration of Rainfall: Duration of rainfall affects the infiltration capacity of the sub-surface. When it rains, infiltration capacity decreases. As a consequence, rainfalls of long durations produce substantial runoff despite mild intensity.
4. Distribution of Rainfall: The distribution and uniformity of rainfall intensity has an effect on runoff. If two drainage basins receive equal amounts of rainfall, the amounts of runoff will not necessarily be equal. One basin may receive its rainfall uniformly throughout the basin with total rainfall never exceeding the infiltration capacity of the sub-surface at any given location. In this case there would be no

surface runoff. The other basin may receive equal amounts of rainfall, but uneven rainfall distribution within the basin. Within this basin a localized area may receive a rainfall intensity exceeding the sub-surface infiltration capacity. In this case runoff would result. Such a condition is generally associated with localized, intense thunderstorms characteristic of the summer weather patterns in Southwest Florida, and probably affects the surface runoff in the larger tidal creek drainage basins.

5. Direction of Storm Movement: The direction in which a storm travels across the drainage basin with respect to the direction of flow of the stream or creek has a decided influence of the resulting peak flows of runoff. (Wisler and Brader 1959) If storm movement were in the direction of the drainage flow, higher peak flows and shorter runoff durations would result because of runoff accumulation and flow along the path of the storm as the storm moved downstream. If a storm moved opposite to the direction of stream flow, runoff would be dispersed in a downstream direction while the rainfall is being dispersed in an upstream direction. Lower peak flows and longer runoff periods result from such conditions due to dispersive effects on runoff.

6. Antecedent Precipitation and Soil Moisture: The amount of moisture contained within a substrate, either from groundwater or antecedent precipitation, has an important effect on the infiltration capacity of the sub-surface. Rainfall following previous rainfall of considerable magnitude may produce significant runoff. This condition is especially pertinent to Southwest Florida during the summer months. Soil moisture is often high during the summer months due to regular rainfall and close proximity of ground water to ground surface. This condition

effectively decreases the infiltration capacity of the sub-surface which in turn increases runoff potential. This factor has been partly responsible for major flooding in this region, especially when severe storms are separated by short time spans as was the case in Lee County in summer 1975 (Miller and Benson 1976) and on North Creek, South Creek, and Catfish Creek in 1961. (USCE Flood Plain Information, Sarasota Co. 1973)

7. Climatic Factors: Climatic factors affecting evaporation and transpiration (i.e. temperature, annual precipitation, wind velocity, relative humidity and average barometric pressure) combine to affect runoff by partially determining how much of the precipitation falling on a drainage basin evaporates or is transpired via vegetation or runs off into the creek or stream.

#### Physical Characteristics of Drainage Basins

1. Land use: Land use is probably the most important of these factors. Different land usages create ground surfaces whose infiltration capacities are quite different. Well vegetated land will have a high capacity to absorb rainfall. Urban land usages, characterized by such impervious ground covers as sidewalks, roads, parking lots, rooftops, storm sewers and paved gutters have infiltration capacities near zero, allowing nearly 100% of the rainfall to run off (USCS, 1975). Urban land usages tend to increase peak discharges of runoff and decrease runoff periods. This increases flood potential (USCS, 1975).

2. Soil type. The predominant soil type or associations (see Appendix E ) greatly influences runoff characteristics due to varying infiltration capacities, resulting from size of soil grains, aggregation, shape, and the arrangements of the soil particles. The limiting

factor in determining the infiltration capacity of a soil is the porosity. Porosity is defined as the "percentage of voids within a given volume of soil aggregate." (Wisler and Brader 1959) Porosity affects not only infiltration capacity but also storage capacity and varies radically from one sub-surface to another. Some rock surfaces have a porosity of less than 1% while certain organic soils have porosities as high as 80 - 90% (Wisler and Brader 1959).

3. Slope: Slope of the drainage basin has a complex relationship to surface runoff. Slope controls overland flow time and concentrations of rainfall in creek channels (Wisler and Brader 1959). Slope also affects the velocity of overland flow, the period of infiltration which in turn affects peak flows of runoff (Wisler and Brader, 1959). In Southwest Florida the slope is very gradual so stream gradients are slight, resulting in low velocities of flow and slow overland flow rates of runoff.

4. The drainage net: The arrangement of the natural stream channels has an important effect on runoff. A well drained soil is often characterized by short length of overland flow, resulting in rapid runoff concentration and high peak flows. Prior to ditching and channelization, drainage basins in this region were probably poorly drained, wet slough and fresh water marsh areas. Historically there was probably no well defined drainage net, however, in the last one hundred years Southwest Florida has been extensively ditched and channelized to drain the sloughs and marshes. The drainage net is now heavily influenced by these man-made alterations.

5. Artificial drainage: In this region, artificial drainage is closely related to the drainage net, and has had a great impact on Southwest Florida. Lowland areas, such as swamps, sloughs and marshes have been made available for pasture<sup>s</sup> ~~land~~ and <sup>ether</sup> agricultural ~~land~~ by draining. Drainage methods include open ditches, canals, and artificial sloughs. Upland areas are also modified in this manner. The net effect of these practices has been to speed up the removal of surface runoff and increase peak flows. Artificial drainage can in some instances decrease flood potential by quickly draining runoff from lowland areas before the concentrated runoff from the upland areas arrives. However the opposite also can happen. Increases in runoff due to artificial drainage in the upland portions of creeks or streams can cause flooding in downstream portions.

It is probable that in the past, flooding in this region was characterized by low peak flows and a long duration of flooding and generally more widespread inundation. Today, flooding is of a slightly different nature. Artificial drainage has stripped the uplands of their water retention capacity and so that a greater percentage of the rainfall is entering moving water bodies. Higher peak flows and shorter flood durations are evidenced and the destructive power of the floods is now greater because of the increased runoff velocities.

Artificial drainage also reduces the period of overland flow which reduces infiltration of the sub-surface. As a result, the water table is lowered causing changes in vegetative cover (marsh or slough vegetation gives way to pasture vegetation). Pasture vegetation does not have the runoff absorption capacity of a marsh further adding to the rapid removal of runoff from land. All but one of the ten tidal

creeks studied have been altered by artificial drainage systems and in some cases their drainage basins have been significantly altered, i.e. Coral Creek, Bowlees Creek, Whitaker Bayou and Alligator Creek, Charlotte County.

### General Characteristics of Tidal Creek Drainage Basins

The small tidal creek drainage basins are generally flatlands with little topographic variation and slopes. Generally, the creeks have sources in marshy, slough areas and flow through flatlands. Because of gentle streambed slopes the tidal creeks have characteristically slow rates of flow, and overland flow rates within the basin are also slow. The secondary drainageways are usually ill-defined or are manifest as depressions on the surface topography.

Historically, the predominant soil types are characterized by high runoff potentials with slow infiltration rates when thoroughly wetted (USGS Soil Survey, Manatee County 1972), (USGS Soil Survey, Sarasota County 1954). However, when adequately drained by ditches, artificial sloughs and canals, the capacity of these soils to absorb rainfall is markedly increased (USGS Soil Survey, Manatee County 1972). This practice is associated with the creation of pastureland and for flood control purposes and is widespread in the tidal creek drainage basins.

#### Summary:

Historically, whenever excessive rainfall occurred, the tidal creek drainage basins were subject to flooding, generally of low peak flow and long duration with flood water standing over large upland areas (USCS 1973). Extensive artificial drainage systems, developed over the years, have drained many previously wet soils, effectively

How about a paragraph on the only drainage in the coastal urbanized areas near the creek mouths - i.e. storm sewers not works (i.e. Bowlees) sewers out falls (i.e. Whitaker Bayou) and developed areas (i.e. Bowlees, ~~and~~ South Creek)

altering the drainage patterns and runoff characteristics. Today, most of the runoff is channeled by man-made waterways into the natural waterways. Where rainfall would once remain as standing water for periods of time, in marshes, sloughs or swamps, the rainfall is now channeled almost immediately into waterways and to the bays and estuaries. While the practice of artificial drainage has helped convert marginal land to a useable form and has helped control upland flooding, it has also contributed to depletion of the water table to salt water intrusion and to high peak flow of short duration (potentially more violent downstream flooding).

Urban and suburban development activities have created impermeable surfaces which greatly increase the amount of runoff (USSCS, 1975; Wanielista 1976; Miller 1972). The removal of natural vegetation has decreased the amount of permeable cover for rainfall absorption and has decreased the amount of water supplied to the atmosphere via transpiration of plants. Generally speaking, the net effect of these factors has been to decrease the amount and duration that water (rainfall) is retained by the tidal creek drainage basins and the region as a whole.

#### Runoff and Water Quality

Water pollution via runoff varies greatly as it is generated from numerous land usages. Generally, the greater man's utilization of land, the greater the water pollution via runoff. Rural runoff can often contribute major quantities of water pollutants. When large areas are devoted to agricultural uses, as in this region of Florida, high concentrations of pollutants are not uncommon, (Omernik 1976). Originating in fertilizers, pesticides and other agricultural chemicals,

Thus the  
the estuarine  
system is  
subjected to  
pulses of  
larger volumes  
of f.w. than  
historically.  
Such pulses  
of f.w. discharge  
may in effect  
bypass the  
estuarine  
meadows  
in the bays  
and the  
mouths of  
the creeks  
and in subliminal  
ways contribute  
to changes  
in patterns

these pollutants are difficult to manage because of their dispersal over large expanses of land.

Many of the hydrological factors mentioned earlier have an important effect on the quality of runoff-influenced waters. The infiltration capacities of various soils, the rainfall absorptive and transpirational characteristics of vegetation, land use, cover crops, agricultural and water management practices, and topography affect the quality of water in this region of Florida. (Omernik 1976; Wanielista, 1976; Hill 1976; Whipple et al. 1974) Various studies show that agricultural land runoff causes low dissolved oxygen values during peak flow periods. Normal runoff rates can cause DO values below 5 mg/l (Wanielista 1976). Other parameters such as BOD<sub>5</sub>, suspended solids, nitrogen, and phosphorous vary depending on agricultural land use (Wanielista 1976). Animal wastes affect water quality by their introduction to receiving waters via runoff as indicated by elevated nitrogen, phosphorous and ammonia levels (Jones, et al. 1976; Flip and Middlebrooks 1975).

The most detrimental nonpoint runoff effect is urban in origin (Bhutani et al. 1975). Urban land surfaces - residential, commercial, and industrial - are generally impermeable with 90 - 100% of the rainfall running off. In the runoff process the water picks up toxic materials from streets, sidewalks, rooftops, and parking lots. Pollutant sources range from animal wastes, vehicle tires, construction activities, <sup>to</sup> garbage, vehicles, lawns, humans, etc. The major types of urban pollutants are solid wastes, litter, chemicals, air deposited substances and vehicle pollutants.

Specific pollutants include heavy metals, nutrients, pesticides, bacteria, and dirt and dust. Extreme concentrations of heavy metals

(10 - 100 x that of sanitary sewage) have been documented. (Wanielista 1976). Harrison (1976) determined that inorganic lead concentrations (5000 - 50000 ppm) commonly found in street dust and easily transported via runoff into receiving waters, constitutes a health hazard. Other heavy metals found in urban runoff include iron, manganese, and zinc (Wanielista 1976).

Four major types of nutrient sources contribute to street surface runoff: 1) grease and oil (including hydrocarbons) from vehicles; 2) ~~bird and~~ animal wastes; 3) food litter; 4) organic materials consisting of wood, leaves, grasses, and other vegetational <sup>material</sup> wastes. These organic materials can produce high biological oxygen demand in the receiving waters. The decrease in oxygen levels can in extreme cases kill aquatic or marine life (Wanielista 1976). Specific nutrient pollutants include nitrates and phosphates which enter receiving waters from lawn runoff (Whipple, Hunter and Yu 1974). Pesticides are sometimes found in street surface contaminants. Typical pesticides detected have been DDD, DDT, Dieldrin and PCB (Wanielista 1976).

#### Florida - Case in Point:

In Florida, numerous cases of runoff induced pollution, both agricultural and urban in origin, have been documented in recent years. Nutrients such as phosphorous and nitrogen are major runoff pollutants in Florida, and especially in Southwest Florida where high concentrations of phosphorous occurs naturally. The contributions of the nutrients nitrogen and phosphorous is usually less than 10% except during an event when overland flow takes place, when these nutrients dominate all others (Wanielista 1976). Donigan (1975) concluded that

organic loadings from parking lots reach pollutional levels comparable to medium strength sewage. Waite and Greenfield (1975) and Sherwood and Matrau (1975) have also identified phosphorous and nitrogen as contributing to water quality problems. In Southwest Florida phosphorous pollution occurs from fertilizers, detergent seepage from septic tanks and drainage from the nearby Hawthorne phosphate deposits (Lincer 1975).

In certain cases, where heavy concentrations of septic tanks predominate, low lying, flood prone areas, septic tank effluent may well be the cause of creek contamination. When septic tanks lie near the water table and are submerged during extremely wet conditions, their effluent can flow into the sub-surface water and lateral flow along a hardpan may transport the effluent into receiving waters. This seems to be the case on Wares Creek in Manatee County (Wanielista 1976).

Runoff from dairies and pastureland entering surface waters results in greatly increased coliform bacteria counts. All rivers draining pastureland in Manatee County show coliform counts greater than 2400 following rains. This condition has been recorded in Hillsborough and Sumter Counties as well (Wanielista 1976).

While there are few specific studies in Southwest Florida, runoff induced pollution is undoubtedly similar to the rest of the state. Several tidal creeks in this region; Bowlees Creek, Whitaker Bayou, Alligator Creek (Charlotte County), Alligator Creek (Sarasota County), and Catfish Creek drain pasture land, agricultural land or urban-suburban land. Runoff is likely a major contributor to nutrient, heavy metal and bacterial contamination in these creeks especially during the wetter summer months.

Wanielista  
1976  
p. 33

Are there any?

1975  
runoff from septic tanks  
artificial drainage  
runoff from pasture, septic tanks, etc.  
runoff from parking lots

# BOWLEES CREEK

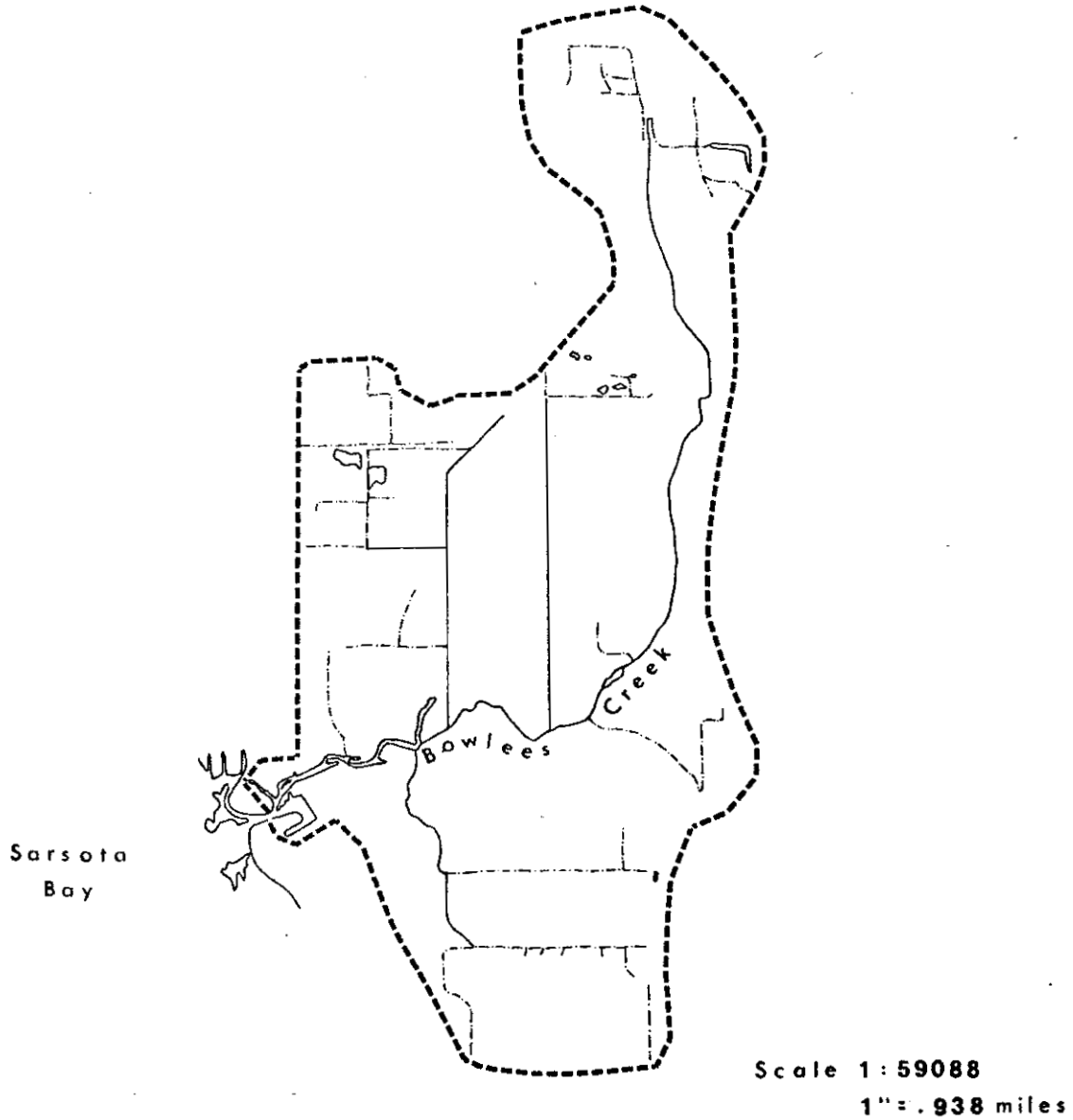
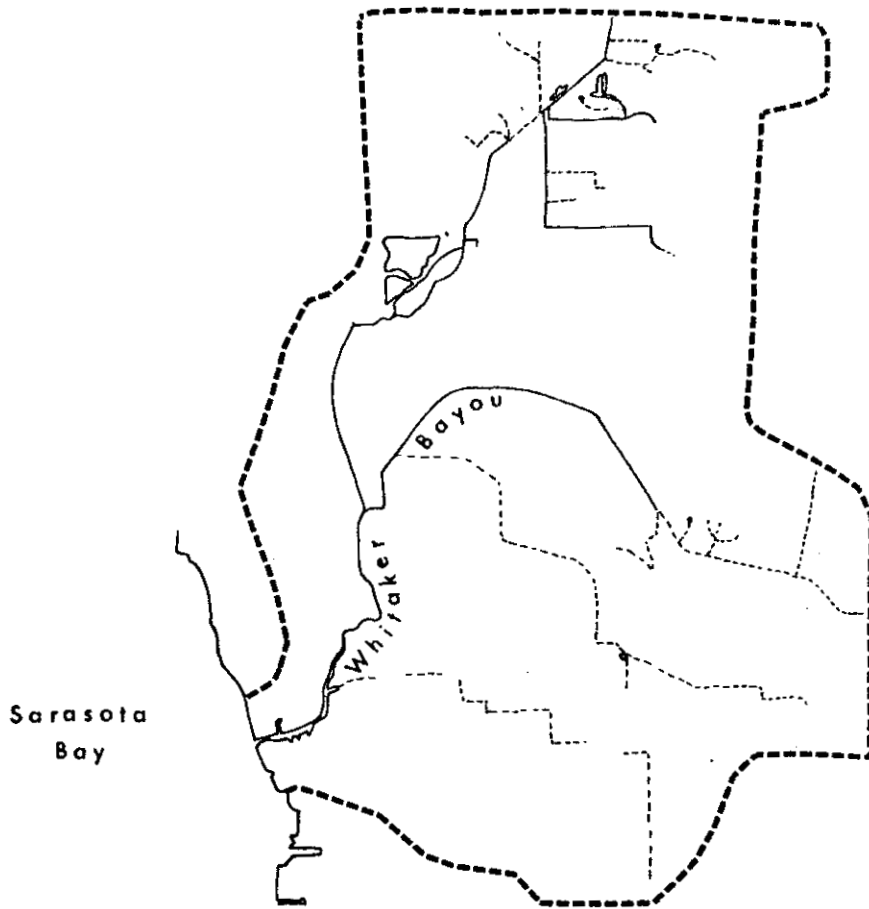


Fig. 9: Drainage basin map for Bowlees Creek

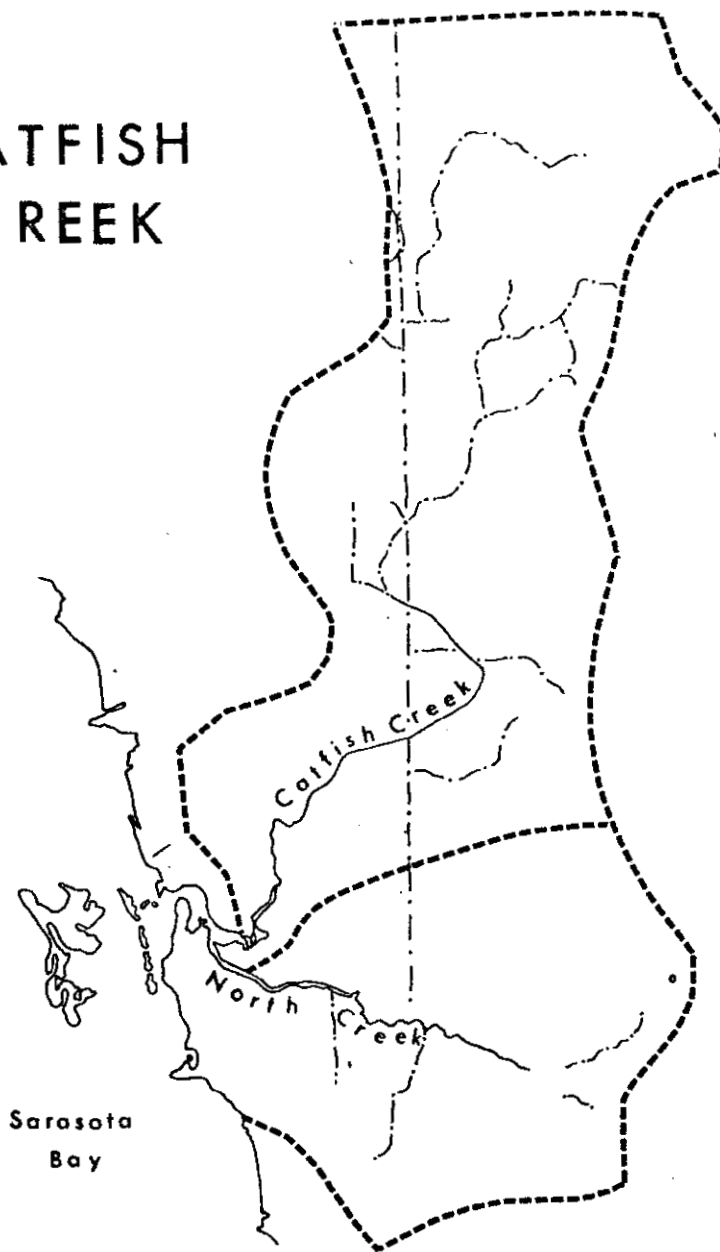
# WHITAKER BAYOU



Scale 1:59088  
1" = .938 miles

Fig. 10: Drainage basin map for Whitaker Bayou

CATFISH  
CREEK



Scale 1:59088  
1" = .938 miles

Sarasota  
Bay

NORTH  
CREEK

Fig. 11: Drainage basin map for Catfish and North Creeks.

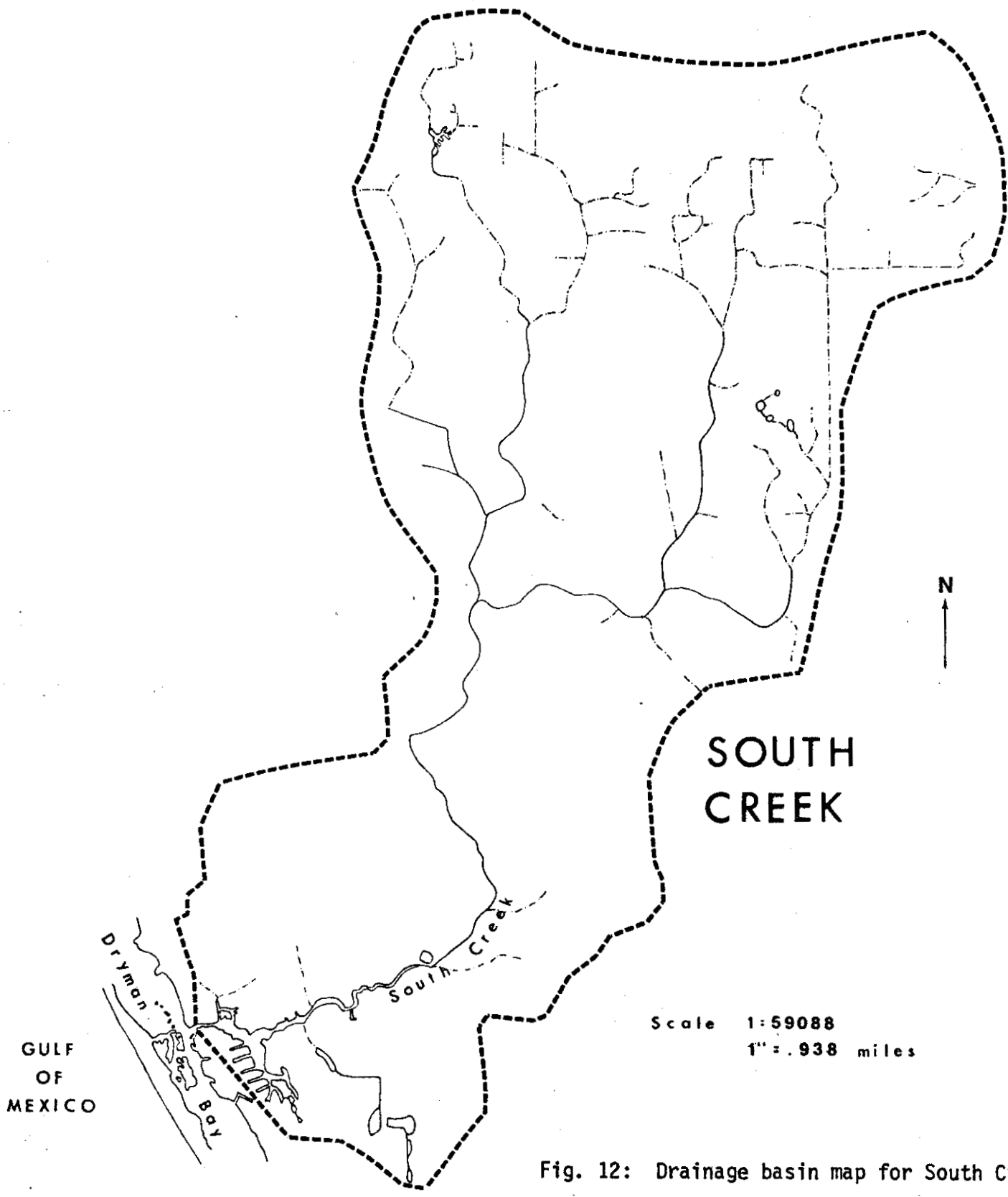


Fig. 12: Drainage basin map for South Creek.

