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College of Engineering

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Gainesville

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THE USE OF REMOTE SENSING IN SOLVING FLORIDA'S GEOLOGICAL AND COASTAL ENGINEERING PROBLEMS

REPORT PERIOD: July 1, 1976 to March 31, 1977

PROJECT DIRECTOR: H. K. Brooks

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SUMMARY STATEMENT

This report is presented in two parts; the first part pertains to all phases of work conducted on the projects during the report period, and the second part is the final report for the selection of suitable sites for sanitary landfill in Volusia County.

Primary activities included the acquisition of imagery, IMAGE 100 System analysis, conventional photo interpretation, evaluation of existing data sources (eg. vegetation, soils, and ground water maps), site investigations for ground truth, and preparation of displays for reports. Discussions were held with personnel from different state and local agencies to evaluate their needs for remote sensing in solving specific problems. Also, talks on remote sensing applications were presented at a Florida Department of Transportation conference and at other meetings by H. K. Brooks and B. E. Ruth.

The Volusia County investigation for selection of suitable landfill sites for the City of Daytona Beach is almost complete with the exception of soil borings and water quality measurements in the immediate vicinity of the Tomoka Road Farm site. Much of our effort has been spent on this project. The results obtained from analysis of imagery provided most of the information needed to evaluate terrain conditions. Initial efforts with the IMAGE 100 analysis of Landsat scenes yielded excellent depiction of structural lineations and swamp areas. Surficial deposits such as old beach ridges were easily identified on both NASA high altitude color infrared (CIR) photography and the color composite of the Landsat scenes. Machine processed imagery proved beneficial for extracting structural elements and large homogeneous features, but certain small detail was best achieved using the CIR photos.

The University of Florida library has an aerial photography file of alternate frames of USDA,SCS photography. A search of this file provided several different dates of suitable coverage for the coastal area at Clearwater Beach. Conventional black/white (B/W) prints of the desired frames were purchased from the U. S. Department of Agriculture, Soil Conservation Service.

IMAGE ANALYSIS METHODS - VOLUSIA COUNTY

The General Electric Company IMAGE 100 System was used in the analysis of Landsat tapes for the identification of soils and terrain elements. Vegetation was used as an indicator of soil and drainage conditions in the Volusia County study. Initial efforts were concentrated on the use of displays at a scale of 1:1 [2] and the selection of training sites to develop themes [3] for the different terrain-vegetation elements. Good results were obtained for identification of water, cypress swamps, and certain highly reflective sandy soil areas. Hardwood swamps, pine plantations, and turkey oak on sandy beach ridges appeared to give similar signatures [4] which could not be separated into different themes. Further analysis indicated that training sites contained a mix of vegetation. The pixels selected for training had excessively broad signature values, resulting from heterogenity of the sample and the overlap of pixels into a different class of vegetation.

The lack of undisturbed natural vegetation and a predominance of man's activity contributed to the difficulties of terrain classification.

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[2] One display element per pixel, or approximately two miles per inch.

[3] A theme is a map of all locations in a given image that corresponds to a given classification (eg. swamp, water, etc.).

[4] A signature characterizes a given ground cover in terms of the reflected radiation in different wave lengths or spectral bands. Landsat has a sensor with four bands: green, red, and two infrared bands.

A variety of techniques were used in the analysis of scenes with the IMAGE 100 System. Careful selection of training sites, some of them consisting of one or more pixels,[1] combined with single cell classification, appeared to give the best approach for analysis of the imagery. The relatively low resolution of the Landsat imagery combined with the heterogeneous character of many features detracted from the ability of the Image 100 System to extract certain highly significant information.

IMAGERY SELECTION AND ACQUISITIONS

A variety of imagery for the different study areas was obtained for the project. The Browse Center located at the State Topographic Office in Tallahassee was used in the search for suitable Landsat imagery and NASA high altitude photography. This facility was used in conjunction with computer listings of imagery from the EROS Data Center. Most of the ERTS scenes covering the study areas had excessive cloud cover or were of low quality. The best scenes were selected from different dates and computer compatible tapes (1600 bpi) were purchased from the EROS Data Center. These tapes were supplemented by other scenes copied from those available at the NASA-KSC facilities (800 bpi tapes). Table 1 presents a listing of the tapes acquired for the project.

Color infrared photography at a scale of 1:130,000 was selected from the available NASA aircraft photography. The Browse Center did not have microfilm of any NASA photography but several cassettes were obtained on short loan and viewed. Coding of the different frames was very poor, making it essential to select the desired frames using the computer listing from the EROS Data Center. These color infrared transparencies are of excellent quality and proved to be extremely valuable for interpretation of certain terrain features.

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[1] A pixel is shorthand for picture element, which for Landsat data corresponds to approximately one acre (180' X 220').

