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BEACH EROSION CONTROL STUDY
AT PASS CHRISTIAN

Prepared For

The Harrison County Board of Supervisors

and

The National Aeronautics and Space Administration

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Remote Sensing Applications Program

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Department of Geology and Geography
Mississippi State University

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CHAPTER I

THE NATURE AND PURPOSE OF THE STUDY

This study analyzes the locational and control aspects of aeolian erosion zones along the sand beach of the Mississippi Gulf Coast in the vicinity of Pass Christian, Mississippi. The specific study area stretches from Henderson Point to the eastern city limits of the community of Pass Christian, a distance of approximately 6.5 miles (Figure I-1).

Location and Setting

The study area constitutes only a small portion of the approximately 60 miles of Gulf shoreline of Mississippi which forms the southern border of the state. This specific 6.5 mile study area is located about midway between Mobile, Alabama, and New Orleans, Louisiana, on the Mississippi Sound, a partially sheltered arm of the Gulf of Mexico. The Sound is a shallow offshore body which extends 75 miles from Mobile Bay, Alabama to Lake Bergne, Louisiana. Its eastern end is separated from the open Gulf by an irregular chain of low, narrow, sand islands 8-12 miles offshore and its western end is separated by a group of mud islands of the Mississippi Delta, known collectively as the Louisiana Marshes. The depth of the Sound is shallow, averaging 12-14 feet and ranging up to 20 feet. In places, depths of six feet may occur up to one mile from the mean sea level (MSL) position of the shore.

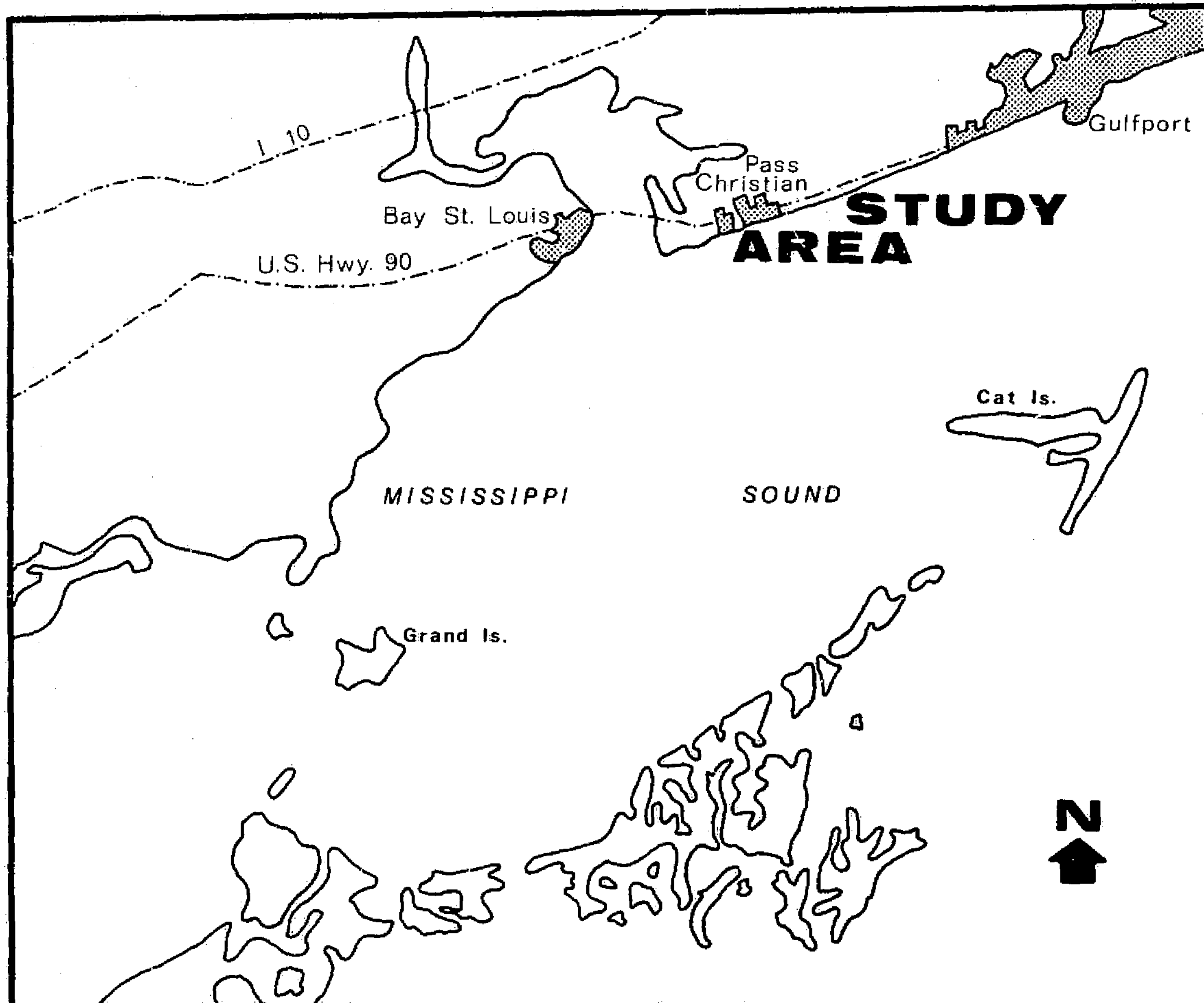


Figure I-1. Map of Mississippi Gulf Coast Study Area.

The present beach, consisting of both foreshore (wave-worked area) and backshore (normally open sand, not wave-worked) is about 200 feet in width. The beach of the study area is situated immediately between the waters of the Sound and U. S. Highway 90, the Coast Road, and the coastal communities.

The local area has a pleasant atmosphere and a delightful climate which, together with its proximity to major cities and inland areas, has resulted in a high tourist recreational potential. The coastal area is thus a center for recreational activity for both local residents and vacationers from distant cities.

These natural advantages of climate and setting have caused this area to be among the fastest population growth areas in the region, and have contributed to the development of the tourist industry which has become one of the leading income producers for the area and the State. The turnover from revenues generated by this industry has greatly benefited the economy of the coastal zone and has, in part, been put to use to improve the coastal physical and cultural environment through the development and preservation of natural and historical features as well as to provide for maintenance of the beach and the resort community. These reinvestments have, in turn, further added to the area's attractiveness and to increased recreational activities and recreational revenues.

This area will continue to play an important role in the economy of the State because tourism in Mississippi, as measured by the sales of gasoline, motel rooms, restaurant sales and tourist attractions, is rapidly rising. According to the MISSISSIPPI GULF COAST TOURIST INDUSTRY REPORT, published by the Bureau of Business Research, School of Business Administration, University of Southern Mississippi, Hattiesburg, Mississippi, the Arab oil embargo and resulting increase in fuel costs have done little to slow the Mississippi tourist index which had a 7 percent increase in 1978. Current forecasts for the area indicate a 9.6 percent growth rate per year. This growth is attributed to the colder winters forcing Northern inhabitants South, and to local residents and residents of neighboring states taking advantage of the beach atmosphere. Thus, tourist use is an increasingly important factor in the area's economy. For these reasons, the beach is a significant asthetic and economic resource of the coastal area, and its existence and maintenance is a key compenent in both the present and future cultural and economic health of the area.

History of the Beach

Prior to 1916 and before the installation of the sea wall in 1925, the Gulf Coast shoreline of this portion of Mississippi was primarily an intermittent sand beach interrupted by narrow mud, shell, and rock flats with only limited sand deposits. This material was derived by wave erosion of the shoreline land mass. The underlying geologic formations in the region from which these materials came are the Port Hudson clays, deposited during the Pleistocene epoch. The marine phase of these deposits, known as the Biloxi beds, consists of alternate layers of blue clay and sand (1).* These original deposits ranged from 80-100 feet in width and up to as much as 200 feet in some instances, and were about 2 feet above MSL.

In a geologic context, the coastal zone setting of this beach and the Sound area appears to be an area of mildly subsiding masses due to the increased weight of the deltaic deposits of the Mississippi River and other rivers depressing the crust of the earth and dragging down much of the surrounding area (2, 3). In addition, the erosive wave action has apparently been causing the land mass to retreat at an undetermined rate. With time, these factors have caused the shoreline to progress inland and become a serious threat to the coastal road, U. S. Highway 90, and the coastal cities and residences. In 1925, this situation led to the establishment of a protective sea wall. During the period 1925-1928, the Harrison County sea wall, designated as a road protection system, was constructed behind the existing beach to protect the road right-of-way and urban areas from wave water damage and erosion (4).

During the period from 1925 to 1942, the original beach in this area entirely disappeared leaving a narrow mud-sand-shell-gravel tidal flat and an exposed, undercut and damaged sea wall. The removal of the beach and the damage of the sea wall appears to have been due to the intensification of the scouring action of the waves produced by the sea wall acting as a wave reflector.

* Footnotes appear at end of text.

Beginning in 1947, the recognition of this problem by both local and federal interests led to a program to repair the sea wall and construct a new artificial beach as wall protection (5). This program was conducted under the authority of Section 2 of the Rivers and Harbors Act approved July 3, 1930 (Public Law No. 520, 71st Congress and Public Law 166, 79th Congress, approved July 31, 1945).

The beach was reconstructed with sand dredged from borrow pits located approximately 1 to ½ mile offshore and containing medium to fine sand with high concentrations of clay. The dredging processes left the clay behind in the water, and the resulting beach is therefore composed largely of medium to fine sand with less than 10% silt and clay, and highly subject to aeolian erosion (6).

The Problem

Since the time of artificial beach creation (1947), the litoral (wave water) and aeolian (wind blown) erosion has proceeded at a rate approximately matched by Corps of Engineers and Harrison County beach nourishment activities, and therefore the beach has, in an overall context, been in a state of apparent equilibrium in terms of sand budget. While sand losses have been in both the litoral and aeolian categories, the aeolian erosion has had particular significance because of its impact on the people of the coastal zone. Aeolian erosion of this type is a problem associated with virtually all sand beaches; however, it is an especially serious issue in areas such as the Mississippi Coast where the shoreline has a low profile (Figure I-2), and where

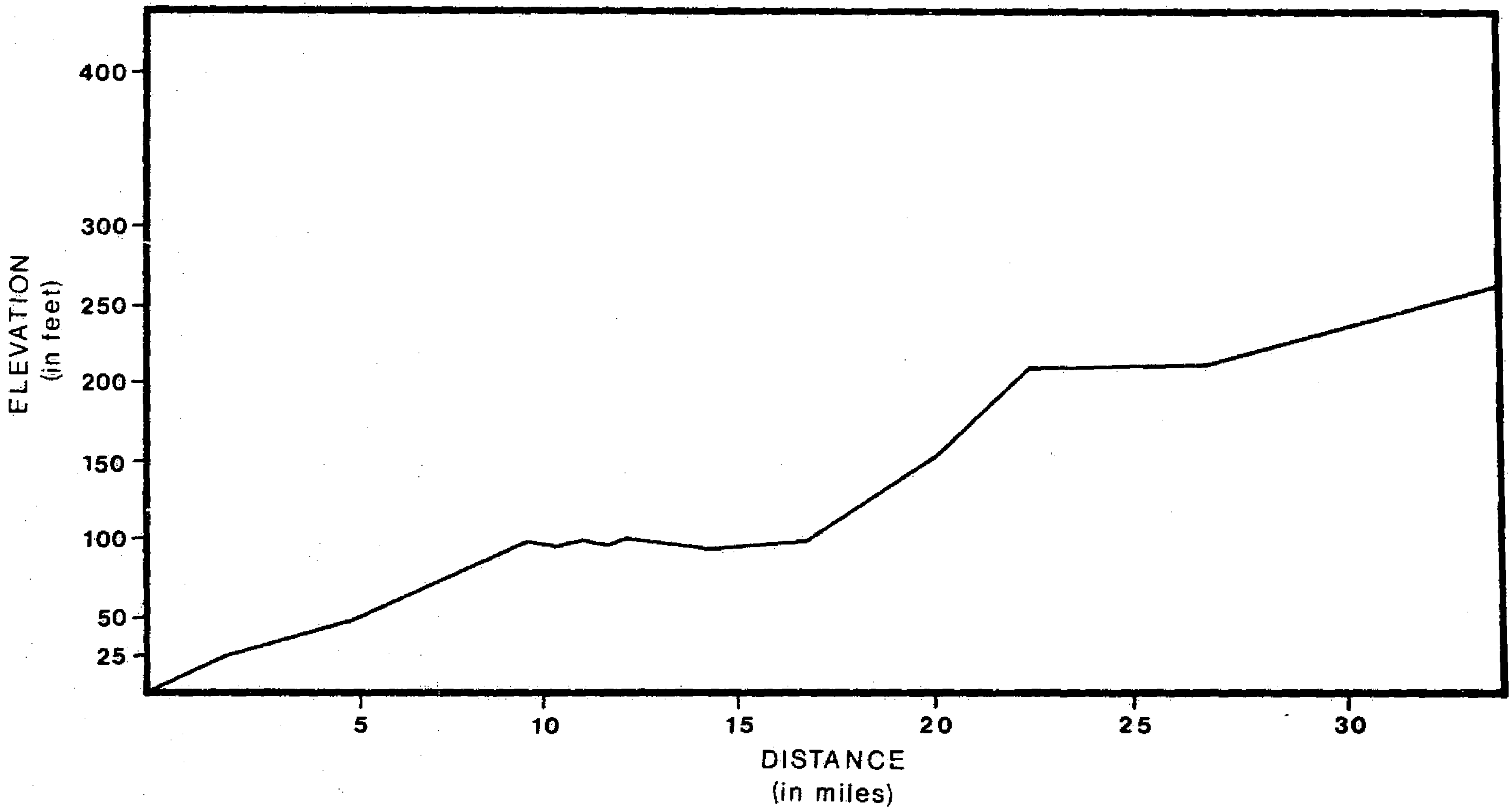


Figure I-2. Coastal Zone Profile.

cultural activities are located immediately adjacent to the beach area. The aeolian erosion, a natural and on-going beach process of this coast, occurs when breezes and winds from the Gulf and Mississippi Sound area blow the loose sand of the beach from the dry portions of the foreshore and the backshore zones onto U. S. Highway 90 and into the towns and cities, storm drains, sidewalks, and vegetation. This erosion and redeposition results in high cleanup costs, property damage, and safety and health hazards to the local communities, and therefore becomes a serious issue.

Mechanics of Aeolian Erosion

Attempts at dealing with the problem of aeolian erosion require a fairly complete understanding of the mechanism of the wind-driven erosion process. A relatively comprehensive literature review has indicated that aeolian erosion is primarily a function of several variables: sand moisture, salt/organic crust, beach topography, off- and onshore structures and local meteorology. The literature suggests that sand erosion is greater from dry beaches with high relief and loose, uncrusted sand surfaces which are exposed to high winds. Further, aeolian erosion occurs differentially from surfaces within the beach area according to many factors and it is virtually impossible in the field to establish the location of zones experiencing high, medium, or low rates of erosion because of the inability to distinguish points of origin of moving particles.

It has been generally established that under the influence of these factors, aeolian erosion tends to exhibit certain patterns. Among these are the fact that erodable sand has a consistent size (diameter of grain) and that the erosion processes may be viewed in detail as movement within an isoceles triangle pointing into the wind. Under this triangular theory, particles are picked up at the apex and rolled or bounced along by the wind and deposited along the base of the triangle. This process becomes quite complicated by the fact that many such triangles exist and overlap one another. Thus, sand particles move generally parallel to the direction of the wind, but not necessarily in precisely the same direction.

<u>Sand Grain Size</u>

Sand grain size of aeolian material has been intensely studied and classified as follows by sieves and weight measuring (7, 8):

Classification	Grain Diameter
Coarse Gravel	8–4mm
Gravel	4–2mm
Fine Gravel	2–1mm
Coarse Sand	1–½mm
Medium Sand	½–¼mm
Fine Sand	¼–1/8mm
Very Fine Sand	1/8–1/16mm
Dust	< 1/16mm

Sand grain size is extremely important because it is among the main factors controlling the erodability of a sand area. Generally, it has been found in sand research that aeolian sand consists mainly of fine to coarse sizes and excludes very fine and very coarse material; the explanation of this phenomenon is called "the large and small particle exclusion rules." The large particle exclusion rule states that generally, large particles tend to be excluded from blowing sand because of their size. This is complemented by the "small particle exclusion rule" which states that in the case of particles smaller than fine sand, there tends to be a general absence from all filled beaches and most sand areas.

Thus, as far as particle movement is concerned, generally, the coarser ingredients are not moved and the finer grains are entirely blown away. For this reason, aeolian erosion and redeposition is a problem of mid-sized particles (See appendix H for detailed discussion).

Problematic Context

A variety of technical and physical solutions for the control of wind-blown sand may be possible; however, within the context of the physical determinants of wind-blown sand and the monetary, aesthetic, and recreational costs and constraints, several administrative and organizational problems exist. This latter complexity is illustrated by the fact that many different governmental and private civic interest groups have regulatory responsibility, input or concern with this portion of the beach. Any physical solution that is not compatible with and conducive to the recreational use of the beach is not an acceptable alternative. For this reason, there is a multidimensional nature to the attempt to solve the problems.

Given the physical conditions of the aeolian erosion problem, and the social, political and economic constraints, the purpose of this research is to investigate the erosion patterns on a selected section of the coastal area of Mississippi, identify these areas within the study site which are experiencing differential erosion, and design stabilizing systems which would have ameliorating effects on the sand movement while improving the environment for recreational activities.

The Approach

The inability to identify the areas of differential erosion and to adequately understand the patterns of beach sand movement was the initial problem in dealing with the erosion situation on the Mississippi Coast. However, several studies indicated that remote sensing methods exist which can circumvent this problem and allow the identification of eroding areas upon which attempts at control might prove successful. Remote sensing, which includes the use of satellite data, holds substantial promise for the identification of erosion zones since the characteristics of eroding beach zones, principally their relative dryness, can be distinguished from the perspective of space imagery. In particular, it has been found in remote sensing erosion studies that as "water is stored in and around the grains of the sediment (of a beach), the surface tension of the water tends to stabilize the sediment, while the water coating the sand grains tends to cause them to become heavier and to have a darker hue." It has also been found that at low tide time "the sand remains wet for a period (distance) far landward of the strand line (line of deposition of shells, trash, etc.) and that, osmotic pressure forces some ground water toward the surface, which maintains a high moisture content for the sand and produces a slightly darker hue in the sand." These darker hues are related to sand stability and are distinguishable as spectral properties of the beaches by satellite sensors (NASA, 600).