# ALLIGATOR CREEK SARASOTA

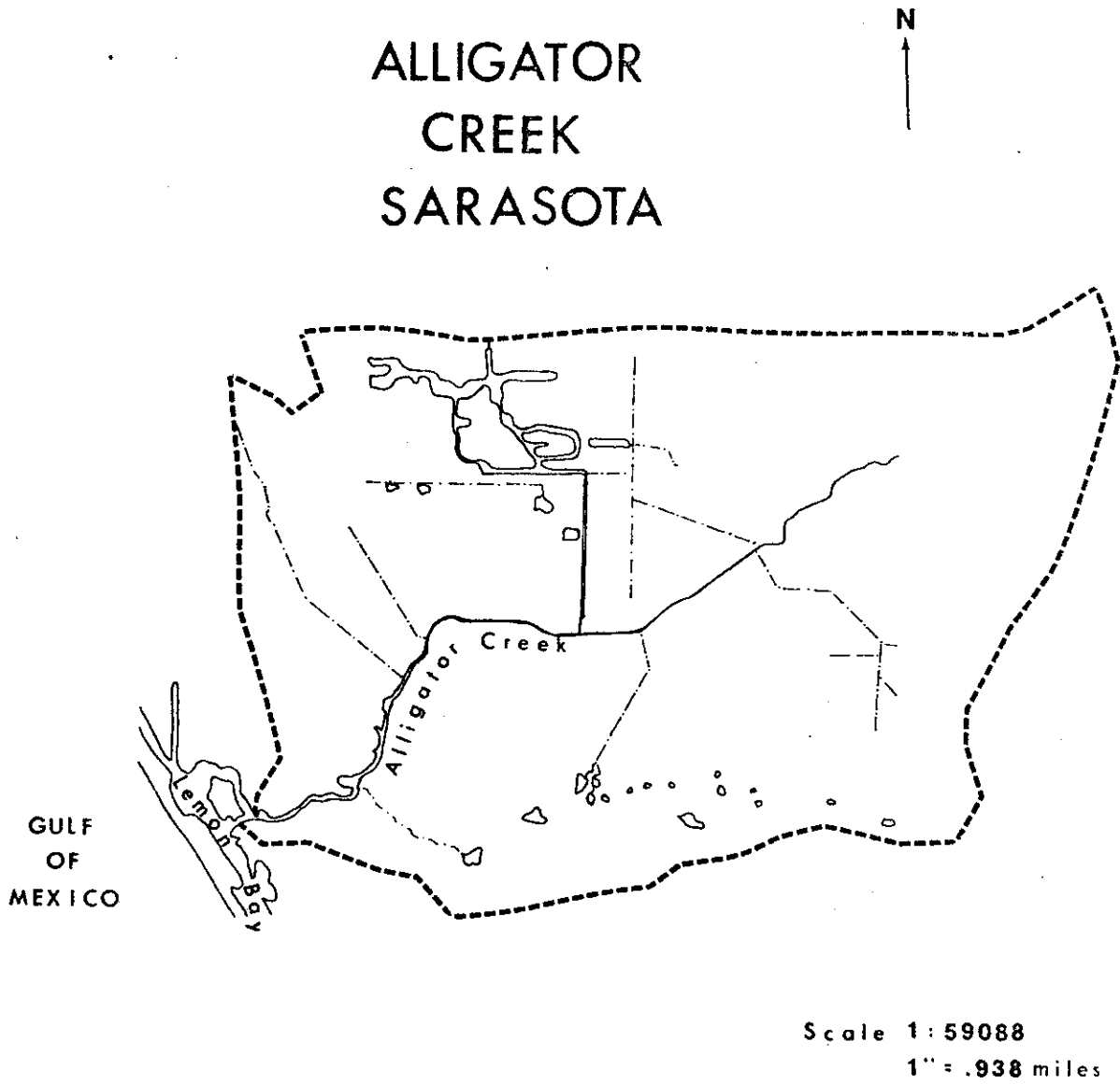


Fig. 13: Drainage basin map for Alligator Creek (Sarasota County)

# ALLIGATOR CREEK CHARLOTTE

N

Scale 1:59088  
1" = .938 miles

40

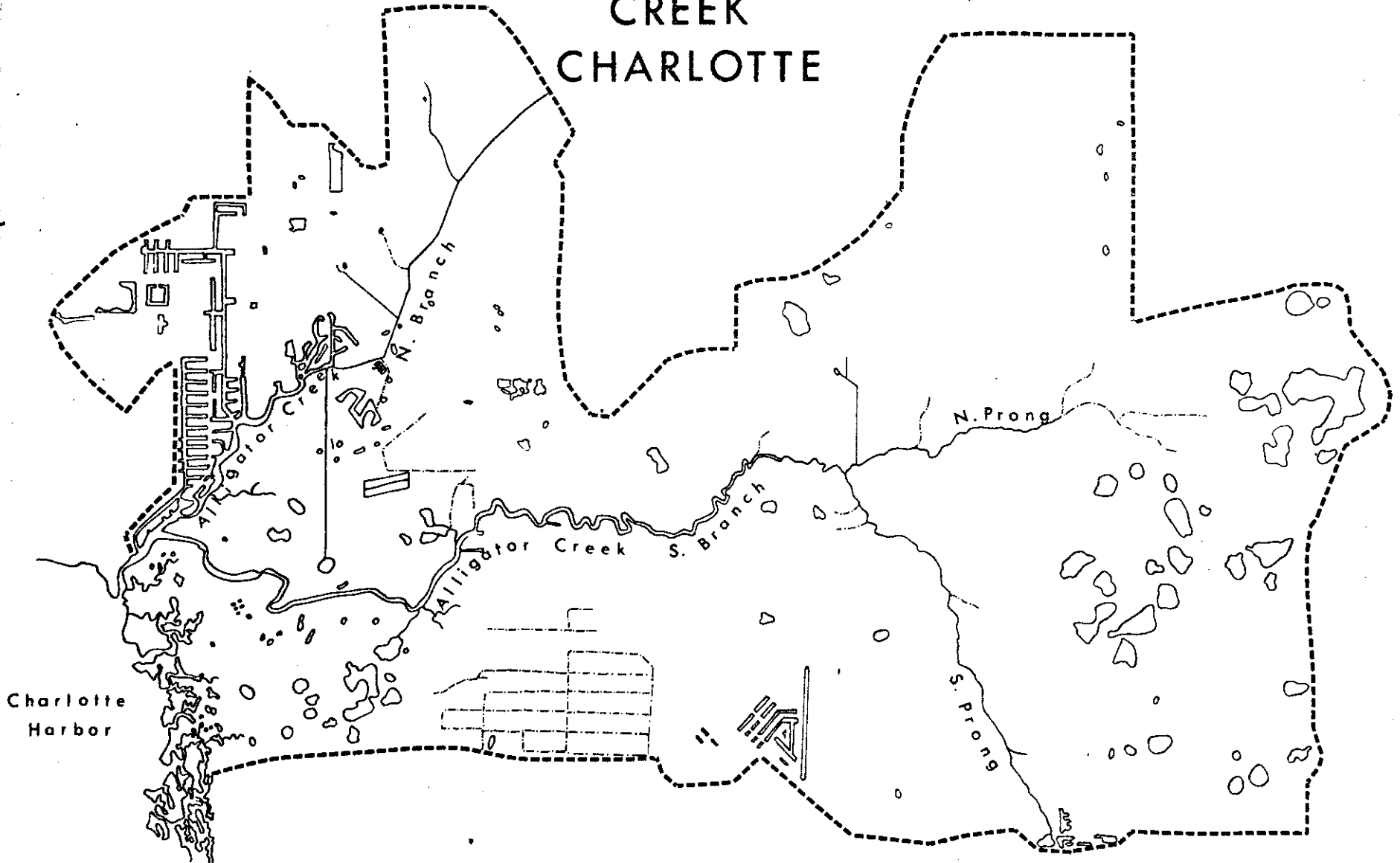


Fig. 14: Drainage basin map for Alligator Creek (Charlotte County)

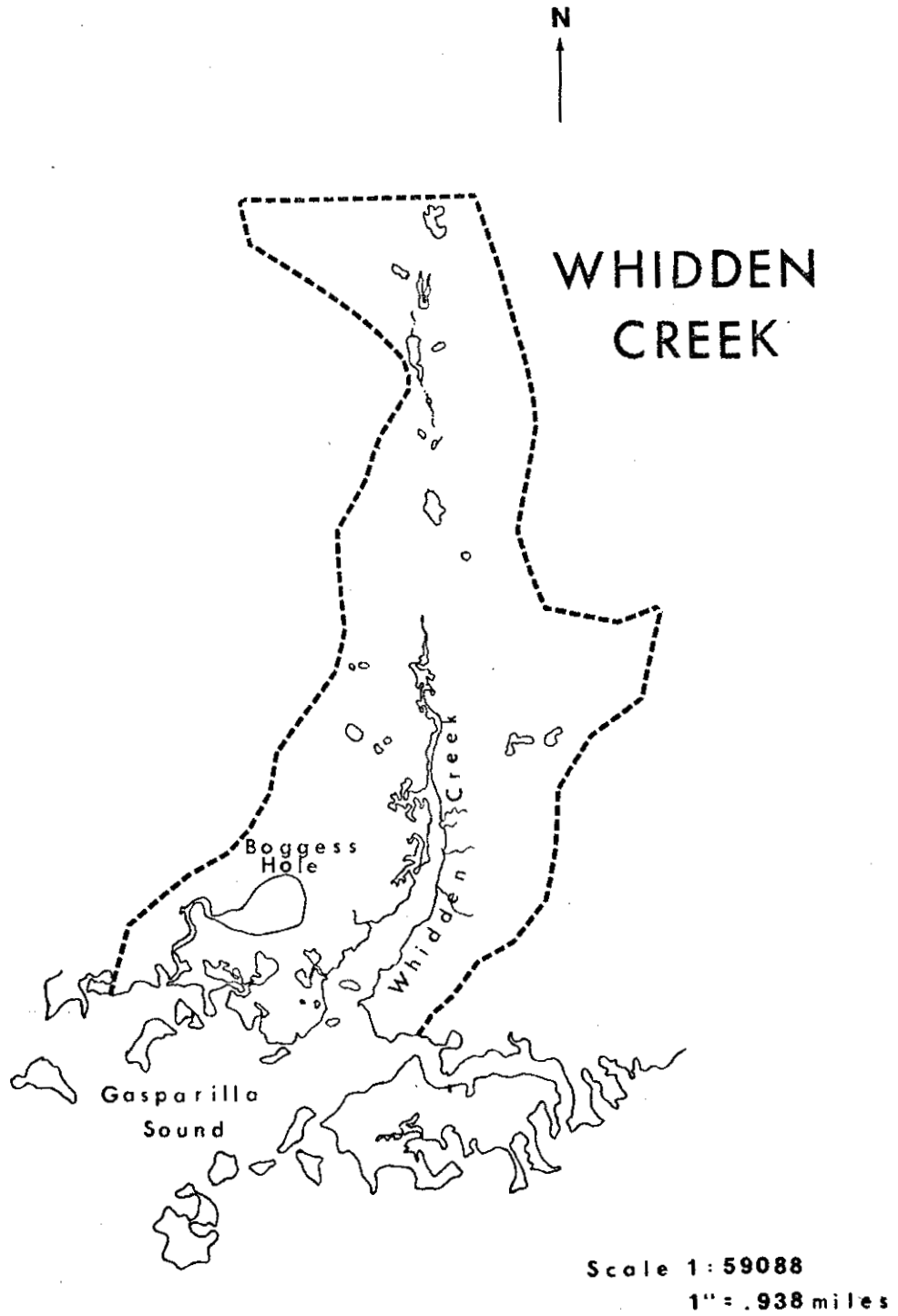


Fig. 15: Drainage basin map for Whidden Creek.

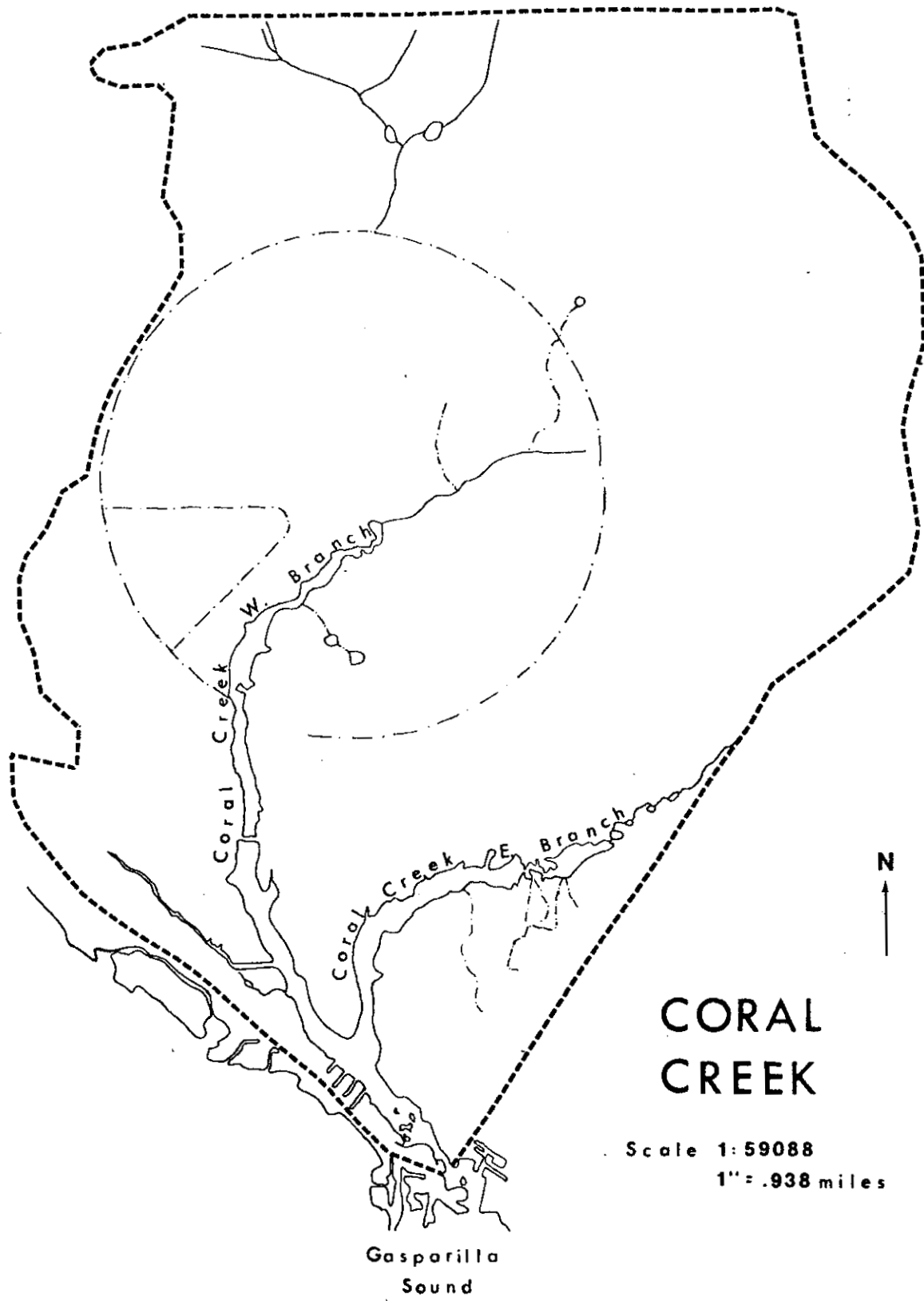
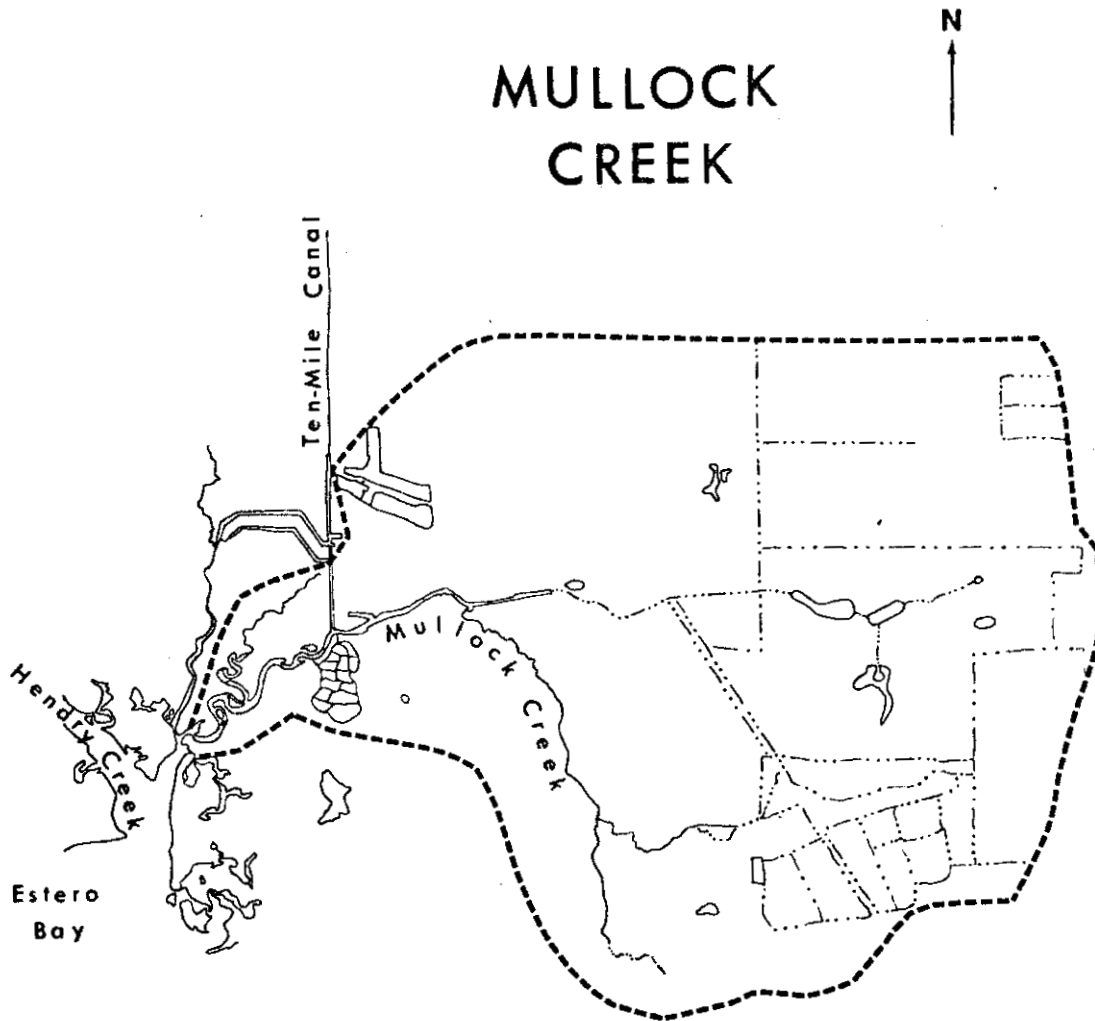


Fig. 16: Drainage basin map for Coral Creek.



Scale 1:59088

1" = .938 miles

Fig. 17: Drainage basin map for Mullock Creek.

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## Water Quality

The importance of the maintenance of good water quality cannot be emphasized enough. Water is one of our single most important natural resources. All life evolved from the ocean and continues to depend on water for existence. In Florida, particularly, water is extremely important. High quality water is a tremendous economic asset to a state whose major industry is tourism. People are attracted to Florida because of its clean water, sandy beaches, and pleasant climate. Water also supports the plant and animal life in the area, much of which is unique. The diverse wildlife not only acts as an attraction for tourists, but is also commercially valuable. The waters of Florida have a valuable supply of finfish and shellfish which are harvested.

At the same time, Florida is one of the most rapidly growing areas of the country and is projected to double in population by 1985. Lee County's average annual growth rate is approximately 9%; most of which is due to immigration. Accordingly, ever increasing needs for potable water must be met. A report for the Board of County Commissioners for Sarasota County has stated, "The Sarasota County population is now within the theoretical range of full utilization of readily available water within its political boundaries." (Env. Element: Phase II; 1975).

The 1976 Water Quality Inventory for the State of Florida states that the freshwater streams, especially in southwestern Florida, are being considered as a potential source of potable water for the rapidly growing metropolitan areas." It would appear then, that the maintenance of high water quality standards is not only important economically for tourism and fishing, but is absolutely essential in order to meet the needs of a rapidly growing population.

Even though clean water is of major importance to the people, the same growth and expansion which necessitates the maintenance of good water is causing continual degradation of many of the aquatic systems in the area. Urban runoff from developed areas, storm sewer discharges, and sewage effluent are being discharged into the streams. In addition, agricultural runoff of fertilizers and other chemical nutrients are further degrading the streams and causing their eutrophication. Higher demand for waterfront property has led to dredge and fill operations which create extensive canal systems whose water quality is difficult to maintain at acceptable levels, while at the same time damaging (and sometimes eliminating) the valuable wetlands ecosystem found along most of Florida's coasts. These wetlands not only provide a habitat for wildlife, and a natural drainage system, but also serve as a filter for the maintenance of high water quality.

Paradoxically, water quality is difficult to define. What constitutes high quality water? Is it the level of production within the ecosystem? Is it compliance with Federal water quality criteria? Is it the economic value of water?

One point of view is that high quality water is water in the absence of man-made pollution. What exactly constitutes "pollution" is a hotly debated question, but can be described as the "condition which exists when the activities of Man result in widespread mortality, decline in species diversity, lowered productivity and overtly 'unpleasant' symptoms" (Perkins, 1974). A state of pollution can be said to exist when the concentration of growth inducing materials and factors exceeds what is optimal for a population, resulting in an initial increase in production with a decrease in diversity, followed by a decrease in production and further decrease in diversity (Fig 18 ).

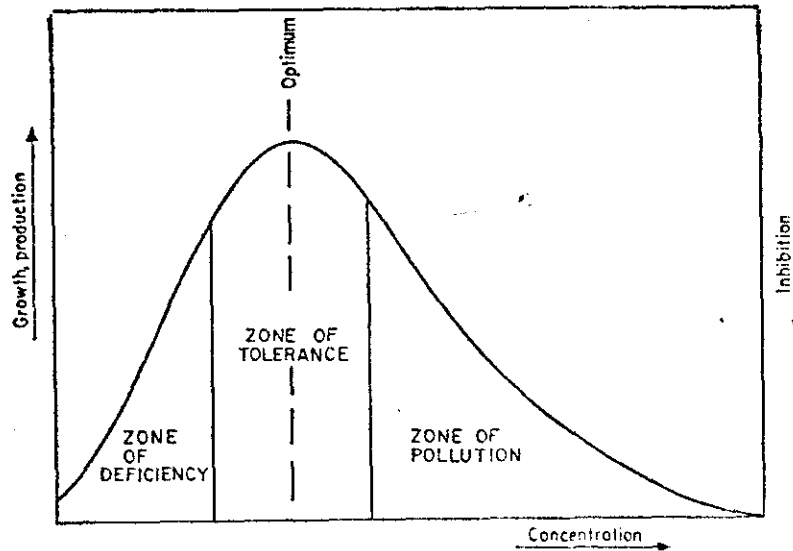


Fig. 18 : The effect of increasing concentration of nutrient substance on growth and production within an ecosystem. (From Perkins, 1974).

In order to cope with the problem of maintaining of good water quality, the U. S. Environmental Protection Agency has established quality criteria which are "expected to support an aquatic ecosystem suitable for the higher uses of water." (Quality Criteria for Water; EPA, 1976). The term "water quality criteria" as used by the EPA specifies concentrations of substances in the water which, when not exceeded, will protect a community or prescribed water use; it should not be confused with a water quality standard which is a legal device based on a quality criterion. The EPA has based the criteria on experimental and in situ observations of "organism responses to a defined stimulus or material under identifiable or regulated environmental

conditions for a specified period of time" (EPA, 1976). Information on the long term effects of various pollutants on many aquatic species must still be obtained. Nevertheless, these criteria form the basis for water quality standards in EPA programs.

The State of Florida has enacted a number of environmental protection statutes. It has established a water quality classification system (Table 1 ), and has adopted standards for minimum allowable water quality. The main goals of the State program are: 1) to manage discharge of domestic and industrial wastes; 2) to control nonpoint source pollution; and 3) to regulate alterations of bottoms and shorelines of State waters (State of Florida, DER, 1976).

*Now - take advantage of the space and fill  
reader with your chapter on water quality etc  
& set rationale for water qual. in the Creek.*

Table 1 : Classifications of Florida waters, with standards for selected parameters.  
EPA criteria are shown at right

	<u>Class I</u>	<u>Class II</u>	<u>Class III</u>	<u>Class IV</u>	<u>Class V</u>	<u>EPA Criteria</u>
	fresh water	salt water				
Use	potable water	shellfish harvesting	Recreation, Wildlife, fish management	Agriculture Industry	Industry Navigation	
pH	+ .01 Min: 6 Max: 8.5	+ .02 Min: 6.5 Max: 8.5	+ .02 Min: 6.5 Max: 8.5	+ 1.0 Min: 6.0 Max: 8.5	+ 1.0 Min: 5.0 Max: 9.5	6.5-9.0: Freshwater 6.5-8.5: Marine
Color	75 color units	75 c.u.	75 c.u.	75 c.u.	75 c.u.	7.5
Turbidity	50 JTU above background	50	50	50	50	such that photosynthesis is reduced no more than 10%
D. O.	5.0 mg/l	Ave: 5.0 Min: 4.0	Ave: 5.0 Min: 4.0	4.0	Ave: 2.0 Min: 1.0	5.0 mg/l
BOD	Not in excess to decrease D. O. below class					
Total Coliform	Ave: 1000/100ml Max: 2400/100mo	Ave: 70/100 ml Max: 230/100ml	Ave: 1000/100 ml <10% exceeding 2400	--	--	--
Fecal Coliform MP/100 ml	Ave: 200 Max: 400	Ave: 14 Max: 43	Ave: 200 Max: 400 <10% 800 < 0%	--	--	Ave: 200 Max: 400
NH <sub>3</sub>	.02 mg/l	--	--	--	--	.02mg/l
NO <sub>3</sub>	10 mg/l	--	--	--	--	10 mg/l
PO <sub>4</sub>	--	0.1 mg/l	--	--	--	0.1 mg/l

### A. Parameters Used to Measure Water Quality:

The number and variety of parameters which can be used to measure water quality are as great as the number of substances present in natural waters. In this study, parameters were chosen which, in our opinion, are most indicative of overall water quality, while at the same time are relatively inexpensive in terms of man-hours required to perform the analysis. The following paragraphs describe the parameters measured in this study.

Salinity was measured at each sample station to determine a salinity gradient for each creek. Because of its effect on the solubility of gases in a liquid, it was also used in conjunction with temperature to determine the percent saturation of dissolved oxygen in the water at the sample stations.

Changes in salinity are influenced by four major factors: 1) distance from the sea; 2) rainfall; 3) runoff from the land; and 4) evaporation. Distance from the sea and amount of runoff are usually the major factors.

Saline waters can be classified as follows: (Perkins, 1974)

<u>Zone</u>	<u>Salinity (0/00)</u>
Hyperhaline	greater than 40
Euhaline	40 - 30
Mixohaline	30 - 0.5
(Mixo)euhaline	greater than 30; less than adjacent euhaline
(Mixo)polyhaline	30 - 18
(Mixo)mesohaline	18 - 5
a-mesohaline	18 - 10
b-mesohaline	10 - 5
(Mixo)oligohaline	5 - 0.5
a-oligohaline	5 - 3
b-oligohaline	3 - 0.5
Freshwater	less than 0.5

Since the salinity in an estuary fluctuates with the changing tides and seasons, ~~the ideal method of study would be to chart the range and the mean of salinities at various stations within an estuary over a~~

complete tidal cycle and at different seasons *should be measured.*

Dissolved Oxygen (DO) Hutchinson (1957) states that "a skillful limnologist can probably learn more about the nature of a lake from a series of oxygen determinations than from any other kind of chemical data." It is, therefore, one of the most commonly measured parameters (Olive, 1976; Rickert, 1975). The concentration of oxygen in estuaries depends mainly on salinity and temperature. Percent saturation is based on these factors (Green, 1967).

Generation of dissolved oxygen in estuaries ~~is~~ <sup>s</sup> dependent on three major factors: 1) re-aeration by direct contact with air; 2) mixing with oxygen rich water from the sea; and 3) photosynthetic activity. (Fig 19 ). Dissolved oxygen is decreased mainly by biological and chemical oxidation reactions in the water. The amount of organic material present in the water affects the DO by creating what is called biochemical oxygen demand (BOD). The oxygen is used in the oxidation of organic matter. Some common sources of organic matter in our creeks are nonpoint source runoff (urban, residential, and agricultural), effluent from wastewater treatment plants and septic tank leachate. BOD is often used as an indicator of organic pollution (Yu, 1973).

Self-purification of a stream depends on the presence of sufficient dissolved oxygen to oxidize the excess organic material (Klein, 1962). Without sufficient replenishment of the oxygen (if the rate of oxygen uptake exceeds the rate of re-aeration) the condition of the creek will worsen until no DO is left and septic conditions prevail. We did not find such an extreme situation within the study area.

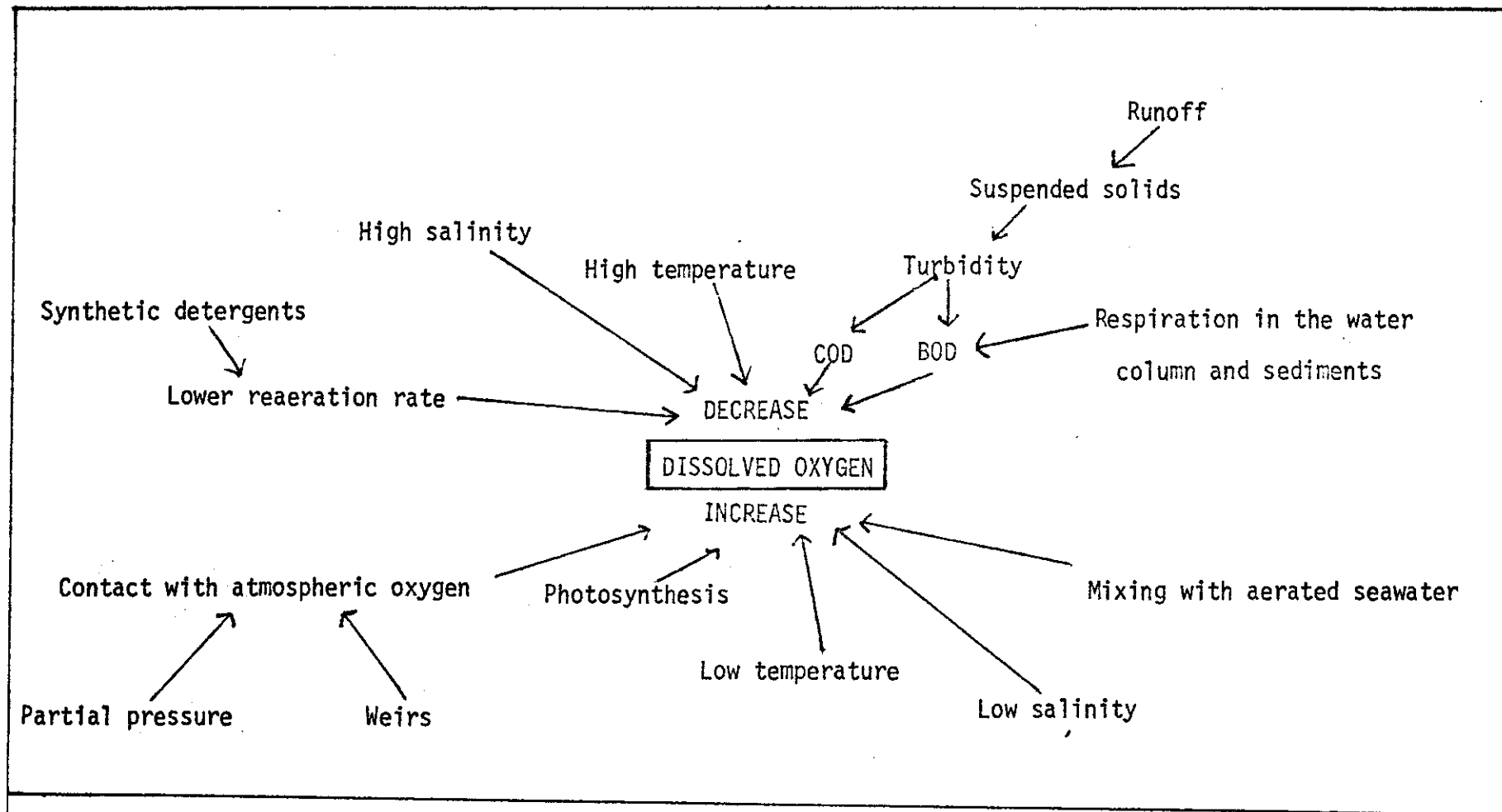


Fig. 19 : Factors affecting dissolved oxygen levels in an estuary.  
Adapted from Morrill, *et. al.*, 1974.

On the basis of numerous studies (Ellis, 1937; Brinley, 1944; and Everatt, 1973) the EPA has established a criterion of 5.0 mg/l as the minimum amount of dissolved oxygen required to maintain good fish populations (EPA 1976). The State of Florida has set up DO criteria stating that an average of 5.0 mg/l must be maintained, with minimum levels no less than 4.0 mg/l.

pH in estuarine systems is quite variable. Values between 6.5 and 9.5 are common (Perkins, 1974). It is regulated by a  $\text{CO}_2$  - bicarbonate - carbonate buffer system ( $\text{pH} = 10.7 - \sqrt{c_m} - \log \frac{\text{HCO}_3^-}{\text{PCO}_2}$ ). Discharge of acid or alkaline effluent into estuarine ecosystem can disrupt the buffer system and produces a change in pH. Changes in pH affect the degree of dissociation of weak acids and bases which then affects the toxicity of various substances (EPA, WQC, 1976).

The EPA criteria for pH are as follows: 6.5 - 9.0 for freshwater and 6.5 - 8.5 ( $\pm 0.2$  from normal range) for marine. The State of Florida criteria for Class III waters are 6.0 - 8.5. In the creeks sampled the pH varied between 7.2 and 8.4.