TABLE 1

COMPUTER COMPATIBLE TAPES

LOCATION	SCENE No	QUALITY	PERCENT CLOUD COVER	DATE
Volusia County and Vicinity	81045152755	5528	10	720906 (a)
	81225152855	2888	10	730305 (b)
	81261152855	8888	10	730410
	82023151655	8885	10	750214 (b)
	81999150915	5888	00	750418
	82329151425	5888	10	751217
	82383151355	8888	00	760209
	85359144715	8888	10	760412
Flagler County and North	81423152635	8888	10	730919
	81657152135	8888	10	740511
	82096152155	8885	10	750428 (b)
Melbourne to Lake Okeechobee	81206152255	8888	10	730214 (b)
	81260152335	8888	10	730409
	81890150845	8888	10	741230
	85286144645	8888	10	760130
	85340144315	8888	10	760324
	85358144205	8888	10	760411
	82490150525	8888	10	760526
Lake Okeechobee to Everglades	81890150915	8688	10	741230
	82436150725	8888	10	760402
Clearwater Beach Area - North	8158615291	8888	00	740301 (b)
	82420151853	8888	10	760317

a) 1600 bpi, unless otherwise noted
b) 800 bpi, copied from CCT at NASA-KSC

Pine plantations are extensive and occur in varying stages of development from bare soil to a heavy canopy. Encroachment of planted pines on swamps and sandy, well drained relic beach ridges drastically alters the relationship between soil moisture and vegetation. Homogeneous stands of native vegetation are either very small or non-existent. In fact, there is virtually no place in the County that does not show some modification due to the activities of man.

Cluster analysis by the IMAGE 100 System was attempted with equally poor results. The clustering technique is a valuable tool when distinct training sites are small and/or difficult to identify. High reflectance areas were successfully subdivided into three categories by clustering on one scene. However, in most scenes, clustering was not as productive as the more traditionally supervised approach, described earlier. Transformation ratioing, additive, and subtractive processing of imagery were also tried without success. These techniques have been successfully used in the regional analysis of overviews[5] where features are large and relatively homogeneous.

As work progressed in the analysis of scenes from different dates, it was obvious that substantial shifts in reflectance existed for scenes covering the months of September, March, and April. Infrared bands 6 and 7[6] had high reflectance due to vigorous growth of vegetation; and all four bands indicated high reflectance from atmo heric haze. The scenes were corrected for haze by using a standard water signature, since water is not susceptible to seasonal variation. This procedure is discussed in a subsequent section of this report.

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5 Typically ten miles per inch.

6 These are reflective bands, not thermal. Landsat C, to be flown in late 1977 or early 1978, will have a thermal channel (band 8).

Image analysis efforts were continued using extreme care in selection of training sites. Ground and aerial inspection of training sites were conducted to assure homogeneity and proper delineation of boundaries. Single pixel training was used to obtain a series of signatures for pixels within the training area. Pixel signatures near boundaries of the training site showed significant shifts in reflectance. These were excluded from the composite of pixels used in establishing themes and histograms[7] for land use classification.

The land use classification categories used in this study are compatible with the system developed by Anderson et.al. (1) and the Florida Land Use and Cover Classification System (2) which is a modification of Anderson's system to include level III categories. A complete classification of Volusia County was not necessary since only a few categories related to the geotechnical and hydrological characteristics of the terrain for the study area.

The 760209 scene was processed using single pixel training in the development of four significant themes: water, cypress and cabbage palm swamps, hardwood swamps containing maple and bay trees, and dense 8-12 year old pine plantations without significant understory. Hardwood and cypress swamps complimented each other without overlap. Pine plantations were depicted accurately, except that several pixels overlapped with the hardwood swamp theme. Additional work will be required to evaluate other categories of pine plantation where density, age, and understory are different.

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[7] Histograms are presented in graphical form to provide a measure of the frequency of variation of pixel intensities for each band.

An attempt was made to compare the signatures for each vegetative category in the scenes from different dates. Two-four quadrant displays were prepared using a visual registration technique. Visual registration seemed to be good, however, close inspection indicated that some skewing and an occasional one to two pixel shift was present between overlapping images. The 720209 scene was used as the standard in each of the two-four quadrant displays. All scenes were corrected for atmospheric haze.

Training sites or previously developed signatures were used to establish themes for the 760209 scene. Each theme was superimposed on other quadrants of the display for the purpose of establishing signatures for different scenes. Poor results were achieved because the obtained signatures were excessively altered and had a large coefficient of variation. This condition was attributed to the lack of registration and the large number of pixels bordering relatively small areas. This could be a valuable technique if the scenes contained relatively large homogeneous areas that minimized the number of border pixels (sometimes called mixed pixels). Alternatively, precision geometric correction techniques could be applied to register the different quadrants to subpixel accuracy.

The quadrant display was used to obtain signatures for small samples within training sites. This technique seemed to give reliable results except where only small sites were available for a particular classification category. Table 2 presents a summary of signatures obtained for seven scenes and six training sites. Signatures for 750214 and 760209 are almost identical and swamp themes for these scenes using a standard signature gave almost identical results. Infrared reflectance was lower for the 751217 scene. This may be attributed to rainfall that was recorded at Deland, Florida. Rainfall records are summarized in Table 3