Furthermore, it has been concluded that, "as the sand dries, on-shore sand tends to move under the force of the more dominant onshore winds, first as sand ripples and eventually as waves or dunes. Since wind velocity seldom reaches levels where coarse material such as shell can be moved, a rougher surface develops which consists primarily of residual material. Because of the drying effect of the moving air, the wind-blown sands dry rapidly and take on a lighter color" (9). These lighter colors are again spectrally distinguishable. Thus, remote sensing in the form of satellite imagery, aircraft and scanner data can be used to provide information on erosion zones that is otherwise unavailable.

A greater understanding of the mechanics of sand movement and some improvement in controlling erosion and improving the environment for recreation should be possible from this work. This progress will likely result because given the objectives of the study, the established factors, the nature of sand erosion, and the ability to measure these factors or their surrogates through remote sensing imagery, we presently possess a means of measuring the existence of erosion and the effect of sand stabilization control systems.

Study Design

Subsequent chapters of this report are developed around the methodology, analysis, proposed solutions, and general conclusions and recommendations. The methodology and analysis sections collectively address the issue of procedures, field work, data gathering and identification of erosion zones. The proposed design solutions consider the characteristics of the beach as they relate to sand stabilization and improved tourist recreational atmosphere.

CHAPTER II

METHODOLOGY

Methodologically, the study of aeolian erosion has been approached through the establishment of three objectives: (1) refining and adapting remote sensing techniques to identify and define those beach areas along the Mississippi Gulf Coast at Pass Christian, Mississippi, which are sources of wind-blown sand; (2) developing procedures for relating remote sensing data, ground truth information, and meteorological data to estimate origin zones of sand movement; and (3) siting and designing sand stabilization or turbulence obstruction features which, when located on the beach, will reduce sand erosion, be aesthetically pleasing, and be consistent with tourist attraction and the conduct of local commercial activities. The methodology and analysis of Objectives 1 and 2, since they relate to understanding the erosion system, are dealt with in Chapters II and III, and the methodology and analysis of Objective III, since they relate to the design of stabilization systems, are considered in Chapter IV.

Objective 1

Objective 1 has been addressed through two tasks - the selection of equipment, software, and approach, and the refinement and adaptation of techniques. The first task of Objective 1, selection of equipment, software and approach, involved the evaluation of alternative digital automatic data processing (ADP) and analogue optical image analysis systems and procedures. Among the digital software packages evaluated were the IBIS [Jet Propulsion Lab (JPL)], ELLTAB [Earth Resources Lab (ERL)], EOD-LARSYS [Johnson Spacecraft Center (JSC)], and Procedure I (Lockheed, LARS-Purdue). These evaluations were performed at the sites of the generating sources, at the MSU Computer Center, or both. The EOD-LARSYS was selected as the most promising package, and the remaining packages were rejected for the purpose of this study as being either too specialized, too elaborate, too unstable, or incompatible with locally available systems.

Among the analogue or image analysis systems evaluated were the Comptal-Aerojet General MDAS, RCA Display Keyboard, Ball Brothers VMTS, I^2S-type signal slicers, color additive viewers, and the Apple microprocessors. These systems possess a wide variety of capabilities and many have unique attributes. For this reason they were found to contribute differentially but complementarily to the identification and definition of aeolian erosion zones. The I^2S-type signal slicers appear to provide the most direct and immediately applicable results. Work is continuing on the application of the remaining analogue and image processing systems with an emphasis on the Apple systems.

The second task of Objective 1, refinement and adaption of selected aeolian analysis techniques, centered on the use of the EOD-LARSYS software package resident on the MSU Univac 1100/80 system and on the I^2S-type image processors at EROS (Bay St. Louis) as the primary analysis systems, and the Aerojet General MDAS (and GE Image 100 located at JSC) as supplementary screening and processing systems.

Refinement and adaption using digital and analogue optical techniques proceeded along two separate but parallel courses.

Digital ADP Activities

Tape Selection and Format Change. The digital approach and analysis began with the selection of a Landsat tape, #14766-49-2-8, from the MSU Landsat files. Preliminary processing of the Landsat CCT's to a computer compatible format had previously been accomplished.

Gray Tone Maps and Histograms. Multi- and single band gray tone dumps were prepared from the tape using the EOD-LARSYS gray tone subroutines to identify the pixels corresponding to the study area. Band 7 (Figure II-1 and Appendix B) provided the greatest discrimination of the study area. From this interim product, a table of pixel line and scan number coordinates identifying the pixels which contained the spectral beach data related to erosive properties was completed (Table II-1). These pixels were grouped into computer readable (convenient scan and line) groups and processed through the training site histogram subroutines of the LARSYS package to develop histograms (Figure II-2 and Appendix C). The histograms of the spectral properties of the beach revealed that although the beach was essentially a monomial spectral group and class in first analysis, there was appreciable spectral variation both among and between given training sets, and therefore within the beach itself.

Erosion Zone Groups. The pixels comprising the study area were processed at JSC through the ISOCLS subroutines of the LARSYS package,

TABLE II-1

PIXEL LINE AND SCAN NUMBER

	LINE	SCAN
	560	762-787
	561	767-782
	562	768-773
	559	779-789
	558	784-793
	557	788-797
	556	791-799
	555	792-800
	554	794-802
	553	797-804
	552	799-806
	551	804-808
	550	805-811
	549	807-813
	548	809-816
	547	812-819
	546	815-823
	545	819-826
	544	822-830
	543	825-833
	542	829-836
	541	832-838
	540	- - -
516	539	835-841
	538	837-843
	537	839-845
	536	841-847
	535	843-850
	534	844-851
	533	845-852
	532	846-853
	531	848-855
	530	851-857
	529	853-859
	528	854-860
	527	856-861
	526	858-863
	525	860-867
	524	863-870
	523	866-872
	522	869-874
	521	871-876
	520	872-877
	519	874-879
	518	875-880
	517	876-880
	516	880-880

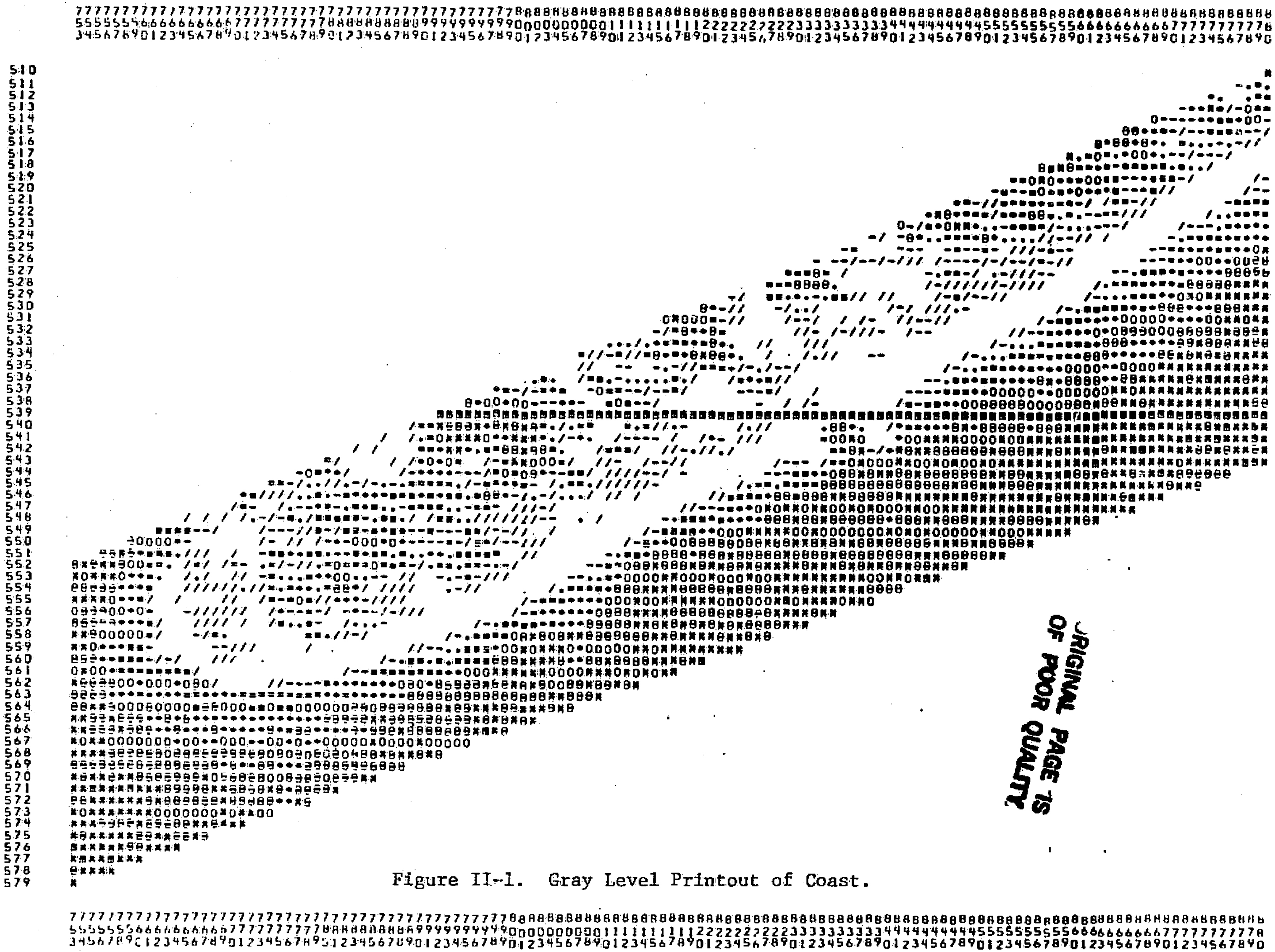


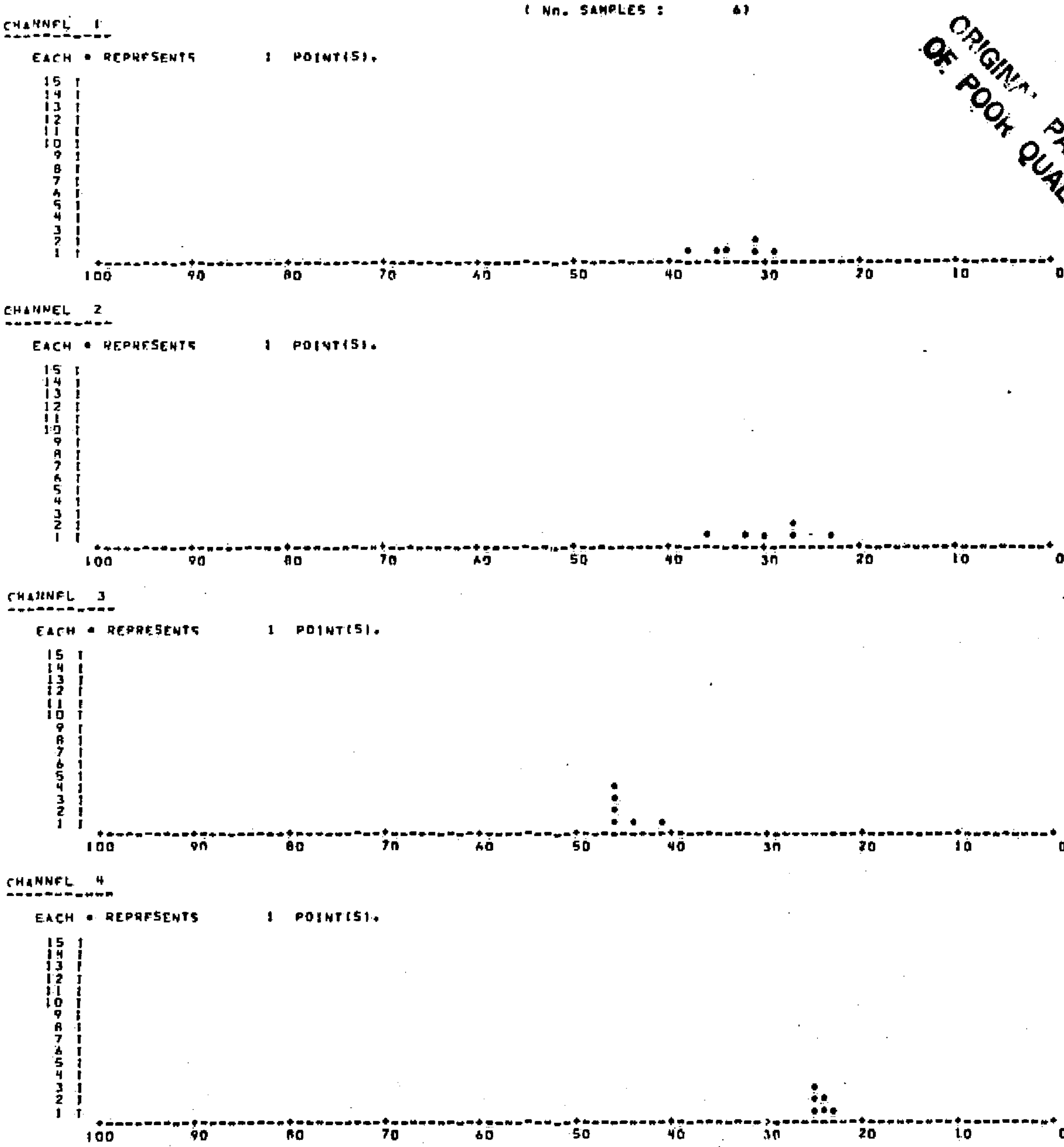
Figure II-1. Gray Level Printout of Coast.

MISSISSIPPI STATE UNIVERSITY
MISSISSIPPI STATE, MISSISSIPPI

HISTOGRAM

FIELD 2

(No. SAMPLES : 6)



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	2	2	1	1	(769, 560)	(774, 560)
2	2	2	1	1	(769, 560)	(774, 560)
3	2	2	1	1	(769, 560)	(774, 560)
4	2	2	1	1	(769, 560)	(774, 560)

Figure II-2. Histogram of Beach Training Site.

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	29.0	38.0	33.0	3.0	24.0	42.0
2	23.0	36.0	29.2	4.1	16.7	41.6
3	41.0	46.0	44.8	1.9	39.2	50.4

and class maps of the beach relative to the erosion factors were developed. This mapping phase, although quite promising, was terminated due to technical difficulties and time constraints at MSU; thus, the ADP refinement and adaption were not completed.

Analogue Optical Image Activities.

Landsat images for the dates of 6/11, 7/7 (L2E30124-15501-5), 7/16, and 8/2, 1978, were ordered in 9 x 9 format from the EROS Data Center, Sioux Falls, South Dakota. Only the 7/7 image has been received. This image, together with several file images of dates not corresponding to ground truth, was processed on the Ball VMIS (Figure II-3), Color Additive Viewer (Figure II-4), and the I^2S and related signal slicers (Figure II-5). The product from these latter signal slicers proved to be the most valuable tools, interims of scale, resolution, and discrimination of sub-beach spectral zones.

The specific analysis processes using the signal slicer systems involve mounting the images in the field of view of the processor's scanning camera, focusing and enlarging the beach zone to a maximum, and progressively refining sub-beach spectral discrimination zones (Figure II-6). The methodology of the refining and electrical/optical tuning of the images involved classifying all features in the image into two categories or colors - all land, and all water (Figure II-7) - inserting a third class (color) statistically (in terms of spectral values) between the all land and all water classes, and progressively moving individual points from the land category to the

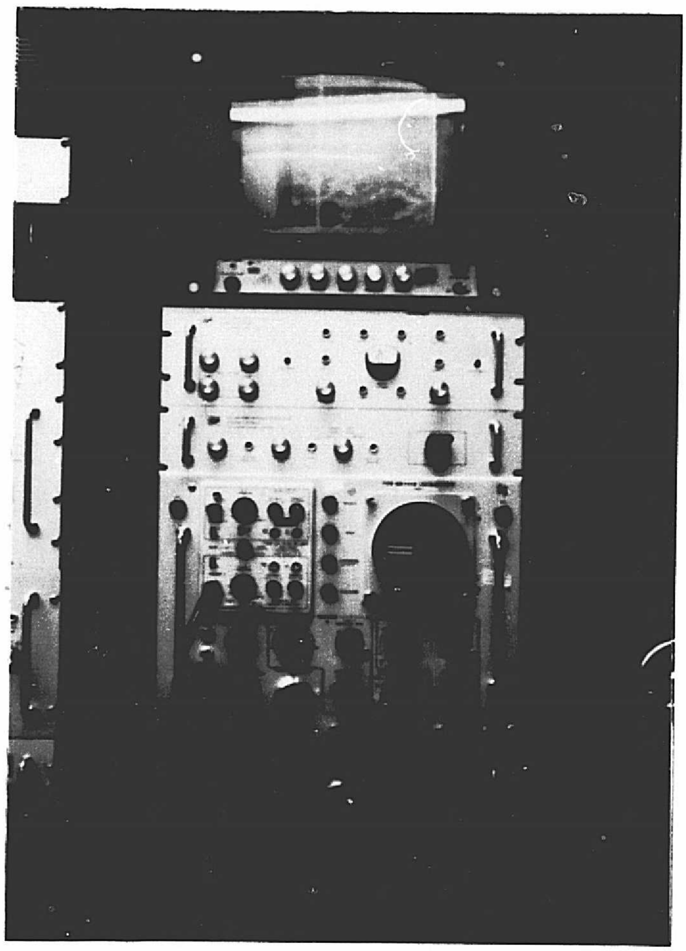


Figure II-3. Image Display on Ball VMIS.

Figure II-4. Image Display on Color Additive Viewer. Beach appears as white area at right center of picture.

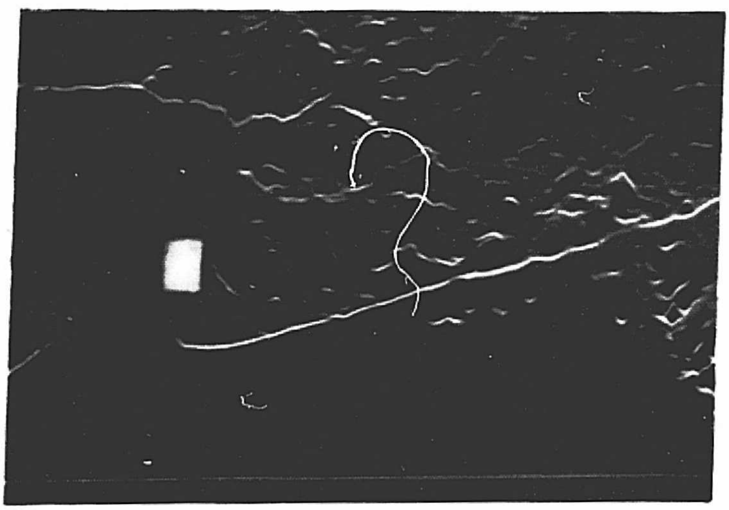


Figure II-5. Image Display on I^2S. Beach appears as thin white line in the center of the image.