A direct relation between pH and dissolved oxygen has been found in Australian estuaries (Rochford, 1951) and in Chesapeake Bay (Pritchard, 1959). Although a similar relationship appeared to exist in the tidal creeks in the present study, the effect was outweighed by other factors (temperature and salinity).

The major importance of nitrogen in the biosphere is that it is an essential component of amino acids and nucleotides and, therefore, of proteins and nucleic acids. It is also a component of other organic compounds such as urea and trimethylamine (occurs in marine fish and invertebrates). Thus, nitrogen fixation is a mechanism for providing utilizable nitrogen in a body of water enabling organisms, most of

which are unable to fix  $N_2$ , to survive. Nitrite ( $NO_2$ ) and nitrate ( $NO_3$ ) are two of the commonly utilizable forms. High concentrations of nitrate in natural waters may cause accelerated growth of aquatic plants ~~material~~ (eutrophication). A major source of nitrates is runoff from agricultural land, residential and urban areas, and golf courses. Ammonia is the major end product of bacterial decomposition of organic matter (Hutchinson, 1957). High concentrations are sometimes due to sewage. Ammonia is also produced by bacterial reduction of nitrate-nitrogen.

Phosphorous, like nitrogen, is an essential nutrient for living systems. It is usually found bound to the bottom sediments in natural waters, and may be released by agitation with seawater. Its release is accompanied by a rise in pH (Perkins, 1974).

Suspended solids is a measure of organic and inorganic particulate matter. Perkins (1974) lists several effects of high suspended solids: "1) Mechanical or abrasive action (e.g. clogging of gills, irritation of tissues); 2) blanketing action or sedimentation; 3) reduction of light penetration; 4) availability as a surface for growth of bacteria and fungi; 5) absorption and/or adsorption of various chemicals; and 6) reduction of temperature fluctuations."

Suspended particles, when they are composed of organic material, lower the dissolved oxygen content of the water by undergoing oxidation reactions. Because the particles reduce light penetration photosynthetic activity decreases, also lowering DO levels.

The EPA water quality criterion for turbidity and suspended solids states that the solids should not reduce the depth of the euphotic zone by more than 10% of the seasonal norm.

Color in water may result from the presence of natural metallic ions, industrial wastes; and plant residues such as leaves, humus and peat. In the tidal creeks in Southwest Florida, the major source of color is organic matter from decaying plants. Because the presence of suspended solids affects the color of waters, "apparent color" is the term used to describe color of unfiltered water.

The color of water is used as a water quality parameter mainly because of aesthetic considerations, although color does affect the penetration of light and therefore reduces photosynthesis (EPA, 1976).

True color may be measured by the platinum-cobalt method (EPA, Manual of Methods, 1976). This method is applicable to waters in which there are no highly colored industrial wastes. Because color depends on pH, pH should be reported with color data (APHA, 1976).

Coliform bacteria comprises all of the facultative, anaerobic, gram-negative, non-spore forming, rod shaped bacteria that ferment lactose with gas formation in 48 hours at 35<sup>o</sup> C (APHA, 1976). Measurement of coliforms is a common practice in water quality analyses. Fecal coliform bacteria are present in the intestinal tracts of warm-blooded animals, and are used as an indicator of pollution from domestic wastewater, which often contains pathogens such as Salmonella.

Recently there has been growing sentiment that the measure of fecal coliforms in water is not the best indicator of water quality. One of the major reasons is that although correlations have been found between fecal coliform levels and some pathogens, the correlation is not consistent. For instance, the level of Salmonella is sometimes found to be in close correlation with the fecal coliform level. In one instance, when the fecal coliform level exceeded 200/100 ml, 85% of the samples

also contained Salmonella. When the level exceeded 2000/100 ml, 98% of the samples contained Salmonella. The count of Salmonella dropped to 28% when fecal coliform levels dropped under 200/100 ml (EPA, 1972). In other studies, however, this <sup>variability of</sup> correlation has not been found.

Whether Escherichia coli is a good indicator organism in seawater is open to question. Carlucci and Pramer (1960) investigated the survival of E. coli in seawater and found that the rate of survival of E. coli in seawater differs from that in freshwater.\* This indicates that coliform counts in seawater should be viewed with reservation.

Studies of fecal coliforms in areas of oyster beds have shown that high levels of fecal coliforms are attributable to high populations of warm blooded animals in the area (Presnell, et. al., 1971).

Despite these reservations, the fecal coliform test is still widely used to indicate fecal pollution. Studies have shown that the probable source of pollution may be found by studying the ratio of fecal coliform to fecal streptococcus bacteria (Smith, et. al., 1971; Russo, 1974). A ratio greater than 4.0 is usually indicative of pollution by human waste, a ratio lower than 0.7 indicates pollution from domestic animals.

EPA criteria for fecal coliforms state that the average fecal coliform count for a particular sample station should not exceed 200/100 ml, with no more than 10% of the samples exceeding 400/100 ml.

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\*The E. coli growth curve for seawater is the inverse of the normal growth curve; that is, there was an initial lag phase followed by a decline which became asymptotic to the zero population line.

## B. Water Quality: An Introduction

There are many methods of presenting water quality data in a form readily utilizable to the reader. Some mathematical models have been proposed (Penumalli, 1976; Willis, 1976; Wallis, 1974), and Foster (1974) developed a computer program for the representation of eight water quality parameters in a scatter diagram.

Maucha's field diagrams (1973) are a good method for showing the relative values of components within a sample, but fall short when a comparison between samples is needed. The polygonal graph (Bonetto, 1975; Morrill, 1974) is a good method for showing differences in water quality between different stations. The latter method will be used for comparison of water quality both within and among the tidal creeks.

In order to provide a comparative picture of water quality in the ten study creeks, data for eight parameters are shown on polygonal graphs. Figure 20, which is the key to the graphs, shows that each parameter is plotted along one axis yielding a closed polygon which can be easily compared with that from another station.

In order to have a basis for comparison, a graph was constructed using EPA criteria for the concentrations plotted. Since there is no EPA criterion for fecal streptococcus bacteria, the value plotted was calculated using the EPA criterion for fecal coliform bacteria (MPN 200/100 ml) and the fecal coliform: fecal streptococcus ratio discussed earlier in the test. Since an FC/FS ratio of 4.0 is the minimal value indicative of predominately human contamination, this was used to obtain a fecal streptococcus count of 50/100 ml.\*

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\*  $FC/FS = 4.0$ ;  $200/FS = 4.0$ ;  $FS = 50/100 \text{ ml}$

The EPA has not established a criterion for  $BOD_5$ , but the State of Florida has stated that  $BOD_5$  should not be such as to decrease dissolved oxygen below class standards. Since the EPA criterion for DO is an average of 5.0 mg/l, (with a minimum value of no less than 4.0 mg/l) 5.0 mg/l was plotted for DO, and 1.0 mg/l was used as a maximal value for BOD. This BOD value does not reflect any formal criterion; it has value only in relation to a theoretical DO of 5.0 mg/l.

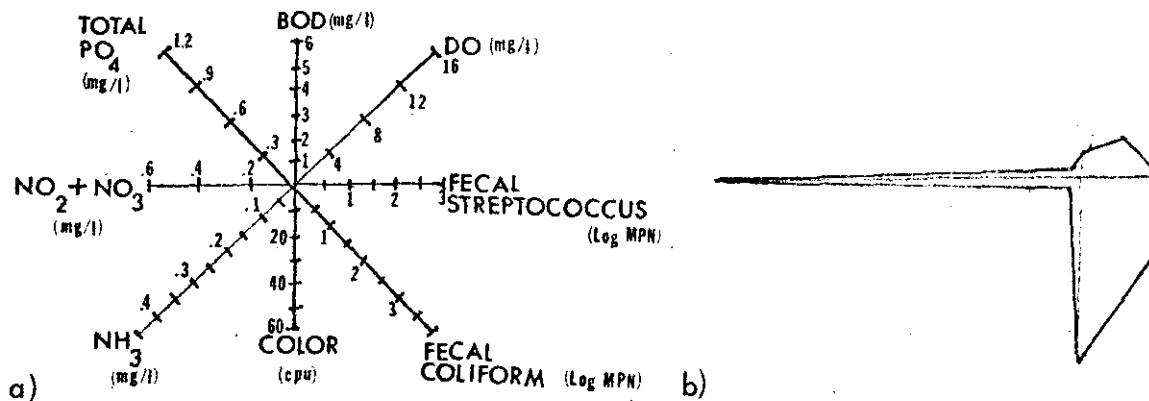


Fig. 20 : a) Key to polygonal graphs showing parameters and concentrations used. b) Polygonal graph showing EPA criteria for minimum allowable water quality to be used as a basis for comparison. (see text).

The graph in Figure 20 is intended to serve as a basis for comparison. It represents what the EPA considers to be the minimal quality water necessary to maintain healthy aquatic and wildlife populations. This does not necessarily mean that it represents high quality water. As has been discussed earlier, there is no single definition of high quality water. Using the polygonal graphs however, one is able to

compare the shapes of those in systems undisturbed by human development with those in other systems. For example, Whidden Creek is a low-lying estuary whose drainage basin has remained totally undisturbed (Fig 31). If one uses the term "high quality water" meaning water in the absence of man-made contamination, then the water in Whidden Creek would be considered high quality, and the general shape of its graphs could be compared to the shapes of graphs from other creeks of the same eco-type, such as Coral Creek.

Another type of creek found within the study area is that which has its headwaters as a freshwater stream in the uplands and its mouth in <sup>a</sup>the mangrove <sup>swamp</sup>marsh. In a relatively undisturbed state, this type of creek is characterized by North Creek (Fig 27). Therefore, the graphs of water quality for North Creek are used as a basis for comparison in this type of ecosystem.

### C. Water Quality in the Study Creeks:

Water samples were collected for analysis on February 15 and 17. Time did not allow sampling all the creeks on the same day. All samples were collected on an ebbing tide. The methods used in the lab are included in App<sup>B</sup>, and rainfall data for the month of February are in App<sup>C</sup>; sample dates are marked with an asterisk.

Initially, only one sample run was planned. The rationale for sampling during the dry season was that any chronic problems due to runoff and septic tank leaching would be more easily distinguishable than in the wet season when a higher water table and greater amount of runoff contribute larger amounts of nutrients and contaminants to the creeks.

Originally we had hoped to rank the creeks with respect to a baseline creek. This was not possible for two reasons: 1) results of this study indicate that there are two basic types of creek ecosystem<sup>s</sup>, and comparisons of water quality between the two may not be valid; and 2) the information obtained was not adequate. Sampling through a full tidal cycle on a bi-monthly basis for at least one year is necessary to establish adequate baseline information. For these reasons, data for each creek are treated separately.

This section is intended to briefly describe the results of the water quality analyses for each of the ten study creeks. Polygonal graphs are used to provide a pictorial summation of the water quality. Maps showing the location of sample stations and wastewater treatment facilities within the drainage basin are included.

Data obtained during the February sample run are shown in Table 2. Results of some of the analyses have been graphed: 1) dissolved oxygen

and BOD<sub>5</sub> (Fig. 21 , Table 3 ); Coliform data (Fig. 22 , Table 4 ); ammonia (Fig 23 ); and total phosphate (Fig. 24 ).

A second sample run was conducted in April. The results have not yet been analyzed, but are presented in App.<sup>on</sup> D.

CREEK	STATION	WATER TEMP	PH	SALINITY	COLOR	SUSPENDED SOLIDS	DISSOLVED OXYGEN	BOD	TOTAL COLIFORM	FECAL COLIFORM	FECAL STREP	AMMONIA NH <sub>3</sub>	NO <sub>3</sub> +NO <sub>2</sub>	TOTAL KJELDAHL NITROGEN	o-PO <sub>4</sub>	TOTAL PO <sub>4</sub>	CHLOROPHYLL <sup>a</sup>
		°C		o/oo	CPU	mg/l	mg/l	mg/l	MPN /100 ml	MPN /100 ml	MPN /100 ml	mg/l	mg/l	mg/l	mg/l	mg/l	mg/m <sup>3</sup>
Bowlees	1	16	7.27	34.0	50	15.6	5.88	2.43	3800	100	100	.12	.01	.03	.07	.06	1.068
	2	16	7.32	7.3	20	11.6	7.23	1.73	300	300	150	.24	.45	.11	.13	.05	0
	3	16	7.50	3.2	20	28.4	9.27	1.75	0	0	340	.26	.26	.42	1.12	1.02	6.622
Whitaker	1	18	7.31	22.4	45	18.0	6.41	>6.41	2800	400	10	Interference	.04	.86	1.50	1.22	1.068
	2	18	7.49	10.5	30	13.6	4.70	2.50	0	0	1300	Interference	.62	.64	.51	.40	0
	3	18	8.00	2.8	15	33.6	12.20	0.44	0	0	60	.10	.01	.66	.44	.40	4.486
Catfish	1	19	7.58	27.7	45	12.4	no sample		200	200	200	.24	.01	.57	.12	.17	0
	2	21	7.51	26.3	45	11.2	no sample		7900	200	200	.16	.01	.64	.21	.17	0

Table 2 - Water quality data for sample run on February 15 - 17. For a discussion of these results, see text.

CREEK	STATION	WATER TEMP °C	pH	SALINITY o/oo	COLOR CPU	SUSPENDED SOLIDS mg/l	DISSOLVED OXYGEN mg/l	BOD mg/l	TOTAL COLIFORM MPN /100 ml	FECAL COLIFORM MPN /100 ml	FECAL STREP MPN /100 ml	AMMONIA NH <sub>3</sub> mg/l	NO <sub>3</sub> +NO <sub>2</sub> mg/l	TOTAL KJELDAHL NITROGEN mg/l	o-PO <sub>4</sub> mg/l	TOTAL PO <sub>4</sub> mg/l	CHLOROPHYLL a mg/m <sup>3</sup>
Catfish	3	18	7.80	3.5	30	8.8	5.95	2.63	500	400	400	.35	.58	1.07	.79	.90	10.736
North	1	17	7.25	32.1	45	23.2	no sample		2900	100	100	.21	.01	.53	.02	.01	0
	2	20	7.20	25.0	45	18.4	8.70	3.75	1100	700	100	.12	.01	.42	.07	.05	12.630
	3	19	7.56	9.4	30	10.8	9.34	3.95	900	300	280	.12	.01	.75	.09	.13	17.366
South	1	19	7.59	31.5	60	12.0	3.79	-.27	243	100	30	not tested	not tested				0
	2	20	7.50	12.3	60	9.6	7.05	.84	0	100	130	.11	.01	.05	.11	.03	0
	3	19	7.41	8.0	50	8.4	4.20	.55	0	600	60	.03	.02	.22	.15	.06	0
(S) Alligator	1	19	8.25	10.8	5	19.2	18.17	2.82	600	0	100	.05	.01	.71	.16	.24	0

Table 2 - Water quality data for sample run on February 15 - 17. For a discussion of these results, see text.

CREEK	STATION	WATER TEMP °C	PH	SALINITY o/oo	COLOR CPU	SUSPENDED SOLIDS mg/l	DISSOLVED OXYGEN mg/l	BOD mg/l	TOTAL COLIFORM MPN /100 ml	FECAL COLIFORM MPN /100 ml	FECAL STREP MPN /100 ml	AMMONIA NH <sub>3</sub> mg/l	NO <sub>3</sub> +NO <sub>2</sub> mg/l	TOTAL KJELDAHL NITROGEN mg/l	o-PO <sub>4</sub> mg/l	TOTAL PO <sub>4</sub> mg/l	CHLOROPHYLL a mg/m <sup>3</sup>
(S) Alligator	2	19	8.10	48	5	9.8	11.21	2.57	600	100	170	.12	.04	1.53	.12	.17	2.136
	3	20	7.80	3.4	10	22.0	6.05	1.77	100	3300	60	.39	.30	1.31	.44	.60	1.922
(C) Alligator	1	19	7.72	31.1	50	27.2	7.04	0.86	3800	100	200	.12	.01	.16	.13	.05	0
	2	22	7.79	9.9	45	43.6	7.10	2.15	400	100	90	.12	.01	.09	.09	.01	1.068
	3	19	7.89	3.8	40	37.6	6.59	.68	1100	600	290	.05	.01	.30	.05	.17	1.495
Coral	1	15	7.90	34.1	45	12.0	8.06	1.40	200	200	10	.14	.01	.57	.05	.17	0
	2	18	8.00	41.2	20	12.0	8.53	.91	7000	7000	10	.39	.01	1.94	.02	.05	0
	3	15	7.70	29.7	35	13.2	6.52	2.30	0	0	30	.19	.01	.57	.17	.28	0

Table 2 - Water quality data for sample run on February 15 - 17. For a discussion of these results, see text.

CREEK	STATION	WATER TEMP °C	pH	SALINITY o/oo	COLOR CPU	SUSPENDED SOLIDS mg/l	DISSOLVED OXYGEN mg/l	BOD mg/l	TOTAL COLIFORM MPN /100 ml	FECAL COLIFORM MPN /100 ml	FECAL STREP MPN /100 ml	AMMONIA NH <sub>3</sub> mg/l	NO <sub>3</sub> +NO <sub>2</sub> mg/l	TOTAL KJELDAHL NITROGEN mg/l	o-PO <sub>4</sub> mg/l	TOTAL PO <sub>4</sub> mg/l	CHLORO PHYLL mg/m <sup>3</sup> a
Whidden	1	17	8.40	37.6	35	28.0	15.30	5.37	0	0	50	.15	.01	1.07	.01	.07	0
	2	18	8.00	32.0	15	22.4	12.10	1.65	0	300	20	.14	.01	.99	.01	.01	0
	3	18	7.80	28.6	15	20.8	15.45	3.00	0	200	10	.14	.01	1.01	.02	.05	0
Mullock	1	16	7.30	23.8	40	13.6	8.71	.81	700	200	10	.12	.01	.20	.50	.76	0
	2	17	7.40	13.3	25	21.2	7.90	.77	0	300	10	.11	.01	.20	.02	.07	0
	3	18	7.30	4.8	20	11.2	7.05	1.65	0	300	20	.07	.01	.20	.01	.03	0

Table 2 - Water quality data for sample run on February 15 - 17. For a discussion of these results, see text.

Table 3 : Dissolved oxygen values expressed as percent saturation for purposes of comparison (February 15 - 17). \* indicates no sample taken.

Creek	Station	Water (°C) Temperature	Salinity ‰	Dissolved Oxygen (mg/l)	Percent Saturation
Bowlees	1	16	34.0	5.9	70
	2	16	7.3	7.2	76
	3	16	3.2	9.3	83
Whitaker	1	18	22.4	6.4	85
	2	18	10.5	4.7	56
	3	18	2.8	12.2	130
Catfish	1	19	27.7	*	*
	2	21	26.3	*	*
	3	18	3.5	6.0	65
North	1	17	32.1	*	*
	2	20	25.0	8.7	94
	3	19	9.4	9.3	106
South	1	19	31.5	3.8	49
	2	20	12.3	7.1	72
	3	19	8.0	4.2	47
Alligator (Sarasota)	1	19	10.8	18.2	207
	2	19	4.8	11.2	124
	3	20	3.4	6.1	68
Alligator (Charlotte)	1	19	31.1	7.0	90
	2	22	9.9	7.1	86
	3	19	3.8	6.6	72
Coral	1	15	34.1	8.1	98
	2	18	41.2	8.5	113
	3	15	29.7	6.5	76
Whidden	1	17	37.6	15.3	190
	2	18	32.0	12.1	154
	3	18	28.6	15.5	192
Mullock	1	16	23.8	8.7	101
	2	17	13.3	7.9	88
	3	18	4.8	7.1	77

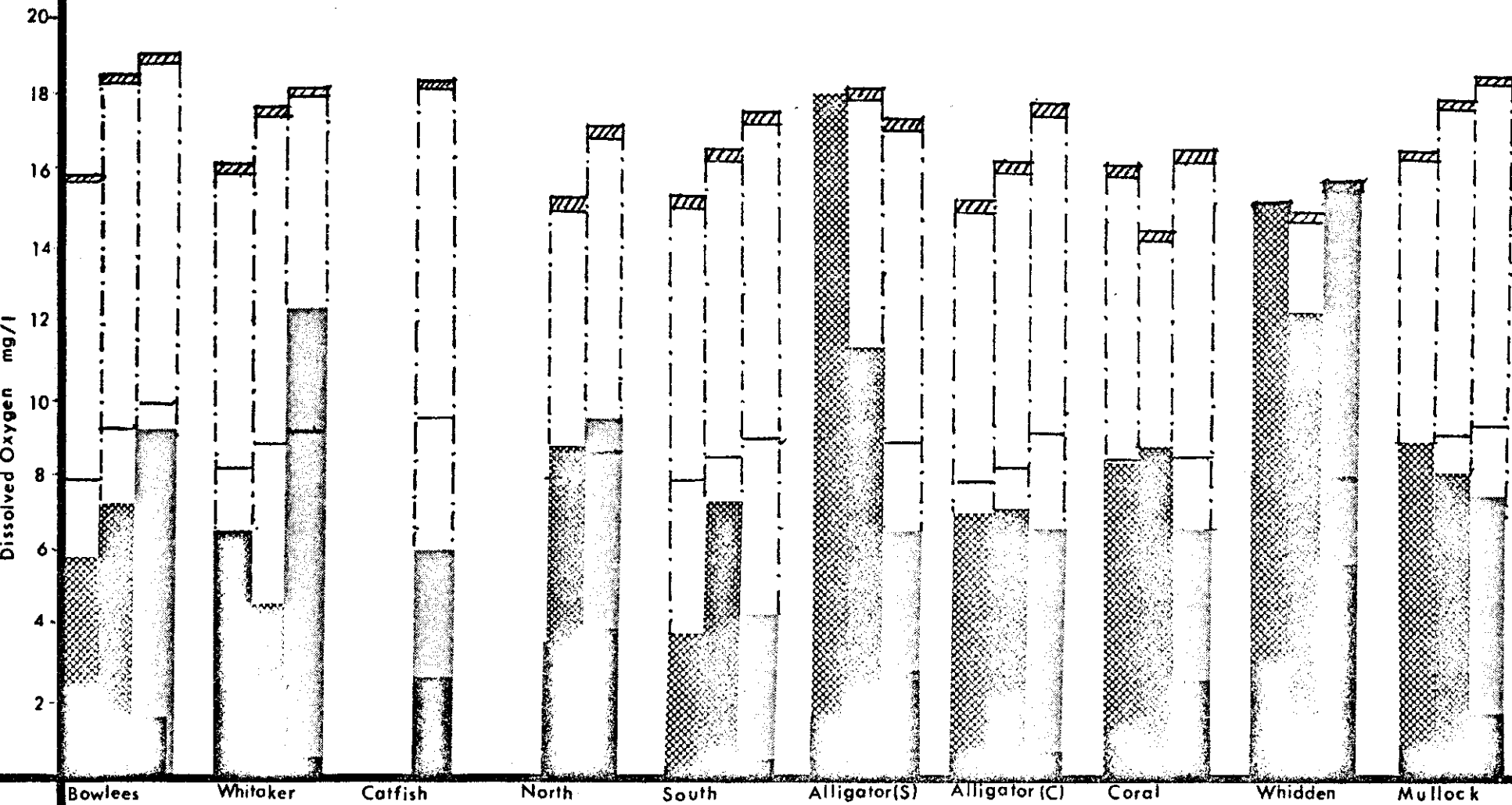


Fig. 21 : Graph of Dissolved oxygen values for ten tidal creeks. Heavily shaded bars show BOD. 100% saturation is shown by a single horizontal line; 200% saturation by a double line. (Data from February 15 - 17 sample run.)

Table 4 : MPN values for fecal coliform and fecal streptococcus bacteria. FC/FS ratio is indicative of the source of contamination. See text for details and discussion. (Data from February 15 - 17 sampling.)

BACTERIOLOGICAL DATA: FECAL COLIFORM: FECAL STREP RATIO				
<u>Creek</u>	<u>Station</u>	<u>Fecal Coliform</u> MPN/100ml	<u>Fecal Streptococcus</u> MPN/100 ml	<u>FC/FS</u>
Bowlees	1	100	300	0.3
	2	300	150	2.0
	3	0	340	0
Whitaker	1	400	10	40.0
	2	0	1300	0
	3	0	60	0
Catfish	1	200	200	1.0
	2	200	200	1.0
	3	400	400	1.0
North	1	100	100	1.0
	2	700	100	7.0
	3	300	280	1.1
South	1	100	30	3.3
	2	100	130	0.8
	3	600	60	10.0
Alligator (Sarasota)	1	0	100	0
	2	100	170	0.6
	3	3300	60	55.0
Alligator (Charlotte)	1	100	200	0.5
	2	100	290	0.3
	3	600	90	0.7
Coral	1	200	10	20.0
	2	7000	10	700.0
	3	0	30	0
Whidden	1	0	50	0
	2	300	20	15.0
	3	200	10	20.0
Mullock	1	200	10	20.0
	2	300	10	30.0
	3	300	120	2.5

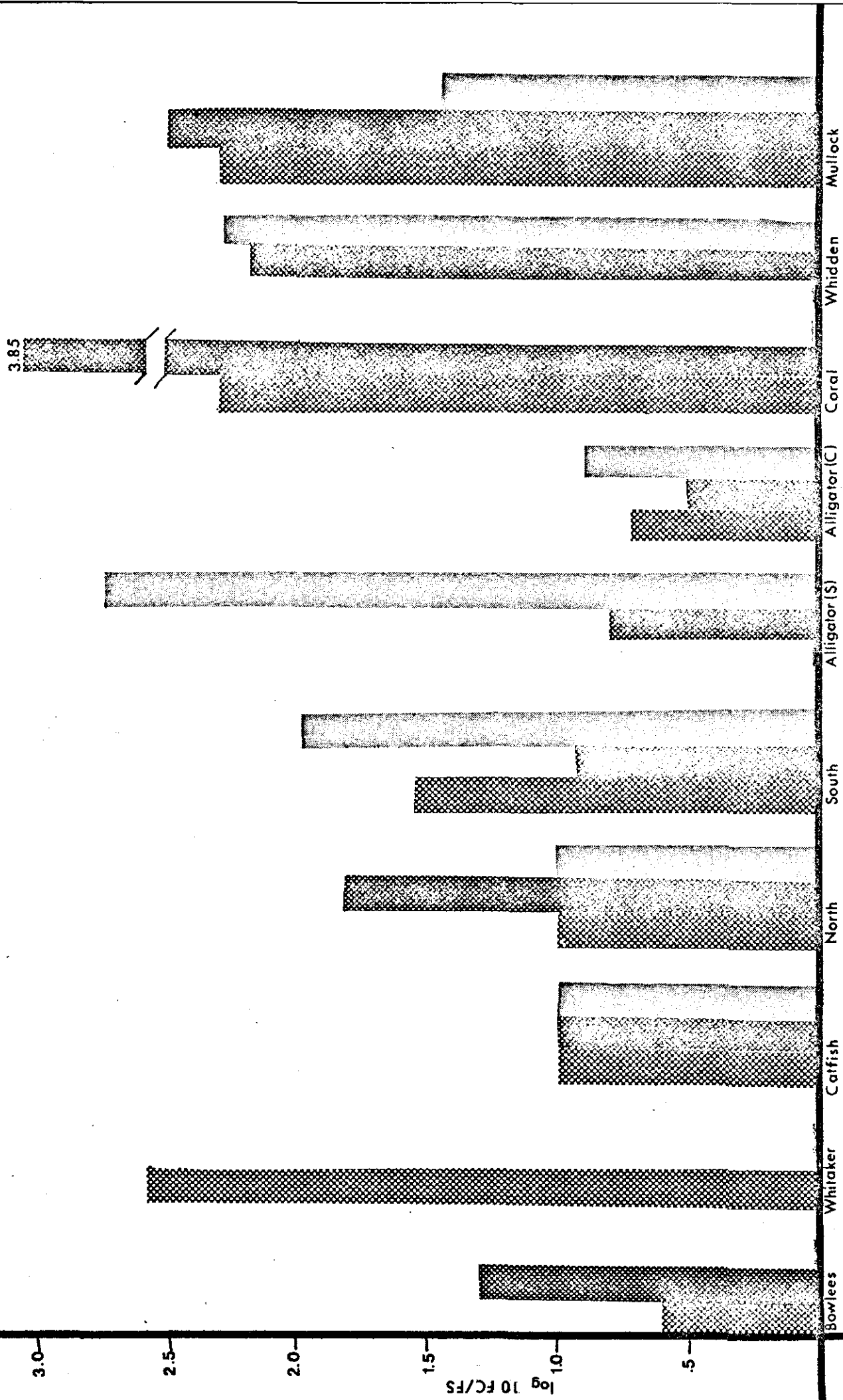


Fig. 22 : Graph showing FC/FS ratios expressed as  $\log_{10} FC/FS$ . For a discussion of these results see text. (Data from February 15 - 17 sample run).

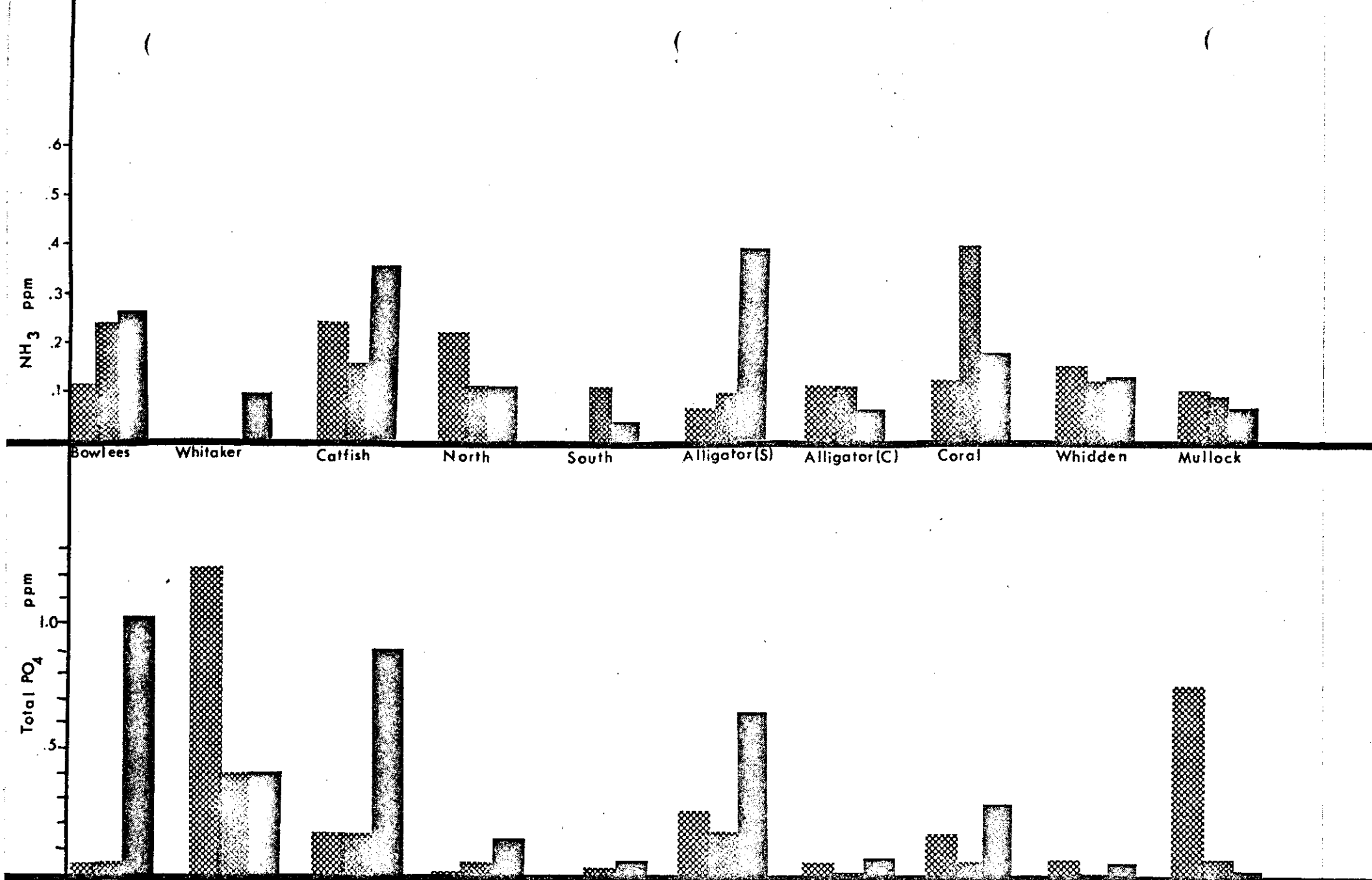


Fig. 23 : Ammonia values (mg/l NH<sub>3</sub>-N) for ten study creeks. No values were available for Stations 1 and 2 on Whitaker Bayou due to interference with the determination. For a discussion of the results, see text.