TABLE 2

QUADRANT DISPLAY SIGNATURE COMPARISON

DATE OF LANDSAT IMAGERY FOR VOLUSIA COUNTY, FLORIDA

FEATURE	720906	730305	730410	750214	750418	751217	760209 (b)
Cypress Swamp (a)	4-5	6-7	4-4	6-6	7-7	5-5	5-6
Site 1	4-5	5-6	3-4	6-6	5-5	5-6	6-6
	14-15	8-10	10-13	8-10	17-19	6-8	8-9
	18-19	9-11	13-15	9-10	20-22	5-6	9-10
Site 2	5-6	6-6	3-4	5-6	6-8	5-5	5-6
	5-7	5-5	2-3	5-6	4-5	4-5	5-7
	13-16	9-11	12-19	10-16	19-22	5-7	7-11
	14-19	9-14	16-25	8-15	19-29	5-8	7-12
Site 3	3-5	3-8	1-4	5-6	6-8	4-6	5-6
	3-5	3-8	2-4	5-7	4-7	4-6	5-6
	7-15	2-11	2-14	6-10	8-19	5-8	6-10
	6-19	4-13	3-17	5-11	8-22	4-8	5-12
Hardwood Swamp	2-4	4-7	2-4	4-5	5-7	4-5	4-5
Site 4	3-4	4-5	1-3	4-5	3-5	3-5	4-5
	12-18	9-13	11-16	10-14	14-18	8-12	10-14
	15-19	12-17	16-21	11-15	16-22	8-12	12-16
Tomoka River	3-5	5-8	2-4	5-6	6-9	4-5	5-6
Vegetation	4-5	5-8	1-5	5-7	4-8	4-6	5-7
Site 5	14-17	10-15	14-23	11-17	16-24	7-12	9-13
(hardwoods, etc.)	17-21	13-19	18-32	12-19	18-30	7-11	11-16
Landfill-Sandy	13-25	15-24	22-33	9-15	17-27	7-13	12-16
(little vegetation)	18-32	18-28	27-39	12-21	19-32	10-18	16-23
Site 6	19-35	16-25	35-38	20-26	22-33	10-19	19-25
	19-32	16-24	32-35	19-25	17-31	8-16	17-23

(a) All reflectance values based on relative range of 64; the four pairs of upper and lower reflectance bounds taken together define a signature consisting of a single spectral "cell".

(b) Uncorrected for atmospheric haze.

TABLE 3

DAILY PRECIPITATION FOR SELECTED DATES FOR
DAYTONA BEACH, FLORIDA AND DELAND, FLORIDA
(CLIMATOLOGICAL DATA: FLORIDA)

YEAR	MONTH	DAY	DAYTONA BEACH	DELAND
72	08	28	.20	.12
		29	.57	.13
		30	--	.07
		31	.42	1.00
72	09	01	--	--
		02	--	--
		03	--	--
		04	--	--
		05	--	--
72	09	06	T	--
TOTAL			1.19	1.32

YEAR	MONTH	DAY	DAYTONA BEACH	DELAND
73	02	24	--	--
		25	--	--
		26	T	--
		27	--	--
		28	--	--
73	03	01	--	--
		02	T	--
		03	--	--
		04	--	--
73	03	05	--	--
TOTAL			T	--

YEAR	MONTH	DAY	DAYTONA BEACH	DELAND
73	04	01	.10	--
		02	--	--
		03	.22	.42
		04	1.21	1.37
		05	--	--
		06	--	--
		07	1.13	1.55
		08	.30	--
		09	--	--
73	04	10	--	--
TOTAL			2.96	2.34

YEAR	MONTH	DAY	DAYTONA BEACH	DELAND
75	02	05	.15	.20
		06	.72	1.00
		07	--	--
		08	--	--
		09	--	--
		10	.05	.12
		11	--	--
		12	.07	.02
		13	--	--
75	02	14	--	--
TOTAL			.99	1.34

YEAR	MONTH	DAY	DAYTONA BEACH	DELAND
75	04	09	T	--
		10	--	--
		11	1.84	--
		12	T	2.78
		13	T	--
		14	.27	--
		15	.72	2.10
		16	--	--
		17	--	--
75	04	18	--	--
TOTAL			2.83	4.88

YEAR	MONTH	DAY	DAYTONA BEACH	DELAND
75	12	08	--	--
		09	--	--
		10	--	--
		11	--	--
		12	T	--
		13	--	--
		14	--	--
		15	.10	--
		16	--	--
75	12	17	--	.03
TOTAL			.10	.03

YEAR	MONTH	DAY	DAYTONA BEACH	DELAND
76	01	31	--	--
76	02	01	.25	--
		02	--	.38
		03	--	--
		04	--	--
		05	--	--
		06	T	--
		07	--	--
		08	--	--
76	02	09	--	--
TOTAL			.25	.38

and Figures 1, 2, and 3. In general, the reduction in reflectance is related to precipitation and moisture conditions immediately prior to the date of the imagery.