Figure II-6. Signal Slice of Beach. Illuminated rectangle in the center of the image is the beach study area. Dark gray irregular line in the center of the rectangle is the beach proper; lighter tones of gray are progressively dissimilar spectral types without moisture distinction.

Figure II-7. Spectral Display of All Land and All Water Interim Class of Beach. Land is black; water is orange.

new category. The effect of this was to cause the third color (category) to appear where those pixels of land which were most water-. like in their spectral signature appeared (Figure II-8). When reversed, the processes moved those points out of the third color first if they were driest, and, if carried on from the water side, created the third category and color in the driest portions of the beach; i.e., those sites and points of the beach which were most like land. For discrimination, a fourth color was added and the dry areas compared and found to be reciprocal with the wet areas. The image products of this analysis constitute a picture of those areas of the beach which are the wettest and driest, and therefore subject to differential degrees of erosion. The analogue optical image analysis refinement and adaption are complete, and the capability to define areas of differential erosion potential is online and operational using these systems.

Thus, two basic complementary and supplementary remote sensing data processing approaches exist or are available to define intra-beach spectral differences as they relate to aeolian erosion potential. Figure II-5 and II-8 particularly relate to the Pass Christian zone.

Objective 2

Objective 2, the development of procedures for relating remote sensing data, ground truth information and meteorological data to zones of sand movement origin, required as a precondition the establishment of a ground truth data picture of the aeolian erosion situation on the Pass Christian Coast, and collection and compilation of data relating to erosion and sand moisture data. The generation of the ground truth

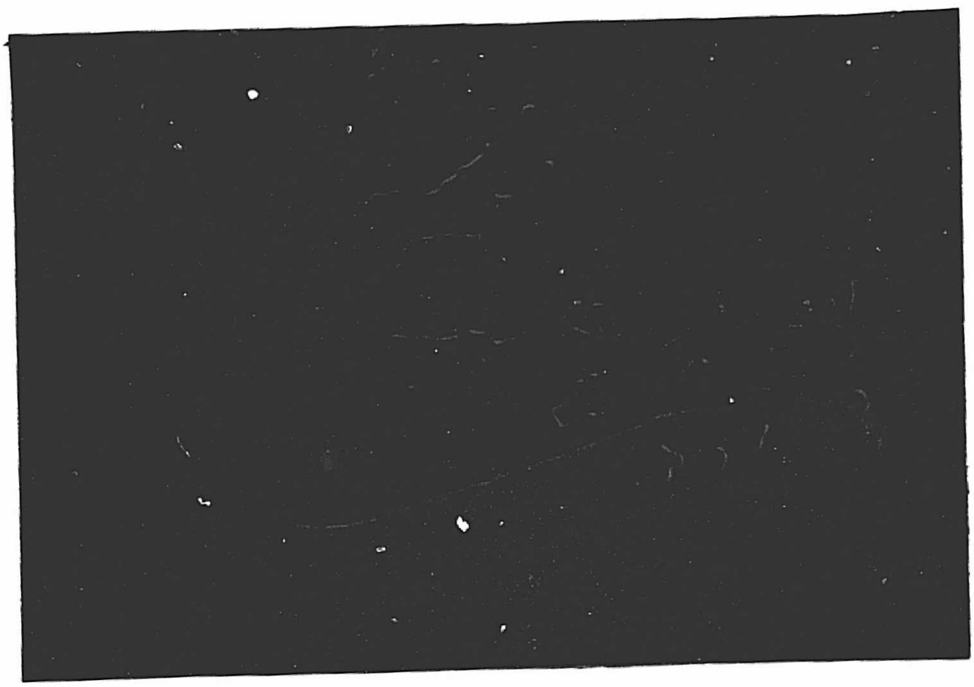


Figure II-8. Spectral Display of Emerging Wet Beach. Beach appears as thin, light colored line near the image center.

thus became a significant and critical phase of this project. Following the completion of the prestudy, Objective 2 was addressed through 4 main tasks: 1) collection and analysis of meteorological data to determine the role of winds in the coastal regime and erosion; 2) collection of beach moisture and topography data; 3) laboratory analysis of beach sand moisture; and 4) analysis, display, and relation of Landsat to ground truth data which began with an essential prestudy reconnaissance and survey of the study area.

Meteorological Data Collection Procedure.

Meteorological data observed and collected at the National Weather Service first order weather station at Mobile, Alabama, and at Keesler Air Force Base, Mississippi, were obtained from the National Climatic Center, Asheville, North Carolina. These data were used to classify the weather of the coastal region into synoptic weather types in order to identify and characterize meteorological parameters contributing to the beach erosion processes.

Field Data Collection Procedures.

An initial trip was designed to be a basic survey and to acquaint the field crews with the study area. Following the prestudy survey and acquisition and preliminary analysis of meteorological data, an extensive field data collection effort spanning many months was conducted. This activity involved a plane table surveying of the beach topography, and collection of sand samples and recording of observations coordinated with satellite overflight times. This phase of activity involved the sub-tasks of calculation of a satellite timetable and the mounting of multi-day, satellite-coordinated ground truth expeditions (Table II-2).

The field methodology of the sand collection expeditions, designed primarily to provide data concerning sand moisture and grain size, was critical and required rapid, timely action as the moisture properties of samples were transient. For these reasons, field procedures consisted of the following steps (variations for expediency occurred but were minimized when possible):

(1) marking of beach pixels at either end of the study area (6, 1' x 1' mirrors and 200 feet of aluminum foil). This task was necessary to facilitate registration of satellite data to the study area.

(2) sample collection, beginning at Henderson Point at least ½ hour before the scheduled overpass time and concluding as rapidly as possible.

 (a) two sand samples, one immediately behind the water wash area on the foreshore, and a second approximately 20 feet seaward of the sea wall on the back shore, were collected at approximately regular intervals, usually every 500 feet except on June 11, 1978, when threatening weather conditions necessitated an acceleration in rate of collection and a change in spacing to approximately 2,000 feet between sample sites for the eastern two-thirds of the beach. The location of each sample was

TABLE II-2

SATELLITE FLYBY

Path 23 Frame 039 is footprint

Path 23 Frame Footprint 039

Availability Status	LS 2	Availability Status	LS 3
A	6/11	N/A	6/1
N/A	6/28	N/A	6/19
A	7/16	A	7/7
A	8/2	N/A	7/25
N/A	8/21	N/A	8/12
N/A	9/8	N/A	8/30
N/A	9/26	N/A	9/17
N/A	10/14	N/A	10/5

mapped or recorded with reference to identifiable locations. Each sample was placed in a metal sample can, numbered and sealed.

(b) sample cans were packed in sealed ice chests and rushed from the beach to the laboratory for processing and analysis.

(3) beaches were staked with red-flagged, pine survey stakes to determine and verify sand removal over varying areas and periods. Stakes were placed at one-quarter mile intervals.

(4) Beaches were tarped and flagged to determine sand deposition over varying periods at quarter mile intervals.

Physical Laboratory Procedures.

Laboratory processing of samples involved a standarized procedure which consisted of the following steps:

(1) The sand sample and container with top were weighed and recorded after removal of sealing tape.

(2) Samples were placed in an oven for at least 12 hours at 100° C.

(3) Samples were removed from the oven, cooled, and reweighed and recorded. Moisture content in percent was determined by

$$\frac{\text{moist weight} - \text{ovendry weight}}{\text{ovendry weight}} \times 100.$$

Containers were weighed and the weights subtracted from the sample weight before calculation of moisture content.

(4) These values were tabulated and summarized into sand moisture tables (Appendix D), plotted and mapped onto workmaps (Figures II-9 - II-12), and generalized into a single map showing potential aeolian erosion zones (Figure II-13).

Landsat Data

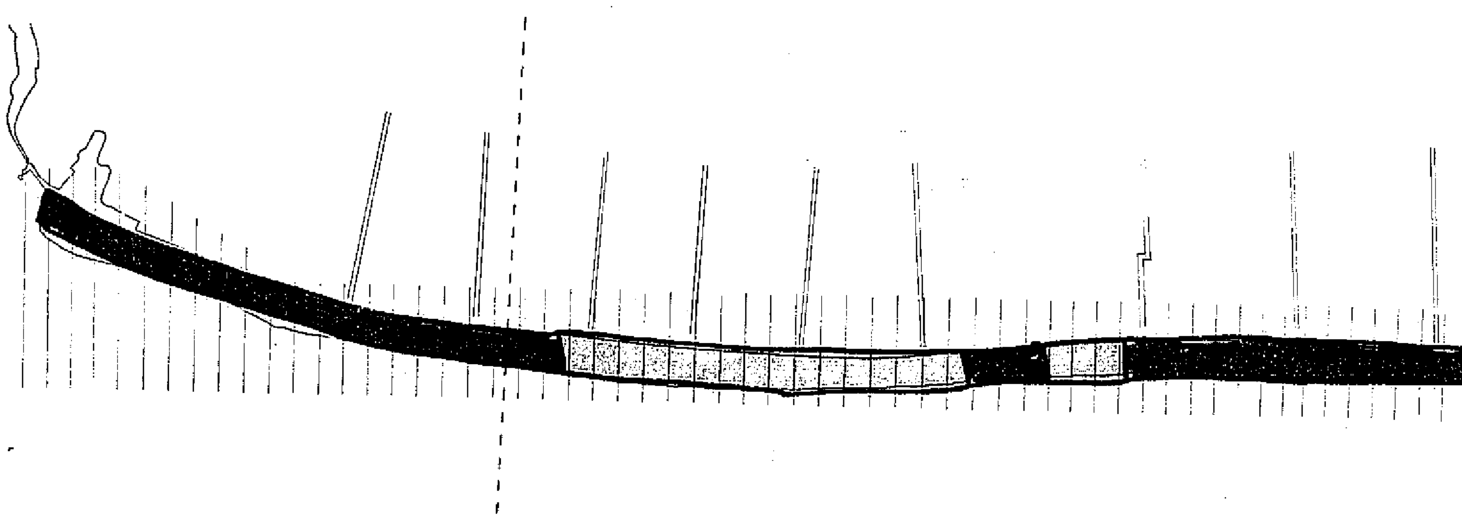
The availability and quality of Landsat computer compatible tapes (CCTs) and images in 70 mm and 9" x 9" format was investigated in browse files at the EROS Users Assistance Center. Browse file inspection indicated that only certain images and tapes were available and of adequate quality over the study area (see Table II-2). The available and acceptable images and tapes were ordered during the summer of 1978. The CCT's have not been received; however, the images have been received and processed using the optical methodology discussed above. As a result of the unavailability of CCT's and the problems of ADP technology setup and timing on the MSU computer facility, the main body of analysis in this study centered on analogue optical image analysis employing the I^2S and related systems (Figures II-4, II-5, and II-6). The image products of this optical methodology are related in an automatic sense to the ground truth of Figures II-9, II-12, and II-13. Thus, graphically, the ground truth data and remote sensing data are related spatially for interpretation and analysis.

Legend for Figures II-9 - II-12

Green = Wet

Yellow = Moderately Wet

Red = Dry



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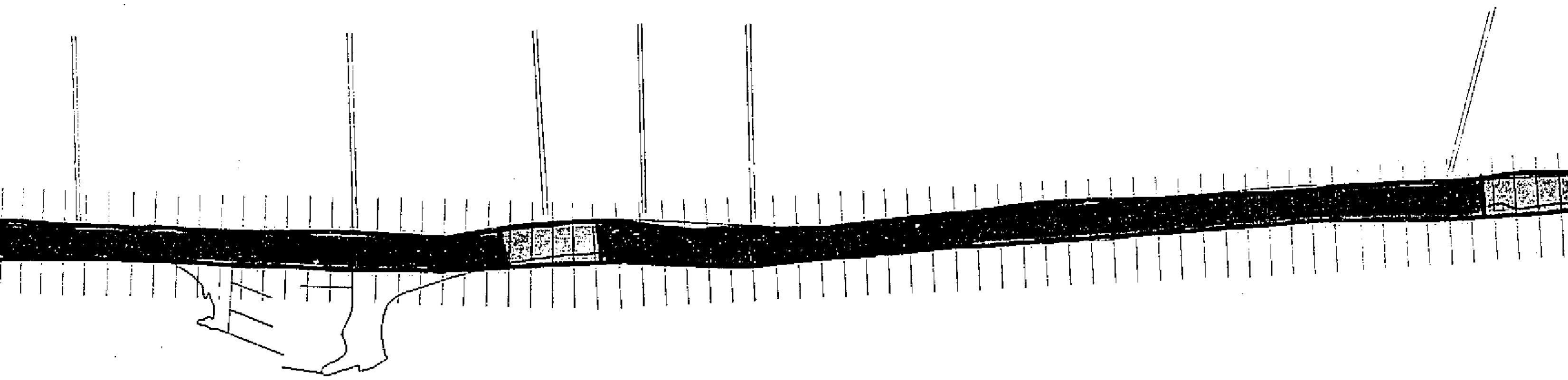

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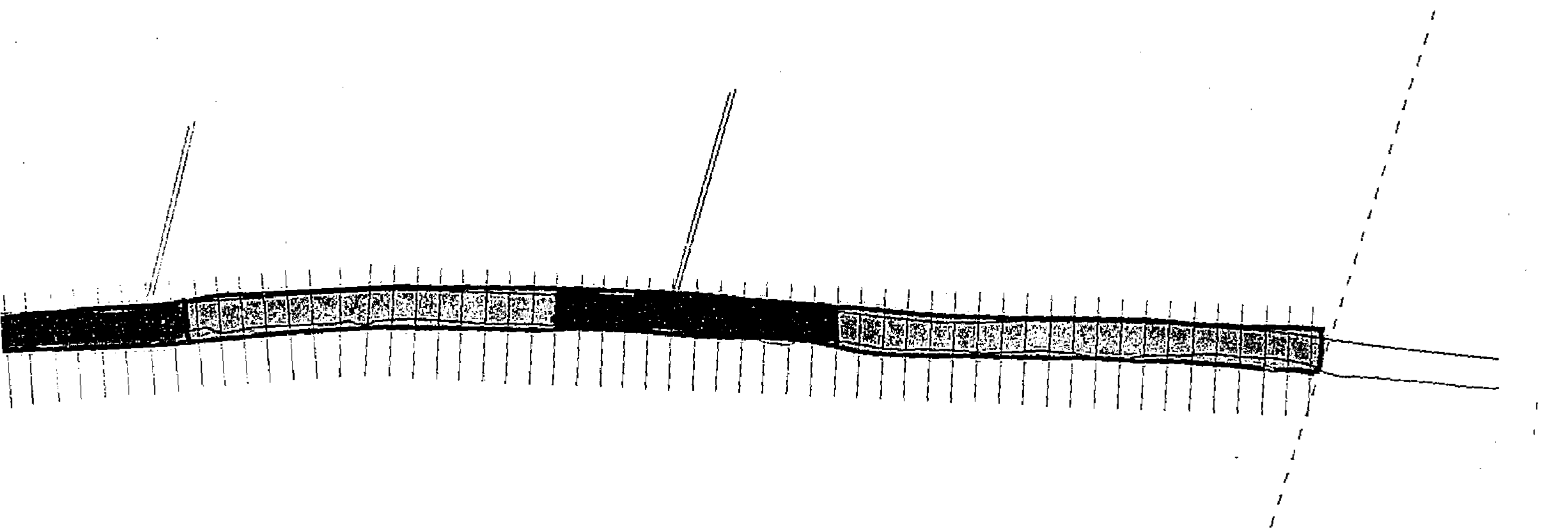

FIGURE II-9

SAND MOISTURE MAP OF BEACH, JUNE 10, 1978

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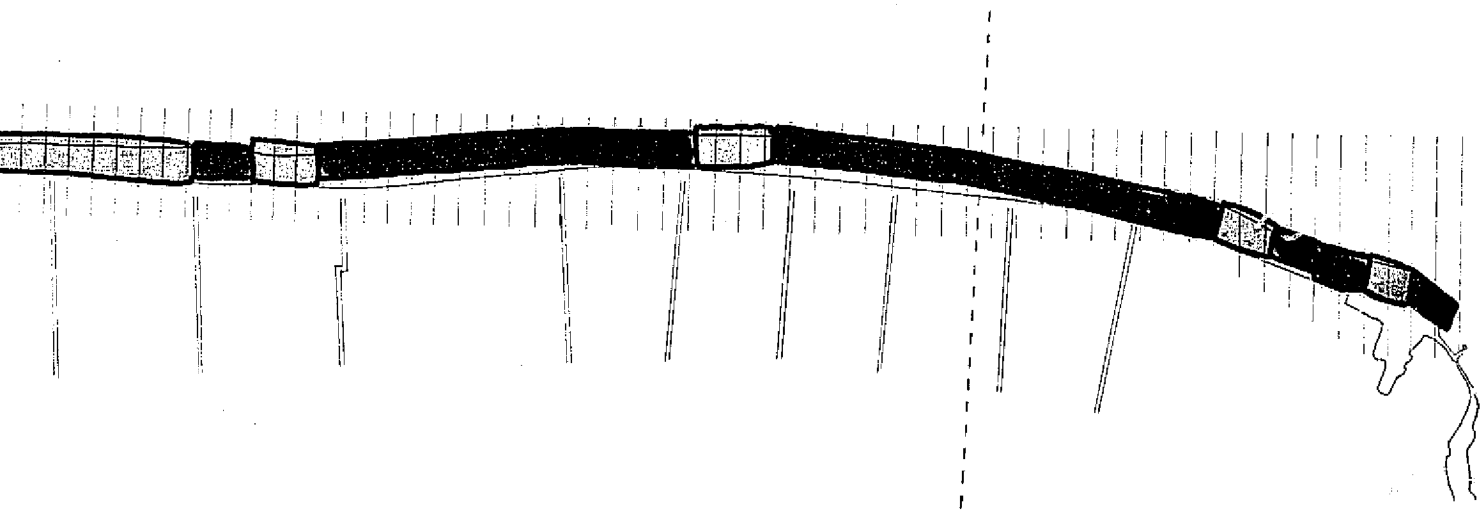