Fig. 24 : Total PO<sub>4</sub> (mg/l) for ten study creeks. See text for discussion.

### Bowlees Creek

Bowlees Creek is the northernmost of the creeks in the study, and is located in Manatee County. In its upper reaches, the creek originates near Samoset and flows south through agricultural land, crossing US 301 just south of Saunder's Road. Just west of 301, the creek is dammed, creating a small lake. From this lake to the boundaries of the Sarasota Bay Country Club, the creek flows through an area of residential development. At the western end of the golf course a weir has been constructed, preventing the upstream penetration of salt water. The creek flows under US 41 and empties into Sarasota Bay. Also included within this drainage basin are the Sarasota/Bradenton Airport and a large marina at US 41. Construction is currently being carried out on US 41 where it crosses Bowlees Creek.

Sample stations for measurement of water quality are indicated in Figure 25: results are shown in Table 2 . These results show that the concentration of nitrates and nitrites is high in relation to values found on other creeks, although falling below values recommended by the EPA. The relatively high concentrations are probably due to runoff from the golf course and the residential area. Values obtained for ammonia were also high (Fig 23 ), and exceeded EPA recommendation at all three stations. Since ammonia is often used as an indicator of pollution from human wastes, and Bowlees Creek drains a residential area, this is not surprising.

Fecal coliform values for all three stations were within EPA criteria. The ratio of fecal coliforms to fecal streptococcus was generally quite low, ranging from 0.0 to 2.0, indicating that contamination is from both animal and human sources (Fig22 ).

BOD ranged from 1.73 to 2.43 mg/l, and was highest at the mouth of the creek. This could be due to the suspended solids in the creek as a result of bridge construction at US 41. Suspended solids were high at station 3, although a large portion was due to living plant matter, and therefore increased rather than decreased DO levels (Fig 21 ).

For further information on water quality in Bowlees Creek, see Manatee County Pollution Control Reports (Stations WSB-20, and WN-14).

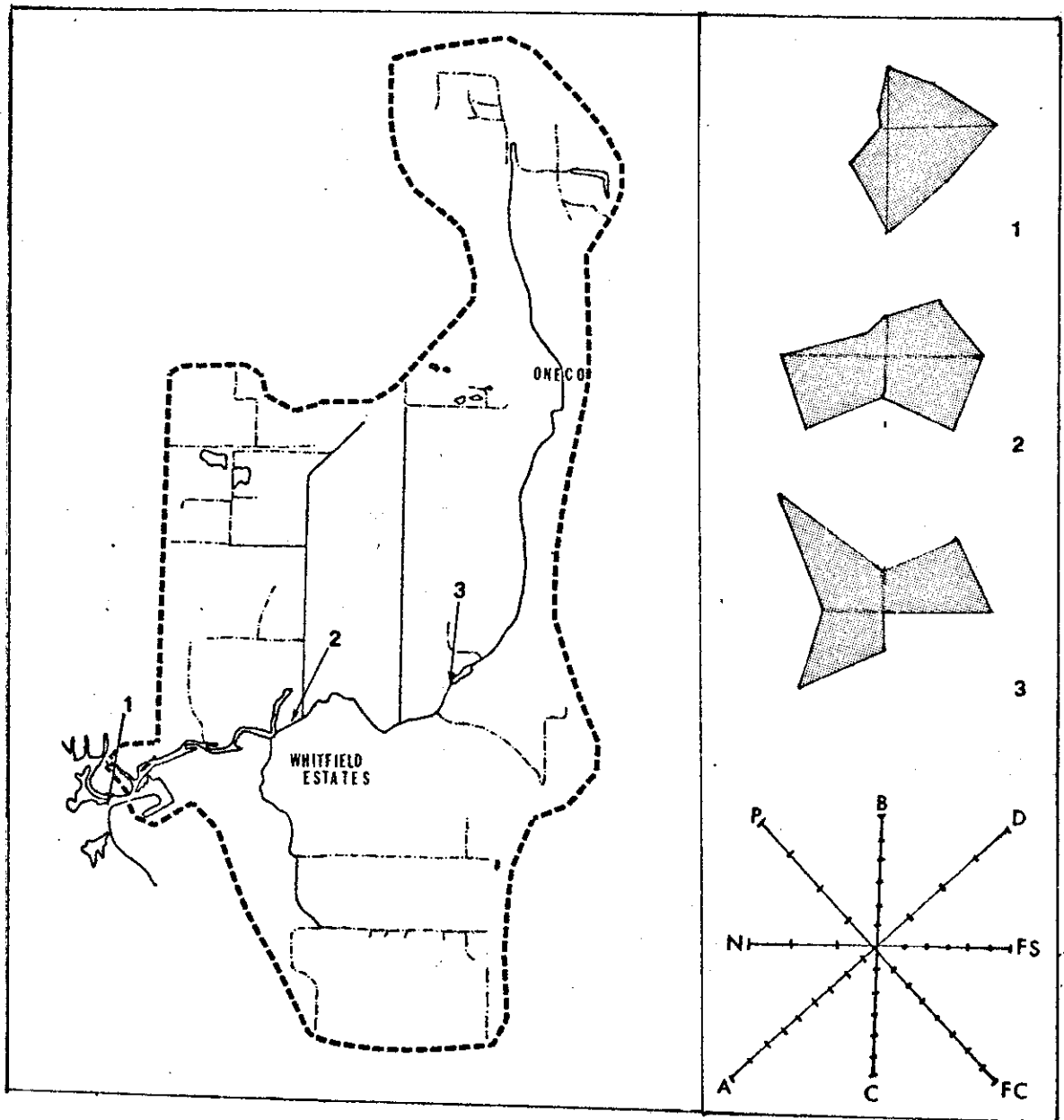


Fig. 25 : Map showing drainage basin and sample station locations for Bowlees Creek. Polygonal graphs at right are for comparative purposes. A "▲" indicates package treatment plant; Δ indicates collection system treatment plant.

was a EPA 4 either North or Middle Creek  
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## Whitaker Bayou

Draining the northern part of the City of Sarasota, Whitaker Bayou is the most "urbanized" of the creeks studied. Because of the flat topography and the large amount of paved area, the delineation of the drainage basin was quite difficult. This difficulty was compounded by the connection formed by Whitaker Bayou with an extensive drainage system, whose main artery is the Pearce Canal. The general flow of water in this system appears to be to the north into the Braden River. Consequently, this area was excluded from the drainage basin.

The northern branch of Whitaker Bayou is joined to the Pearce Canal just north of the Manatee/Sarasota County Line. From there it flows south through the Sarasota Kennel Club's parking lot, then through the city, under US 41, emptying into Sarasota Bay north of Payne Terminal. Another branch consists of an extensive series of drainage ditches which drain a golf course, a number of residential areas, and agricultural land east of US 301 in the area of 27th street.

This creek, in its lower reaches is subject to a great deal of stress, from both urban runoff and discharge of treated sewage from Sarasota's Sewage Disposal Plant.

Sample station locations are indicated in Figure 26 . Stations 1 and 2 are located within the City. The first was at the mouth of the creek just below the Sarasota sewage treatment plant outfall; the second, where the creek passes under 27th Street. The third sample station was located in the Tri Par Trailer Park just upstream of the package treatment plant.

As can be seen from the results (Table 2), station 2 had the highest recorded nitrate/nitrite value of all the creeks. This is probably in conjunction with high ammonia values. However, due to inter-

ference with the test at stations 1 and 2, ammonia was not determined. This is unfortunate because the effect of the Sarasota wastewater treatment plant on levels of ammonia was not determined. At the upstream station, relatively low values for both ammonia and nitrate/nitrite were obtained. Numbers of fecal coliform and total coliform bacteria varied greatly between stations of the creek (Table 4 ; Figure 22 ). However, the FC/FS ratio at station 1 is quite interesting. As has already been mentioned, a ratio greater than 4.0 indicates contamination from human sources. A value as high as 40.0 is quite unusual in the tidal creeks. It could be due to the presence of live-aboard boats in this section of the bayou and to the proximity of the sample station to the treatment plant's outfall.

Initial dissolved oxygen values (Fig. 21 : Table 3 ) were all above minimum State standards, ranging from 4.7 to 12.2 mg/l. Stations 1 and 2, however, had relatively high BOD values, causing the DO to fall below State standards at the end of the five day incubation period. In fact, the biochemical oxygen demand at the mouth of Whitaker Bayou was so high that there was no dissolved oxygen remaining after five days, making an accurate determination of the BOD impossible without further testing. At station 3, the situation was quite different. The DO was high, 12.2 mg/l, and the BOD was low (0.44 mg/l). The high DO content is probably due to the large amounts of submerged vascular plants found at this station (Elodea sp.).

Originally, Whitaker Bayou was probably much like North Creek, but the polygonal graphs of the water quality (Fig. 26 and Fig. 27 ) no longer resemble one another. Notice, however, a similarity between the graphs of station 3 on Whitaker Bayou and station 3 on Bowlees Creek,

both located on segments of their respective creeks which receive runoff from residential development.

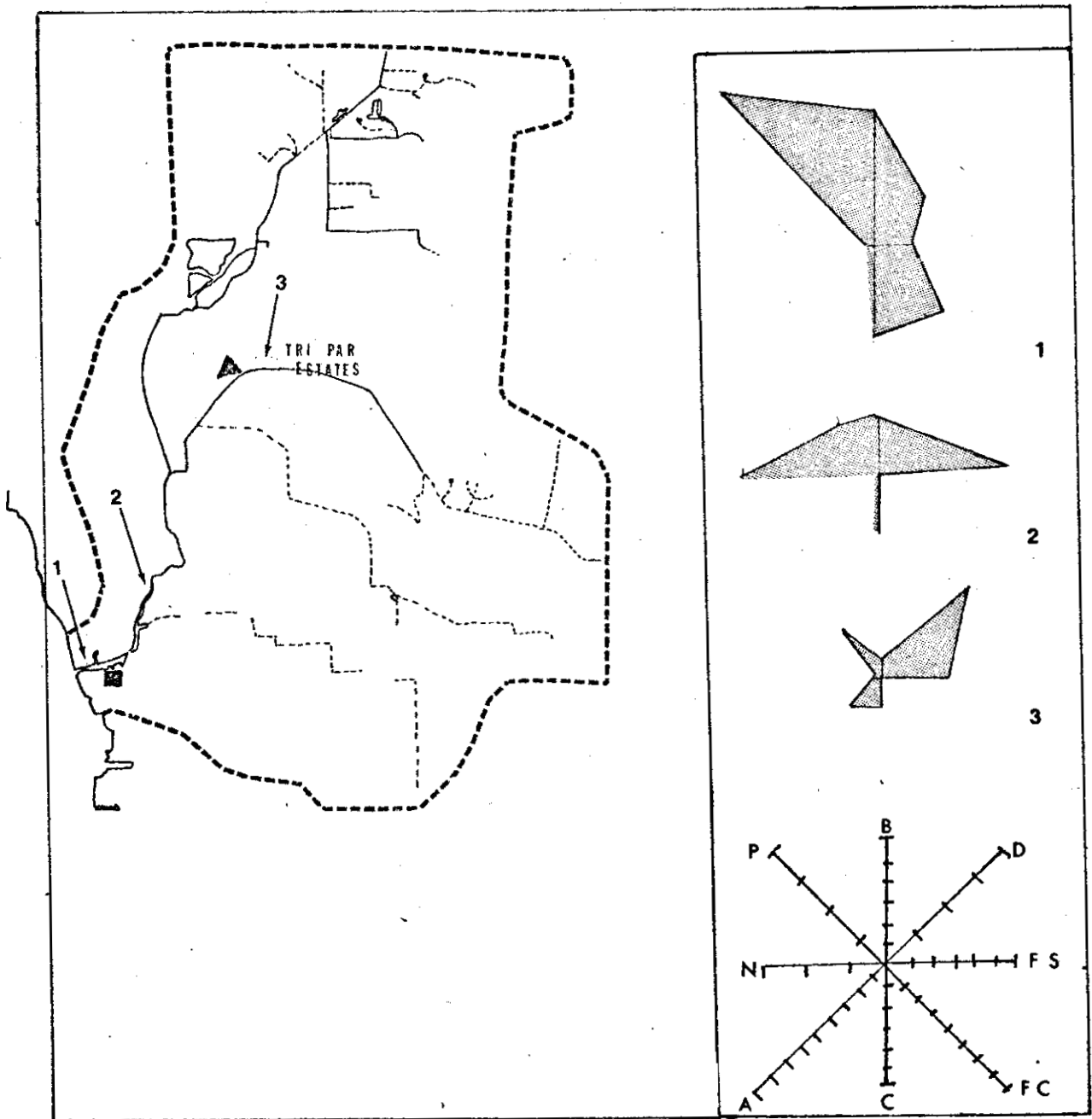


Fig. 26 : Map showing the drainage basin and sample station locations for Whitaker Bayou. Polygonal graphs at the right of the map are for comparative purposes (see text). A "▲" indicates a package treatment plant; △ indicates collection system treatment plant.

## Catfish and North Creeks

Catfish and North Creeks form a small drainage basin just east of Vamo and south of SR 72. Catfish Creek has its headwaters in a golf course just off of SR 72 (TWP 375 R18E Sect 13). Thence it flows south through unimproved pasture and pine flatwoods until it reaches US 41 and Vamo. There it receives runoff from two trailer parks (with package plant aeration settling ponds located near the banks of the creek) and a residential area before joining with North Creek prior to emptying into Little Sarasota Bay. Much of the creek upstream from US 41 is just a network of seasonally wet drainage ditches (Fig. 27 ).

The North Creek basin lies immediately to the south of the Catfish Creek basin. The headwaters of North Creek are approximately 2.5 miles inland from Little Sarasota Bay (TWP 38S; R18E; Sect. 2). The creek flows west through pine flatwoods, then through a small amount of development just east of US 41. It joins Catfish Creek approximately  $\frac{1}{2}$  mile from the bay.

Sample station locations for Catfish Creek are shown on the map in Figure 27 . Station 1 is located upstream of the confluence of Catfish Creek with North Creek. Station 2 is located downstream of Vamo, and station 3 is located at US 41, downstream from two trailer parks with "totally retained" package plants. Sample station 1 on North Creek was located at the mouth of the creek, downstream of the confluence of Catfish and North Creeks. Station 2 was located at US 41. Station 3 was located at the junction of the creek with a major drainage ditch.

All three stations on Catfish had relatively high ammonia levels (Fig. 23 ), with station 3 having the highest value (0.35 ppm). This

could be due to horizontal seepage from the settling ponds in the adjacent trailer parks. Ammonia values for station 2 and 3 on North Creek were somewhat lower than the values obtained on Catfish Creek. The ammonia value for station 1 was comparable to values obtained at Catfish station 1. Nitrate/nitrite values were low (0.01 - 0.02) at all stations with the exception of Catfish station 3 (0.58 ppm). This could be due to runoff from the trailer parks combined with seepage from the settling ponds.

Fecal coliform counts for all stations were within State standards for Class III waters, ranging from 200/100 ml to 400/100 ml. Total coliform counts were variable, ranging from 200, to 7900/100 ml (Table 4 ). The FC/FS ratio for all stations, with the exception of station 2 on North Creek, equalled 1.0, but at station 2 the FC/FS ratio was 7.0, indicating the presence of human contamination. Since this sample station is immediately downstream from the residential development at US 41 the high FC/FS ratio could be due to septic tank seepage.

Dissolved oxygen and BOD were sampled at only three of the six stations. BOD values were relatively high, ranging from 2.63 to 3.95 mg/l, and caused DO values to fall below the minimum State standard of 4.0 mg/l at station 3 on Catfish Creek at the end of the five day incubation period.

For additional information on the North Creek/Catfish Creek drainage basin, see: Sauers (1976); Evans (1976); Tropical Bioindustries (1974); and U. S. Army Corps of Engineers (Flood Plain Information 1973).

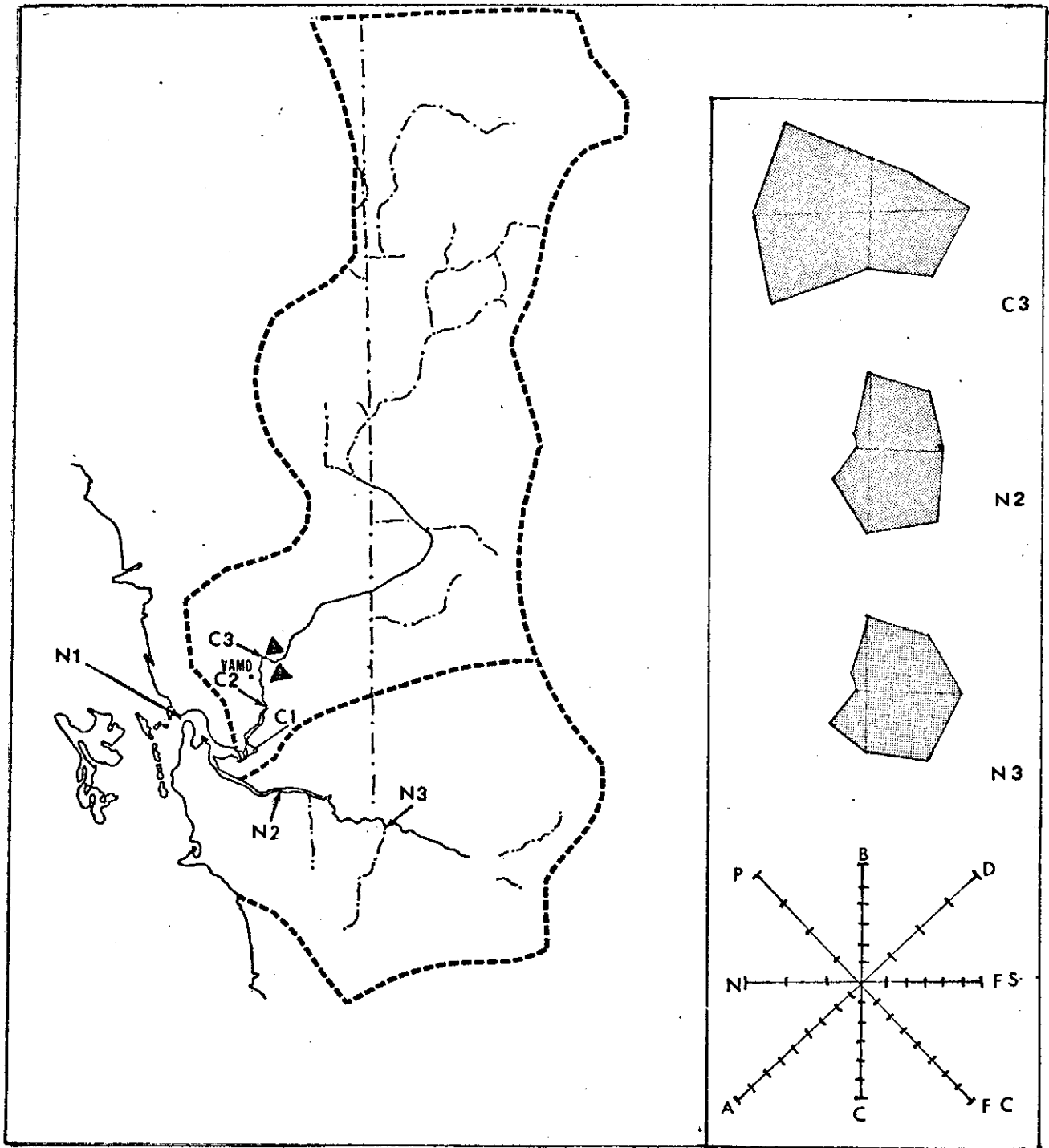


Fig. 27 : Map showing drainage basins for Catfish (North) and North Creek. Sample station locations are marked. Graphs shown are for station #3 on Catfish; and stations 2 and 3 on North. Graphs for North Creek may be used as a basis for comparison (For discussion see text). A "▲" indicates package treatment plants; △ indicates collection system treatment plants.

## South Creek

South Creek is located immediately south of the North/Catfish Creek basin. Its drainage basin is quite extensive and forms the southern and eastern boundary of the North/Catfish basin. At its headwaters, South Creek is a large network of ditches which extend as far north as SR 72 and as far east as the Cow Pen Slough Drainage Basin. The creek flows south from SR 72 through unimproved pasture and pine flatwoods until it enters Oscar Scherer State Park. Just inside the eastern boundaries of the park a weir has been placed, preventing upstream penetration of salt water. The creek flows under US 41 where it passes through an area of dredging and residential development before emptying into Dryman Bay.

Sample station locations are shown in Figure 28 . Station 1 was located downstream of US 41; station 2 and 3 were within the park. Station 2 was located downstream of the small boat launch and 3 was at the footbridge just below the dam. Results of the water quality analyses are in Table 2 .

Nutrient analysis was carried out for only stations 2 and 3 within the park. Both stations had very low ammonia and nitrate/nitrite levels. This was expected since there is no intensive agricultural or residential development upstream of these stations. Bacteriological tests (Fig. 22 : Table 4 ) show that fecal coliform numbers at stations 1 and 2 were within State standards. At station 3 the fecal coliform count was 600/100 ml, and the FC/FS ratio was 10.0 indicating contamination from human sources. This could be due to the close proximity of a park recreation area with associated septic tank facilities.

Dissolved oxygen levels were low, ranging from 3.79 to 7.05 mg/l (Fig. 21 ; Table 3 ). Percent saturation values for stations 1 and 3 were the lowest obtained in the entire study area. Extremely low BOD values were obtained, none of which exceeded 1.0 mg/l. One possible explanation for this is that vegetation on the banks of the creek formed a canopy which prevented sunlight from penetrating to the water, thereby reducing photosynthetic activity.

→ In other studies of South Creek the DO levels were even lower (Lugo, 1970).

For additional information on the South Creek drainage basin see: Lugo, et. al. (1970); Stubensky (1974); Lincer (1975); and U. S. Army Corps of Engineers (Flood Plain Information, 1973).

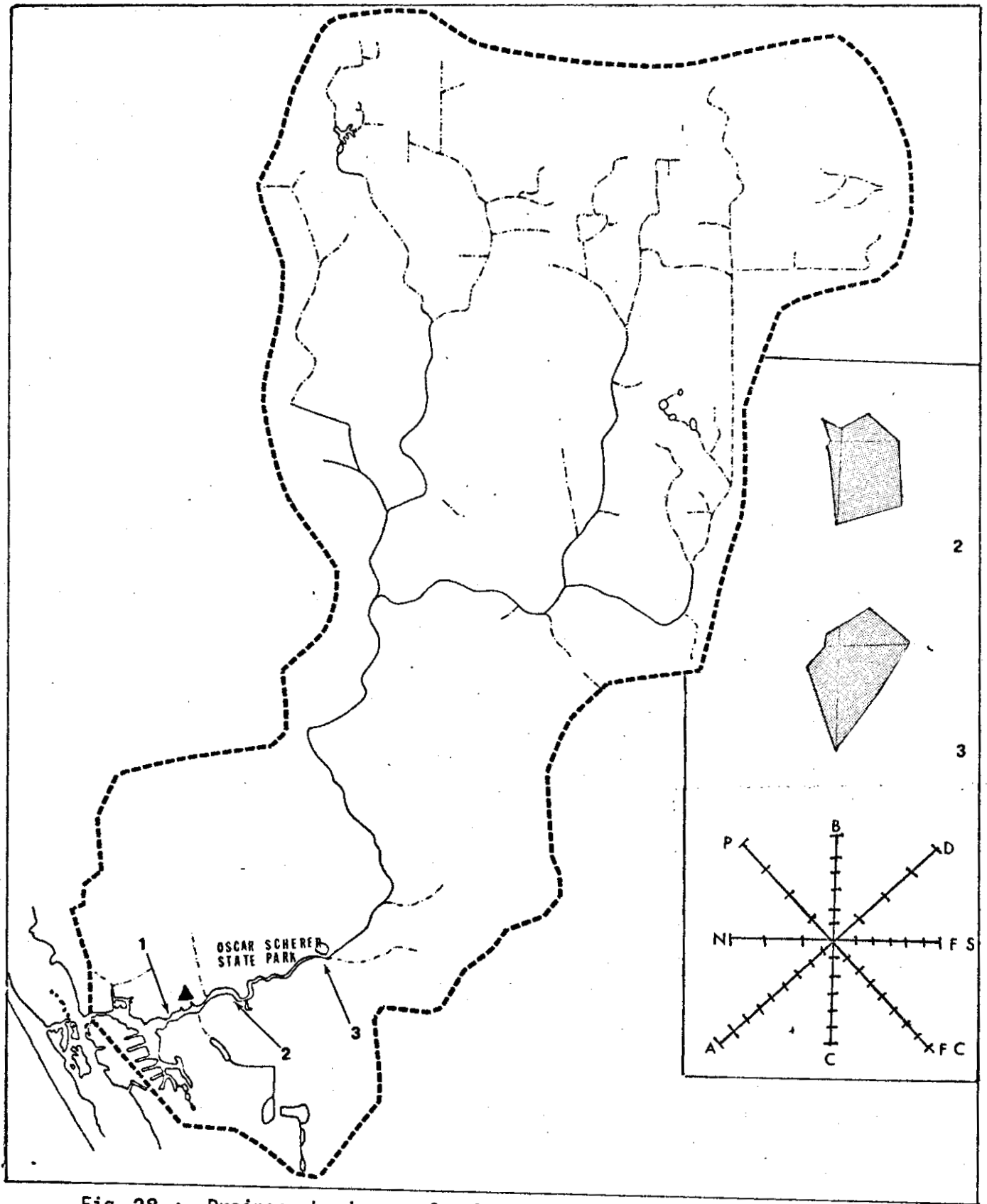


Fig. 28 : Drainage basin map for South Creek showing sample station locations. Graphs at right are for comparative purposes. (Data from Station #1 was not graphed.) A "▲" indicates package treatment plants; ▲ indicates collection system treatment plant.

### Alligator Creek (Sarasota County)

Alligator Creek is located in South Venice (TWP 39; R19E) in Sarasota County. Its drainage basin extends east past the Venice East Subdivision and south to the Township Line. The northern limit lies along Center Road. The headwaters of the creek lie in Section 24 just south of Center Road. It flows southwest through a large tract of land, owned by the Gulfstream Land and Development Corporation, which is the location of the proposed Jacaranda West Planned Unit Development. It enters Section 27, bounded on the south by the Venice East Subdivision and on the north by the Jacaranda West development.

The Jacaranda West development is bounded on the west by the South Venice and Venice Gardens Subdivisions, both of which are in the Alligator Creek drainage basin. West of the Venice East Subdivision, the south bank of the creek is bordered by unimproved pasture until the creek flows through the Venice Groves Subdivision just east of US 41. Downstream of US 41, Alligator Creek flows through the middle of the South Venice Subdivision until it empties into the north end of Lemon Bay.

Sample station locations are shown on the map in Figure 29. Station 1 was located at the Shamrock Drive bridge, approximately  $\frac{1}{2}$  mile from the mouth of the creek. Station 2 was located at US 41, and station 3 was located just downstream from the Jacaranda West PUD and the Venice East Subdivision. Results are in Table 2.

Ammonia and nitrate/nitrite values at station 1 were low (Fig. 23 ). At station 2 the value obtained for ammonia was slightly higher than at station 1, though less than the average value of 0.16 ppm calculated for

all the creeks. At station 3, however, the ammonia value was the highest found on any creek, equalled only by Coral Creek (Fig. 32 ). Since this station is immediately downstream of the Jacaranda West and the Venice East treatment plants, the high ammonia values suggest that there may be some seepage from the retention ponds. This is supported by a fecal coliform count of 3300/100 ml, yielding an extremely high FC/FS ratio of 55. (Fig. 22 ).

Nitrate/nitrite values were also quite high at station 3 (0.39 ppm). Perhaps this is due to runoff from the golf course combined with seepage from the retention ponds.

The polygonal graphs show a marked similarity between station 3 on Alligator (Fig. 29 ) and station 3 on Catfish Creek (Fig. 27 ). These stations are both located near ~~to~~ secondary package plants, suggesting that a graph of this general shape could be indicative of human contamination.

For additional information on the Alligator Creek (Sarasota) drainage basin, consult Development of Regional Impact Application for Jacaranda West (Gulfstream Land and Development Corporation, 1975).



### Alligator Creek (Charlotte County)

Alligator Creek (Charlotte) has the largest drainage basin of any of the study creeks. The creek has two main forks. The North Fork joins the main channel approximately  $\frac{1}{2}$  mile upstream from where it empties into Charlotte Harbor. It is a natural channel upstream to just west of US 41. This portion of the creek has undergone rapid residential development over the past ten years. Artificial channels from as far north as Charlotte Park presently drain into the North Fork. East of US 41, the North Fork is a man-made canal which drains part of the City of Punta Gorda. It extends east draining agricultural, undeveloped, and some pasture land.