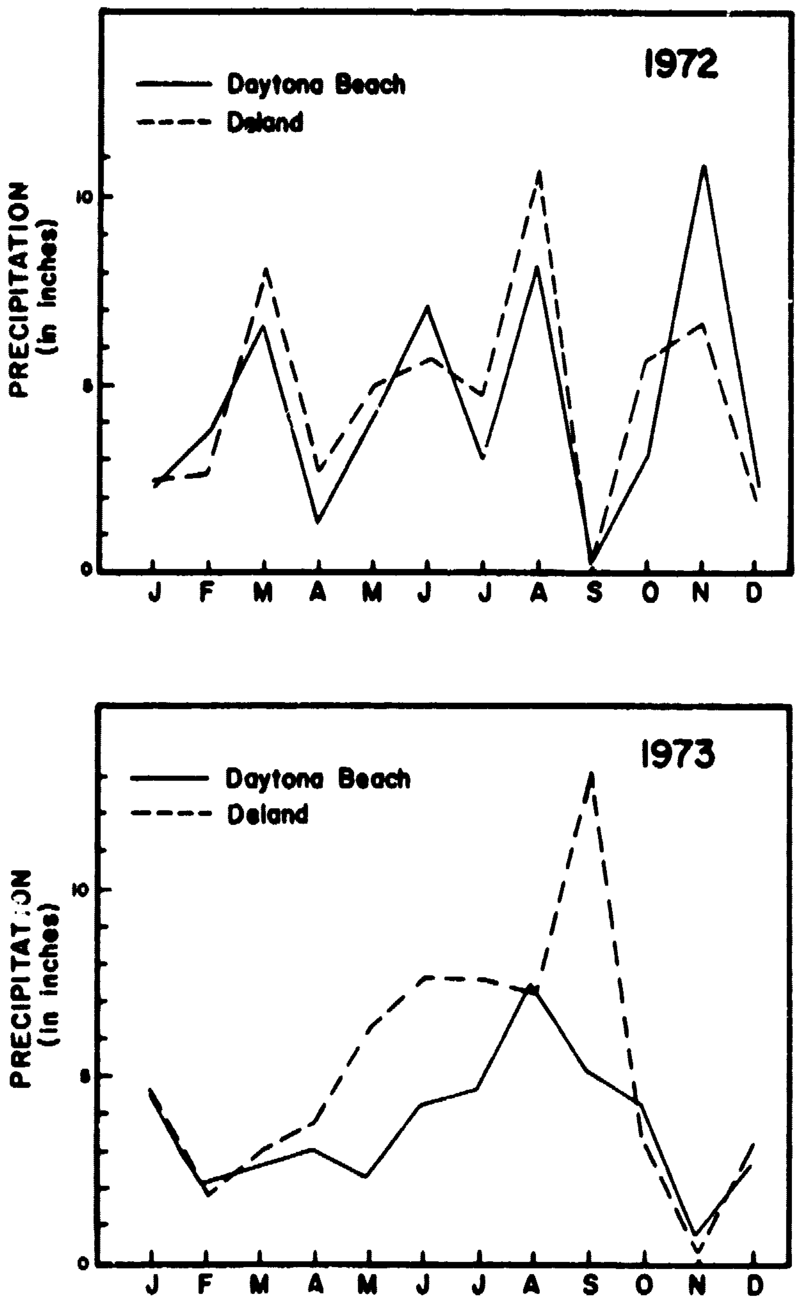
In summary, the Volusia County study indicated that the most viable approach to automated image analysis of Florida woodlands was the use of composite single pixel training in homogeneous sites in combination with single cell classification of different terrain categories.

ATMOSPHERIC HAZE CORRECTION

Initial analysis of terrain conditions using Landsat tapes neglected the effect of atmospheric haze because the scenes that were viewed appeared to be haze free. Subsequent work with scenes from the months of April and September indicated the need for haze correction. Signatures for water were obtained for the offshore area by training on the ocean, excluding shallow water and surf zone areas. Several scenes (750214 and 751217) appeared to be haze free and scatter diagrams of channel 1 (band 4) versus channel 2 (band 5) for the entire scene (including land area) provided a linear relation that intersected at the origin (0.0 relative reflectance). Since the intercept occurred at the origin, it was assumed that atmospheric haze was minimal and that these two scenes could be used as a standard to correct other scenes for haze (3). The difference between ocean reflectance values and the standard reflectance was subtracted from the reflectance of each scene.

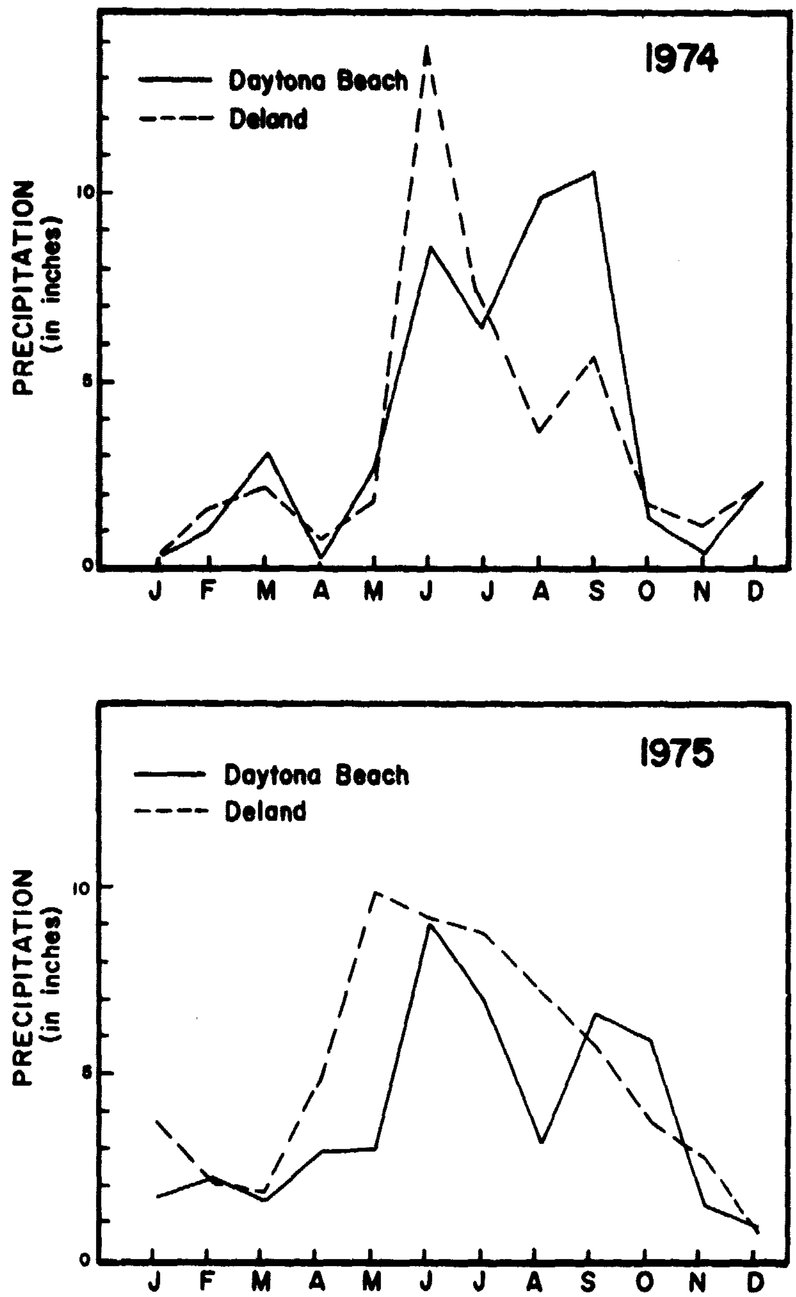
All corrections were originally based on a range of relative reflectance of 256. Table 4 presents the relative reflectance values (based on a range of 64) for the ocean training sites for each scene, the reflectance correction, and the reflectance after correction. Close inspection of these values indicated that further adjustment was necessary, since