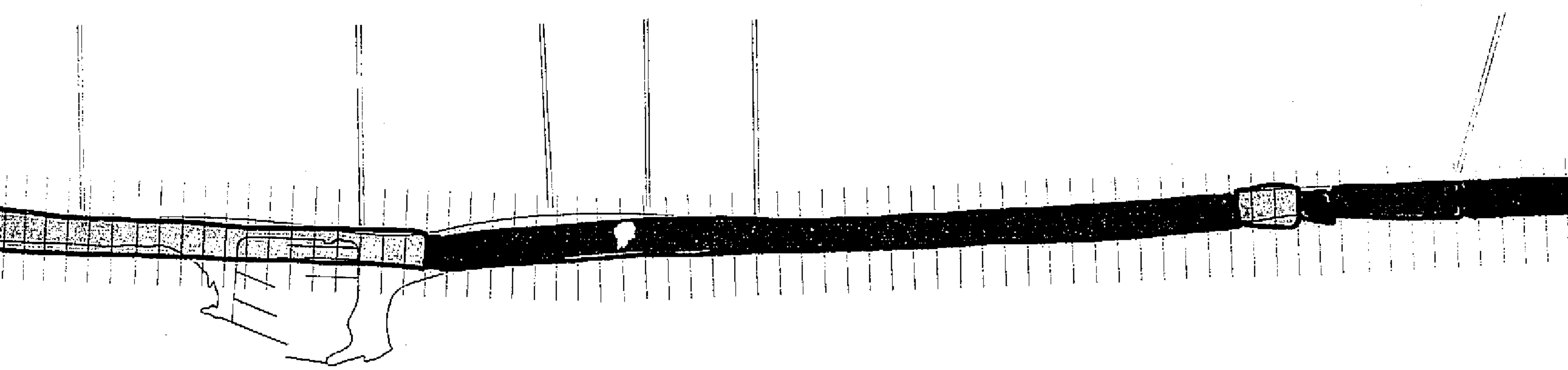

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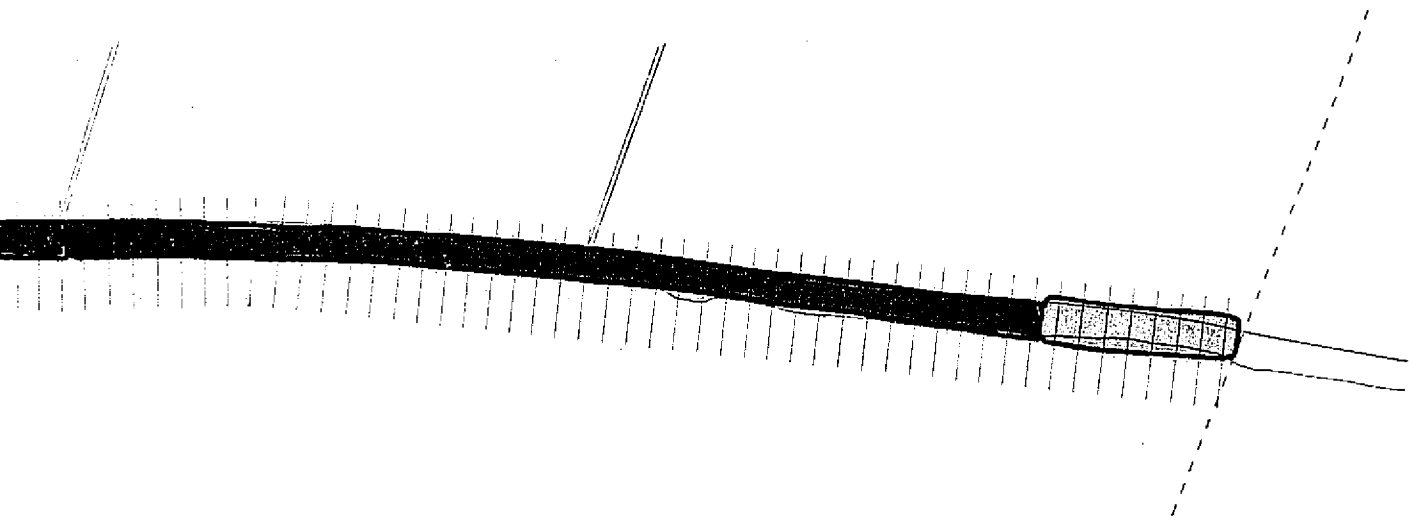

FIGURE II-10
SAND MOISTURE MAP OF BEACH, July 7, 1978

3

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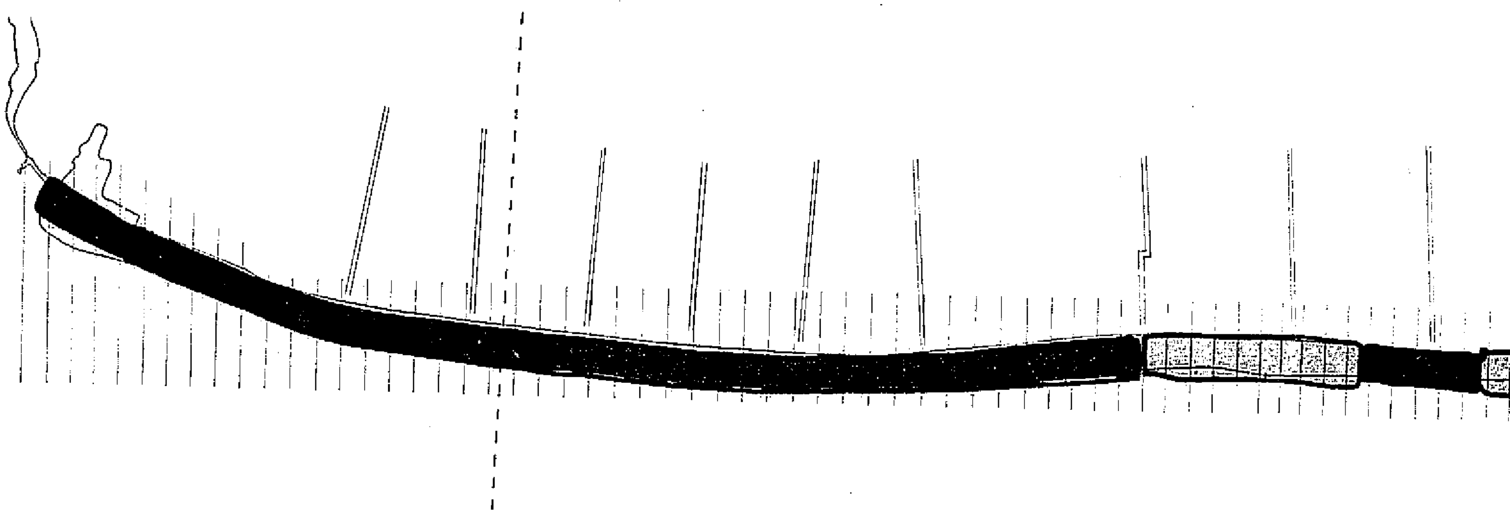

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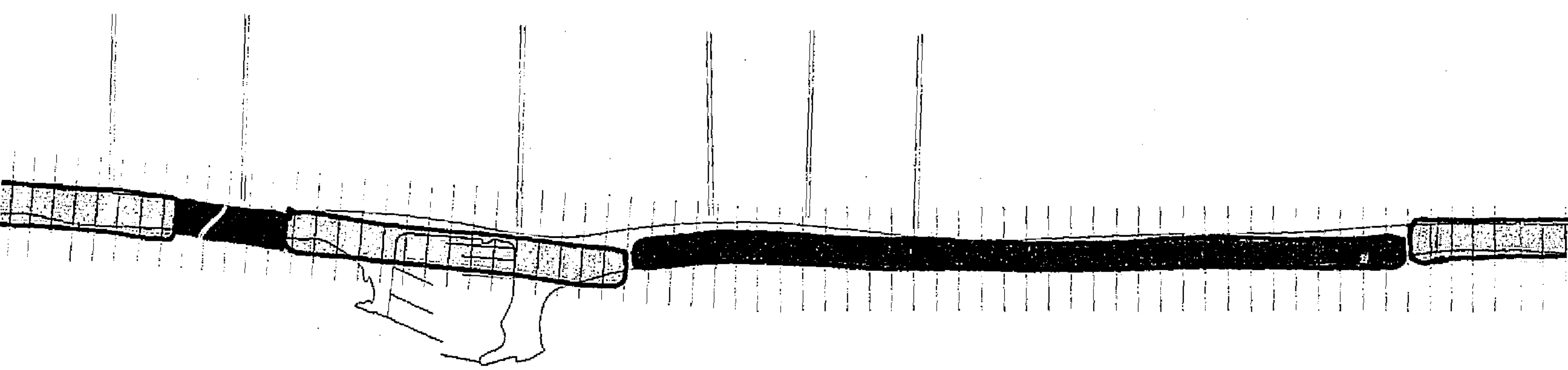

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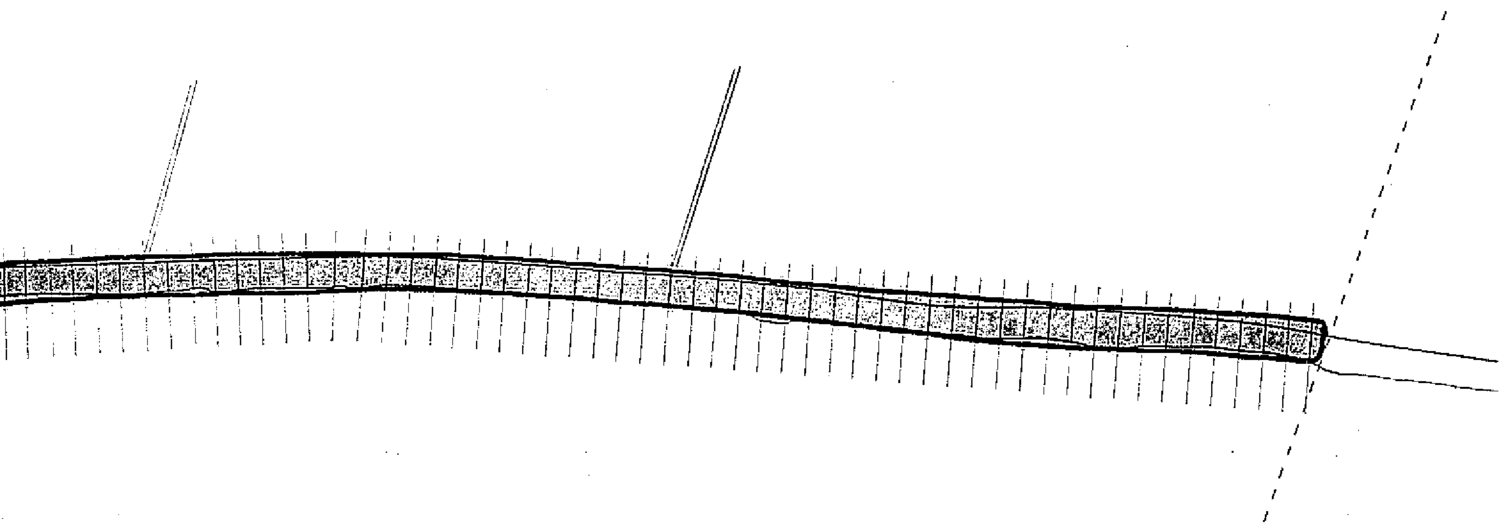

FIGURE II - 11

SAND MOISTURE MAP OF BEACH, July 16, 1978

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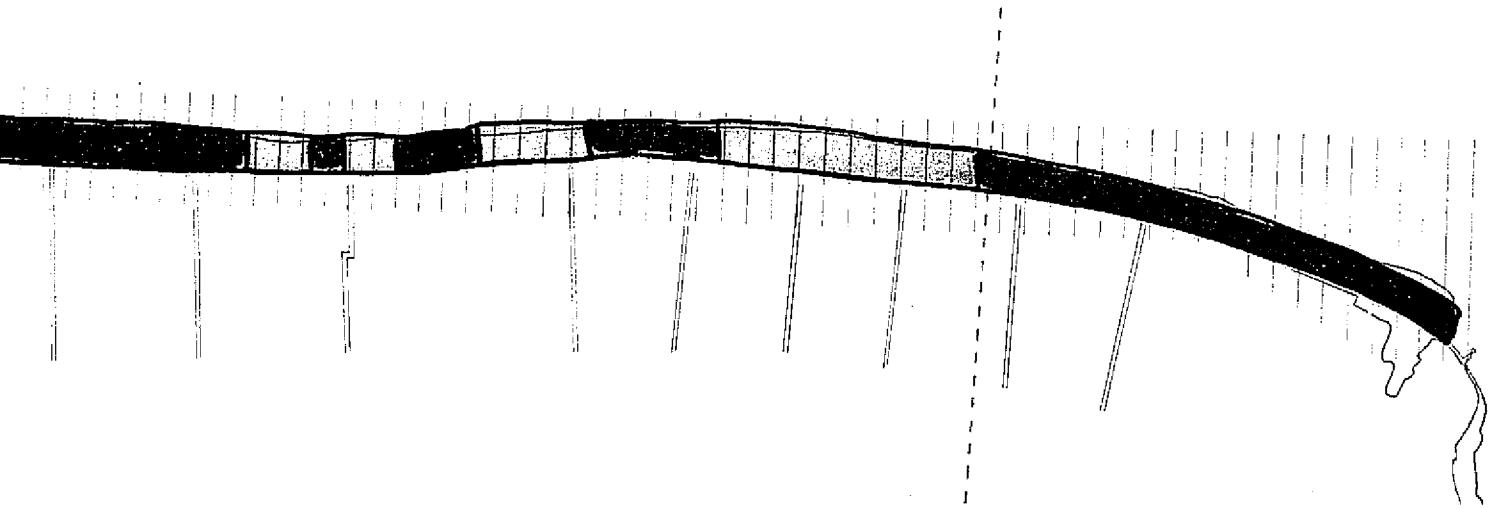

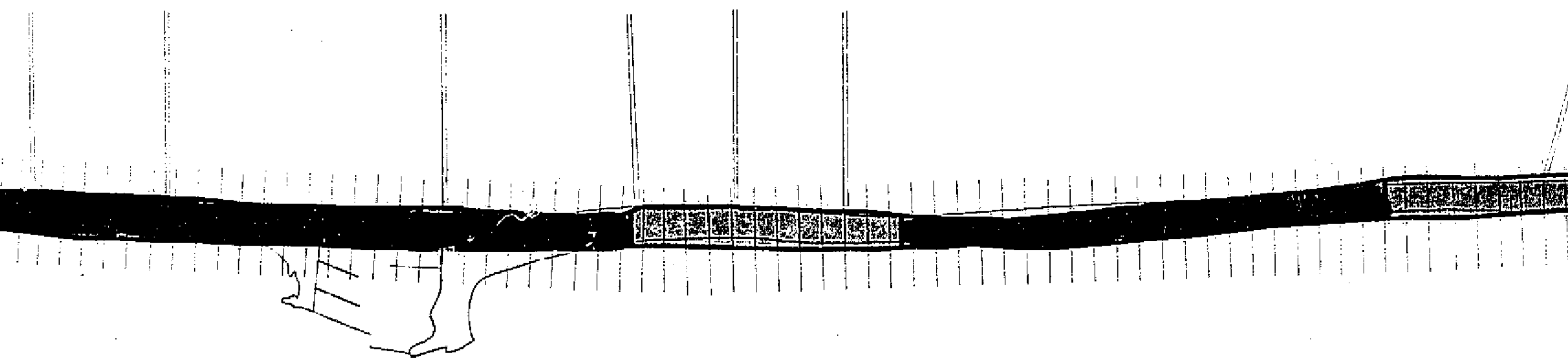

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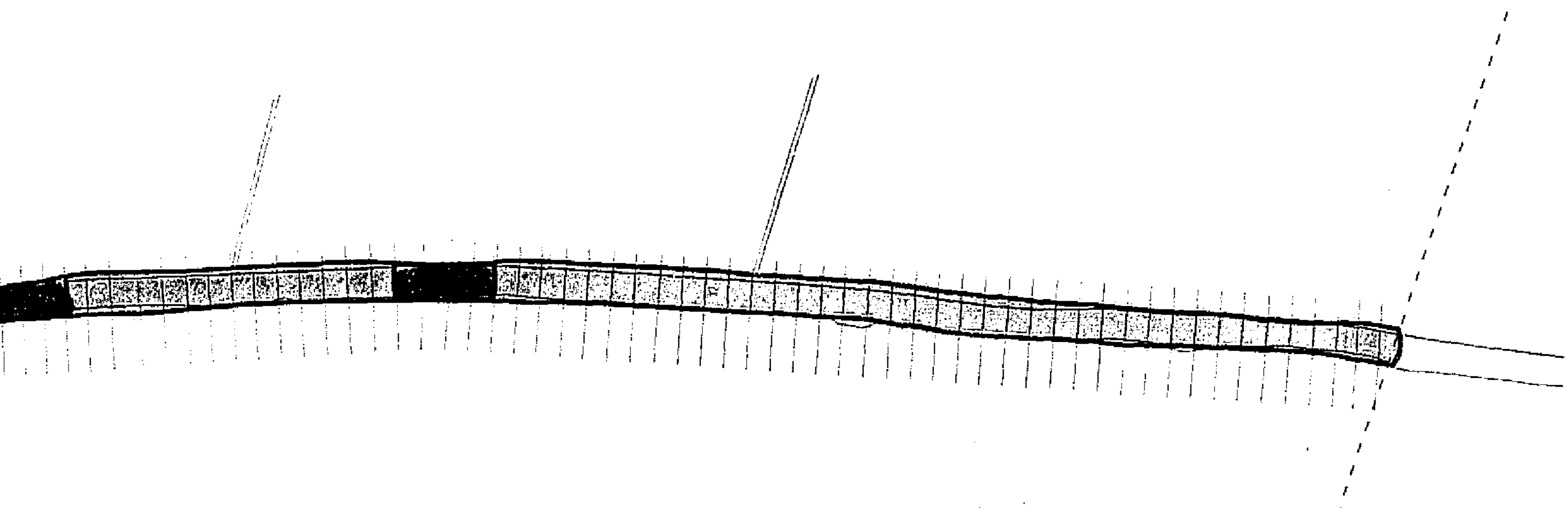

FIGURE II - 12
SAND MOISTURE MAP OF BEACH, AUGUST 2, 1978

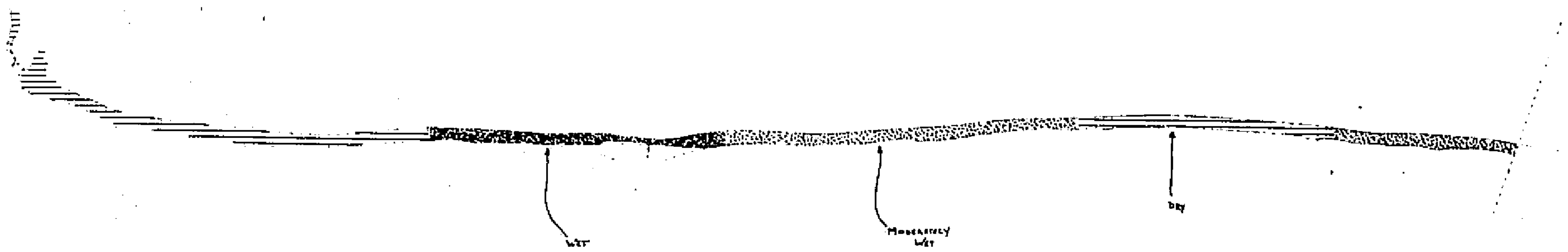

Figure II - 13
Summary Moisture Zone Map

CHAPTER III

ANALYSIS

The ground truth data on beach morphology, off- and onshore structures, sand moisture, and the products of the analysis of Landsat-defined erosion areas were related, analyzed, and interpreted. The meteorological analysis characterized the weather during 1977 and results of these analyses are discussed individually in the following sections.