The main channel of Alligator Creek has its headwaters in the C. M. Webb Wildlife Management Area. At its source, it is divided into a South Prong and a North Prong which merge in the center of the loop formed by Jones Loop Road. This area is used mainly as pastureland with a small amount of residential development. The North Prong also receives runoff from the Charlotte Ranchettes Development; while the South Prong drains South Punta Gorda Heights. After the juncture at Jones Loop Road, the creek flows west through agricultural and pasture land to Taylor Road. Downstream of Taylor Road there is a dam which in recent years has begun to leak, allowing salt water to intrude into the freshwater portion of the creek.

From Taylor Road, the land use is chiefly residential until just west of Burnt Store Road (SR 765). Downstream from the Trailer Park at Burnt Store Road the land on both sides of the creek is chiefly undeveloped. It should be noted however, the Punta Gorda Isles, Inc. has filed an Environmental Impact Statement for the development of the tract

of land located between the North and South Forks of Alligator Creek and US 41. This development would involve 1,015 acres including a golf course, 127 multi-family homesites, and 1,452 single family homesites (Environmental Impact Statement). Between 1970 and 1973 approximately 30% of the waterways were dredged. In 1973 all work was stopped.

Sample station locations are shown on the map in Figure 30. Station 1 was located at the mouth of Alligator Creek downstream of the confluence of the North Fork and main channel. Station 2 was located at US 41 and 3 was located at Taylor Road just above the dam. Results from the tests are given in Table 2.

Ammonia values at all stations on the creek were low, ranging from 0.05 to 0.12 ppm (Fig. 23 ). Nitrate/nitrite values were also low at 0.01 ppm. These results are in accordance with the FC/FS ratio which was between 0.3 and 0.7 at all stations, indicating that contamination is due chiefly to animal sources. Dissolved oxygen levels were well above minimum State standards, ranging from 6.6 to 7.1 mg/l. BOD values were low, ranging from 0.68 to 2.15 mg/l. The general shape of the polygonal graphs for Alligator Creek corresponds closely with the shape of the graphs for North and South Creeks.

For further information on water quality in Alligator Creek see: 1) Environmental Impact Statement; Section 15; Punta Gorda Isles (U. S. Army Corps of Engineers, 1976) 2) Finger-Fill Canal Studies; Florida and North Carolina (Hicks, D. B. et. al., 1975); and 3) Phase I of the Water Management Study for West Central Charlotte County (Johnson Engineering, 1976).

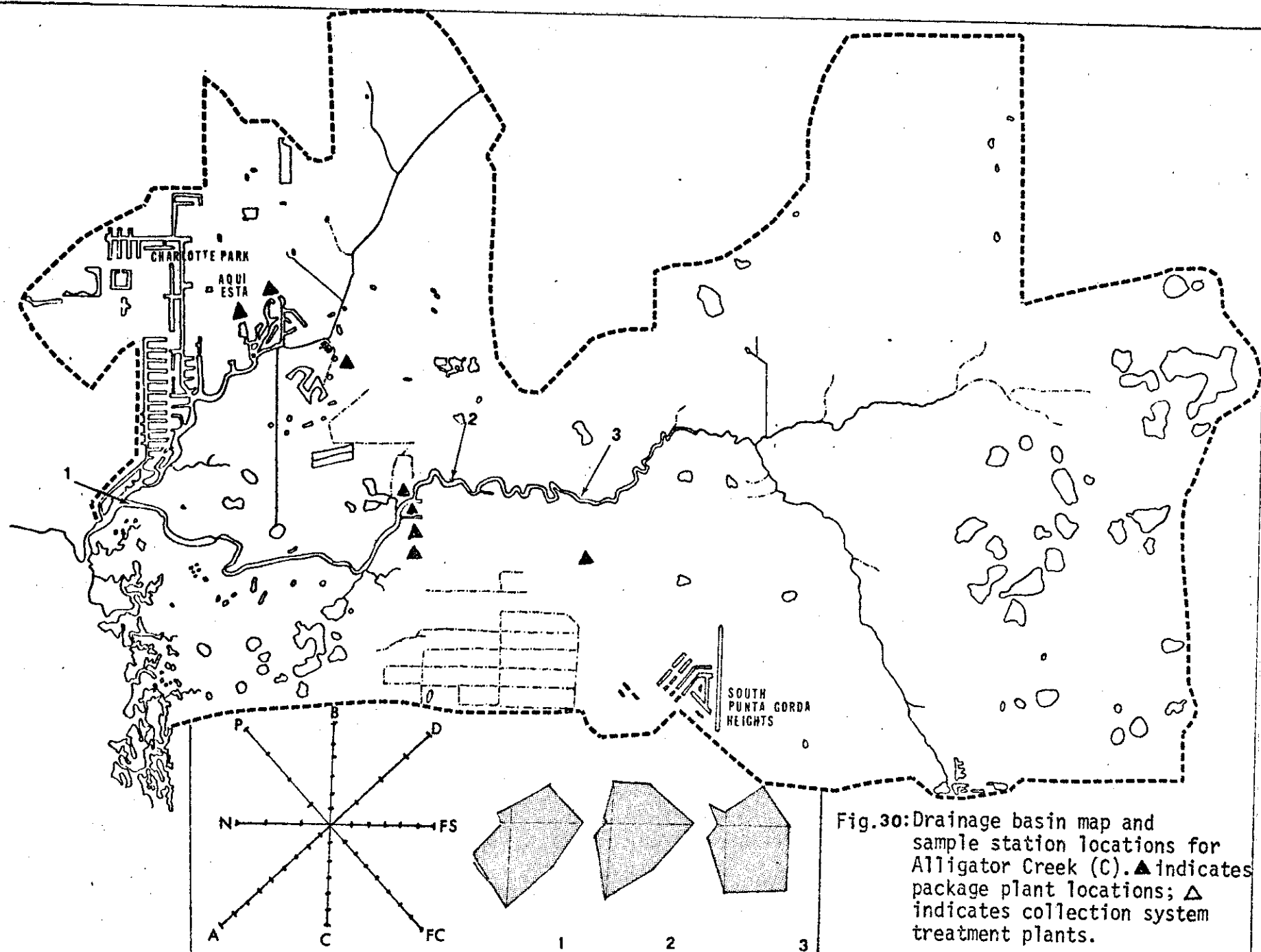


Fig.30:Drainage basin map and sample station locations for Alligator Creek (C).▲indicates package plant locations; △ indicates collection system treatment plants.

### Whidden Creek

Whidden Creek drains part of the southern end of Cape Haze. It is the only creek of the ten studied whose drainage basin consists of totally undeveloped land. The northern boundary of the drainage basin is formed by a dirt service road (Township 41S; Range 21E; Sections 33 and 34) at the southern end of the property owned by General Development Corporation. The topography of the entire south end of the peninsula is extremely flat, making delineation of a drainage basin difficult. The maximum change in elevation over the entire area is five feet, so that during heavy rains drainage basin lines are meaningless.

The creek flows south from the NW corner of Section 10 (TWP 42S; R 21E) through dense mangrove vegetation to its estuarine mouth in Gasparilla Sound. At its mouth is located a large Indian mound known as Mound Key.

Sample station locations are shown in Figure 31, and results of the analyses are in Table 2. The situation on Whidden Creek is quite interesting. It is part of one of the most productive ecosystems in the world, that is, the mangrove swamp. As has been discussed earlier, Whidden Creek may be considered as a basis for comparison with other creeks in this type of ecosystem.

Data from this study show that dissolved oxygen levels were the highest obtained on any of the study creeks. Percent saturation values were extremely high, ranging from 154 - 192% (Table 3). BOD values were also high in relation to values for the other creeks. Since human contamination does not seem possible, the high BOD is probably due to the large amount of <sup>organic</sup> matter from the mangroves. This is supported by the

fact that although dissolved nutrients ( $\text{NO}_2$  and  $\text{NO}_3$ ) levels were low, the total kjeldahl nitrogen was much higher than for most of the other creeks, indicating that the nitrogen is bound up in organic compounds. Suspended solids are also relatively high, giving further support to this idea.

The FC/FS ratio is quite high at stations 2 and 3. As has been stated high coliform counts in areas with oyster bars could be due to a high population of warm blooded animals (Presnell, 1971), and Whidden Creek has a large population of birds. Normally, high fecal coliform counts are considered indicative of poor water quality because of their utility in showing the presence of human contamination. In this case, however, the high values are indicative of a large population of animals with accompanying biological activity (and productivity). The difficulty in defining high water quality becomes apparent here.

It should be noted that the area immediately to the north of the Whidden Creek drainage basin is platted for development by General Development Corporation. Further observation and testing on Whidden Creek should be carried out to provide baseline information.

For additional information on the development it may be obtained in South Gulf Cove Redesign (General Development Corporation, 1975).

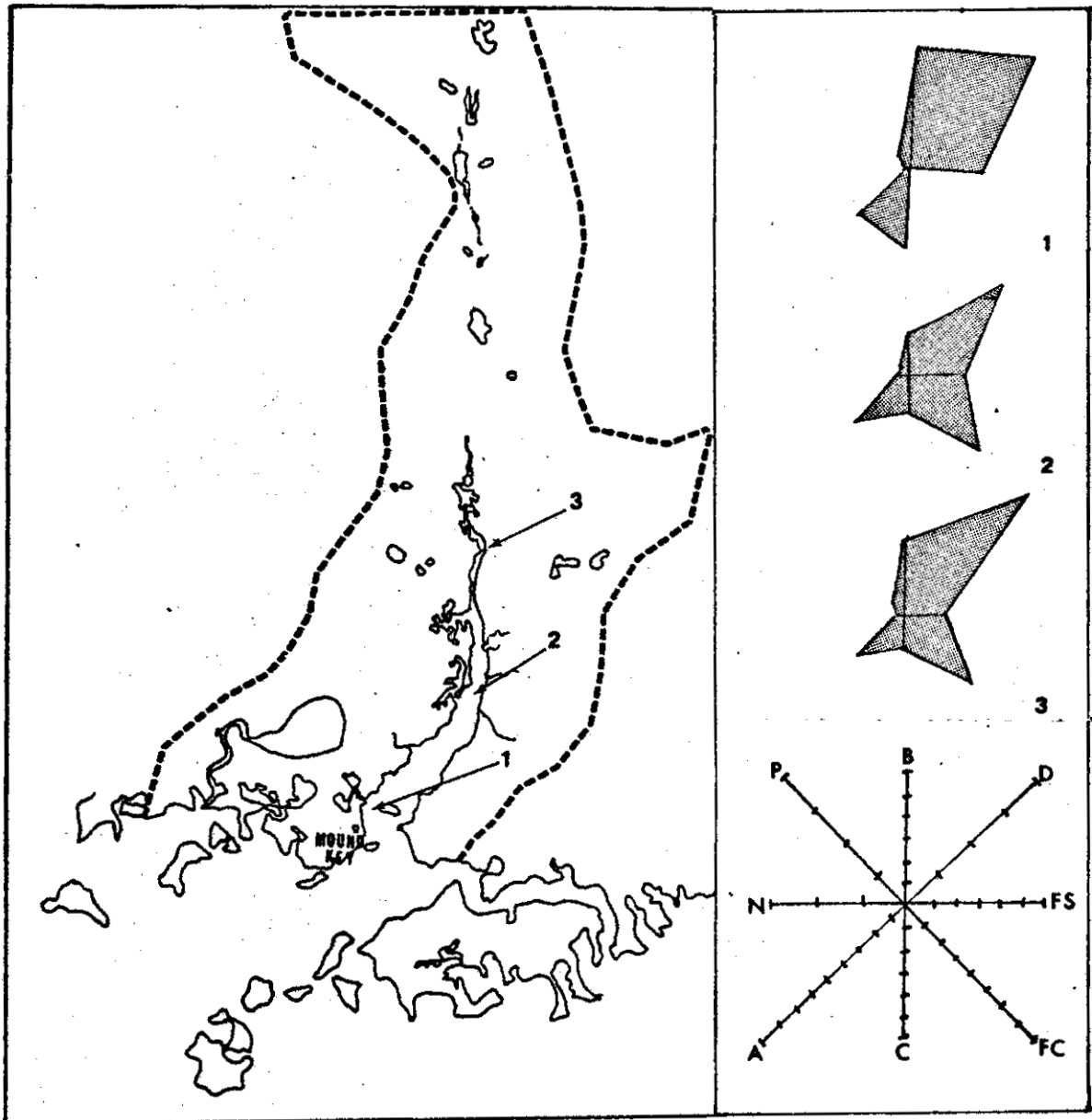


Fig. 31 : Drainage basin map and sample station locations for Whidden Creek. Graphs at right may be used as a basis for comparison (for discussion see text). "▲" indicates package treatment plant; △ indicates collection system treatment plant.

## Coral Creek

Coral Creek is wide, shallow creek which flows through an area of mangrove and salt marsh vegetation. It has two main branches. The East Branch has its headwaters in Township 41S, Range 22E, Section 31 just east of the Seaboard Coastline Railroad. It flows southwest through an area of land which has been cleared, but is presently undeveloped until it joins the West Branch just north of Placida. Thence, it flows southeast, emptying into Gasparilla Sound at Placida.

The West Branch of Coral Creek represents a unique situation. Its natural drainage basin has been changed by the development of Rotunda West. Presently, only a small part of Rotunda West is fully developed. However, drainage canals have been dredged for the entire area, changing the drainage patterns of the West Branch of Coral Creek and Buck Creek. Because of the construction of a circular ditch (Fig. 32) water which previously drained into Buck and Coral Creeks now flows into the ditch.

The natural headwaters of the West branch are within the Rotunda West development (TWP 41S; R21E; Sect. 18). The creek flows south through Rotunda West to a land dam located in Township 41S; Range 20E; Section 35. Flow through (over) this dam is slow. Downstream of the dam there is residential development on the west bank of the creek. Some dredge and fill operations have been carried out on the spit of land between the two branches of the creek.

Sample station locations are shown on the map in Figure 32. Station 1 was located at the mouth of the creek at SR 771; station 3 was just downstream of the dam on the West Branch near the single family development; and station 2 was at the headwaters of the East Branch.

Results of the water analyses (Table 2 ) show that nitrate/nitrite levels were low at all three stations. Ammonia values for station 1 and 3 were comparable to values found on the other creeks. However, at station 2, the ammonia values were the highest obtained on any creek. This could be due to the lack of tidal flushing combined with the highly concentrated fecal wastes from a large population of birds.

Comparison of the polygonal graphs (Fig. 32) for this creek shows that the water in the two branches is of a different nature. The graph showing data from station 2 in the East Branch is similar in shape to those of stations 2 and 3 on Whidden Creek. Since both Whidden Creek and the East Branch of Coral Creek are undisturbed mangrove systems, this is not surprising. As described for Whidden Creek, the high productivity of this system, combined with a large population of birds and aquatic life, causes DO, fecal coliform, and ammonia levels to be high.

The graph showing data from station 3 on the West Branch is somewhat different. This could be due to the disturbed nature of this branch. Ammonia concentration and bacterial counts were lower than for the East Branch station, while dissolved nutrients were higher. This could be due to runoff of fertilizers from the homes on the West Bank.

Salinity was unusually high at station 2 (41.2%). A possible reason for this is that tidal water reaches this area only periodically; the tidal water tends to collect, due possibly to a slight depressom in elevation. Subsequent evaporation would then create hypersaline conditions.

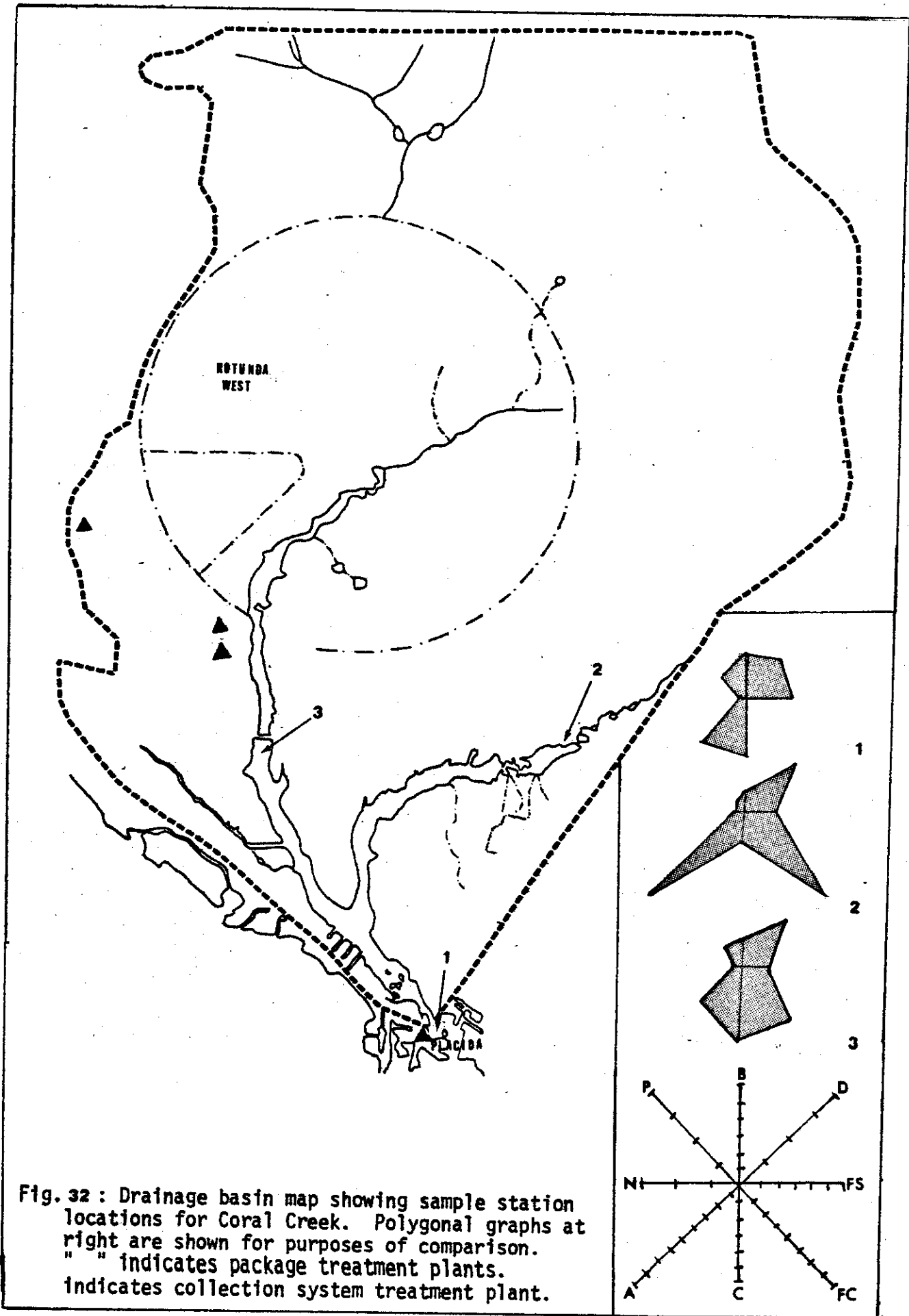


Fig. 32 : Drainage basin map showing sample station locations for Coral Creek. Polygonal graphs at right are shown for purposes of comparison. " " indicates package treatment plants. indicates collection system treatment plant.

### Mullock Creek

Mullock Creek is the southernmost of the creeks studied. It is located approximately ten miles south of Fort Myers, (T46S; R24-5E). Its drainage basin extends east from Estero Bay to the San Carlos Park development. It is bounded on the south by the Estero River drainage basin. The northern portion of its basin has been drastically altered by the construction of the Ten Mile Canal. The Canal extends north to the City of Ft. Myers, including the Ft. Myers airport. It also drains the Six Mile Cypress. This adds approximately 53 square miles to the drainage basin of Mullock Creek (Johnson Engineering, 1972), most of which is contained within the Six Mile Cypress.

Like many of the creeks studied, Mullock Creek, in its upper reaches, is a network of man-made canals which flow through a number of residential developments around US 41. Downstream of US 41 the creek receives runoff from a number of trailer parks and from some low density residential development before entering an area of dense mangrove vegetation. Approximately one mile from its mouth on Estero Bay the creek is joined by the Ten Mile Canal.

Sample station locations are shown on the map in Figure 33. Station 1 was located at the mouth of the creek; 2 was located where the Ten Mile Canal empties into the creek; 3 was located just west of US 41 where the creek becomes unnavigable.

The shapes of the polygonal graphs for Mullock Creek indicate that the general nature of the water quality in its upper reaches, is similar to that of North Creek. Toward the mouth, below the junction with the Ten Mile Canal, the water quality changes. The FC/FS ratio and the concentration of ammonia increases, indicating possible human con-

tamination. However, it is accompanied by an increase in dissolved oxygen. Since this segment of Mullock Creek is mainly undeveloped mangrove swamp, the situation appears to be similar to that found on Whidden Creek.

Unusually high phosphate levels occurred at station 1. There is no apparent explanation for this.

For a description of the Ten Mile drainage basin, see the report to the Lee County Board of County Commissioners: Water Management in Lee County. (Johnson Engineering, 1972).

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In addition to the references cited for specific creeks, the Sarasota County Department of Pollution Control issues Monthly Reports on air and water quality for stations within the County. These reports include water quality information for Whitaker Bayou (Station #549, 553, 558); Catfish Creek (Station #638, 639); North Creek (Station #587); South Creek (Station #588, 615); and Alligator Creek (Station #620, 621, 622, 619).

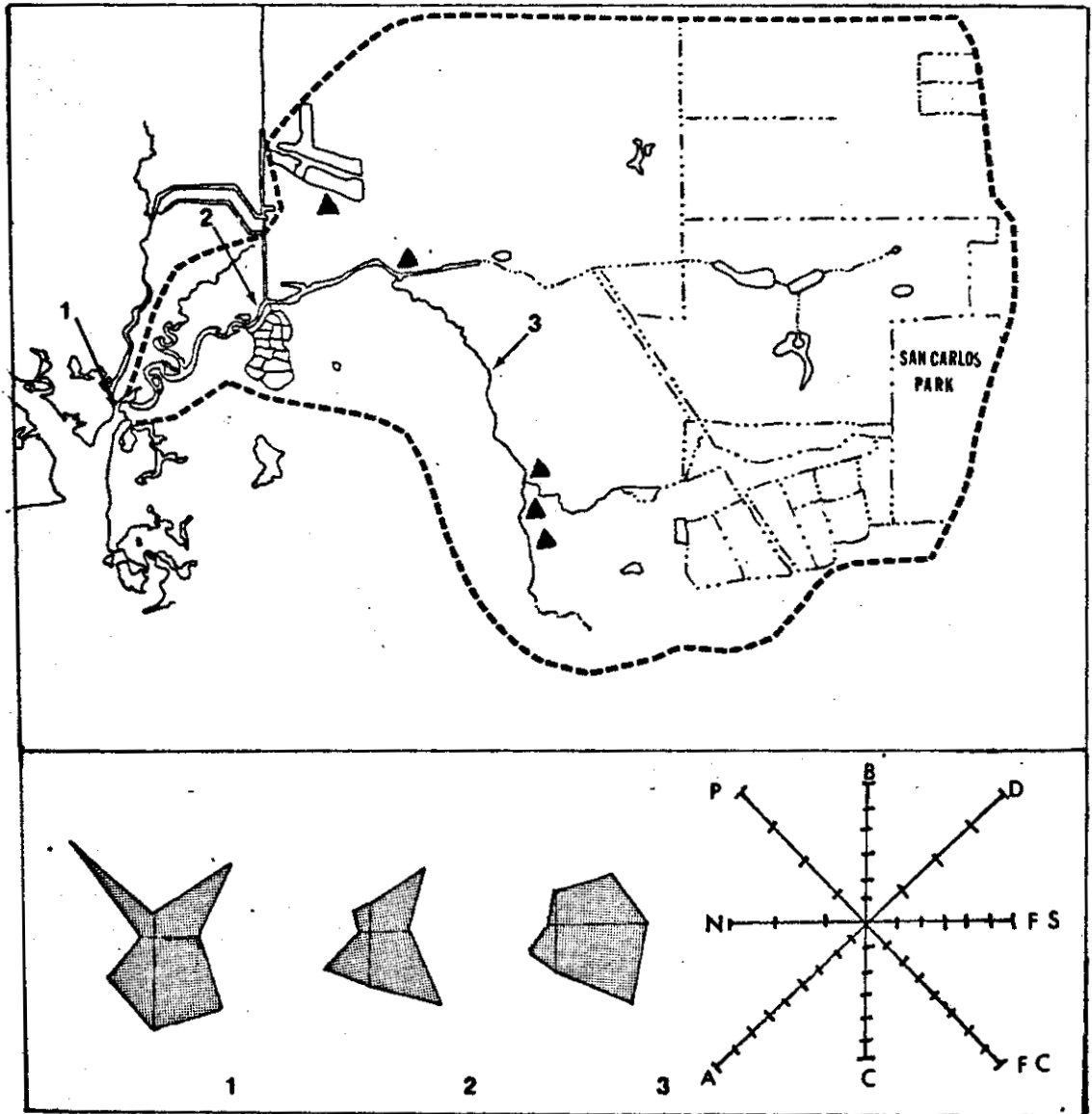


Fig. 33 : Drainage basin map showing sample station locations for Mullock Creek. Polygonal graphs are shown for purposes of comparison. "▲" indicates package treatment plants; Δ indicates collection system treatment plants.

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## Biological Vectors

The biological properties of an ecosystem are in many ways determined by the sum of the physical and chemical forces of the environment. Certain gross environmental factors such as rainfall and temperature delineate the biome of a habitat, but within these regional limitations there are a plethora of possible microenvironments (Odum, 1959). Within these microenvironments the relationship between an environment and its inhabitants is reciprocal. This means that biological inhabitants help to form and shape their own environment.

Vegetation is one of the strongest biological vectors in an ecosystem. By altering wind movement, moisture, and soil temperature, terrestrial vegetation influences and moderates the microclimate of an area (Odum, 1959). Aquatic and marine vegetation is effective in changing the dissolved oxygen, nutrient content, and pH of its environment (Wahlquist, 1972).

There are four categories of vegetation present in the tidal creek ecosystem: 1) terrestrial vegetation, 2) phytoplankton, 3) rooted aquatic vascular plants and 4) floating aquatic vascular plants. Each category has an integral function in the structure of tidal creeks.

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of  
fishes

A. Vegetational Communities and Soil Association<sup>S</sup>

There is generally a close association between undisturbed terrestrial vegetational communities and soil types (Wildermuth, et. al., 1959). This section discusses this relationship and the vegetational communities found on the two relatively undisturbed creeks in our study.

North Creek:

An assessment and vegetation mapping of the Oaks property on North Creek west of Highway 41 was undertaken by Tropical Bioindustries Development Company in April of 1974. Because the entire drainage basin is of ecological importance we extended and augmented the available vegetational information in April of 1977.

Using USGS aerial photographs and the Sarasota County Soil Survey, we ground truthed the drainage basin on shore and by canoe. The resulting vegetation map (Fig. 34 ) delineates five major vegetational communities. An excerpt from the Soil Survey, with the drainage basin boundary is included in Figure 35 to complement the vegetation map.

Description of Communities

1. Oak Hammock. This community is located on a circular mound at the mouth of North Creek and on higher ground immediately across the creek. An abrupt rise in elevation causes a shift from red, white, and black mangroves to freshwater upland species (Tropical Bioindustries, 1974). This hammock has a dense canopy of cedar and oak as well as an occasional cabbage palm.

Species list (Tropical Bioindustries, 1974):

TREES

Quercus virginiana - live oak, 40' (12-30"), abundant.

TREES (cont.)

Juniperus silicicola - southern red cedar, 40' (12-15"), common.

Quercus laurifolia - laurel oak, few

Sabal palmetto - cabbage palms, 35', common

Persea borbonia - red bay - 12', few

Pinus elliottii - slash pine, 55' (15"), few

Coccoloba uvifera - sea grape, few, small

Ximenia americana - hop plum, vine-like

Psidium guajava - guava, few

Eugenia axillaxis - white stopper, few, shrub-like

SHRUBS

Psychotria undata - wild coffee, common

Callicarpa americana - beauty berry, few

Ardisia escallonioides - marlberry, common

Chiococca alba - snowberry, few

Lantana involucrata - lantana, 5', locally common

Quercus pumila - running oak

Erythrina herbacea - coral bean, few

Rhus copallina - southern sumac

Myrsine guianensis - myrsine, few

Randia aculeata - white indigo berry

Bumelia reclinata - milk buckthorn

Schinus terebinthifolius - Brazilian pepper, few

Yucca aloifolia - Spanish dagger

HERBS

Iva frutescens - marsh elder

Tillandsia usneoides - Spanish moss

The associated soil type for the Oak Hammock community is Parkwood fine sand (Pb). This is a somewhat poorly drained hammock soil usually supporting a mixture of oak, maple, and other hardwoods with an undergrowth of cabbage palmetto, shrubs and vines. This soil has moderate to large amounts of organic matter and nitrogen but is limited in other essential plant nutrients. Because its sandy layers are rapidly permeable to air and water there is very little runoff and internal drainage is affected by the level of the water table (Wildermuth et. al., 1959).

2. Pine Flatwood. The pine flatwoods supports a sparse to moderate stand of longleaf and slash pine with a thick undergrowth of saw palmetto, wiregrass, huckleberry, and runner oak. There are only a few areas within the mapped area with a completely closed pine canopy. For the most part the pines are scattered and in many cases, large areas are without pines. This is particularly true in the area just north of the creek and east of Highway 41.

Species List (Tropical Bioindustries, 1974)

#### TREES

Quercus chapmanii - Chapman's oak

Q. myrtifolia - scrub oak

Q. virginiana var. virginiana - live oak

Q. virginiana var. geminata - sand live oak

P. elliotii var. elliotii - slash pine

#### SHRUBS

Lyonia ferruginea - rusty lyonia

L. lucida - fetherbush

Ilex glabra - gallberry

SHRUBS (cont.)Vaccinium myrsinites - blueberryV. arboreum - sparkleberryRhus copallina - southern sumacMyrica cerifera - wax myrtleM. Pusilla - dwarf wax myrtleSerenoa repens - saw palmetto, denseSchinus terebinthifolius - Brazilian pepperVINESSmilax spp. - catbrier, commonHERBSPteridium aquilinum - bracken fern

The soils characteristic of the pine flatwoods are Immokalee (Ia), Pomello (Pf), and Leon (Ld, Lc). These are somewhat poorly drained soils with a shallow layer of sand over an organic pan. This soil association occurs extensively on level sites throughout the county (Soil Survey, 1959). Lakewood (Lb) and Adamsville (Aa) are two unassociated soils that also support pine flatwoods within the drainage basin.

3. Scrub Community. This community is dominated by a dense thicket of scrub oak and wax myrtle underlain with palmetto and grasses and a thin upper canopy of large pines. This community dominates where the soils are better drained and the hardpan lower than the surrounding flatwood community. It forms a dense understory approximately a hundred feet either side of the creek and gradually phases into the pine flatwoods. The species are similar to the pine flatwoods, but with a shift in dominance toward scrub oak and wax myrtle.