FIGURE 1



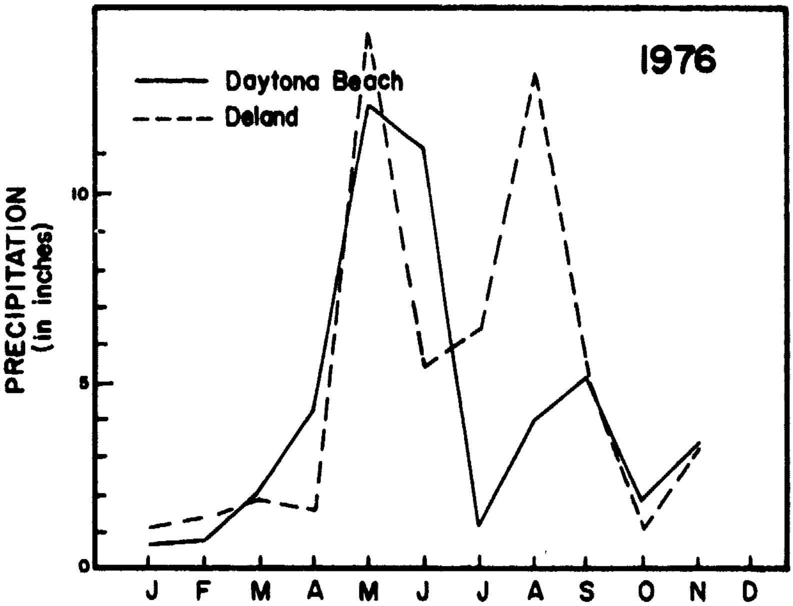
MONTHLY PRECIPITATION FOR THE CITIES OF DAYTONA BEACH, FLORIDA AND DELAND, FLORIDA (CLIMATOLOGICAL DATA: FLORIDA)

FIGURE 2



MONTHLY PRECIPITATION FOR THE CITIES OF DAYTONA BEACH, FLORIDA AND DELAND, FLORIDA (CLIMATOLOGICAL DATA: FLORIDA)

FIGURE 3



MONTHLY PRECIPITATION FOR THE CITIES OF DAYTONA BEACH, FLORIDA AND DELAND, FLORIDA (CLIMATOLOGICAL DATA: FLORIDA)

TABLE 4

RELATIVE REFLECTANCE AND HAZE CORRECTION BASED ON OCEAN MEASUREMENTS

	720906	730305	730410	750214	750418	751217	760209	760317 (b)
Range in Reflectance (a):								
Band 4	15-17	9.5-11.5	12-15	3-7	9-12	3-6	4-7	5-6
Band 5	8-10	5-6	7-9	1-4	5-7	1-4	2-5	3-4
Band 6	5-6	2-4	4-6	0-2	2-5	0-2	0-3	0-2
Band 7	2-4	0-2	2-5	0-1	0-3	0-0	0-1	0-0
Mean Reflectance:								
Band 4	16.1	10.15	13.2	4.1	10.6	4.4	5.6	5.3
Band 5	9.3	5.4	7.6	2.7	5.7	2.7	3.5	3.3
Band 6	5.7	4.0	5.3	0.6	3.5	0.4	1.1	1.2
Band 7	2.9	1.1	3.3	0.0	1.4	0.0	0.0	0.0
Correction for Haze:								
Band 4	-11.75	-5.5	-9		-6		-1.25	
Band 5	-6	-2.5	-5		-3		-0.75	
Band 6	-5	-2.5	-5		-3		0.0	
Band 7	-3	-1	-3.25		-1.25		0.0	
Range in Reflectance after Correction:		Not Obtained		No Correction		No Correction		
Band 4	3-5		5-7		4-5		2-6	
Band 5	2-4		2-3.5		2-3		1-5	
Band 6	0-1		0-1		0-1		0-3	
Band 7	0-1		0-0.5		0-0		0-1	
Mean after Correction:								
Band 4	4.1		6.0		4.6		4.1	
Band 5	3.3		2.8		2.6		2.9	
Band 6	0.7		0.3		0.5		1.1	
Band 7	0.1		0.05		0.0		0.0	

(a) All reflectance values based on relative range of 64.
(b) Image for Clearwater Beach area.

corrected values of relative reflectance for the ocean were not identical to the standard. However, scatter diagrams of band 4 versus band 5 for all scenes did appear to intersect the origin at 0.0.