Beach Morphology

The plane table surveys of the beach indicated that it is essentially flat (Figure III-1) with very slight local relief, approximately 18 inches maximum. The beach tapers gradually from the water wash line at mean sea level to a sand height at the sea wall and roadbed of approximately 2 to 4 ft. in a horizontal distance of 200 to 400 ft. (Sheet 1 through Sheet 6); thus, with a slope of 1 to 2%. The greater portion of the small relief difference is immediately against the sea wall. Periodic evaluation of the beach throughout the research period indicated that despite notable sand movement in certain areas, no essential variation in beach morphology occurred with the exception of sand collection and buildup at the sea wall. The stability of the beach form and moderation of the sand buildup at the sea wall appear to be due largely to the beach maintenance practices which involve daily combing of most areas of the beach by sand sifters. These large machines effectively level the evolving microforms, remove vegetation, and, coupled with the dozing and scraping of sand

BEACH TOPOGRAPHY - CONTOUR INTERVAL = 2 FT WITH 1 FT SUPPLEMENTAL CONTOURS

FIGURE III - 1
PLANE TABLE SURVEY OF BEACH

accumulations back from the sea wall, tend to produce an apparent equilibrium of beach form. Thus, beach morphology remained generally constant and effectively played no role in differential erosion.

Off- and Onshore Features.

With the exception of the Pass Christian harbor and marina facility, both ground truth and remote sensing data on existence of off- and onshore features related to the local aeolian erosion did not reveal any significant feature. Considering the direction and velocity of the predominant winds and the suspected land-sea breeze, reduced erosion due to wind obstruction is very limited and is indicated only in the areas immediately adjacent to this complex. Thus, although off- and onshore features and local wind regime may tend to exert differential influences in terms of their moderation of erosion, data from this study are insufficient to establish this relation.

Sand Moisture Content.

Ground truth data on sand moisture (Appendix D and Figures II-9 - II-13) reveal this variable to be the only established factor of erosion which exhibits clearly pronounced variance throughout the study area. Sand moisture variance occurs not only throughout the beach, but also throughout the study period. From Figures II-9 - II-13, it is apparent that the sand moisture patterns of the beach were not permanent and regular in nature, but dynamic and variable with time. These variances, however, did tend to form patterns of zones with some consistency, and thereby revealed tendencies for greater or lesser moisture and correspondingly greater or lesser erosion. From Figure II-13, five basic zones within the study area can be distinguished on a basis of sand moisture content. These five zones are (1) a severely eroding zone stretching from Henderson Point on the west to approximately Magnolia Avenue, (2) a slight to moderate erosion zone stretching from the vicinity of Magnolia Avenue to slightly east of the Pass Christian harbor and marina facility, (3) an alternating slight to severe erosion zone extending from the Pass Christian marina area to the vicinity of Menge Avenue, (4) a severe erosion zone extending from Menge Avenue to approximately 2500 ft. east of Espe Road and (5) a moderate erosion zone running from the latter point to the eastern edge of the study area.* Thus the principle erosion character of the study area is one of variance of potential among zones of substantial size.

Landsat Defined Erosion Areas.

The remote sensing image data (Figures III-2 - III-6) generated on the July 7, 1978, image using the I^2S and related signal slicers clearly

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*Although numerous field trips were conducted to the study area, these zones were established with data gathered on only four field trips. Unstable weather conditions, satellite timing problems, image/data non-availability, sample spoilage, errors in data collection, or other problems compromised the integrity of many samples causing their exclusion from the final report.

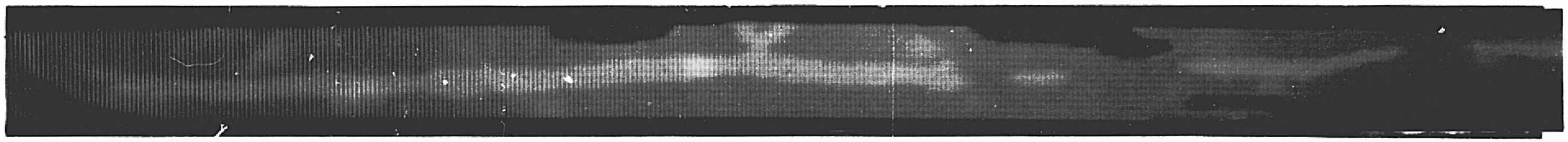


Figure III-2. Landsat Defined Erosion Zones. Illuminated rectangle in the center of the image is the beach study area. White, broken area in the image center is the beach proper.

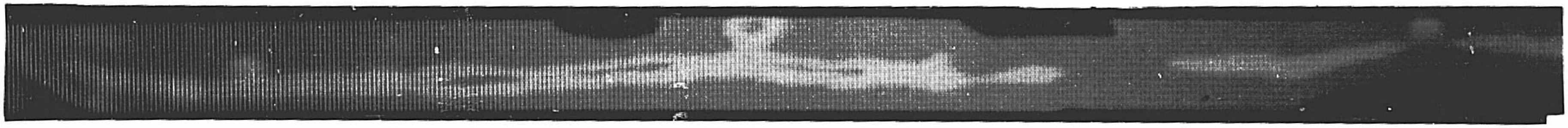


Figure III-3. Landsat Defined Erosion Zones. Emerging dark areas within the white beach zone are wet areas; gray tones outside of beach are spectral zones denoting undefined noise classes.

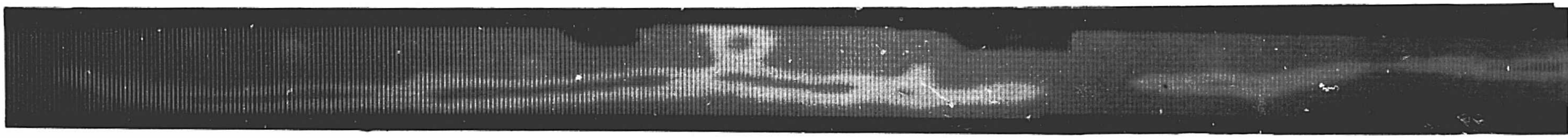


Figure III-4. Landsat Defined Erosion Zones. Expanded dark areas within white beach area represent augmented moist areas. The additional areas of dark gray over those present in Figure III-3 represent areas of lower moisture levels.

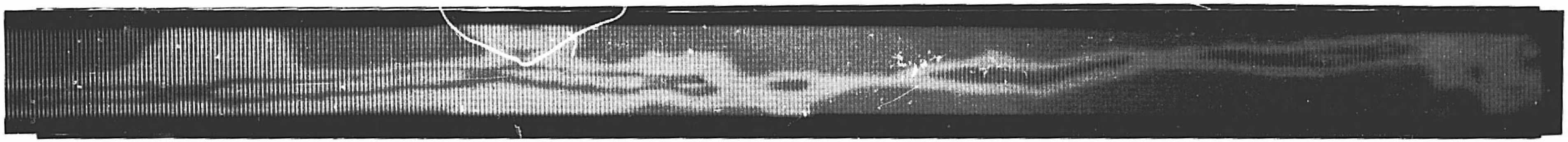


Figure III-5. Landsat Defined Erosion Zones. Expanded dark gray zones indicate areas of still further defined moisture. The additional dark gray zones over those present in Figure III-4, however, represent somewhat drier areas. The light gray areas in the middle of the dark gray areas within the beach indicate a zonation of the moist portions of the beach. This effectively produces a contour map of beach sand moisture. The light gray tones within the dark gray areas replicate the original dark gray beach zones illustrated in Figure III-3.

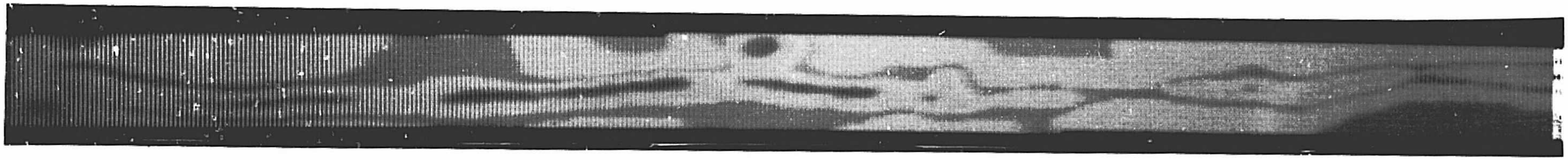


Figure III-6. Landsat Defined Erosion Zones. Light gray zones within the beach highlight the most moist portions of the beach. Together with the other gray tones present, the image indicates 5 levels of moisture classes within the beach.

reveal the existence of spectral zones of relatively dry areas on the beach which closely correspond with those identified from the July 7 sand moisture data (Figure II-10). It is significant to note that the remote sensing image contains three zones which correspond to dry sand areas and therefore to zones of high erosive sand, one west of Pass Christian, one east of Pass Christian, and one extending from approximately Menge Road to approximately 3000 ft. east of Espe Road. Further, it is possible to observe that the satellite and computer-defined erosion regions do not extend to the extreme western end of Henderson Point, but taper off and break up with interruptions of wet and stable sands in the vicinity of Fort Henry and Lady Mary Avenues. In Figure III-6, the beach moisture/erosion zone map, it can be noted that only on the July 7 field data is the highly erosive zone interrupted in this area.

Generally then, the Landsat satellite data of Figure III-6 revealed a marked pattern of correspondence with the erosion danger zones of Figure II-10. Although further study is obviously needed to verify the consistency of predictability of this imagery method, satellite data are clearly a valuable indicator of potential beach erosion sites.

Meteorological Analysis.

Local meteorological phenomena are central to the issue of aeolian sand erosion because weather events contribute energy to physical processes on the beach, and given the potential erosion state, are the driving force of erosion. An important consideration in understanding the input of atmospheric elements in the beach erosion problem is that coastal environments are meteorologically unique. Physical processes of air, sea, and land interact at the shoreline, producing a triple interface which creates atmospheric motion on several scales. The objectives of this project cannot be met without at least some understanding of three scales of motion:

1) synoptic scale

2) mesoscale

3) microscale

The synoptic scale includes weather phenomena such as tropical cyclones and mid-latitude traveling cyclones. Mesoscale activity is illustrated by the land-sea breeze phenomenon, and microscale motions involve small, chaotic eddies (turbulence) initiated by thermal or mechanical causes.

Major sand erosion factors in the synoptic scale are wind speed and direction, atmospheric moisture content, and precipitation patterns and frequencies. Wind direction and speed governs the amount of aeolian erosion, the direction of transport of the sand, and areas of deposition of the blown sand. Moisture content of the air masses governs evaporation rates and consequently the sand moisture profile. Precipitation governs moisture and cohesiveness of sand grains, directly affecting the potential for aeolian processes.

The most important mesoscale activity relevant to this project is the land-sea breeze phenomenon, and its existence is governed partially by the synoptic scale occurrences. The land-sea breeze phenomenon is a local wind regime superimposed on the larger regional wind patterns determined by synoptic scale pressure fields - the distribution of high and low barometric pressure. Some synoptic scale weather situations prohibit the land-sea breeze from becoming established, whereas other situations allow or enhance its establishment. One objective of this climatic analysis is to determine if a land-sea breeze phenomenon exists in the study area, what its characteristics are, what patterns of synoptic scale weather events favor or discourage its development, and what the annual regime of the phenomenon is. Answers to these questions should provide insight into the weather's contribution to beach erosion.

Microscale characteristics are complex, and identifying their interactions in detail is outside the scope of this project. However, this level of meteorological activity is recognized as being extremely important and functional in the design of mechanical structures to alter wind erosion, and this is the perspective from which characterization of micro-scale motions will be approached.

In order to develop a procedure to relate meteorological events and conditions to the beach erosion problem, it was necessary to identify the aforementioned characteristics at all three levels of motion. For that purpose, weather along the coast was classified into synoptic weather types. Muller (1977) has published the results of a classification of daily weather at New Orleans, Louisiana, into eight all-inclusive synoptic weather types. These eight types - Pacific High, Continental High, Frontal Overrunning, Coastal Return, Gulf Return, Frontal Gulf

Return, Gulf High, and Gulf Tropical Disturbance - are based upon regional atmospheric circulation patterns and can effectively index local wind flow. Detailed descriptions of the synoptic weather types can be found in Muller's work (1977).

Wax, Muller, and Borengasser (1978) have shown these eight synoptic weather types to be useful in a number of environmental and resource management problems. The weather along the Mississippi Gulf Coast fits into Muller's eight types, and the 1977 climatic data observed at the First Order Weather Station of the National Weather Service in Mobile, Alabama, were used to construct a synoptic weather-type calendar for that year.

Initial analysis of these data, grouped by synoptic weather types, provided identification and characterization of synoptic scale wind speed and direction, air temperature, dew point temperature, relative humidity, and cloud cover associated with each type. Additionally, the analysis established precipitation characteristics and frequencies, and durations of each of the synoptic weather types in 1977. Selected data, characterizing the meteorological parameters associated with the different types of weather, are included in tabular form in Appendix E.

Further analysis evaluated the synoptic weather types and the seasons most conducive to development of the land-sea breeze phenomenon. Results of the analysis using Mobile data were discouraging. Evidentally, the data collected at the Mobile site were too far removed from the beach itself and were not representative of the conditions at the study site. However, the land-sea breeze phenomenon was evident in the data for two of the eight synoptic weather types (Appendix E, Table 3).

The Gulf High weather type, characterized generally by westerly-southwesterly winds, showed a marked diurnal change in wind speed and direction in July. Characteristic wind for that weather type in July was westerly at 3 knots at 0600 hours, whereas the wind at 1500 hours blew at 19 knots from the south, manifesting the directional and velocity changes associated with the land-sea breeze. The Gulf High weather type was present at the Mobile site 42% of the time during July, and 54% of the monthly precipitation was recorded during the occurrence of this weather type. Over the entire year, however, the Gulf High weather type occurred only 16% of the time, and produced just 7% of the total annual precipitation. Therefore, this weather type is clearly seasonal in its impact on the beach processes.

The Pacific High weather type, characterized by westerly winds on the average (Appendix E, Table 3), exhibited a similar diurnal wind shift during October. Winds at 0600 blew at 5 knots from the NNW, and winds at 1500 blew from the SSE at 11 knots. This weather type was present 6% of the time during October and 2% of the time for the entire year, producing no precipitation during any of its occurrences. The impact of this weather type thus appears to be relatively unimportant even though the land-sea breeze occurs in the type.

Further examination of the data in Appendix E, Tables 1 through 15, revealed no evidence of diurnal wind shifts. However, these tabulated data show the average conditions of the other meteorological parameters as they relate to the beach erosion problem both annually (Appendix E, Tables 8 & 15) and seasonally (Tables 4 and 7). For example, nearly ½ of the total annual precipitation fell during combined Frontal Overrunning and Frontal Gulf Return synoptic weather types (Table 2), although together these two were present only about 1/3 of the time during the year (Table 1). Additionally, temperature and relative humidity, cloud cover, and windspeed and direction are illustrated for each of the weather types. Therefore, this method of analyzing the meteorological data appears to be a meaningful procedure for evaluating the weather element of the beach erosion problem, providing useful information on moisture/energy exchanges as well as on wind patterns.

The analysis was therefore extended to the Keesler Air Force Base data, collected at a site nearer to and more representative of the study site. Since only the Gulf High and Pacific High weather types were indicated as conducive to the formation of the land-sea breeze phenomenon, the analysis of data observed at this site was limited to these two weather types plus the one other high pressure synoptic weather type, Continental High. However, only characteristic wind speeds and directions for 0600 and 1500 were assessed. The resulting data are shown in Table III-1.

Inspection of Table III-1 shows that during March and December the land-sea breeze occurs in the Pacific High weather type. It also appears to occur in the Gulf High weather type during April, June, July, September, and October, and in the Continental High weather type during

Table III-1: Characteristic Wind Directions* and Speed** for Selected Synoptic Weather Types, Keesler AFB, Mississippi, 1977

	Pacific High		Gulf High		Continental High	
	0600	1500	0600	1500	0600	1500
Jan	31/10	28/14	27/08	27/06	35/10	35/11
Feb			22/05	18/10	04/06	33/08
Mar	32/06	21/08	25/02	20/13	02/08	29/10
Apr			35/03	25/10	34/05	31/09
May			14/11	14/10	02/05	05/04
June			29/07	20/13	03/04	12/08
July			32/05	22/10		
Aug						
Sept			31/03	22/10	03/06	12/07
Oct	32/03	34/06	30/02	21/09	01/06	06/08
Nov	29/03	25/09			34/05	09/06
Dec	06/05	19/05	18/06	22/05	35/04	30/07

*in azimuth x 10, ** in knots (31/10 = wind from 310° at 10 knots; 18/06 = wind from 180° at 6 knots)

March, June, and September. It is especially worth noting that in almost every case, the afternoon wind speeds (sea breeze) were higher than the morning wind speeds (land breeze). This affirms the sea breeze as a viable contributor of energy to the beach erosion process.

It appears that further investigation into the meteorological and climatological aspects of beach erosion processes is justified by these preliminary findings. There is clearly a substantial relationship between the beach erosion problem and the frequencies and extremes of meteorological/climatological parameters. This analysis has pointed out that only certain weather types favor the land-sea breeze occurrence. Further, the analysis shows a definite seasonality to the distribution of its occurrence. Further study could strengthen these conclusions, and could possibly indicate more of the relationships between atmospheric elements and the beach erosion problem in Mississippi.

Summary

Collectively, these forces and factors operate to influence the erosion patterns of this study area and to produce the zones illustrated in Figure II-13. With this zonation as a basis, and the mechanics of erosion (Chapter 1) and the principal mechanism the land-sea breeze established, it is possible to consider the nature of systems that would reduce the problem.

CHAPTER IV

DESIGN SOLUTION

Introduction

Objective 3 of this research, the siting and design of sand stabilization or turbulence obstruction features which are consistent with tourist attraction, and the economic well being of local commercial activities, must be met primarily by a design effort. The emphasis of this effort is focused on modifying the nature of the erosion zones defined in the previous chapters, while preserving or improving the recreational and economic environment of the area. Thus, the basic task of Objective 3 is to create a design which will:

1. Stop or retard aeolian erosion of the beach and sand deposition on the adjacent roadway.
2. Be aesthetically pleasing to all who physically and visually use the beach.
3. Provide for user needs and safety.
4. Facilitate or lessen the need for both beach and highway maintenance.