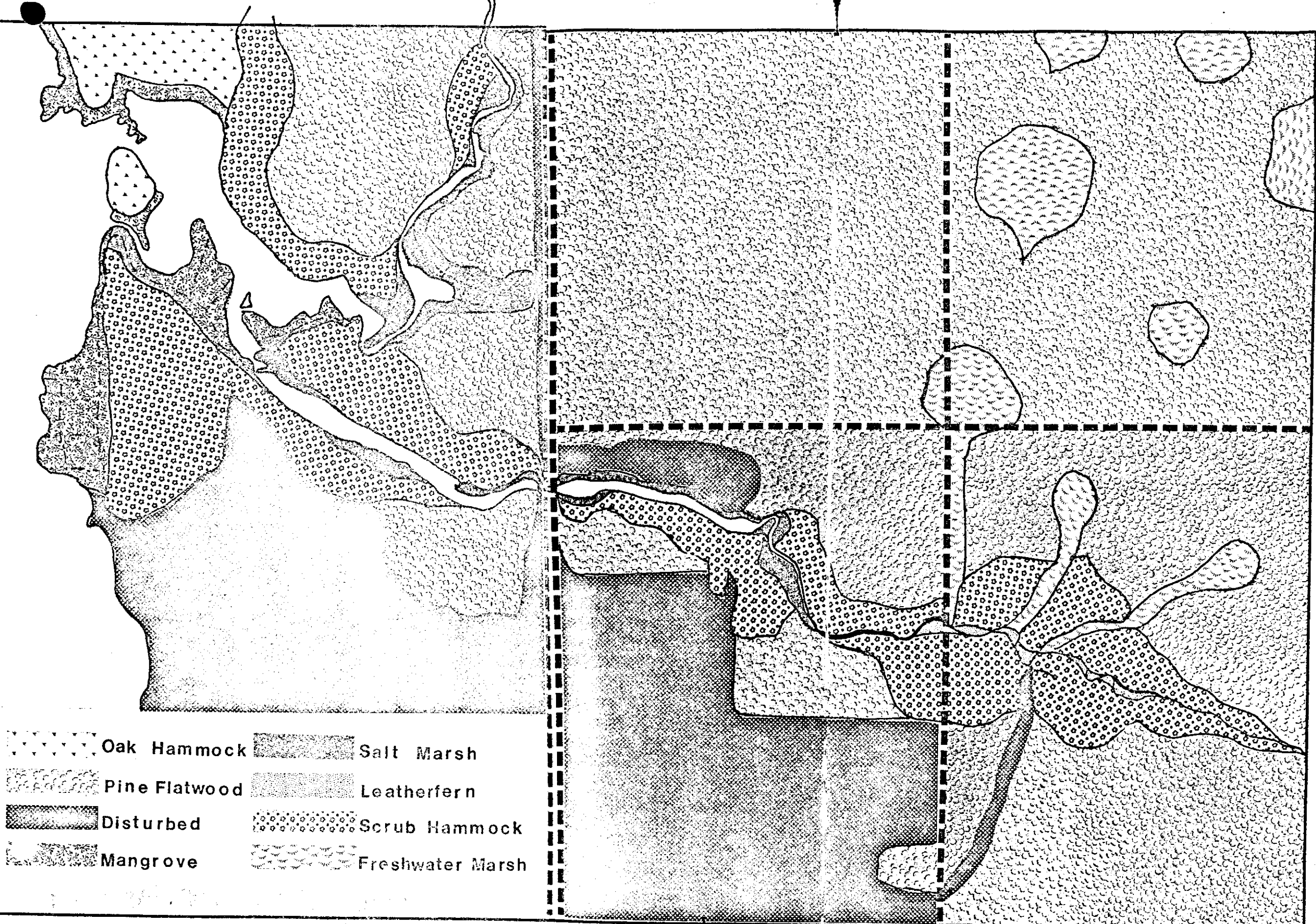
The soil association is similar to the pine flatwoods but with a noticeable predominance of Pomello (Pf) and Lakewood fine (Lb) soils.

These soils are better drained than the Immokalee and Leon soils and may indicate a slight increase in slope (2 to 5 percent) along the edge of the creek (Wildermuth et. al., 1959).

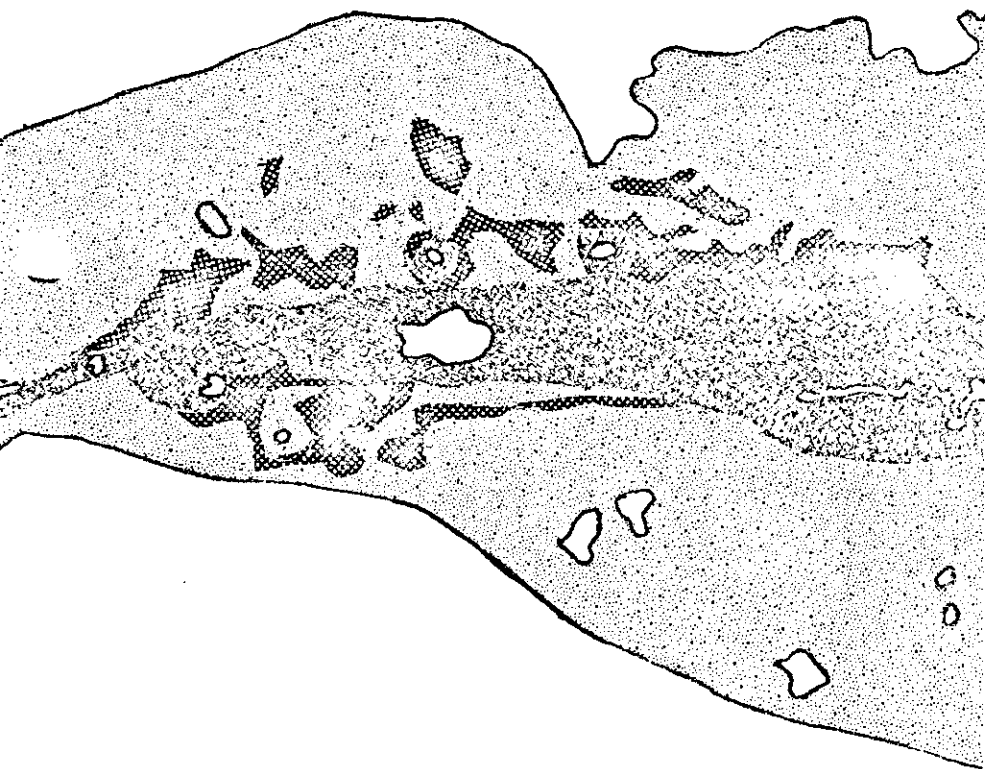
4. Freshwater Marsh and Slough Community. This community occupies circular depressions in the pine flatwood area which tend to collect rainwater during the wet season. These seasonal ponds fill with water during the wet season and remain wetter than surrounding areas the rest of the year. These holding basins are considered crucial to the shallow aquifer recharge system.

Species List (GDC, 1975)

- Spartina bakeri - cordgrass
- Andropogon virginicus - beardgrass
- Cyperus esculentus - sedge
- Rhynchospora inundata - sedge
- Blechnum serrulatum - swamp fern
- Rhexia cubensis - meadow beauties
- Mynica cerifera - wax myrtle
- Cladium jamaicensis - sawgrass
- Rhynchospora tracyi - beakrush
- Eleocharis cellulosa - spikerush
- E. vivipara - spikerush
- Scirpus americanus - bulrush
- Hypericum aspalathoides - St. John's wort
- Eriocaulon decangulare - pipe wort
- Pontederia lanceolata - pickerelweed
- Typha latifolia - cut tail
- Sagittaria - arrowhead







The soil associations of this community consist of Delray (Da), Pompano (Pg, Ph) and Plummer (Pd) soils. These are poorly to very poorly drained soils with a shallow sand phase underlain with alkaline material.

5. Shoreline Communities. This is an association of three vegetational communities that occupy the shoreline of North Creek. The uppermost shoreline community is dominated by leather ferns.

This species occupies the steep banks of the upland portion of the creek.

The salt marsh (Tb) community occupies the wider, flatter shores from near the mouth of the creek to about one half mile east of Highway 41. This community is dominated by black rush (Juncus roemerianus) and salt marsh cordgrass (Spartina alterniflora and S. Patens).

From the confluence of North and Catfish creek and extending to the bay, the shoreline is dominated by red (Rhizophora Mangle), black (Avicennia germinans), and white mangroves (Laguncularia racemosa). Reds usually dominate the seaward side of the strand while blacks dominate the inland side.

The soils associated with these shoreline communities (Tc) are not well defined, but are described as being inundated with salt water and usually containing large amounts of organic matter.

#### Whidden Creek

Using REDI aerial photograph number 63 (1975) and ground truthing from canoe and foot, we delineated five major vegetational communities. The resulting vegetation map is presented in Fig. 36 . The lack of an extensive Charlotte County soil survey made the study of associative soil types impossible.

## Description of Communities

1. Pine Flatwood. This community is characterized by a thin canopy of large slash and longleaf pine with a dense understory of saw palmettos. The pine flatwoods occupy the elevated portions of the drainage basin and are basically similar to the North Creek pine-flatwood community.
2. Mangrove Community. A dense thicket of predominately red and black mangroves occupies the low lying sections of the drainage basin. The outer borders of this community are probably marked by the mean high tide line.

The mangrove community of Whidden Creek was not damaged by the unusually cold winter of 1977. This may be due to the latitude of the area or its close proximity to the warm waters of Charlotte Harbor.

3. Saltern Community. This community occupies narrow sections between the low lying mangrove community and the higher pine flatwoods.

Saltern refers to a combination of salt flat and salt barren communities. Salt barrens tend to be slight depressions in a saltern region where the waters of storms and high tides have evaporated forming a hypersaline region inhospitable to most plant life. The salt flats around these barrens are slightly elevated and therefore less subject to hypersalinity. Salt flats are normally occupied by a variety of succulents and sedges adapted for this harsh environment.

Species List (GDC, 1975)

Conocarpus erecta - buttonwood

Laguncularia racemosa - white mangrove

Avicennia germinans - black mangrove

Monanthocloe littoralis - keygrass

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## Species list (GDC, 1975) (Cont.)

- Distichlis spicata - Salt grass  
Sporobdus virginicus - drop seed  
Spartina alterniflora - smooth cordgrass  
Eleocharis caribaeu - spike rush  
Eleocharis atropurpurea - spike rush  
Eleocharis cellulosu - spike rush  
Phloxerux vermicularis - beach carpet  
Sesuvium portulacastrum - sea purslane  
Salicornia virginica - glass wort  
Butis maritima - salt wort  
Agalinis maritima - false foxglove  
Diodia rigida - button weed

4. Oak-Cabbage Palm Hammock. This hammock occupies a long curved shell mound surrounding Boggess Hole in the western section of the drainage basin. It is thought by some that the mound was formed from shell and sand dredged from Boggess Hole by the Indians or Spanish. Regardless of its origin, the mound forms an elevated ridge better drained than the surrounding area. The hammock is dominated by live, laurel, and scrub oak and large cabbage palms.

5. Tropical Hammock. This hammock occupies the thirty-foot high Indian mound on Mound Key at the mouth of Whidden Creek. The soil is characterized as an elevated permeable substrate composed largely of shell and coarse sediment. This area supports an unusual variety of flora dominated by large gumbo limbo trees.

Species List - *Example*

- Bursera simaruba - gumbo limbo

## Species List (Cont.)

Ficus aurea - strangler fig

Opuntia stricta - cactus

Yucca aloifolia - Spanish bayonet

Carica papaya - papaya

## B. Chlorophyll a and Phytoplankton

Phytoplankton (microscopic aquatic plants which depend on the movement of waters for their own movement) are photosynthetic and are an important primary producers in many aquatic environment. Because chlorophyll a and other pigments are necessary for photosynthesis, the quantities of these pigments is an indirect measure of plankton production.

The spectrophotometric method of Strickland and Parsons (1967) was used to determine chlorophyll a and phaeo-pigments to obtain a rough idea of the productivity of phytoplankton in the tidal creeks (see appendix B for methods). Table 5 shows the results of the chlorophyll a tests on three stations on each creek.

Table 5: Results of Chlorophyll a tests on ten tidal creeks

Station #	mg/liter			Station #	mg/liter		
	1	2	3		1	2	3
Bowlees	1.068	0	6.622	Alligator Sar	0	2.136	1.922
Whitaker	1.068	0	4.486	Alligator Ch	0	1.068	1.495
Catfish	0	0	10.736	Coral	0	0	0
North	0	12.630	17.366	Whidden	0	0	0
South	0	0	0	Mullock	0	0	0

### Discussion

The overall results were surprisingly low. The highest values were found in the uppermost stations of Bowlees, Whitaker, Catfish, and North and on the middle station of North Creek. No significant chlorophyll a was found at the mouths of any creek though low values were reported for the mouth of Bowlees and Whitaker. Coral, Whidden, and Mullock showed no measurable concentration at any station.

The availability of inorganic nitrogen ( $\text{NO}_2$  and  $\text{NO}_3$ ) and ortho-phosphates is normally the major limiting factor in the growth of

Phytoplankton (Mackenthum, 1974).

Figures 37 and 38 show chlorophyll a plotted against inorganic nitrogen and ortho-phosphates respectively.

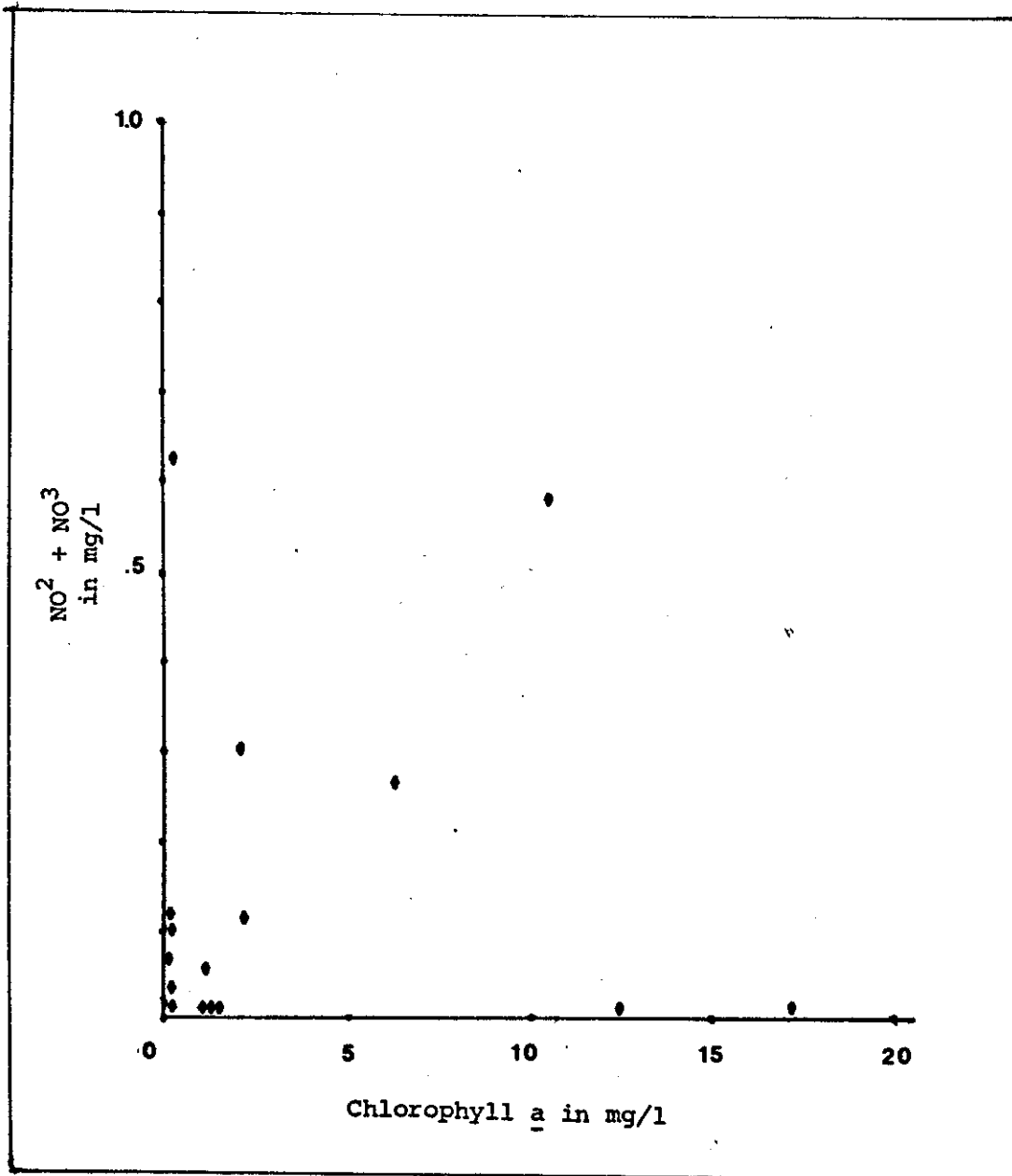


Fig. 37 Chlorophyll a vs NO<sub>2</sub> + NO<sub>3</sub>

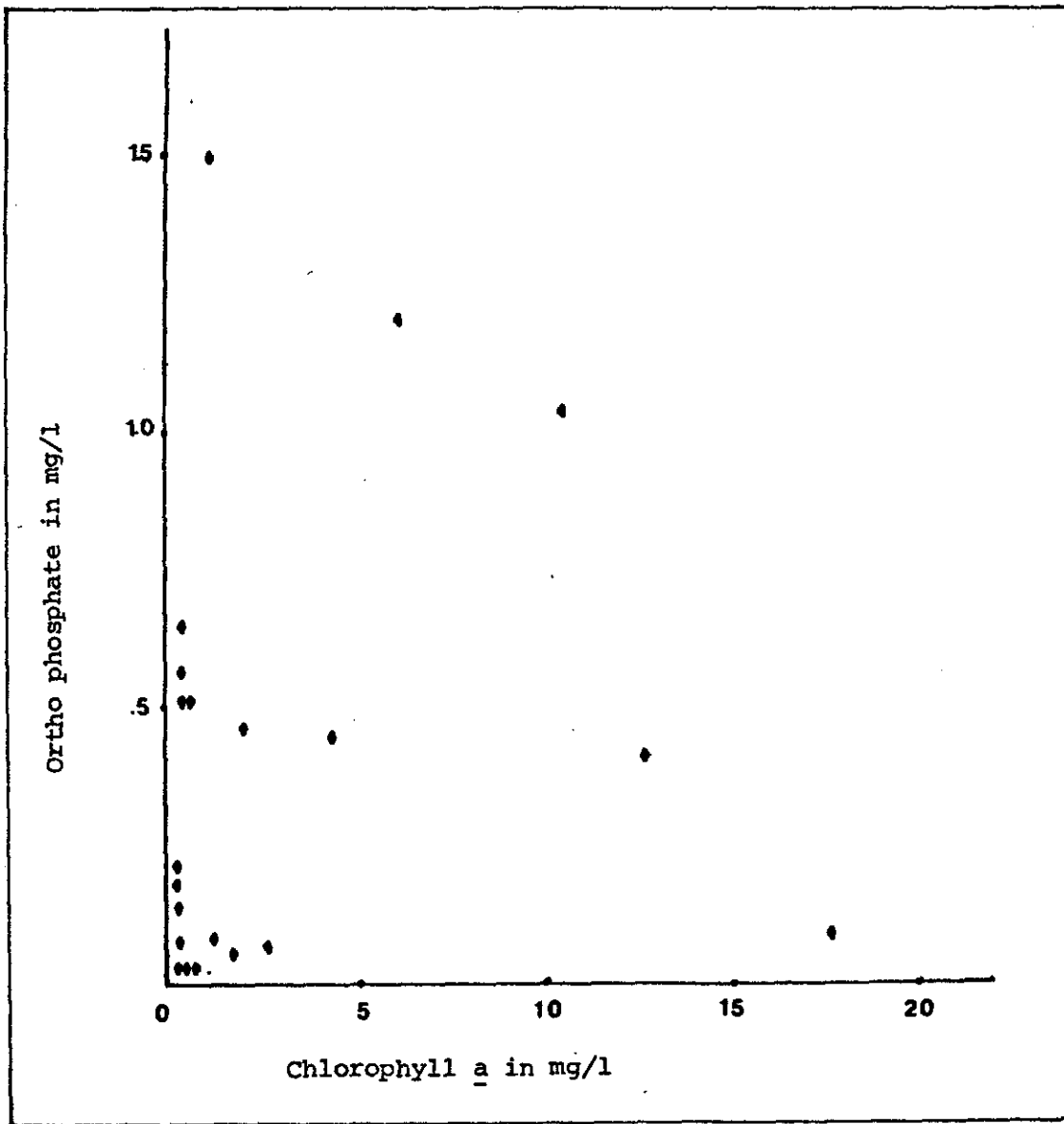


Fig.38 Chlorophyll a vs Ortho-Phosphates

Our limited data shows no significant correlation between chlorophyll a and dissolved nitrogen or phosphorus.

One of the problems involved in a chlorophyll a to dissolved nutrient correlation is that blooms of plankton quickly assimilate dissolved nutrients in waters (Mackenthum, 1972). This may result in high chlorophyll a but almost no dissolved nutrients. The comparatively high chlorophyll a found at station 3 on North Creek may be due to dissolved nutrients that have already been assimilated.

Other factors such as availability of sunlight and turbidity may be more important (Odum and Heald, 1975). Odum and Heald (1975) also suggest that the general productivity of phytoplankton is insignificant in shallow estuaries of the southeastern United States. This may account for the lack of chlorophyll a in Whidden, Coral, and Mullock Creek which are similar to the detritus based mangrove systems studied by Odum and Heald. In these systems the primary energy supply is vascular plant detritus rather than phytoplankton (Odum and Heald, 1975).

In conclusion, we feel that the phytoplankton communities of tidal creeks are in need of extensive study. The importance of phytoplankton in tidal creek productivity is unresolved and the possible limiting factors are complex. A thorough study of the relationship between particulate carbon, particulate nitrogen, ATP, and chlorophyll a might answer some questions on the relative importance of phytoplankton as well as detritus and bacteria in tidal creeks (Kirby-Smith, 1976).

### C. Rooted Aquatic Vascular Plants

The vegetational map of North Creek (Figure 34), shows three communities of rooted aquatic vascular plants; 1) freshwater pond and slough, 2) salt marsh, and 3) mangrove. The detritus produced by these communities is probably the trophic basis for the productivity of a tidal creek (Cummins, 1974; Odum and Heald, 1975). Consequently the health of a tidal creek is dependent on the health of these three communities. Figure 39 illustrates the roles and importance of these communities.

All three communities donate detritus to be stored, transported, and processed by tidal creeks. This detritus quickly undergoes a process of leaching and microbial colonization. It is then utilized by three types of detritus feeders; 1) grinders, 2) deposit feeders, and 3) filter feeders (Odum and Heald, 1975). These detritivores include only a few species but many individuals in a system and comprise an important trophic link between detritus production and the production of higher consumers (Odum *et. al.*, 1972).

Mangroves have been found to remove from 10 to 100% of the dissolved nitrogen and phosphorous from waters entering the forest (Lugo and Snedaker, 1974). This activity is attributable to the redox processes of the soil, the activities of periphyton prop roots, and uptake by extensive nets of fine roots at the surface of the soil (Lugo and Snedaker, 1974). The net result of this cycling process is the import of inorganic compounds from land and an export of detritus to the estuary.

Rooted aquatic plants help moderate hydrological extremes, preventing erosion and excessive inflow of dissolved nutrients due to

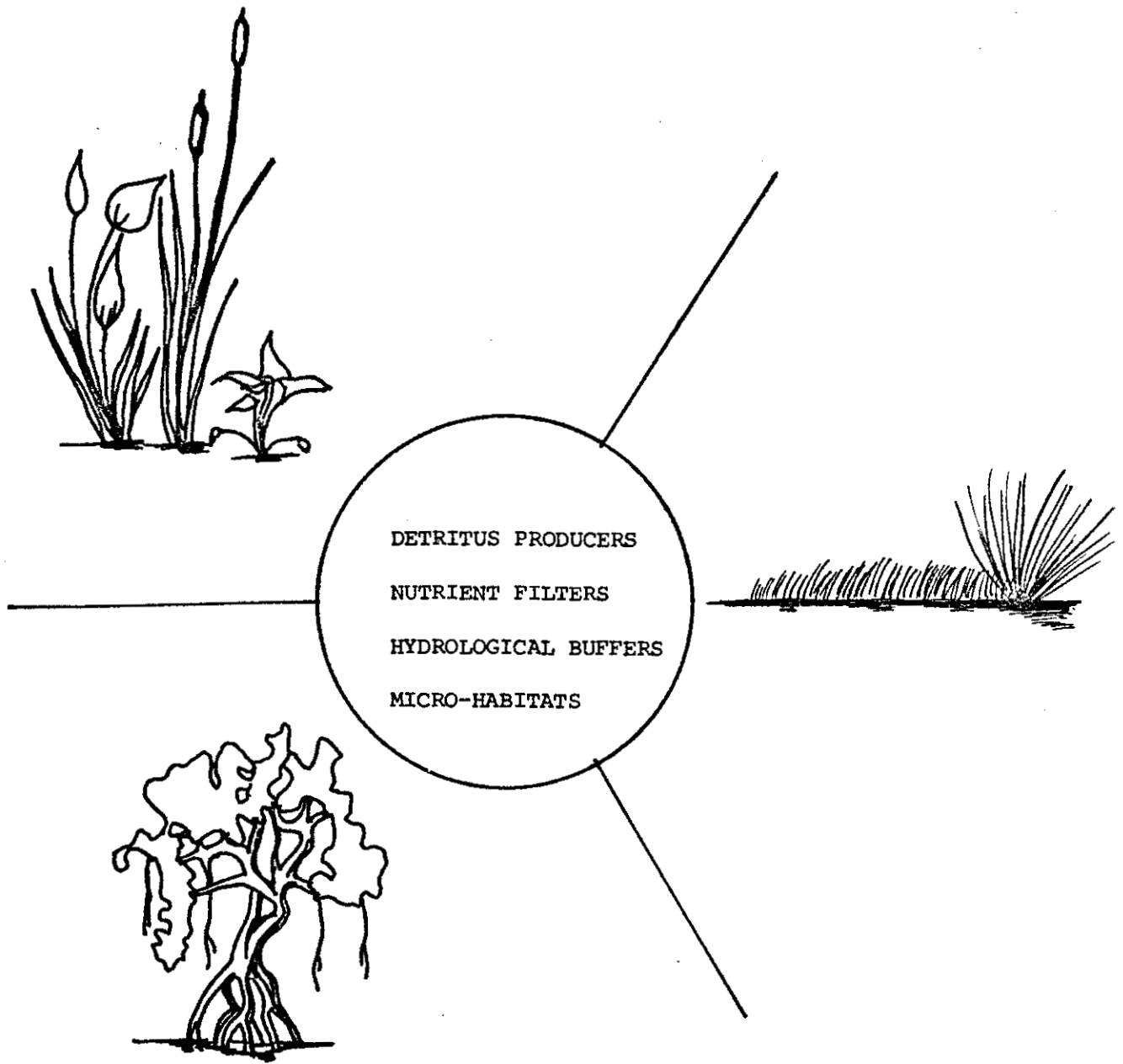


Fig. 39 The Importance of Rooted Aquatic Vascular Plants

stormwater runoff ( Omernik , 1976 ). Freshwater ponds act as holding basins for the runoff from surrounding uplands. The ecosystems of these ponds have adapted to the rapid nutrient recycling brought on by periodic flooding (Kahl, 1964). Salt marsh sedges and mangroves are also useful in stabilizing shorelines.

The uniqueness of these microhabitats is well documented. The behavior and life cycle of the Wood Stork (Mysteria american) is closely tied to the seasonal fluctuations of fresh water ponds. The beginning of the dry season and the subsequent increase in fish density marks the beginning of the Wood Stork breeding season (Kahl, 1964). The pneumatophores and trunks of mangroves support species of algae as well as crustaceans and mullosks. Leaves of marsh sedges act as surfaces for the attachment of bacteria and periphyton (Correll et. al., 1975).

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#### D. Floating Aquatic Vascular Plants

Water hyacinth (Eichores crassipes) is the most prolific aquatic weed in Florida. It reproduces vegetatively, rapidly invades new sites, and causes rapid changes in habitats (Morris, 1974). Introduced in the 1800's it is now found in such large numbers that it often chokes and clogs waterways causing flooding hazards and preventing navigation. Studies indicate that the biomass of hyacinths will double in volume every 12.5 days in the presence of abundant nutrients and sunlight (Moody, 1973).

Agricultural and domestic pollution has undoubtedly increased the phosphorous and nitrogen levels in Florida's waters (Moody, 1973), but nutrient levels in natural waters are often sufficiently high to support hyacinths (Morris, unpublished). Wahlquist (1972) reports that phosphorous, which is naturally abundant in the waters of southwest Florida, is the limiting factor in the growth of hyacinths.

Dense growths of water hyacinth are found in the upland sections of Bowlees, Alligator (Sarasota) and Alligator (Charlotte) Creeks. These creek sections have been straightened and dredged and are subject to agricultural and suburban runoff.

Water hyacinths have been shown to effectively remove nitrogen and phosphorous from nutrient enriched waters and contribute positively to overall water quality (Moody, 1973, Wahlquist, 1972). At the same time they displace native species of aquatic plants and the associated animal life as well as impairing stream flow. Lincer (1975) concluded that hyacinth were contributing to the eutrophication of Dona and Roberts Bay.

The problem of managing water hyacinths so that they are allowed to improve water quality but are prevented from choking waterways and displacing desirable species of plants and animals is a difficult one. Three techniques are presently employed for controlling hyacinths; 1) drawdowns, 2) herbicides, and 3) mechanical harvesting. Drawdowns involve the diverting or damming of waters to dry up troublesome areas. This technique would be difficult to employ in tidal creeks and would still lead to eutrophication. Herbicides are presently very popular, but the mass deaths and sinking of sprayed hyacinths may overload already nutrified waters. The large amounts of decaying vegetation may also lead to depletion of dissolved oxygen and result in fish kills (Moody, 1973). Mechanical harvesting offers the greatest degree of selectivity and flexibility. With this method the hyacinths may either be collected and removed from the water or it may be crushed and returned to the water. Most importantly, some hyacinths may be left to act as biological filters. This method was employed, with no apparent side effects, on the St. Johns River until the mid 1950's when herbicides were introduced (Moody, 1973).