The degree of reliability of the atmospheric haze correction can be determined only by conducting an experiment. Obviously, scenes having variable and non-uniform haze conditions would be erroneously corrected if the haze conditions in the training areas were not representative of the entire scene. In our case, the corrected scenes appeared to have fairly uniform haze conditions.

CONTACTS WITH AGENCIES

Discussions were held with personnel from different state and local agencies to inform them of our capabilities in remote sensing. Those that expressed interest in remote sensing applications in their areas are listed below:

1. Northwest Florida Water Management District
2. St. Johns Water Management District
3. County of Volusia, Planning & Development Department, Public Works Department and Water Quality Management Program.

Both the St. Johns Water Management District and the Northwest Florida Water Management District have specific water management projects that require our assistance.

PROJECT WORK PLAN

Some additional field work for water quality measurements will be performed to provide information for a supplement to the sanitary landfill site selection report. Concurrently, work will be initiated on the location of construction materials for highway Route 80, south of Lake Okeechobee. Existing Florida Department of Transportation soil maps, that were developed from SCS soil maps, have been obtained for use in the project. Image analysis, ground truth information, collection of other data, and preparation of the project report will probably be completed by June 1977.

The Clearwater Inlet Project will be flown using underwater targets and B/W and color film to collect water depth information from photogrammetric and densiometric analysis. The test site should provide comparisons between depths based on both methods and actual fathometer values. If good correlation exists, a densiometric approach will be applied to imagery obtained on different dates.

Our effort to develop new projects in cooperation with different agencies and to distribute information will be expanded in the future. Technical papers will be prepared on the geological and remote sensing aspects of the Volusia County study for presentation and publication in scientific journals.

REFERENCES

1. Anderson, J. R., Hardy, E. E., Roach, J. T., and Witmer, R. J., "A Land Use and Land Cover Classification System for Use With Remote Sensor Data", U. S. Geological Survey, Professional Paper 964, p. 28.

2. The Florida Land Use and Cover Classification System: A Technical Report, Florida Department of Administration, Division, April, 1976.

3. Potter, J. F. and Medlowitz, M. A., "On the Determination of Haze Levels from Landsat Data", Proceedings, X-International Symposium on Remote Sensing of Environment, Vol. 1 & 2, Environmental Research Institute of Michigan, October, 1975.

PROGRESS REPORT

ON

CLEARWATER INLET STABILITY STUDY BY REMOTE SENSING

Attn: Joseph Vitale
University Affairs

Submitted by:

Y. H. Wang
Coastal and Oceanographic Engineering Laboratory
Engineering and Industry Experimental Station
University of Florida

TABLE OF CONTENTS

I. PRESENT STUDY

The present study is not aimed at data collection, but instead, the development of a technique to solve engineering problems frequently encountered on beaches and inlets. Because of the steady rise in sea level and the activities of man in the coastal zone, sand is eroding from our beaches, sand is depositing in inlets, and navigation channels are changing. Remote sensing has the potential to monitor the changes that are taking place so that appropriate and timely correction can be made.

II. WORK ACCOMPLISHED

A. Initial Phase

In the first phase of the study, the principal investigator spent some time becoming familiar with the NASA information distribution system and previous work which had been conducted in the area.

B. Aerial Photographs

A series of aerial photographs of Clearwater Inlet was assembled from various sources covering the time period 1926 to 1977. Attempts were made to superimpose all of these photographs to show the evolutionary changes. This was difficult because of the variation in flight altitude, camera angle, etc. The task was further complicated by the fact that dredging and construction operations had been conducted during the 50-year period. Nevertheless, a general trend of accretion and erosion was noticeable.

C. IMAGE 100 SYSTEM

In early September, a trip was arranged to visit NASA Center at Cape Kennedy, where the investigator learned many things, such as color CRT display, cluster synthesis, window display, gray level slicing, ratioing techniques, etc. It was an exciting and stimulating experience. People there were friendly and helpful. Other equipment used for viewing photo negatives and prints was also of interest.

D. Spectral Analysis of Landsat Imagery

A multispectral scanner Landsat magnetic tape dated March 3, 1976 was acquired and analyzed at the General Electric facility at Daytona Beach, Florida. The analysis of the Landsat imagery included the following:

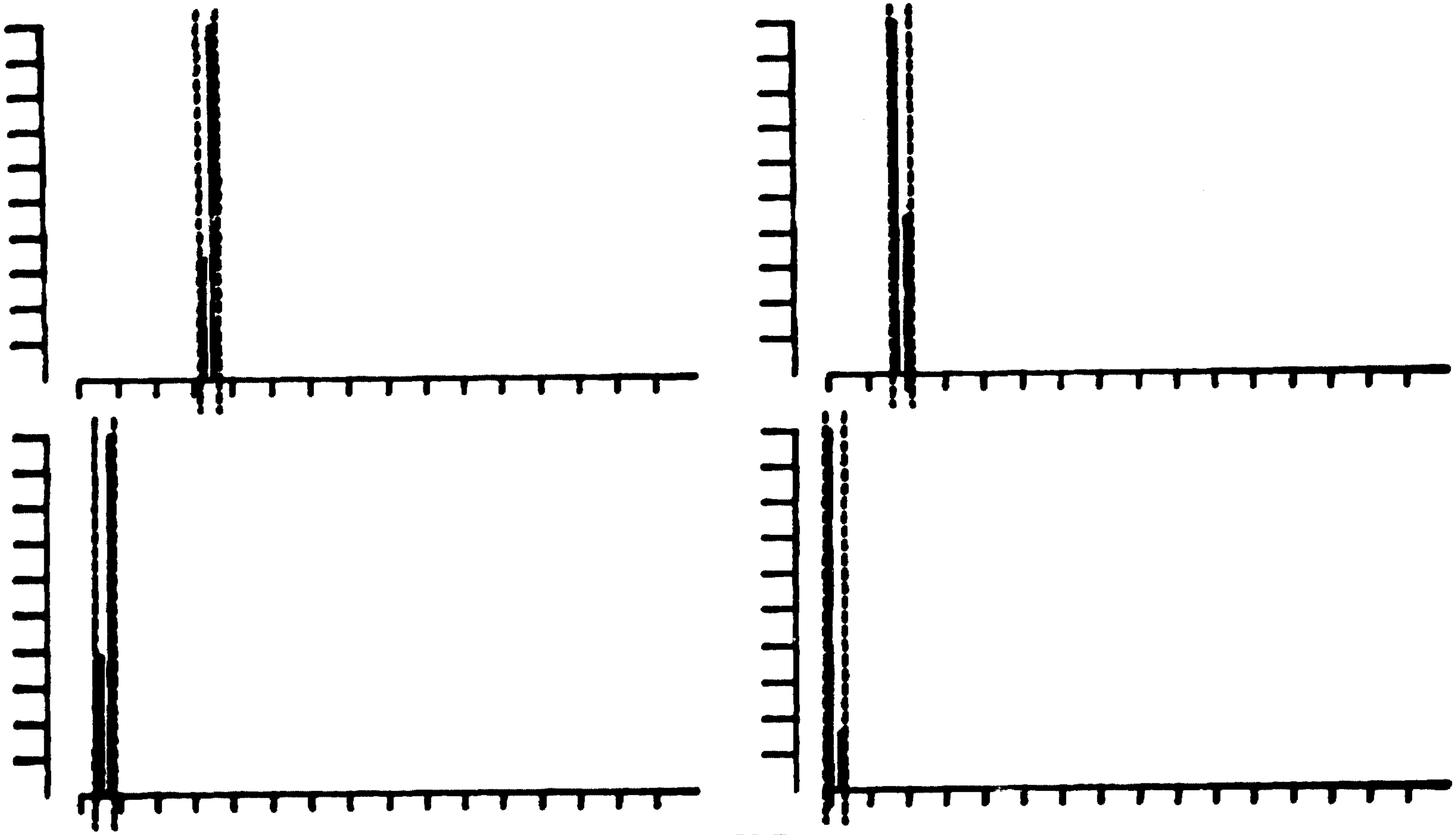
1. Single cell signature acquisition: The pixel counts for each of the four channels were determined for selected areas of interest. The upper and lower limits of the gray level distributions in each channel were also defined.

2. Binary search multicell signature acquisition: A multi-dimensional histogram analysis was performed from the shore to the deep water region. The pertinent statistics were displayed on the graphics terminal.

3. Single pixel training: This technique was found to be very useful for analyzing the specific features observed near the Clearwater Inlet.

4. One-dimensional histogram display: The one-dimensional histograms of the four channels and their corresponding statistical parameters fo. each channel were obtained for the areas of interest. A sample of these displays is given in Figure 4.

5. Cluster synthesis: Based on training data acquired during N-dimensional histogram acquisition, the thresholds were selected and then, five clusters were generated. These



```
$$$ OVERVIEW $$$      +  COMPARISON FILE:
$  LB  UB DEL    PEAK  MEAN    VAR +
1  13  14  2      27.  13.7    0.2 +
2   7   8  2      25.   7.3    0.2 +
3   2   3  2      26.   2.7    0.2 +
4   0   1  2      31.   0.1    0.1 +
TRAINING AREA=    36. PIXELS       +
ALARMED AREA= 22496.PIXELS(  8.6%)+
TYPE: CHANNEL $   OR E(X)IT
```

FIGURE 4

ONE-DIMENSIONAL HISTOGRAM DISPLAY SAMPLE clusters were of great value in helping to understand the physical environment. A sample of the cluster mean reflectance values is given in Figure 5. The results of a cluster analysis for Clearwater Inlet, as shown in Figure 6, indicated favorable correlation with available bathymetry.

6. Other manipulations: The window display technique was employed and proved to be very helpful for study of a specific area such as the Clearwater Inlet channel and vicinity. We also found that the gray level slicer was useful; contrast stretch often dramatically improved the displayed scene.

E. Ground Truth Measurements

Two hydrographic surveys were carried out for interpretation of the results of spectral analysis of Landsat imagery. The Engineering Department of the City of Clearwater supported and participated in the field operations. They are well aware of and appreciate the NASA remote sensing program.

F. Interpretation of the Results from IMAGE 100 Manipulation

Effort has been made to assign a meaning to various signatures of Landsat images through field observation and ground truth measurements, but the attempts have met with only limited success. However, identification of sand bars, the deep channel route of the inlet realigning the navigation channel, the deep trench behind the jetty, turbidity and plume configuration, ...etc. has been made through signature interpretation. All of this information will be blended with knowledge and experience in coastal engineering to provide a recommendation for stabilizing the Clearwater Inlet.