The scope of design work in this study is necessarily at a conceptual rather than a work-plan level because of legal, consent, and judicial restrictions. These limitations are based on the principle that the Mississippi Practice Act prohibits the practice of landscape architecture without a license. Also, sound legitimate design procedures require consent and input from local citizens and interest groups, and judicial and permit limitations have been established regarding the erection of structures or modifications on the beach. These factors, together with normal development procedures, suggest a course of development involving design refinement, public input, and activity approval before construction modification.

Methodology

The landscape architectural processes utilized for conceptual problem solution involve the steps of:

1. site analysis observations, focusing on human use and natural condition;
2. interpretation of implications,
3. generalization of solution; and
4. presentation of conceptual plan.

Site Observations - Human Activities.

(See Sheet 1, 2 of 6 at the end of this chapter). The beach was observed approximately 20 times during the field work design phases of this study, with emphasis on prime use periods (July 4th and Labor Day). The principal objectives of this observation were to record beach design factors and to determine areas of use and beach conditions. The primary use of the beach is clearly recreational. This area is the site of some of the most intensive beach-oriented tourism in the State of Mississippi. The significance of the intensity of this human activity on the beach is that it seems to be related to erosion zones where the presence of people and their movements break up the natural salt and organic crust and disturb the vegetation, thereby destroying the natural stabilization systems of the beach.

Observations indicated that most people were attracted to Henderson Point, located at the far western end of the study area. Twenty-five random interviews were conducted and the reported reasons for this concentration of activities included:

1. The area is attractive because it is physically removed from the highway (U. S. 90), thus allowing off-road parking and reduced road noise.
2. A large stand of trees provides shade and an asthetic environment in contrast to a seemingly endless barren strip of sand.
3. The trees and vegetation provide personal privacy and shelter and seclusion for changing clothes.
4. Drinking water is available.

In the beach zone east of Henderson Point and west of the Pass Christian Marina, beach use was random and dispersed. General beach use in this area is discouraged by the lack of adequate parking. Parking is parallel or pull-in (see Sheet 3 of 6) without physical separation from the flow of traffic, thus constituting a safety hazard. Even on the heaviest days of use (July 4 and Labor Day), people did not occupy the entire width of sand (approximately 200 ft.) from U. S. 90 to the water in this area. In the sparsely used areas, virtually all recreational activity occurred within fifty feet of the water, and in high concentration use areas seldom more than 100 ft. of beach was occupied. These observations were consistent throughout the entire length of the study area, and suggest that the 6.5 miles of two-hundred foot wide sand beach are significantly in excess of current and projected beach needs.

The area in the vicinity of the Pass Christian Marina and Harbor is a relatively heavily used recreational spot. Apparently this area is attractive because of the supporting amenities of the community, the visual variety of the marina, and the earlier attempts at beach-scaping (dead palms) which provided a visual break in the beach scene.

East of the Pass Christian Marina, the beach is largely an open, uninterrupted and seldom used area with the exception of two Least Tern nesting reserves where human activities are presumably excluded. These areas are slightly grassed and not frequented by the tourists or maintenance crews. Human use of this eastern section of the beach is scattered, random, and dispersed. Erosion seems lower in nesting reserves where developing grasses are reducing sand movement considerably. Generally, the processes operating within these areas have precipitated the development of miniature dunes and clumps of beach grasses which have trapped blowing sand and slowed surface winds below erosion thresholds.

Site Observations - Natural Systems.

(See Sheets 1, 2 of 6). Field observations and meteorological records indicate that from the point of erosion and recreation, winds are the dominant natural features on the beach. This factor coupled with the human pressures produces a complex system which in turn interacts and influences the condition of the beach and its suitability for human recreational activity. Generally, it appears that the prevailing wind is east-southeast at an average speed of 20 mph (measured several feet above the ground). This wind appears to be dominant aeolian erosion factor.

Erosion and sand deposition occur unevenly throughout the area; deposition in particular, varies according to inland obstructions. This appears to be verified by the fact that the wide median islands of U. S. 90 which are well planted with grass, shrubs, and trees, offer a considerable barrier to sand drifting from the coastward eastbound lanes to the more inland westbound lanes. Substantial mounds of sand develop on the shore side of these islands with some deposition on inland lane. In contrast, narrow concrete islands provide little obstruction to wind-driven sand, and in the areas of U. S. 90 divided by three narrower islands, sand accumulates on the inland, west bound lanes and on private property further inland (see Sheet 3 of 6).

In addition to the sand, vegetation, wind, and water, the major remaining natural component of the beach is the sun. The sun is especially important as a design factor because of its dominance; conceptually in design, there should be shade for relief in warm weather, and open sunny areas for cooler temperature periods. The sun angles were plotted to determine how the design concept will be influenced during summer and winter. The sun angle was found to be at a maximum solar altitude (height overhead) of 83 degrees during summer (June 22) and at a minimum solar altitude of 37 degrees during winter (December 22) (see Illustration No. 1). These values suggest that in order to provide for summer shade and winter sun, the north side of the design should be planted more heavily with trees than the southern side. Also, the tree species on the north could be more dense, in terms of foliage, than the species on the southern side.

Generalizations and Implications.

The above observations support several generalizations relating to the design of stabilization systems:

1. erosion appears to occur throughout the study area and seems most severe in zones I, III, and IV of Figures II-10 and III-6;
2. the transport and deposition factors of sand which regulate its accumulation on roads and inland public and private property, are related to the narrow separation between beach and roadway, the narrow traffic islands, and the general absence of vegetation;
3. the presence of intensive human pressure (tourist use and maintenance activities) is not conducive to the development of wind-stable beach areas;
4. generally, even at very high use periods, the beach zone exhibits low levels of occupancy with peak period concentrations as low as 25 people per mile. Higher concentrations have been noted in the vicinity of Henderson Point and the Pass Christian Marina.

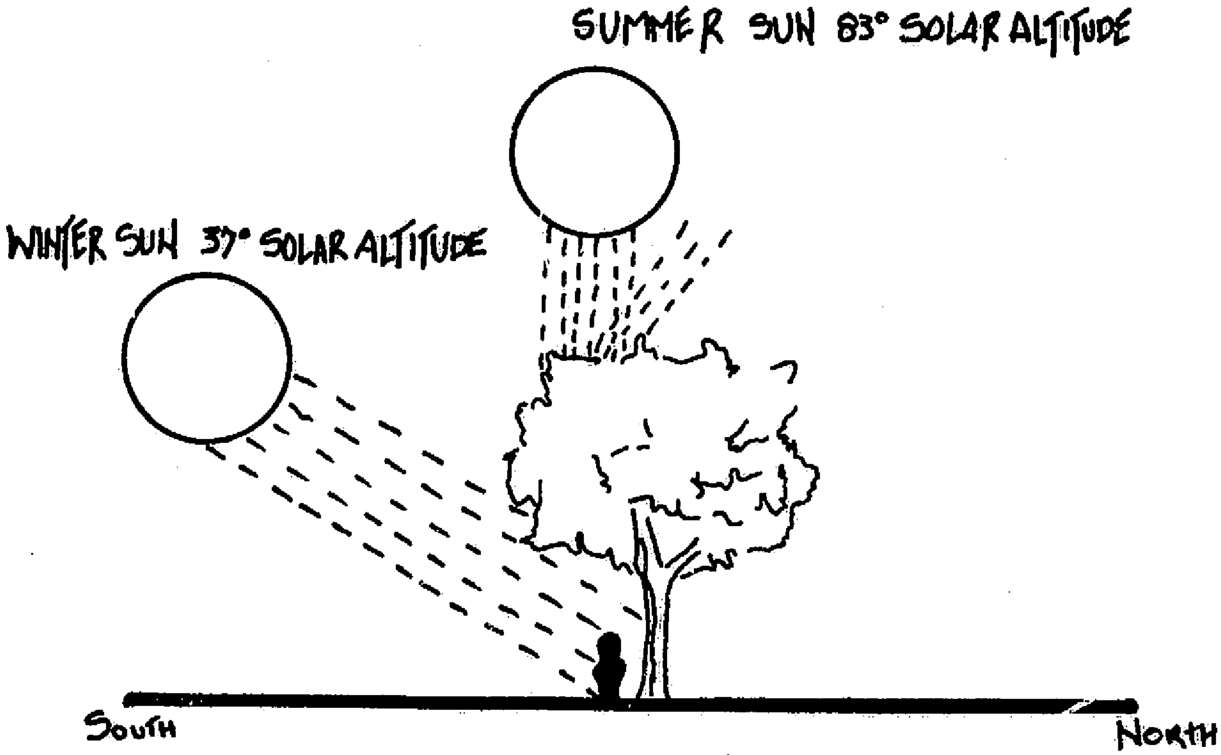


ILLUSTRATION 1

Based on these observations, the following accomplishments would be beneficial in improving the recreational quality of the beach and reducing erosion:

1. provide a separation distance and wind obstruction system between erosive beach areas and the roadways.
2. increase the volume and variety of vegetation on the beaches, or between the beach and road.
3. create certain high-use zones to attract users within the broad expanse of the beach study area, thereby lessening the population pressure on the undeveloped, major portion of the beach, and allowing natural processes to effect stabilization in low-use zones.
4. establish additional or expand existing Least Tern areas in the undeveloped portion of the beach where human activity will be at a minimum.
5. establish or encourage natural processes within the large undeveloped areas (backshore) to allow the natural vegetation to establish a micro-stabilizing environment.
6. provide services and facilities at high-use areas to increase beach utility.

Generalized Plan

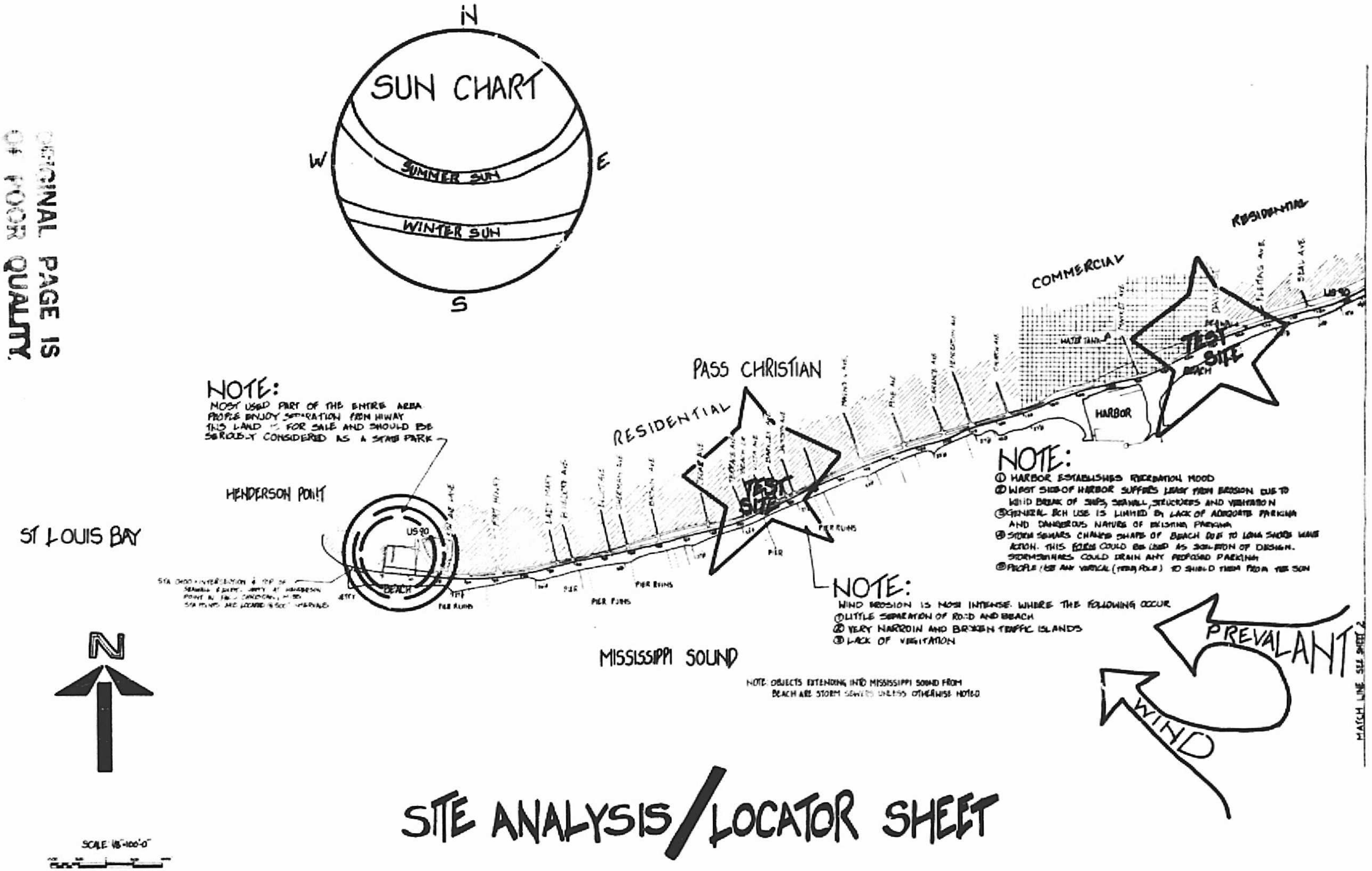
Given the above suggestions regarding present beach-use patterns, low levels of user service, and associated maintenance and erosion potential, the possibility exists to provide greater tourist beach satisfaction and reduced erosion through a strategy of beach facility design, arrangement, and location which will influence user behavior. The key component of such a strategy would be an environment which encourages people to use selected special areas very intensively, and to avoid other areas entirely.

The two principal mechanisms employed to influence this behavior are the design and establishment of attractive amenity sites, and the setting of restrictions. The attractive amenity sites of the strategy include vegetation, berms or dunes, activity elements, and adjacent off-road parking areas (see Sheets 4, 5, and 6 of 6). Activity elements proposed as part of a designed site would not only provide physical facilities, but also a psychological atmosphere conducive to recreational use.

The psychological factors of this atmosphere would be based on the concept that design elements act as a reference point to provide variety in the visually uncomplicated and simple environment of the beach. This is illustrated by the fact that vertical tree trunks provide a sense of psychological security, while the overhead foliage provides shade and enclosure. The psychological role of such elements can be conceptualized by visualizing the sensation of walking through a large, freshly plowed field and experiencing the feeling of exposure in contrast to the feeling of walking through a forested area of the same size. The trees aid the individual in relating to the space through the feeling of enclosure provided by the trunks and overhead canopy which form walls and ceilings. Similarly, these features also provide anonymity as it is possible to stand next to a tree and feel "at one" with, and a part of the environment. The only verticals presently existing in the beach vicinity are trees at certain points along the highway (U. S. 90) median and a few dead palms on the beach. The importance of such features and the validity of atmosphere notion controlling human activities is suggested by the fact that people have been regularly observed sitting next to and in the shade of these dead palms (see Sheet 3 of 6) seeking relief from the sun, lying in the shade of parked cars, and parking and picnicking on the medians under trees. This behavior suggests that trees incorporated into the beach landscape would channel activities by keeping people off of the medians and on the beach in selected high use zones. Vegetation used in this manner would eliminate the existing single, large, visually boring expanse by breaking up the beach into smaller areas.

The counterpart of the creation of attractive amenity zones, restrictions or prohibition of activities in certain areas, would result in a further lessening of the human pressures on the natural stability system throughout the broad expanse of under-used beach. This, coupled with the establishment of additional or enlargement of existing Least Tern nesting areas, could have the effect of materially reducing erosion and improving the environment.

Under this set of strategies, largely for psychological reasons and convenience, recreational use of the beach would tend to become concentrated in certain zones. This concentration of activities into small, well-designed, high use zones separated by broad expanses of natural conditions, such as low maintenance backshore areas and expanded wildlife habitats, would provide an opportunity to better serve recreational users through concentration of facilities for trash deposit and removal, bath facilities, and food and beverage service and parking. These activities would result in lower maintenance costs, a more aesthetically, pleasing environment, and greater tourist attraction.