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## Visual Quality of the Tidal Creeks of Southwest Florida

"The visual environment is seen not as a passive backdrop to human activity, but as a stage on which people move. Visual quality relates primarily to human appreciative perception. Ecological thinking, as vision across boundaries, encourages viewers of the coastal zone to experience interconnections with a geological, biological and personal past."

ref

### Introduction

The National Environmental Protection Act of 1972 and the Coastal Zone Management Act of 1972 specify that visual values in the environment be given full consideration, and that standard methods be developed to facilitate evaluations of the visual quality in the environment.

Accordingly, planning agencies, consulting firms and research institutes are beginning to consider visual quality as an integral part of the overall planning process. It is apparent to these groups that the visual quality of the interface between natural and man-made systems is often a reliable yardstick for overall environmental quality.

As of today, visual quality research is not well developed. While testing and experimentation have yielded results, little practical application of these results has ensued. Almost everyone agrees that visual quality of the environment is an important aspect to be included in the planning process. Yet this aspect is still not accepted on a par with social, economic or biological concerns.

While a strong case can be made for the intimate connection between visual quality and the environment, what exactly is meant by visual quality? The number of definitions are endless, not only do visual landscapes change with the coming and going of human activity, but human interpretations of visual quality vary according to changing conceptual frameworks and evolving cultural influences. The discussion

and debates surrounding the formulation and definition of visual quality centers around the extent to which it can be defined in the first place. Where do our responses to the visual environment fall in relation to personal, subjective values, on the one hand, and objective principles on the other? Until we can identify these human values, we cannot begin to define visual quality in the environment, let alone take the necessary steps to preserve and protect it.

In order to discuss visual quality further, we must introduce aesthetics, the branch of philosophy concerned with that which is beautiful in art and nature. Perceptions of visual quality are intimately connected with aesthetic judgements. Yet, the nature of the relationship is ambiguous. It is not clear where aesthetic judgements fall in relation to highly personalized conceptions of beauty, on the one hand, and universal principles on the other. Fortunately, research in the field of visual quality suggests that aesthetic judgements fall somewhere in between.

Litton (1974) classified the "aesthetic experience" into general components whose interplay often creates a complex response of observer-user to a particular landscape (Fig. 40 ). Three general components define this relationship: the observer's state of mind, the context of observation and the environmental stimulus. Since the observer's state of mind is a function of the anticipated use of an area, the anticipated use will partially determine the expectations and desires brought to a situation. These expectations and desires <sup>then</sup> will partially determine the aesthetic experience of the situation. The context of observation includes the events that occur as one approaches the environment and the events that occur upon arrival (Litton et. al., 1974). The complete

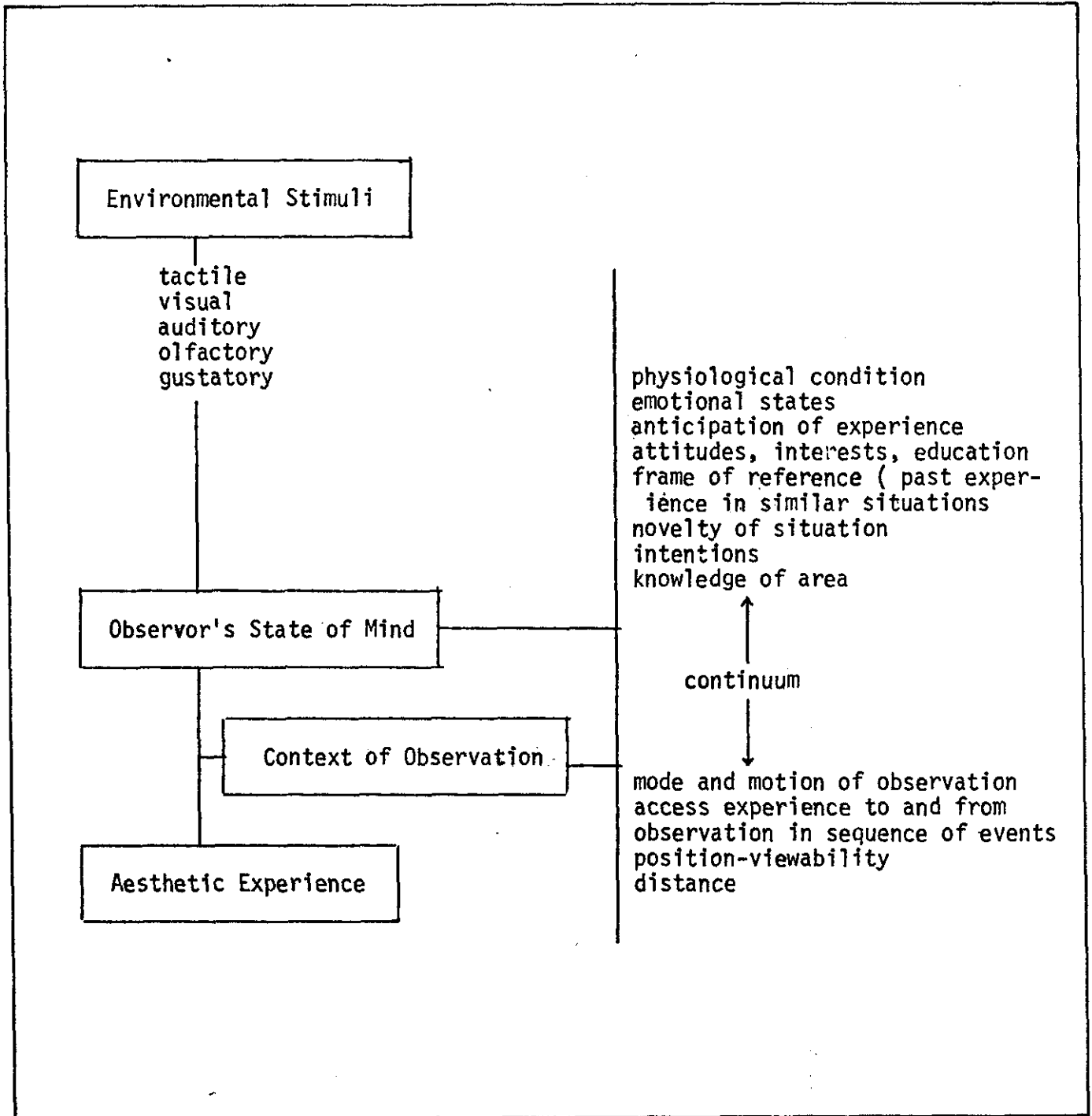


Fig. 40 Model of Aesthetic Response ( from Litton et. al., 1974 )

analysis of the aesthetic experience requires the objective appraisal of the environmental stimulus. Litton subdivides environmental stimuli into two classes: those which are visual and those which are sensed by non-visual means.

#### The Visual Quality Research Paradigm

*Debits*

The visual quality or landscape aesthetic research paradigm varies in its objectives and methodologies. In general, the research attempts to develop a useful definition of visual quality and to identify the environmental factors affecting visual quality. The research in this field is classed into general categories: 1) experimental systems designed to evaluate peoples' preferences for landscapes, and 2) experimental systems designed to evaluate landscapes based on landscape classification systems.

#### Landscape Classification Systems

*Debits*

Descriptive landscape classification systems are the most widely used. However, there is little standardization of technique and a plethora of confusing terms. Land use, presence of water, scale of landform, presence of man-made objects, landscape composition, form, line, color and continuity are descriptive terms that reappear throughout the literature in this field. One methodology uses subjective lists of adjectives referred to as a semantic differential (Calvin et. al., 1972; Zube et. al., 1974). These adjectives, descriptive of landscapes, are presumed to relate to visual quality. Other studies utilize simple landscape element checklists in which subjects weigh and rank landscape elements based on well-defined scaling devices (Fraser, 1976; Kobayashi, 1976). Still other studies employ simple numerical rating or ranking systems (Zube et. al., 1974; Morisawa, 1976). The most sophisticated

studies use computer models to evaluate visual quality (Steinitz and Paulson, 1976). The scope, sophistication, complexity and degree of objectivity vs. subjectivity of methodologies vary greatly and the terminologies are often contradictory (Viohl, 1975).

Viohl (1975) proposes three general categories under which landscape terminologies may be classed. <sup>(Fig. 11)</sup> The first, "Landscape Elements", includes those physical features such as topography, land use, man-made objects, and vegetation. The second category, "Properties of Landscape Elements", includes such terms as scale, (height, width, and depth) and color. The third category reflects the observed dimensional relationships between elements and properties of landscapes. Examples include "complexity/diversity/variety", "surprise/mystery", and view characteristics such as enframement, enclosure, and focal point (Viohl, 1975).

Landscape elements, properties and dimensions form the integral components of landscape classification schemes. There are two general types of classification schemes: the qualitative (purely descriptive) schemes as exemplified by Litton (1968, 1974) and the quantitative (assigning numbers or weighing various landscape components) as exemplified by Leopold (1968). While landscape classification schemes provide a basis for landscape evaluation, these approaches are weak in determining the relationships between the easily definable and measurable landscape elements and properties, and abstract landscape dimensions. Knowledge and understanding of such relationships will provide a firm basis for determining what constitutes scenic or visual quality in the environment.

#### Landscape Preference/Perception Studies

One approach in determining the relationships between landscape

Landscape Elements

topography/relief/slope  
land use  
water forms  
land forms  
vegetational forms  
man-made objects

Properties of Landscape Elements

scale ( height , width , depth )  
color  
edges  
textures

Dimensions of Landscape Elements

complexity/diversity/variety  
uniqueness/novelty/contrast  
naturalness  
urbanization  
pollution  
unity/harmony/order/compatibility/coherence  
disharmony/misfit  
pattern/sequence  
movement/rhythm  
surprise/mystery  
character types/regional identity  
view characteristics: enframement, enclosure, focal point,  
observer position, direction  
scenic " beauty "

Fig.41 Landscape Components ( from Viohl, 1975 )

elements and properties to landscape dimensions is to evaluate visual quality as a function of peoples' preferences for landscapes. If one assumes that such preferences relate directly or indirectly to scenic quality, the results provide an evaluation of landscape quality (Viohl, 1975). Based on preference/perception studies, one landscape dimension <sup>that</sup> positively correlated <sup>s</sup> with peoples' preferences for landscapes is complexity or diversity. People tend to prefer landscapes with a diversity or variety of landscape elements and properties such as land and water forms, patterns of land use, and vegetational pattern (Zube, 1973; Wolwill, 1968). A second dimension highly correlatable with peoples' preferences is naturalness; the preference for natural landscapes over urban landscapes <sup>ie</sup> (Wolwill, 1968; Morisawa, 1976; Zube et. al., 1974) <sup>not clear</sup> and others. (Land use compatibility) is another dimension that correlates with peoples' preferences of landscapes (Hendrix and Fabos, 1974; Zube et. al., 1974). Other dimensions that correlate with peoples' preferences include uniqueness (Leopold, 1969), and presence of water (Zube, 1973; Litton, 1974).

*define*

While certain landscape dimensions are directly related to peoples' preferences for landscapes, the relationships between landscape dimensions and the physical characteristics of landscapes are not entirely clear. The two general approaches to the assessment of landscape quality - descriptive landscape classification studies and landscape perception/preference studies - often overlap. Further studies to determine the relationships between definable landscape elements and properties to landscape dimensions are in order.

*note*

The visual quality research paradigm has been criticized regarding the subjectivity of experimental methodologies. Critics claim

that because of investigator biases in establishing classificatory schemes, and the ambiguous nature of aesthetic judgements, visual quality research does not have a high degree of scientific validity or explanatory power. While these criticisms may be valid, it is questionable whether objectivity of method is even applicable to evaluations of visual quality. Milbrath (1976) states, "Quality is not definable in terms of a specifiable quantity of any one or several physical entities that remain stable over time from place to place". Furthermore, it is questionable whether objective measures can, or even should be used to measure visual quality. One cannot validly infer a subjective aesthetic experience of visual quality from an objective statement of condition (Milbrath, 1976). The notion that someday we might have an empirical, objectively quantifiable system of values for the measurement of visual quality creates philosophical entrapments. For instance, would it not ruin the character of regional environments if only those areas of high scenic value were preserved? Will one objective regional landscape evaluation method necessarily apply to all regions? Also, we cannot assume that the objective method of today will apply in the future. Does it really matter whether visual quality evaluations are objective or subjective "as long as the criteria are clear, logically constructed, and subject to scrutiny" (Litton, 1974).

#### Generic Nature of the Southwest Florida Tidal Creek Landscapes

*Regions* { Tidal creeks are small estuarian water bodies with fresh water sources and are characterized by a fresh water to brackish to salt water gradient from headwaters to mouth. The creeks are characterized by little topographic variation resulting in low diversity of landform and scale. Since the studies of Halverson, Burns and Randell (1969) show that people prefer landscapes with a variety of landform and landform

*Subsets*

scale, any attempt to evaluate tidal creek landscapes must consider other landscape components. A major visual component of the creeks is the interface between land and water. This interface combined with shoreline vegetation and its succession from mouth to headwaters, plus land use, man-made objects and view characteristics form the general visual characteristics of the Southwest Florida Tidal Creek landscapes. For purposes of this study the local creek landscapes were classified based upon view characteristics under the following scheme based on the work of Litton (1968).

Landscape Classification Framework for Tidal Creeks of Southwest Florida

1. Feature Landscape: a landscape dominated by the presence of a particular feature (either natural or man-made) in which the surroundings are subordinated and the lines of visual tension converge on a single element or group of elements.
2. Enclosed Panoramic Landscape: a landscape in which there is a continuity of sides around a base plane, or bowl-like form. Generally, the lines of visual tension first draw the viewer to a central area and then to the surrounding landscape edges.
3. Open Panoramic Landscape: a landscape emphasizing horizontally dominant lines of visual tension, little sense of boundary and a strong sense of openness.
4. Shoreline Landscape: a landscape emphasizing horizontally dominant lines of visual tension such as the interface and contrast between land and water.
5. Focal Landscape: a landscape in which parallel lines or aligned objects appear to converge to a focal point.

6. Detail Landscape: a landscape where a small segment of a larger landscape is isolated from the overall pattern. Generally, detail landscapes are "micro-landscapes".

7. Undergrowth Landscapes: a landscape where the arrangement and profusion of vegetative understory creates irregular lines of visual tension.

Methodology for the Evaluation of the Visual Quality of Southwest Florida Tidal Creeks

In attempting to evaluate the visual quality of the selected tidal creeks in Southwest Florida, our objectives were: 1) provide planners with a useful tool in making environmentally related decisions, 2) develop a visual quality baseline for a region devoid of such information, and 3) determine the comparative scenic quality of ten tidal creeks.

Media of Presentation, and Type of response format were two primary methodological considerations in developing a comparative measure of the scenic quality of the tidal creeks of Southwest Florida.

Media of Presentation: The studies of Zube et. al. (1974); and Dunn (1975); and Schaeffer et. al. (1969) concluded that black and white and color photographs of landscapes adequately represent actual landscapes.

Therefore 35 mm color transparencies were chosen for landscape representation. The color slides <sup>were</sup> could be displayed on a light table or projected on a screen depending on response format.

From an ~~extensive~~ slide inventory of 40 - 60 slides per creek, taken along the length of each of ten tidal creeks, a final inventory of 90 slides (9 slides per creek in 7 landscape categories) was developed. The selection of slides was based on the following criteria: 1) each slide should be representative of a particular land use or natural con-

Balance  
with  
criteria  
mentioned  
in  
first  
chapter

dition of a particular creek, 2) each slide should be representative of a particular location along the creek length so that each set of 9 slides included sites along the entire creek length, from mouth to headwaters, 3) each slide should be of good photographic quality, and 4) each slide should fit reasonably well into one of the aforementioned landscape categories under the following scheme for each creek:

Feature Landscape: 2 slides, one natural feature and one man-made feature (if present on the creek).

Enclosed Panoramic Landscape: 1 slide

Open Panoramic Landscape: 1 slide

Shoreline Landscape: 1 slide

Focal Landscape: 2 slides

Detail Landscape: 1 slide, either man-made or natural

Undergrowth Landscape: 1 slide

Response Formats: Methods often employed to establish preferences for photographs of landscapes include rating, rank ordering, semantic differentials, and adjective lists. A rating response format (The Likert Interval Scale) and a rank ordering response format (A Forced Q-sort procedure) were chosen for this study. The forced Q-sort procedure requires the subject to sort a number of items into a set number of piles according to a pre-established distribution of items per pile. The piles take on qualitative meaning according to the concept under consideration and may be quantified by assigning an ordinal scale value to each pile (Zube et. al., 1974). Parametric or non-parametric statistical analysis of the ordinal scale values across the entire subject population can be performed to determine the significance of data. The second response format chosen was the Likert Interval Scale

which utilizes a non-continuous interval scale of, for example, 1 to 10, representing the range of the particular concept in question. Again, parametric or non-parametric statistical analysis can be utilized to determine significance of data.

Similarity of results of response formats would strengthen data based generalizations about the concept in question.

#### Q-Sort Response Format

Subjects were asked to sort 90 slides of typical creek landscapes into 7 piles. The number of slides per pile was proportional to the distribution of 56 landscape views employed by Zube *et. al.* (1974) in the following manner:

Pile #	1	2	3	4	5	6	7
# of slides/pile	5	11	18	22	18	11	5

Pile #1 was assigned highest scenic quality, Pile #2: higher scenic quality, Pile #3; high scenic quality, Pile #4: neutral scenic quality, Pile #5: low scenic quality, Pile #6: lower scenic quality, and Pile #7: lowest scenic quality. The 90 slides were presented on two light tables with 45 slides on each table. The Q-Sort procedure was administered to 20 New College students representing various disciplines of study.

#### Likert Interval Scale Response Format

Subjects were asked to rate the same 90 slides from 1 to 7 on an interval scale of perceived scenic quality. A 1 rating represented highest scenic quality, a 2 rating: higher scenic quality, a 3 rating: high scenic quality, a 4 rating: neutral scenic quality, a 5 rating: low scenic quality, a 6 rating: lower scenic quality, and a 7 rating: lowest scenic quality. In this test, the 90 slides were presented randomly on a large projection screen and the order was reversed when presented to

another subject group in order to nullify the possible effects of fatigue upon overall subject ratings. Subjects were given approximately 20 seconds to evaluate, rate and record the scenic quality of each slide before the next slide was presented. The Likert Interval Scale Procedure was administered to three subject groups: 18 students of the Humanities and the Environment Course at New College of USF, 8 members of the Environmental Confederation of Southwest Florida, and 24 members of an introductory ecology class at Edison Community College, in Ft. Myers.

#### Statistical Analysis of Data

The two response formats; the Forced Q-Sort Procedure and the Likert Interval Scale Procedure utilized non-continuous interval scales. (Note: data obtained from the Q-Sort procedure were given quantitative scale values by assigning each pile its ordinal equivalent, i.e. slides placed in Pile #3 received an ordinal scale value of 3, etc.) The two response formats were chosen to determine (the <sup>people's preferences</sup> comparative scenic quality of) the tidal creeks. For reasons of empirical rigor, non-parametric statistical analyses were performed. First, a Friedman Two-Way Classification Test was used to statistically determine the relative differences of <sup>of preference</sup> overall scenic quality) of the tidal creeks. In order to determine if these differences were statistically significant, and not due to chance, a second statistical procedure was employed; a Wilcoxon T-test. In conjunction, these two non-parametric statistical tests were used to analyze the data from both the Q-Sort Response Format and the Likert Interval Scale response format (Appendix F ). Statistical results are summarized in Tables 6 and 7 .

*Use Preference Ranking*

Table 6 Summation of Median Ranks and Overall Scenic Groupings ( Q-sort Test )

$\Sigma R^1$	Creek	Sub-group <sup>2</sup>	Scenic Quality
61.5	South Creek	A	High
63.5	North Creek	A	High
86.5	Catfish Creek	B	Moderate
96.0	Mullock Creek	B	Moderate
104.0	Alligator Creek ( Sarasota Co. )	B	Moderate
111.0	Whidden Creek	B	Moderate
119.5	Coral Creek	B	Moderate
119.5	Alligator Creek ( Charlotte Co. )	B	Moderate
163.0	Whitaker Bayou	C	Low
170.0	Bowlees Creek	C	Low

*Preference Rank*

Table 7 Summation of Median Ranks and Overall Scenic Groupings ( Likert Scale )

$\Sigma R^1$	Creek	Sub-group <sup>2</sup>	Scenic Quality
155.0	North Creek	A	High
158.5	South Creek	A	High
202.0	Whidden Creek	B*	Mod. High
234.0	Mullock Creek	B*	Mod. High
249.5	Catfish Creek	B*	Mod. High
270.0	Alligator Creek ( Sarasota Co. )	B	Moderate
272.0	Coral Creek	B	Moderate
290.0	Alligator Creek ( Charlotte Co. )	B	Moderate
439.5	Bowlees Creek	C	Low
475.5	Whitaker Bayou	C	Low

1.  $\Sigma R$  = summation of median rankings across entire subject population

2. Sub-groups represent statistically distinct groupings based on  $\Sigma R$

## Results

Three major scenic quality sub-groups were determined for the Q-Sort procedure and four major sub-groups were determined for the Likert Interval Scale procedure. However, the fourth sub-group for the Likert Interval Scale procedure (B) can be combined with sub-group B\* and considered as one major sub-group because their significance of difference is minor.

Treating sub-groups B and B\* as one major sub-group, the overall composition of all subgroups across both response formats is identical for equivalent sub-groups (Table 6,7). This indicated that the Forced Q-Sort and the Likert Interval Scaling procedures yielded comparable results. While the same creeks appear in similar statistically significant groups, the within-group ordinal sequence changes (Tables 6,7). Differences in ordinal arrangement may be due to the following: 1) the nature of the forced (Q-Sort) vs the unforced (Likert Interval Scale) distributions implicit in the landscape evaluation response formats, 2) differences in subject sample size, 3) differences in medial presentation techniques, or 4) in a larger sense, possible attitudinal differences between sample groups. North and South Creeks received the highest cumulative scenic value by both procedures and their scores are reflected in a significantly higher grouping than the other creeks and scenically are the most preferred of the ten creeks. Both North and South Creeks are characterized as upland creeks with relatively natural stream banks and drainage basins and well developed, diverse shoreline vegetational communities. The two creeks display a diversity of landscape features as created by the vegetational succession from creek mouth (a mangrove estuary) to the headwaters (upland scrub hammock) and

the topographic variation along the banks of the upland portions. The diversely vegetated, enclosed, canopied landscape characterizes large portions of drainage basin and this type of landscape seems to be preferred. The next major sub-group, exhibiting moderate to moderately high scenic quality, consists of Whidden Creek, Mullock Creek, Catfish Creek, Alligator Creek (Charlotte County), Alligator Creek (Sarasota County) and Coral Creek. Again, while the relative within-sub-group positioning changed depending on response format, the sub-group composition was constant. The ecological conditions of the creeks in this sub-group vary from pristine, in the case of Whidden Creek, to highly disturbed, in the case of Alligator Creek (Charlotte County). Both upland tidal creeks and estuarine tidal creeks are represented in this major sub-group. Whitaker Bayou and Bowlees Creek comprise the lowest scenic quality sub-group. Both are characterized by heavy man-made development as indicated by the presence of seawalls, residential development, a golf course, marinas, and a scarcity of natural vegetational communities.

The negative effect of man-made objects on scenic quality is clearly distinguishable in the overall ratings of the lowest scenic sub-group. Whitaker Bayou and Bowlees Creek have been heavily altered by man. The lack of a diversity of natural vegetation and the presence of seawalls, residential development, and other man-made objects clearly reduces the perceived scenic quality of these two creeks. This finding is consistent with the results of Carls (1976) and Wolwill (1968). The functioning landscape elements determining the scenic ratings of the moderate scenic sub-group are not as clear. It seems inconsistent that two creeks, one natural and one disturbed would receive similar overall scenic ratings. However, closer inspection of the landscape characteristics

of two such creeks clarifies this condition. While Whidden Creek is the least disturbed by man, it is strictly a mangrove estuary and, therefore, does not exhibit the visual diversity inherent in the well-defined vegetational succession and variety of land-water spatial relationships found on North or South Creek. Alligator Creek (Charlotte County), on the other hand, while characterized by the visual diversity of salt water mouth to fresh water headland succession, has been altered and developed by man. The presence of such man-made features as seawalls, residential developments, trailer parks, bridges, docks, marinas and weirs appears to have a negative effect on perceptions of scenic quality. These negative effects nullify the positive landscape features such as vegetational and topographic diversity and most likely mediates the overall scenic ratings of Alligator Creek (Charlotte County). As evidenced by the high scenic ratings of North and South Creeks and the low scenic ratings of Bowlees Creek and Whitaker Bayou, the results clearly suggest that people prefer natural landscapes over urban-suburban landscapes and as such is consistent with the findings of (Carls, 1976; Zube et. al., 1974; Wolwill, 1968). Furthermore, the results suggest that vegetation has a positive effect on perceived scenic quality which again is consistent with the findings of (Zube et. al., 1974). The most scenic tidal creek landscapes display a variety of vegetational features such as well developed, overhanging canopies, species diversity, and scalar variations. The implications of this relationship is important to the overall planning and environmental management of the tidal creeks because vegetation can serve as a pleasing buffer between man-made objects and the natural creek environments.

In summary, topography and landform along the tidal creeks of Southwest Florida are relatively constant and probably have little effect

on variations of perceived scenic quality. As mentioned before the succession of vegetation along the tidal creeks becomes increasingly important to scenic quality and in combination with landscape elements such as land use, presence of water and man-made objects, comprises the visually important characteristics of tidal creek landscapes. Landscape properties such as scale, texture, edge and color, combine visually with landscape elements and form dynamic relationships to landscape dimension such as complexity/diversity/variety, naturalness and view characteristics.

Lastly, it is important to note that this study was designed to comparatively measure the scenic or visual quality of tidal creeks of Southwest Florida and as such does not conclusively identify the salient landscape elements, properties and dimensions nor the relationship of these landscape components to peoples' preferences. Little is known about these relationships.

In conclusion, in order to facilitate a more complete understanding of the visual quality of these creeks, studies should be initiated in which specific landscape elements, properties and dimensions are measured and compared to peoples' preferences. This study would provide insight into the relationships of specific landscape components to human values. Such knowledge would provide planners and landscape architects with an invaluable tool for measuring the seemingly intangible qualities of the visual environment. Furthermore, this knowledge would be instrumental in preserving, maintaining and creating visually exciting and ecologically compatible interfaces between natural and man-altered environments.

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Summary

*+ J.P. Recommendations*

Initially this study attempted to rank ten tidal creeks in Southwest Florida on the basis of water quality tests and aesthetic analysis. This type of ranking was not possible because there appear to be two basic types of creek ecosystems within this coastal region. Our water quality data indicate that high quality water in each of the two systems may be different.

The two basic systems are: 1) that which has an upland fresh-water component and an estuarine mouth, and 2) that which lacks a lotic section and is totally estuarine in nature. In a natural state, the former is characterized by North Creek and the latter by Whidden Creek.

Although a ranking of the creeks was not possible on the basis of water quality tests, data from our aesthetic analysis indicate that the creeks may be classified into groups. North and South Creeks, both relatively undisturbed upland creeks, were consistently ranked most highly; while Bowlees Creek and Whitaker Bayou, again both upland creeks, but having the greatest amount of man-made alteration, were consistently ranked lowest in scenic quality. The two estuarine creeks (Whidden and Coral), both relatively undisturbed, had moderate scenic quality. People seem to prefer areas without man-made alterations, but with some visual diversity.

In conclusion, tidal creeks in Southwest Florida may be divided into two eco-types and grouped according to their scenic quality.

A. Recommendations for Management:

1. The mangrove areas and salt marshes located at the mouths of the tidal creeks are valuable filters of water from the uplands enroute to the coastal waters. They act as a storm buffer, serve as a nursery for many species of gamefish, and are the habitat of many water fowl. The red mangrove is already protected by law, but the role which black and white mangroves play, as well as the salt marsh grasses, is yet to be fully determined. These areas should be preserved wherever possible.
2. Disturbed shorelines should be revegetated with mangroves and marsh grasses.
3. Dredging, ditching, and channelization should be kept to a minimum in order to retard the rate at which water flows from the uplands, enabling the wetlands to efficiently filter the upland water. Where ditching does occur it should mimic a natural meandering stream channel.
4. Reestablish natural drainage basins where possible, utilizing existing freshwater ponds and marshes for storm water retention, thereby reducing runoff.
5. Establish artificial catchment basins where natural ponds are not available.
6. Application of fertilizers should be carried out during the dry season, with a setback of 50 feet from the creek.
7. Aquatic weeds, such as water hyacinth, should be managed by selective, mechanical harvesting. This would allow these plants to absorb excess dissolved nutrients and prevent obstruction of the waterway.
8. Existing septic tanks and wastewater retention ponds should be

periodically checked. Inefficient systems should be replaced.

9. Existing saltwater/freshwater barriers should be repaired and maintained in order to maintain adequate water levels in the upland areas and to prevent further intrusion of saltwater.

10. Freeflowing wells, whose water is high in chlorides and mineral salts, should be capped.

11. Specific policies concerned with visual quality in the environment should be adopted and implemented at the State and local level.

12. General design guidelines should be adopted that are more sympathetic and compatible with the maintenance of visually pleasing environmental settings. These guidelines should be developed by various experienced and capable individuals from private/public institutions.

13. Planning processes should be conducted with reference to the:

- 1) Accessibility to present and future users of the environment.
- 2) All landscapes, regardless of ecological condition having inherent aesthetic value.
- 3) The inherent visual elements, properties, and dimensions should be recognized; and development should be planned to complement these landscape components.
- 4) The visual characteristics of the region should be identified.
- 5) Planning should recognize the unity of environmental settings. Evaluations of segments of continuous environments should not be treated as if they had no connection to larger continuous environment.
- 6) Development should reinforce, not break the unity and continuity of natural drainage systems.
- 7) The aesthetic qualities of the environment must be considered at

the pre-planning stage.

- 8) Visual quality evaluation should incorporate a multi-disciplinary approach.

B. Recommendations for Future Research:

1. This study shows that there is a discrepancy between EPA criteria for water quality and the water quality found in the natural tidal creeks. A more valuable method of evaluating the creeks may be to establish environmental baselines for use in conjunction with a continued monitoring program.
2. Visual quality research needs to incorporate cost/benefit analysis into the visual evaluation.
3. Behavioral Relationships to visual quality should be determined by:
  - 1) Determining landscape elements universally liked by people.
  - 2) Determining landscape elements universally disliked.
  - 3) Determining the correlation between the above mentioned landscape factors and overall personal values in relation to the visual environment.