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*** SEMI-UNSUPERVISED CLUSTERING 10 000 ***

FILE - COMSIG NDH.1                    VERSION =    1

*** SEMI-UNSUPERVISED CLUSTERING

                       7 ITTERATIONS

CLUSTER  CELLS    ----------MEANS---------
   1      4543       49     44     24
   2      5260       55     47     25
   3      2240       54     51     31
   4       660       57     56     44
   5       300       64     66     51

TYPE CLUSTER #, THEME TRACK #  TO  DISPLAY   >
```

FIGURE 5

SEMI-UNSUPERVISED CLUSTERING

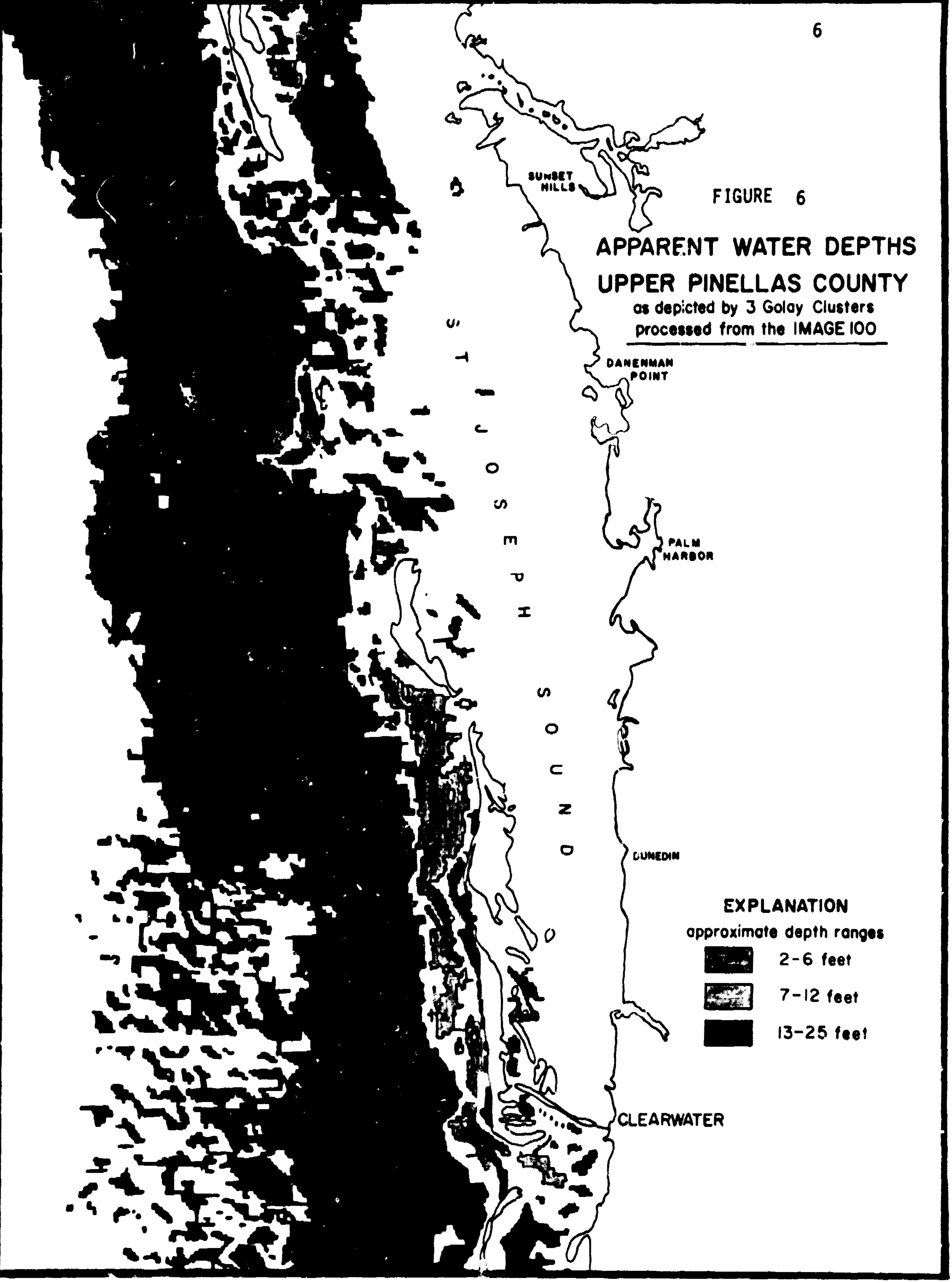
FIGURE 6
APPARENT WATER DEPTHS
UPPER PINELLAS COUNTY
as depicted by 3 Golay Clusters
processed from the IMAGE 100
SUNSET HILLS
DANENMAN POINT
PALM HARBOR
DUNEDIN
CLEARWATER
ST JOSEPH SOUND
EXPLANATION
approximate depth ranges
2-6 feet
7-12 feet
13-25 feet

III. WORK IN PROGRESS

A. Hydrographic Survey and Aerial Photography

It is felt that a much closer look at the area with ground truth calibration would be of great benefit. Knowledge derived from the photographic mission will be processed by the IMAGE 100 System to help in the interpretation of Landsat imagery analysis.

B. Securing More OCS and Landsat Multispectral Magnetic Tapes for Analysis

C. Anticipated Results

1. The pattern and nature of the littoral environment at Clearwater Inlet will be determined.

2. The magnitude and rate of various changes in the inlet will be made.

3. A recommendation will be made to the City of Clearwater for stabilizing the inlet.