SITE ANALYSIS/LOCATOR SHEET

SCALE 1/8"=100'-0"

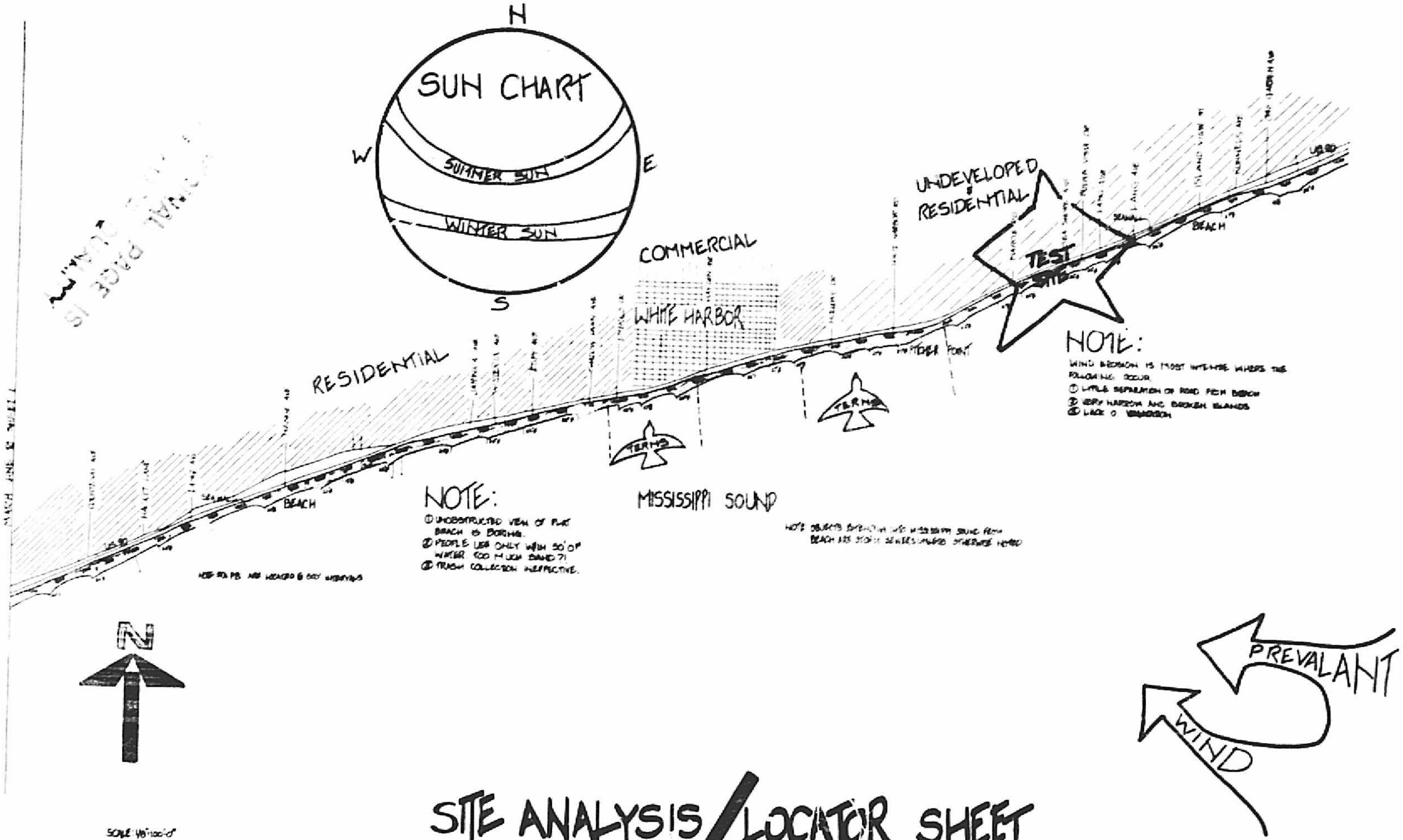
HARRISON COUNTY BEACH EROSION CONTROL

HARRISON COUNTY-MISSISSIPPI

DEPARTMENT OF GEOGRAPHY/GEOLOGY

DESIGN BY V. NEIE - DEPARTMENT OF LANDSCAPE ARCHITECTURE - MISSISSIPPI STATE UNIVERSITY

sheet 1 of 6



SITE ANALYSIS/LOCATOR SHEET

HARRISON COUNTY BEACH EROSION CONTROL

HARRISON COUNTY-MISSISSIPPI

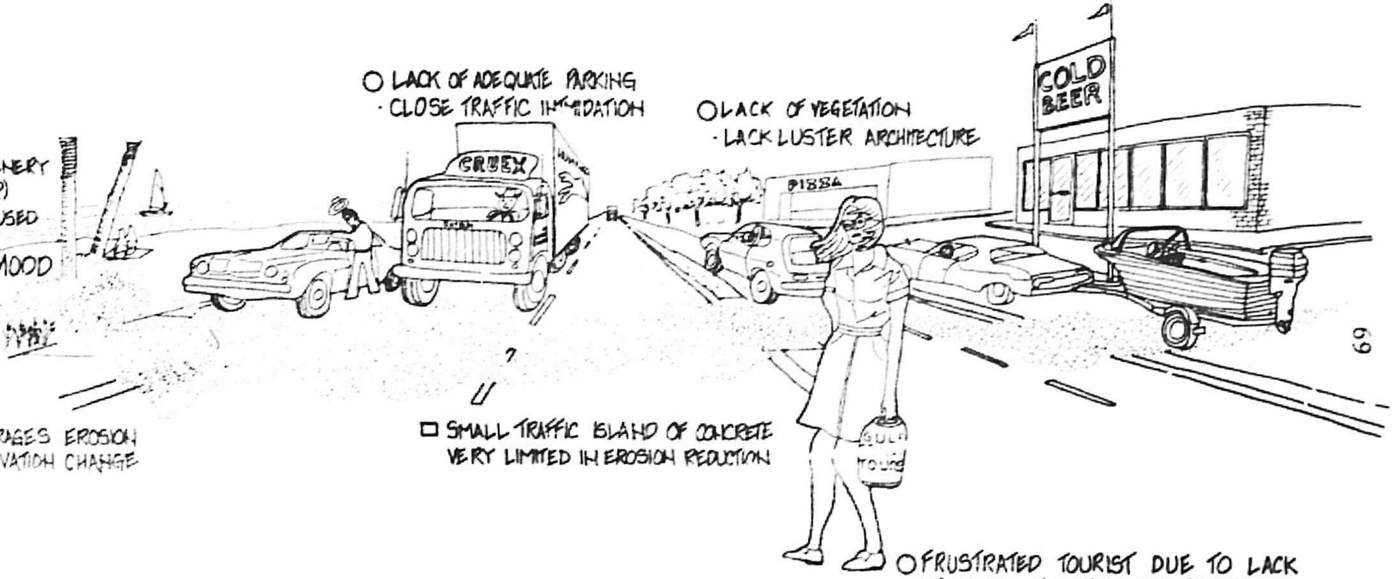
DEPARTMENT OF GEOGRAPHY/GEOLOGY-DR. GARY HIGGS ASSOCIATE PROFESSOR

DESIGN BY V. NEIE - DEPARTMENT OF LANDSCAPE ARCHITECTURE - MISSISSIPPI STATE UNIVERSITY

sheet 5 of 6

EROSION FACTORS ▫

○ AESTHETIC FACTORS



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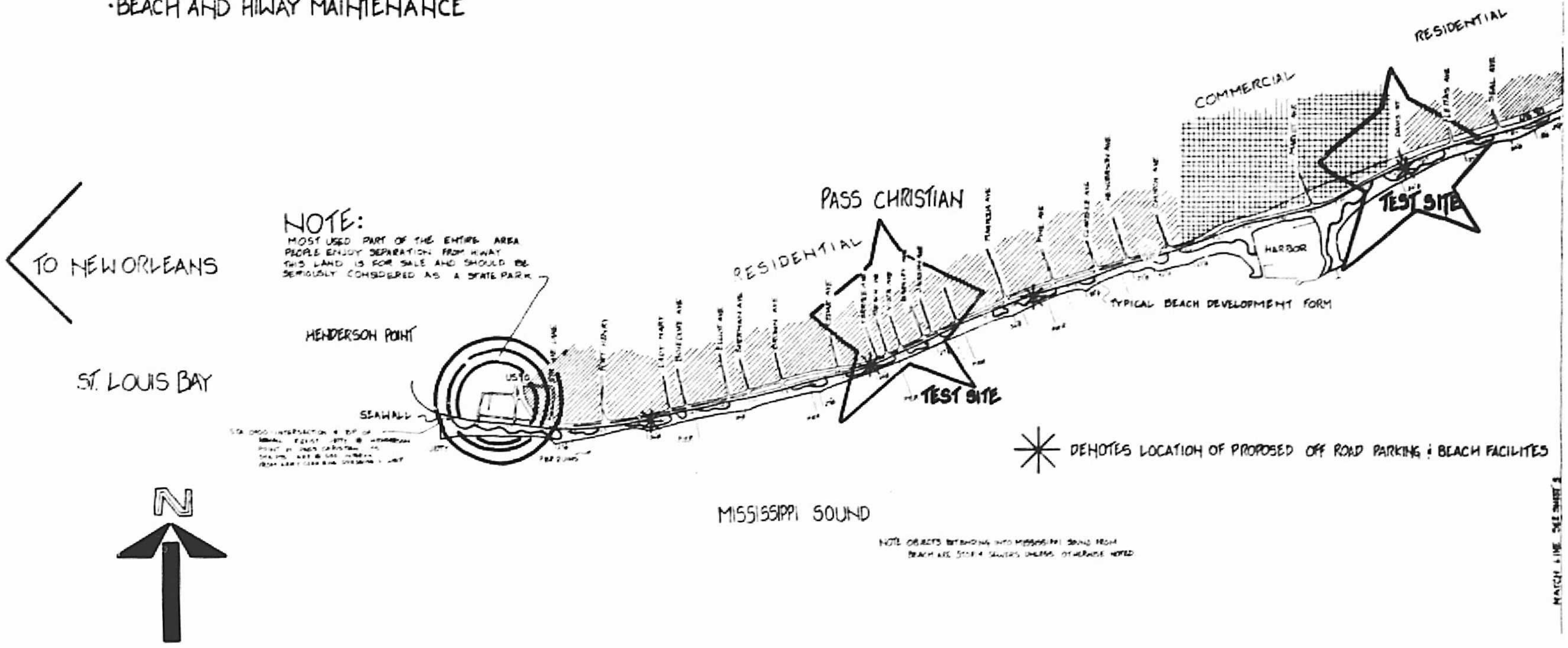
EROSION & AESTHETICAL PROBLEMS

HARRISON COUNTY BEACH EROSION CONTROL
HARRISON COUNTY-MISSISSIPPI
DEPARTMENT OF GEOGRAPHY/GEOLOGY-DR. GARY HIGGS ASSOCIATE PROFESSOR
DESIGN BY V. NEIE-DEPARTMENT OF LANDSCAPE ARCHITECTURE-MISSISSIPPI STATE UNIVERSITY

sheet 3 of 6

•DESIGN GOAL•

- STOP/RETARD AEOLIAN EROSION WITH AN AESTHETICLY UNIFYING CONCEPT FOR THE MISSISSIPPI GULF COAST WITH REGARD FOR:
  - •USER NEEDS AND SAFETY
  - •TOURIST INDUSTRY
  - •BEACH AND HIWAY MAINTENANCE



PRELIMINARY BEACH PLAN

SCALE 1/8"=100'-0"

HARRISON COUNTY BEACH EROSION CONTROL

sheet 4 of 6

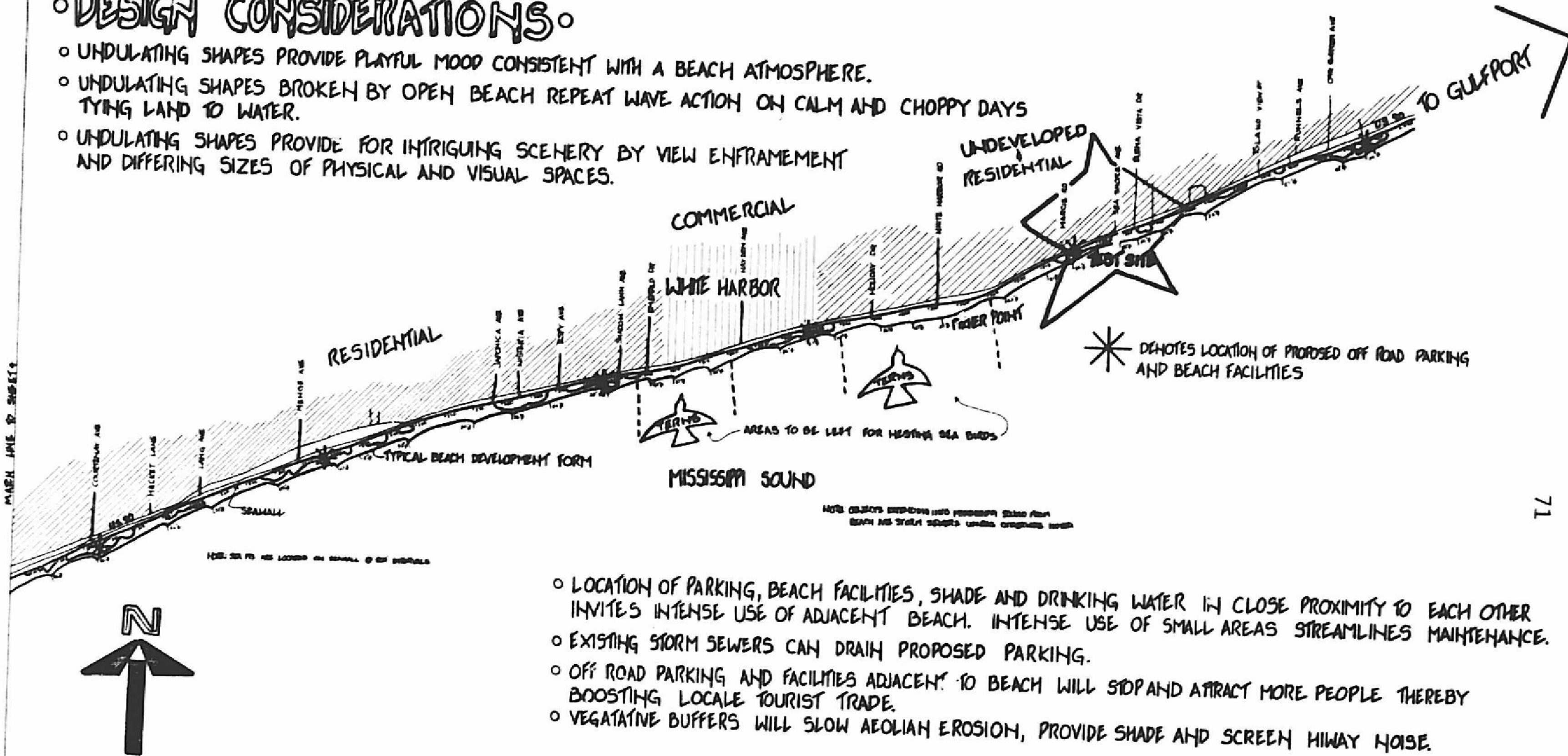
HARRISON COUNTY-MISSISSIPPI

DEPARTMENT OF GEOGRAPHY/GEOLOGY

DESIGN BY V. NEIE - DEPARTMENT OF LANDSCAPE ARCHITECTURE - MISSISSIPPI STATE UNIVERSITY

DESIGN CONSIDERATIONS

- UNDULATING SHAPES PROVIDE PLAYFUL MOOD CONSISTENT WITH A BEACH ATMOSPHERE.
- UNDULATING SHAPES BROKEN BY OPEN BEACH REPEAT WAVE ACTION ON CALM AND CHOPPY DAYS TYING LAND TO WATER.
- UNDULATING SHAPES PROVIDE FOR INTRIGUING SCENERY BY VIEW ENFRAMEMENT AND DIFFERING SIZES OF PHYSICAL AND VISUAL SPACES.



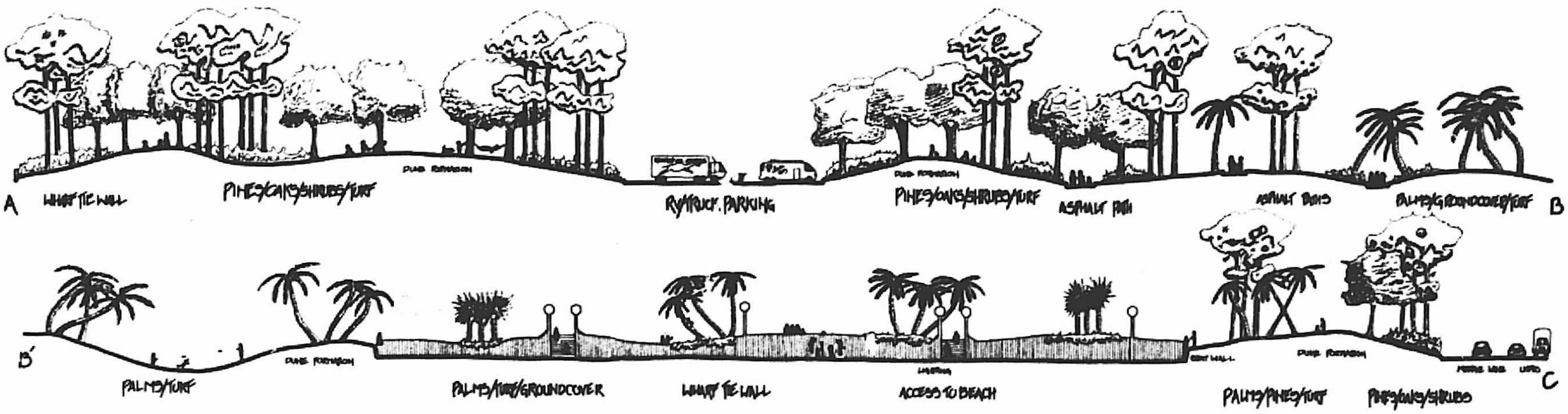
- LOCATION OF PARKING, BEACH FACILITIES, SHADE AND DRINKING WATER IN CLOSE PROXIMITY TO EACH OTHER INVITES INTENSE USE OF ADJACENT BEACH. INTENSE USE OF SMALL AREAS STREAMLINES MAINTENANCE.
- EXISTING STORM SEWERS CAN DRAIN PROPOSED PARKING.
- OFF ROAD PARKING AND FACILITIES ADJACENT TO BEACH WILL STOP AND ATTRACT MORE PEOPLE THEREBY BOOSTING LOCALE TOURIST TRADE.
- VEGATATIVE BUFFERS WILL SLOW AEOLIAN EROSION, PROVIDE SHADE AND SCREEN HIWAY NOISE.

PRELIMINARY BEACH PLAN

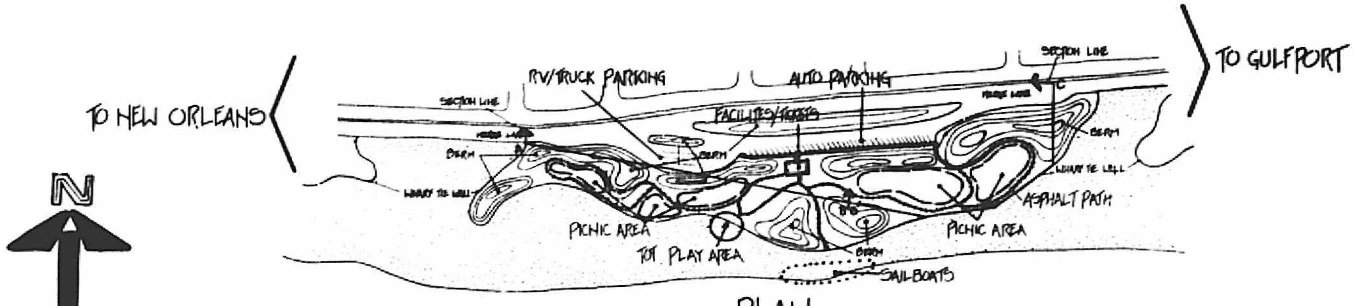
HARRISON COUNTY BEACH EROSION CONTROL
HARRISON COUNTY-MISSISSIPPI

DEPARTMENT OF GEOGRAPHY/GEOLOGY-DR. GARY HIGGS ASSOCIATE PROFESSOR
DESIGN BY V. NEIE-DEPARTMENT OF LANDSCAPE ARCHITECTURE-MISSISSIPPI STATE UNIVERSITY

sheet 5 of 6



SECTION SCALE 1"=20'



PLAN SCALE 1"=100'

SCALE AS SHOWN

TYPICAL DEVELOPMENT

HARRISON COUNTY BEACH EROSION CONTROL

HARRISON COUNTY-MISSISSIPPI

DEPARTMENT OF GEOGRAPHY/GEOLOGY-DR. GARY HIGGS ASSOCIATE PROFESSOR
DESIGN BY V. NEIE-DEPARTMENT OF LANDSCAPE ARCHITECTURE-MISSISSIPPI STATE UNIVERSITY

sheet 6 of 6

Chapter V

OVERALL DESIGN AND SPECIFIC SITE PLAN

General Beach Land Use

Along the beach section of this study area, two locations have special properties which render these sites uniquely suited for the location of high-use zones. These are Henderson Point and the area in the vicinity of the Pass Christian Harbor Marina. Henderson Point, while not centrally involved with the aeolian erosion and redeposition problem, is significant for consideration as a special case because of its setting. It is privately owned, currently for sale, undeveloped (with the exception of two mobile homes), moderately vegetated, has good roadway access and a high-use factor due to this attractive atmosphere (see Sheet 1 or 6). This location has good potential for development as a high-use zone to provide overnight camping as well as daylight recreational use. Benefits derived from such a facility at this site would include preservation of the attractive atmosphere, control over the future land use of Henderson Point, regulation of commercialization, and stimulation of both first and subsequent tourist visits to this strategic west-end of the beach zone.