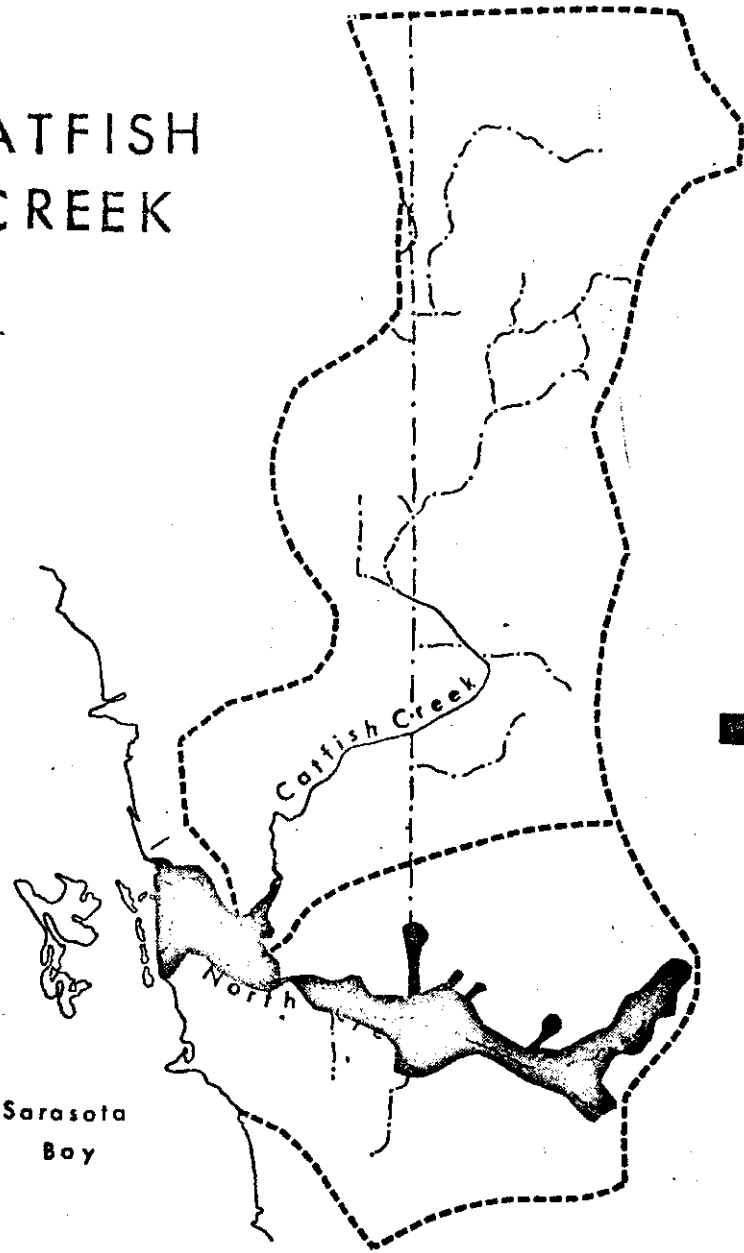
Answers to these questions will provide basic operating principles for planners.

C. Recommendation for Preservation:

The continued monitoring of a baseline tidal creek system necessitates the immediate preservation of the two undisturbed eco-types in Southwest Florida. North Creek and Whidden Creek are our choices for preservation. These creeks are the least disturbed of the two tidal creek systems described earlier. Ideally, the entire drainage basin of each creek should be preserved in its natural state.

An alternative to full preservation is delineation of a greenbelt. This would act as a biological buffer zone between the tidal creeks and upland development. The proposed greenbelt zone for North and Whidden Creek is based on vegetational communities (Figs.43,44)

CATFISH  
CREEK



Scale 1:59088  
1" = .938 miles

Proposed Greenbelt

NORTH  
CREEK

Fig.43 North Creek Drainage Basin and Proposed Greenbelt

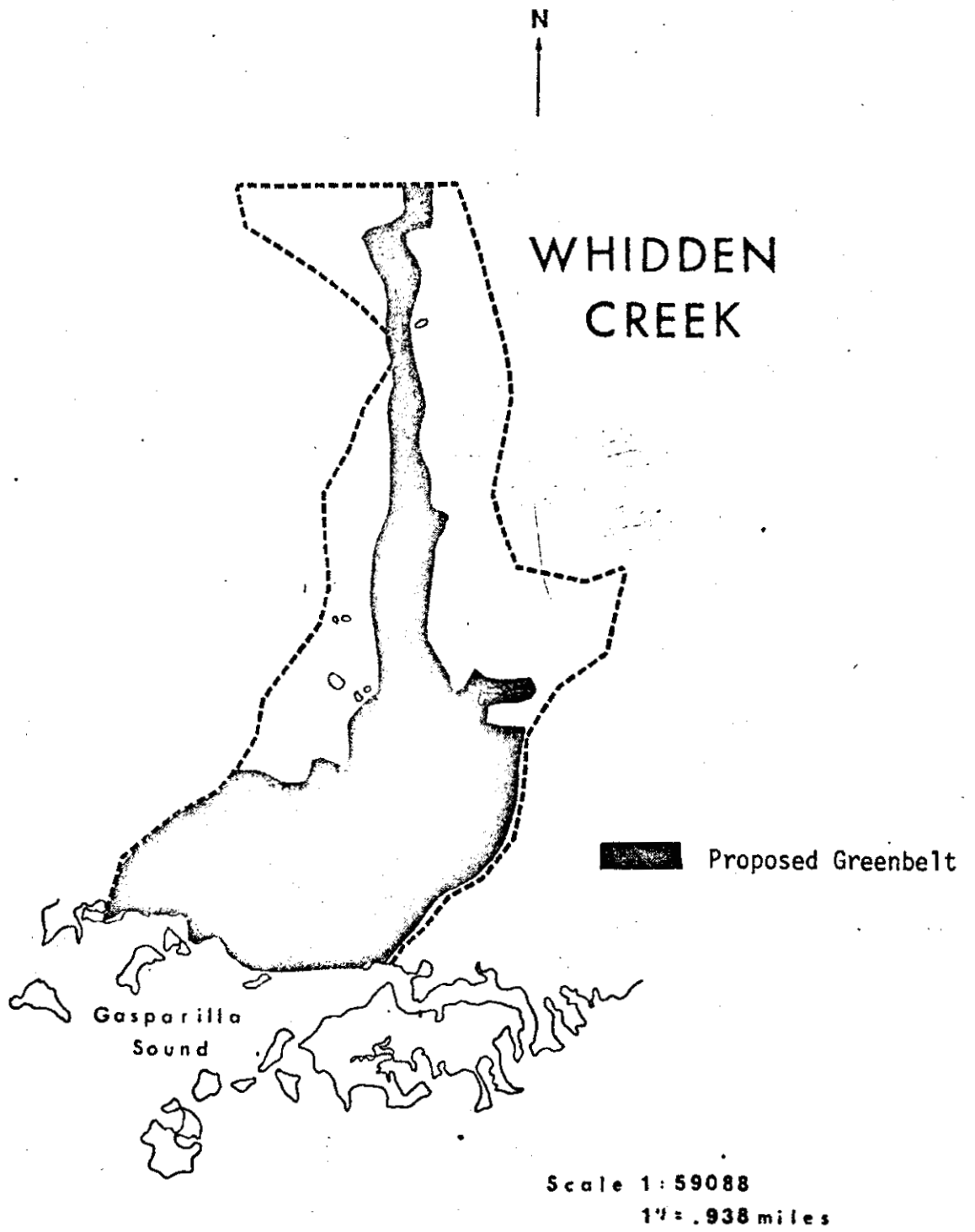


Fig. 44: Whidden Creek drainage basin and proposed greenbelt.

APPENDIX A

Appendix A

List of Tidal Creeks within Study Area:

Manatee County:

1. Palma Sola
- \*2. Bowlees

Sarasota County:

- |              |                |
|--------------|----------------|
| *1. Whitaker | *9. South      |
| 2. Hog       | *10. Catfish   |
| 3. Hudson    | *11. Alligator |
| 4. Matheny   | 12. Phillippi  |
| 5. Holiday   | 13. Shackett   |
| 6. Elligraw  | 14. Hatchet    |
| 7. Clower    | 15. Curry      |
| *8. North    | 16. Forked     |

Charlotte County:

- |                |                      |
|----------------|----------------------|
| 1. Godfrey     | 11. Whidden Branch   |
| 2. Ainger      | *12. Alligator       |
| 3. Oyster      | 13. Big Mound        |
| 4. Buck        | 14. Winegourd        |
| 5. Lemon       | 15. Blind            |
| *6. Coral      | 16. Bear Branch      |
| 7. Catfish     | 17. Hog Branch       |
| *8. Whidden    | 18. Trout            |
| 9. Sister Pond | 19. Lewis            |
| 10. Rock       | 20. Little Alligator |

Lee County:

- |                 |              |
|-----------------|--------------|
| 1. Yucca Pen    | 7. Underhill |
| 2. Hendry       | 8. Jewfish   |
| *3. Mullock     | 9. Shell     |
| 4. Gator Slouth | 10. Mud      |
| 5. Big Dead     | 11. Spring   |
| 6. Sand         |              |

APPENDIX B

## Appendix B

### Methods for Analysis of Water Quality:

Nitrates, nitrites, total kjeldahl nitrogen, ammonia, total phosphate, and ortho-phosphate were analyzed by the Environmental Quality Lab of General Development Corporation.

Dissolved oxygen was determined with the Winkler Titration with the Azide Modification (Standard Methods for the Examination of Water and Wastewater, APHA, 1975). BOD samples were incubated in the dark for five days at 20° C, and DO determined (APHA, 1975).

Membrane filtration (Standard Methods, APHA, 1975) was used to determine numbers of fecal streptococcus bacteria in the samples. Coliform bacteria counts, both fecal and total, were obtained using Millipore "coli-count" water testers.

Suspended solids were tested for using membrane filtration (0.45  $\mu$ , 47 mm, membrane filters) with subsequent drying at 85° C for 24 hours.

Color was measured using the Platinum - Cobalt method outlined in the EPA Manual of Methods for the Analysis of Water and Wastes (1976).

pH was measured in the lab on a Corning Model #12 Research Grade pH meter.

Salinity was measured according to the hydrometric method described in Standard Methods for the Examination of Water and Wastewater (APHA, 1975). When the hydrometers were compared to the silver-nitrate titration (Strickland and Parsons, 1968), the hydrometric readings were found to be slightly higher (1 - 3°/oo). Chlorosity, determined by the Environmental Quality Lab of General Development Corporation, was converted to salinity according to the equation (Strickland and

Parsons, 1968):

$$S \text{ (o/oo)} = 0.030 + 1.8050 \text{ cl (o/oo)}$$

The salinities thus calculated were much lower than those calculated from hydrometric readings. Results are reported using data obtained with the hydrometric method.

Spectrophotometric determination of chlorophyll a and phaeo-pigments was used to obtain a rough idea of the productivity of phytoplankton in the tidal creeks. The method was obtained from Strickland and Parsons (1968) with two major modifications; 1) overnight extraction was replaced by employing a Thomas tissue grinder, and 2) chlorophyll a and phaeo-pigments were calculated using Lorenzen's equations (1967).

Samples of 500 ml were collected in situ and approximately 1 ml of suspended  $\text{MgCO}_3$  was added to prevent acidification. The samples were brought back to the lab and filtered through Gelman 0.4 micron glass filters in subdued lighting. The filters were then folded twice and placed in an A. H. Thomas tissue grinder and 2 - 3 ml of 90% acetone was added. The filters were then ground for approximately one minute.

The suspension was transferred to a centrifuge tube and rinsed with a small amount of 90% acetone so that the final volume measured 10 ml. The tubes were then stoppered and centrifuged at 2000 - 2500 rpm for 2 - 5 minutes, then shaken and recentrifuged at 1000 - 1500 rpm for another 2 - 5 minutes.

The supernatant was decanted into spectrophotometer cuvettes and the extinction values measured with a B&L spectronic 20 colorimeter. The sample tubes were blanked against a cell containing filter, ground and centrifuged in 90% acetone, at 665 and 750 rpm. Then two drops of

HCl were added to the cuvette and the extinction remeasured at 665 nm to eliminate interference from phaeo-pigments (Strickland and Parsons, 1968).

The concentrations of chlorophyll a were corrected for the presence of phaeo-pigments as follows (Lorenzen, 1967);

$$\text{Chl } a \text{ (Mg/M}_3\text{)} = 26.7 \frac{(665_0 - 665_a)}{V \times l} \quad \text{XV}$$

Where  $665_0$  is the extinction at  $6650 \text{ \AA}$  before acidification,  $665_a$  is the extinction at  $6650 \text{ \AA}$  after acidification,  $V$  the volume of acetone in ml,  $V$  the volume of water filtered (Liters), and  $l$  the path length of cuvette (cm). Extinction values at  $7500 \text{ \AA}$  was used as a check for the presence of filter residue (Strickland and Parsons, 1968).

APPENDIX C

Appendix C

Rainfall data for February and April, 1977

<u>Date</u>		<u>Sarasota</u>	<u>Venice</u>	<u>Date</u>	<u>Sarasota</u>	<u>Venice</u>
February	1	.25	.34	April	1	.00
	2	.00	.00		2	.00
	3	.00	.00		3	.00
	4	.10	.02		4	.10
	5	.21	.30		5	.00
	6	.00	.00		6	.03
	7	.00	.00		7	.00
	8	.00	.00		8	.00
	9	.00	.00		9	.00
	10	.00	.00		10	.00
	11	.00	.00		11	.00
	12	.00	.00		12	.00
	13	.00	.00		13	.00
	14	.03	.01		14	.00
	*15	.00	.00		15	T
	16	.02	.00		16	.28
	*17	.00	.00		17	.00
	18	.00	.00		18	.00
	19	.00	.00		19	.00
	20	.00	.00		20	.00
	21	.02	T		21	.00
	22	.00	.00		22	.00
	23	.00	.00		23	.00
	24	.00	.00		24	.53
	25	.88	.60		25	.05
	26	.00	.00		26	.00
	27	.00	.00		27	.10
	28	.00	.00		28	.00
					29	.00
					30	.00

APPENDIX D

Results of sample run conducted April 15 - 17. Data not yet complete.

CREEK	STATION	WATER TEMP °C	PH	SALINITY o/oo	COLOR CPU	TURBIDITY SUSPENDED SOLIDS JTV mg/l	DISSOLVED OXYGEN mg/l	BOD mg/l	TOTAL COLIFORM MPN /100 ml	FECAL COLIFORM MPN /100 ml	FECAL STREP MPN /100 ml	AMMONIA NH <sub>3</sub> mg/l	NO <sub>3</sub> +NO <sub>2</sub> mg/l	TOTAL KJELDAHL NITROGEN mg/l	o-PO <sub>4</sub> mg/l	TOTAL PO <sub>4</sub> mg/l	CHLOROPHYLL a mg/m <sup>3</sup>
Bowlees	1	25	8.3	39.4	5	1.5	6.45	2.55	0	12000	44						
	2	25	8.3	21.0	35	2.7	6.70	5.43	900	10200	1400						
	3	27	8.9	3.5	50	2.3	7.47	1.71	200	700	706						
Whitaker	1	25	8.0	27.5	15	1.7	6.16	5.11	300	1500	50						
	2	25	8.7	24.6	70	5.0	31.56	19.66	100	3100	140						
	3	23	7.8	4.7	50	4.5	19.66	1.73	1600	6000	110						
Catfish	1	28	8.0	37.5	40	2.6	5.43	4.68	0	1600	4						
	2	29	8.1	32.0	50	5.1	5.55	5.55	200	3500	116						

Table - Water quality data for sample run on February 15 - 17. For a discussion of these results, see text.

CREEK	STATION	WATER TEMP °C	PH	SALINITY o/oo	COLOR CPU	Turbidity SUSPENDED SOLIDS JTV mg/l	DISSOLVED OXYGEN mg/l	BOD mg/l	TOTAL COLIFORM MPN /100 ml	FECAL COLIFORM MPN /100 ml	FECAL STREP MPN /100 ml	AMMONIA NH <sub>3</sub> mg/l	NO <sub>3</sub> +NO <sub>2</sub> mg/l	TOTAL KJELDAHL NITROGEN mg/l	o-PO <sub>4</sub> mg/l	TOTAL PO <sub>4</sub> mg/l	CHLOROPHYLL a mg/m <sup>3</sup>
Catfish	3	29	7.9	2.6	50	3.2	2.95	2.69	6500	600	1460						
North	1	25	8.3	38.6	5	1.7	6.79	1.51	500	5000	0						
	2	27	7.9	36.0	30	1.7	4.74	3.89	1700	3200	16						
	3	28	8.3	21.4	45	3.2	7.41	6.80	100	2500	24						
South	1	25	8.2	37.0	5	3.0	5.97	0.86	400	2500	8						
	2	27	8.0	32.3	20	1.7	5.98	2.04	2800	1400	38						
	3	27	7.8	32.0	20	2.8	2.57	1.85	1000	1000	14						
(S) Alligator	1	25	8.1	34.8	15	4.5	6.22	1.67	100	600	2						

Table - Water Quality data for sample run on February 15 - 17. For a discussion of these results, see text.

CREEK	STATION	WATER TEMP °C	pH	SALINITY o/oo	COLOR CPU	Turbidity SUSPENDED SOLIDS JTV mg/l	DISSOLVED OXYGEN mg/l	BOD mg/l	TOTAL COLIFORM MPN /100 ml	FECAL COLIFORM MPN /100 ml	FECAL STREP MPN /100 ml	AMMONIA NH <sub>3</sub> mg/l	NO <sub>3</sub> +NO <sub>2</sub> mg/l	TOTAL KJELDAHL NITROGEN mg/l	o-PO <sub>4</sub> mg/l	TOTAL PO <sub>4</sub> mg/l	CHLOROPHYLL a mg/m <sup>3</sup>
(s) Alligator	2	26	8.2	31.9	35	3.0	7.25	4.70	900	800	10						
	3	25	8.0	3.2	60	1.8	12.70	3.63	0	308	260						
(c) Alligator	1	23	8.2	33.5	15	0.8	6.25	0.85	2300	TNTC	200						
	2	26	8.0	21.2	30	1.6	5.93	2.14	2200	154	100						
	3	25	7.4	2.8	30	1.0	4.25	0.49	400	40	200						
Coral	1	25	8.3	38.4	5	1.1	7.65	1.29	0	1600	0						
	2	27	8.5	39.4	35	2.7	6.91	5.80	0	140	190						
	3	30	8.5	48	30	3.2	8.20	3.55	0	8	2						

Table - Water Quality data for sample run on February 15 - 17. For a discussion of these results, see text.

CREEK	STATION	WATER TEMP °C	PH	SALINITY o/oo	COLOR CPU	Turbidity SUSPENDED SOLIDS JTV mg/l	DISSOLVED OXYGEN mg/l	BOD mg/l	TOTAL COLIFORM MPN /100 ml	FECAL COLIFORM MPN /100 ml	FECAL STREP MPN /100 ml	AMMONIA NH <sub>3</sub> mg/l	NO <sub>3</sub> +NO <sub>2</sub> mg/l	TOTAL KJELDAHL NITROGEN mg/l	o-PO <sub>4</sub> mg/l	TOTAL PO <sub>4</sub> mg/l	CHLOROPHYLL a mg/m <sup>3</sup>
Whidden	1	29		42.7	25	2.4	8.63	3.77	0	6	0						
	2	29		42.3	40	1.9	8.06	3.01	1300	0	50						
	3	30		44.7	50	3.0	7.83	5.95	1700	0	232						
Mullock	1	24		36.4	20	4.3	6.33	1.67	700	0	2						
	2	26		34.6	30	2.8	5.42	1.89	900	4	0						
	3	27		30.7	40	2.5	3.56	3.33	600	124	76						

Table - Water Quality data for sample run on February 15 - 17. For a discussion of these results, see text.

APPENDIX E

## Appendix E

### Major Soil Associations of the Tidal Creeks

#### Introduction

Soil associations are well-defined groups of soils that occur in close association. They influence agricultural types and practices, runoff characteristics, vegetational communities, and groundwater. Soil associations found within the tidal creek drainage basins are generally poorly drained. However artificial drainage has effectively increased the absorptive capacities of some soils. The soils in this region are generally derived from layers of unconsolidated marine sands. They are not naturally fertile or productive and are usually low in organic matter with the exception of those soils found along the immediate stream course.

#### Alligator Creek (Charlotte County)

##### 1. Salt Water Marsh

This soil association is described by deep to shallow very poorly drained, mucky organic soils characteristic of low, wet mangrove swamps that are subject to tidal flooding. This association is found at the mouth of the South Branch and along the entire North Branch.

##### 2. Bradenton, Wabasso, Felda Association

The association is characterized by broad lowlands of slightly acid to alkaline, poorly drained, sandy, loamy soils with an organic, stained black pan. These soils are found mainly in the central portions of the drainage basin.

##### 3. Myakka, Immokalee, Pompano Association

This association is characterized by deep, nearly level and gently

Alligator Creek (Sarasota County) (cont.)

sandy soils, underlain by alkaline and calcaereous materials. These soils are often present in sloughs and depressions, and occur on the immediate creek banks from the mouth to the upland regions of the creek.

3. Adamsville, Bradenton, Broward, Keri, Parkwood, Suniland Association

This association is characterized by somewhat poorly drained sandy soils, shallow over alkaline, with clayey material. These soils are underlain or influenced by calcaereous sediments. This soil association is found in one small area just east of U S Highway 41 and south of the creek proper.

4. Immokalee, Leon, Pomello Associations

This soil association is the most widespread in the drainage basin and is characterized by level to nearly level, poorly drained, sandy soils over an organic hardpan.

Bowlees Creek

1. Pomello, Myakka, St. Lucie Association

This association is characterized by nearly level to gently sloping, moderately well to poorly drained, sandy soils that have weakly cemented layers interspersed with excessively drained white, sandy soils. This association is found in a small area from north of the mouth through Whitfield Estates to the western edge of the Sarasota/Bradenton airport.

2. Immokalee, Myakka, Placid Association

This association is characterized by nearly level to gently sloping, poorly drained, sandy soils that have a weakly cemented

### Bowlees Creek (cont.)

layers and very poorly drained deep soils. These soils are found in an area from the airport north to the golf course and east to U S Highway 301.

#### 3. Wabasso, Bradenton, Myakka Association

This association is characterized by nearly level, poorly drained, sandy soils that have weakly cemented layers or a loamy subsoil or both. It is found in the northeast edge of the drainage basin, just east of U S Highway 301.

#### 4. Broward, Bradenton, Manatee Association

The association is characterized by nearly level, somewhat poorly drained, sandy soil, underlain by limestone and poorly and very poorly drained sandy soils that have loamy subsoils. It is found throughout the northern portion of the drainage basin.

### Catfish Creek:

#### 1. Immokalee, Leon, Pomello Association

This association is characterized by level to nearly level, poorly drained, sandy soils over organic hardpan. This association is widespread throughout the entire drainage basin.

#### 2. Lakewood, St. Lucie Association

This soil association is characterized by excessively drained, sandy soil occurring on conspicuous low ridges a few feet higher than the surrounding terrain. It is found as a small pocket at the western tip of the drainage basin.

#### 3. Adamsville, Bradenton, Broward, Keri, Parkwood, Sunniland Association

The association is characterized by somewhat poorly drained sandy soils, with clayey layers and it is underlain or influenced by

### Catfish Creek (cont.)

calcareous sediments. It is found along the northeastern edge of the drainage basin.

### Coral Creek

#### 1. Pomello, St. Lucie, Paola Association

This association is characterized by low knolls and narrow ridges of white, sandy soils often associated with poorly drained gray soils. It is found on the peninsula between the north and south branches of Coral Creek, and also along the western edge of the mouth.

#### 2. Myakka, Pomello, Basinger Association

The association is characterized by nearly level, broad lowlands of acid-gray, sandy soils with a brown organic pan and associated white sands on low knolls and acid, poorly drained soils in depression. This association is found along the periphery of the drainage basin from Rotunda West to the Seaboard Coast Railroad.

### Mullock Creek

#### 1. Salt Water Marsh Association

This soil association is described by deep to shallow, very poorly drained, mucky, organic soils characteristic of low wet mangrove swamps that are subject to tidal flooding. This association is found in the western portion of the drainage basin.

#### 2. Pomello Association

The association is characterized by deep, nearly level and gently sloping, moderately well drained soils, sandy throughout with a weakly cemented sand layer. It is found in the southwest portion of the drainage basin near U S Highway 41.

### Mullock Creek (cont.)

#### 3. Keri-Ft. Drum-Hallandale Association

This association is characterized by deep and shallow, nearly level, poorly drained and somewhat poorly drained soils, sandy throughout with a loamy subsoil. These soils are characteristic of broad uplands and are present in the north-central portion of the drainage basin, east of the ten-mile canal.

#### 4. Immokalee-Myakka-Pompano Association

The soil association is characterized by deep, nearly level and gently sloping, poorly drained soils, sandy throughout, with and without a weakly cemented, sandy subsoil layer. Often found on broad uplands or sloughs, this soil association is found in the northeast portion of the drainage basin, east of Highway 41.

### North Creek

#### 1. Immokalee, Leon, Pomello Association

This association is characterized by level to nearly level, poorly drained sandy soils over an organic hardpan. This association covers nearly the whole drainage basin.

#### 2. Adamsville, Bradenton, Broward, Keri, Parkwood, Sunniland Association

This association is characterized as somewhat poorly drained, sandy soils with clayey materials, shallow, over alkaline materials and underlain of influenced by calcaereous sediments. It is found in one isolated pocket at the southern boundary of the drainage basin.

### South Creek

#### 1. Immokalee, Leon, Pomello Association

### South Creek (cont.)

This association is characterized by level to nearly level poorly drained soils underlain by an organic hardpan. Almost the entire downstream portion of the drainage basin contains this soil association.

#### 2. Lakewood, St. Lucie Association

This association is characterized by excessively drained, sandy soils occurring on inconspicuous low ridges a few feet above the surrounding terrain. It is found on the tip of land at the southern portion of the mouth of South Creek.

#### 3. Adamsville, Parkwood, Bradenton, Broward, Keri, Sunniland Association

This soil association is characterized by somewhat poorly drained, sandy soils, shallow, over alkaline materials with clayey materials and underlain by calcaereous sediments. This soil association dominates the upland (northern) portions of the drainage basin.

#### 4. Arzell, Charlotte, Managee, Felda, Delray, Pompano Association

This association is characterized by poorly drained to very poorly drained soils underlain by alkaline and calcaereous materials. It is found along with the Adamsville, Keri, Parkwood, Bradenton, Broward, Sunniland Association in the upland portions of the drainage basin in sloughs and depressions.

### Whidden Creek

#### 1. Saltwater Marsh

This soil association is characterized by deep to shallow, very poorly drained, mucky, organic soils, characteristic of low, wet mangrove swamps subject to tidal flooding. The entire Whidden

Alligator Creek (Charlotte County) (cont.)

sloping poorly drained soils, sandy throughout with and without weakly cemented, sandy subsoil layers. These soils are normally found on broad uplands and in sloughs, and are present in the eastern portions of the drainage basin surrounding the North and South prongs of the South Branch.

4. Pomello, St. Lucie, Paola Association

This association is characterized by low knolls and narrow ridges of white, sandy soils and are often found in conjunction with poorly drained, gray, sandy soils. This association is found in a small area between the north and south prongs of the South Branch of Alligator Creek.

5. Adamsville, Pompano, Keri Association

This soil association is characterized by broad lowlands of poorly drained soils, slightly alkaline or acid, and associated poorly drained soils commonly found in depressions. The periphery of the eastern half of the drainage basin contains this soil association, as does a small area just southeast of the junction of the South Branch and US Highway 41.

Alligator Creek (Sarasota County)

1. Lakewood-St. Lucie Association

This association is characterized by excessively drained, sandy soils occurring on inconspicuous low ridges. It is found on small land areas either side of the mouth of the Alligator Creek drainage basin.

2. Arzell, Charlotte, Manatee, Felda, Delray, Pompano Association

This association is characterized by poor to very poorly drained

Whidden Creek (cont.)

Creek drainage basin consists of this soil association.

Whitaker Bayou

1. Errant Soils

These are described as being soils altered or made by man and are prevalent from the mouth to just north of Myrtle Avenue in the more heavily urbanized sections of the drainage basin.

2. Adamsville, Bradenton, Parkwood, Broward, Keri, Sunniland Association

This soil association is characterized by somewhat poorly drained soils, shallow over alkaline material. It is found along a thin strip east of the bayou and running parallel to the railroad tracks.

3. Arzell, Charlotte, Manatee, Felda, Delray, Pompano Association

This association is characterized by poorly to very poorly drained soils over alkaline materials. It is found along the immediate stream banks along most of the upstream portions of the natural stream bed.

4. Immokalee, Pomello, Leon Association

This association is characterized by level to nearly level, poorly drained, sandy soils over an organic hardpan. It is found interspersed throughout the drainage basin and is the most common soil association in the basin.

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APPENDIX F

## Appendix F

### Statistical Analysis Procedures

The two response formats, the forced Q-Sort procedure and Likert Interval Scale utilizing non-continuous interval scales were chosen to determine a comparative scenic evaluation of the tidal creeks. For reasons of empirical rigor, non-parametric statistical procedures were employed for data analysis: First, a Freidman Two-Way Classification test was used to determine statistically, the relative differences of overall scenic beauty. In order to determine if these differences were significant and not due to chance, a Wilcoxon T-test was utilized. In conjunction these two non-parametric tests were used to analyze the data from both the Q-sort and the Likert Interval Scale response formats.

### The Freidman Two-Way Classification Test

1. Determine the median rating for each of ten, 9 slide creek sets by subject.
2. Rank the median ratings for each of ten creeks by subject.
3. Sum the ranks for individual creeks across the entire subject population.
4. Test the null hypothesis using the Freidmann Equation:

$$Fr = \frac{12}{ab(a+1)} \left[ \sum_{a} \left( \sum_{IJ} R \right)^2 \right] - 3b(a+1)$$

where:

a = # of creeks

b = # of subjects

5. Determine the Chi-square for degrees of freedom (a-1) with Alpha (  $\alpha$  ) equal to .01 (= the probability of making a type 1 error which is the probability of results being due to chance).
6. Compare this value with Fr value. If Fr is greater than the Chi-square value the results  $R_{IJ}$  are not due to chance.

The Wilcoxon T-test: This test determines whether specific groups of creek values (  $\sum R_{IJ}$  ) are significantly different.

1. Determine major sub-groups based on  $\sum R_{IJ}$
2. Determine median rating for each major sub-group across the entire subject population.
3. Determine differences in median ratings between paired sub-groups.
4. Rank the absolute value of the differences between median rating discounting zeros.
5. Sign the ranks based on signs as determined in Step 4.
6. Sum the + ranks and the - ranks and take the smaller as the Wilcoxon T.
7. Check value of Wilcoxon T for each overall sub-group comp based on n = # of differences, discounting zeros, of paired sub-group comparisons across the entire subject population for  $\alpha = .01$ .  
If the Wilcoxon T value is less than value determined from the Wilcoxon Signed Rank Table, results are statistically significant, i.e. are not due to chance.