The Pass Christian site is more directly involved in the aeolian erosion and deposition problem than the Henderson Point site, and for this reason, development here is more pertinent to the issue of stabilization. This location, therefore, is a prime choice for test sites for evaluation of a stabilization system (see Sheet 1 of 6).

The Pass Christian site has several attributes that render it suitable as a high use zone. These include the presence of a harbor/marina which establishes a mood consistent with beach recreation. The key element of this mood is aesthetic scenes, including varying land uses and private and commercial vessels and activities. This site could be a major focal point drawing users from other portions of the beach, thereby reducing the pressure on the low-use and restricted-use areas. Aside from the aesthetics, the beach area west of the Harbor suffers less erosion than the beach area east of the Harbor; this is possibly due to the windbreak provided by the boats and structures (see Figure II-10).

The remaining beach areas between these sites, and to the eastern end of the study area in the vicinity of Pitcher Point, are not sufficiently differentiated to provide a basis for distinguishing specific sites. Thus, two additional test locations have been arbitrarily designated; one within the high erosion area midway between Henderson Point and Pass Christian, and a second in the moderate erosion zone immediately east of Pitcher Point (see Sheets 4, 5 of 6).

Low-use areas outside of these three sites may experience a decrease in use. This change may in turn enable a reduction in maintenance effort and allow development on the backshore of natural micro-dune systems for erosion control. It will also result in preservation of the foreshore portion for use by those individuals seeking solitude and greater privacy than that afforded at the high-use sites. The recreational use of the narrow foreshore sand allows stabilization uses of backshore areas. Among the alternative backshore uses is off-road parking and wind-break vegetation. Additional benefits derived from such a plan are removal of parked vehicles from the roadway, increased margin of safety for driver and pedestrian, less parking difficulty, and improved movement of road traffic. Throughout the low-use areas, dune-like formations covered with beach grasses would evolve, providing open expanses of beach to separate high-use areas.

Conceptual Site Plan of High-Use Design

In the design of the high-use areas at designated points, the basic manmade character of the beach is the fundamental feature and must be considered together with the erosion and human activities of the area. Designs concerned with shaping the pattern of use of the beach are logically stronger if they recognize and reflect these considerations.

As nebulous as this design principal seems, there is a method of deriving such a design by form study. Conceptually, the principal of form study seeks to accomplish these objectives in simulation of natural forms by a manmade structure. The freedom and mood of relaxation necessary for a recreational atmosphere can be expressed in flowing lines in contrast to the tension of hard corners. A sense of isolation and focus, as well as confinement for the high-use zones, can be obtained with variations in elevations and use of plant materials to form "exterior rooms." Elevation changes can be calculated to control views, to curb road noise, to direct people, and to provide privacy or open areas for those few beach users who might prefer open or isolated views.

All of these concepts of design can be synthesized into a design which accommodates the objectives of the study and focuses on the specific test sites along the beach. The key features of the beach have been evaluated in the form of a Relationship Matrix (Figure V-1). In this matrix, all of the features considered are listed on two axes of a graph and their relationship to one another is indicated according to a functional, corresponding value. The following ratings were employed:

Good Symbiosis - work well with each other and enhance each other.

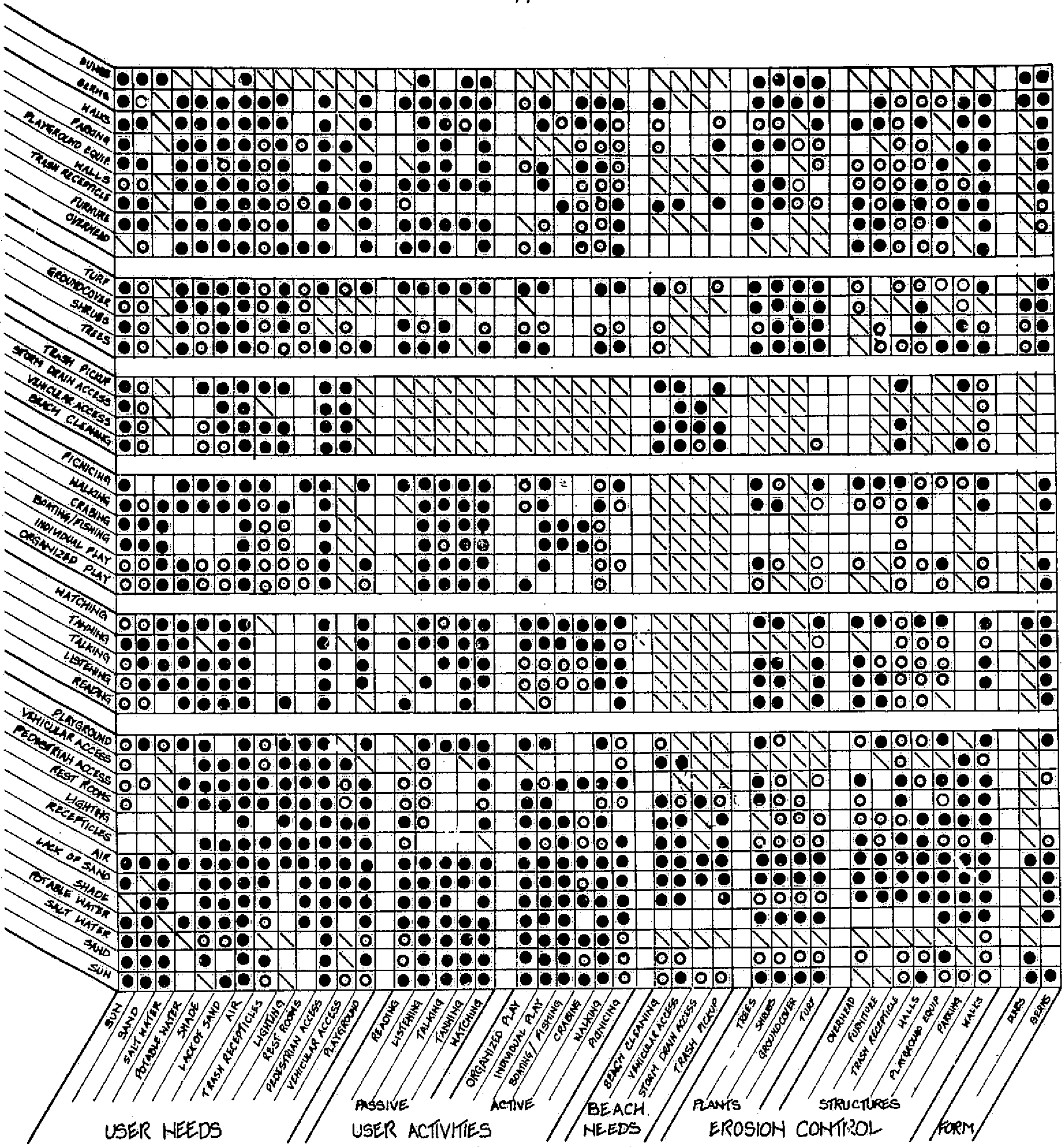
Symbiosis - work well with each other.

Neutral - no affect.

Conflict - work against each other.

Forms.

The analysis of features begins with form study. Considering elements in the Landform class relative to their erosive properties, it can be noted that walls stop blowing sand more effectively than any other form. This principal is based on Bagnold's finding that the angle of repose of sand is a maximum of 34 degrees against a vertical surface (see Illustration 2) (Bagnlid). This value is useful in determination of height and width of a drift equal to the height of an obstacle. (Appendix



RELATIONSHIP MATRIX

GOOD SYMBIOSIS-● , SYMBIOSIS-O , NEUTRAL-□ , CONFLICT-⧅

Figure V-1

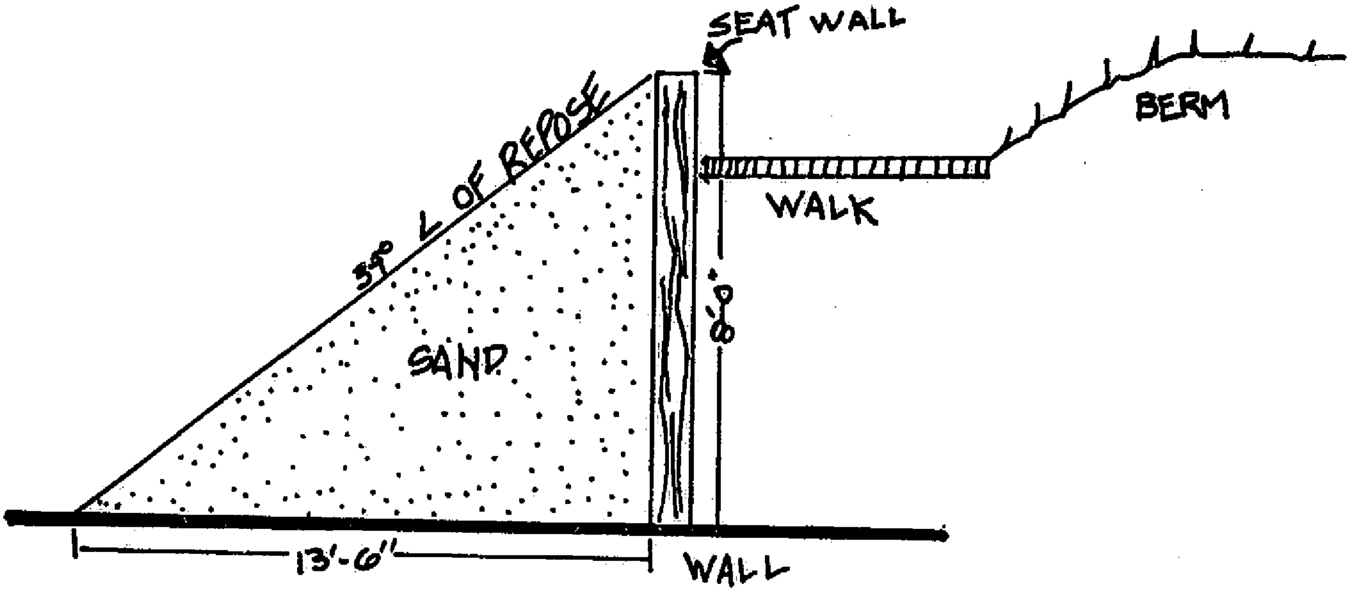


ILLUSTRATION 2

F). For example, a structure eight feet tall would require a drift thirteen feet wide prior to its overtaking the top of the structure. Furthermore, sand will react differently to different obstacles in that it will be deposited at the base of a solid wall, but be blown around and through an ill-defined structure, such as an elevated plant form. Therefore, the most limiting factor of erosion is a solid structure, with plant forms being secondary. A review of the Relationship Matrix indicates that a wall will be a compatible design component with all beach elements except dunes, groundcover, storm drains, vehicular access, beach- cleaning activities, and salt water. These points of conflict can, however, be circumvented if the wall encloses the dunes, does not shade out groundcover, avoids storm drains, leaves openings for maintenance vehicles to access the beach, and does not extend into the water. Thus, walls appear to have the properties necessary for an important component of the high-use stabilization system and could be the fundamental element in the site plans.

In considering the form the wall is to take, the initial design concept of merging the manmade aspect of the beach with its recreational nature and erosion control must be employed in a manner such that a manmade quality could be retained with a feeling of freedom yet confinement. Also, the study principal that form should follow the shape of natural functions is especially important in this environment and suggests that the wind, the dominant erosive force, will dictate the form. Given these principals, a plastic flowing form which emulates a wave seems most conducive to the concept and most compatible with the function of blunting and re-directing the wind. In a theoretical and practical sense, a wall in the shape of a wave would facilitate the aesthetic and stabilization goals in several ways:

1. the wave shape will have the property of blunting and re-directing the wind so as to cause it to reduce its energy and cause a drop in wind-blown sand as well as retarding sand creeping along the ground;
2. the advantage of this shape in a contextual image capacity is that it repeats the waves on the water and ties the land and water closer together in a visual sense. Additionally, with these wave forms (walls) elevated in the shape of a dune they resemble islands in the sand. The sand can be viewed as a fluid medium forming a transition between the dune and the water;
3. A wall outlining the shape of a dune-like island would enable maintenance of the beach, since it will not obstruct cleaning. At the same time, the wall will serve as a barrier between the sand and the roadway. Such a feature would allow sand buildup on the seaward portion of the wall to be redistributed, thus preventing loss onto the roadway. In this manner, the wall will function as the current sea wall does with the exception that there will be less sand collected in front of it, because the foreshore area will be smaller

than the present beach width. The well lighted wooden wall, as depicted on Sheet 6 of 6, would serve as a retention wall on the beach side and a seat wall on the road side (see Illustration 2). If beach access is open to the wind, then a buffer wall should be placed in front of the access to prevent sand from blowing up the steps (see Illustration below).

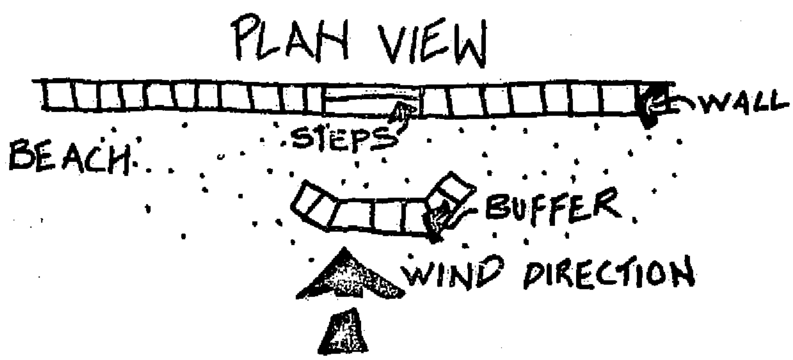


Illustration 3. Plan View

The portion of the beach behind the wall is designed as a high use site.

Generally, a wall with the above characteristics is compatible with concentrated human use areas. However, such a beach wall has certain constraints which influence how it may be used within the beach setting. These constraints include:

C -2

a. A fifty foot setback from the water to allow unobstructed foreshore use for the observed user patterns as well as for maintenance machinery access to the foreshore.

b. The radius of the wall must be fifty feet or greater due to size requirement of beach equipment.

Macro Exterior Design Consideration of High Use Zones

Proceeding from the basic form study premise that form is dictated by function, the free flowing lines of the wall (the fundamental design component) should be assembled into a coherent design unifying the entire beach. One method of unification is through repetition of form; however, repetition of form can lead to boredom. This problem can be eliminated through the modulation of the sizes of repeated shapes.

Size modulation requires that size be determined by the way the viewer experiences the design. In the instance of the beach, there are two possible perspective views, that of the pedestrian and that of the occupant of a moving vehicle. In terms of freedom of concentration and perception, these two settings are at opposite ends of the attention scale. The contrast of these modes of attention is illustrated by the time difference between walking one hundred feet along the beach and driving that same distance at fifty miles per hour on the coastal highway. In these two situations, perceptual exposure variance may range from several minutes to a fraction of a second. During the walk there is an abundant opportunity (time and freedom of attention) to view the surroundings and, therefore, shapes can be small and intimate.

During the drive vision time and attention is very limited; hence, the visual experience can only involve large sizes and macro proportions of design. Relative to this difference in viewer capacity, the design must possess both large and small forms. Sheets 4 and 5 of 6 show a suggested size and location for larger forms with the following functions:

1. the flowing shapes repeat the basic wave theme but provide size fluctuation which breaks up the visual bordom of similar pattern repetition;
2. the shapes are sufficiently large for the auto viewer to experience;
3. open areas between shapes are left so that the beach will still touch the roadway. These openings will not inhibit erosion at these points, but they do provide an unobstructed perspective of the water, and in this manner each space will act as a picture with the walls serving as a frame;
4. concentration of such shapes and features and associated visual and functional service amenities will be attractive and encourage intense beach use in those zones designated as high use.

<u>Micro Interior Design Consideration and Component</u>

Areas within the high use zones are listed in the Relationship Matrix as User Activities and classified into two categories - passive and active activities. In a conceptual and locational sense, the passive forms of activities should be spatially separated from active forms as they are often incompatible. The shape and size of features and areas within a typical high use zone are illustrated on sheet 6 of 6. Within these areas the pedestrians will be able to relate to the shapes most directly, if the shapes are modulated with elevation change. Berms or dunes can be incorporated into this wavy concept for repetition of general shape as well as for controlling different areas of enclosure and views. Reference to the Relationship Matrix will reveal that berms are more compatible than dunes. This is true mainly because dunes characteristically have fragile vegetation which will not stand trampling by pedestrians. In contrast, berms are generally covered with turf which accommodates heavy pedestrian use (Appendix G). The combination of these factors, walls and berms or dunes, provides the design with the man-made quality, a sense of unity and freedom, interest to both vehicular and pedestrian viewers, and the ability to curb erosion.

Movement between areas of activity within these high-use zones can be directed to the facilities, picnic areas, play area, and boat area by locating these facilities between dune formations. This directed movement can be enhanced with vegetation and channeled by asphalt paths for orientation and a firm walking surface.

The picnic area adjacent to the Childrens Play Area is generally for active groups and families with children, while the Picnic Areas isolated from the Childrens Play Area would accommodate other groups. Picnic Areas should be provided with picnic tables, drinking water, and trash recepticles and be positioned in such a manner as to take advantage of the winter sun, with generous tree plantings to filter the summer sun. The Play Area should be located to bridge the gap between beach and green space. A boat frame for climbing or a wall for sliding are much more attractive to young imaginations than the standard swing set and teeter-totters. The Facilities Office should include restrooms for changing and convenience, drinking fountains, and an information board for the area.

CHAPTER VI

CONCLUSION

Landsat imagery and data can be effectively used to identify areas of differential aeolian erosion on beaches. Aeolian erosion on the Mississippi Gulf Coast has essentially the same basic physical processes or aspects of aeolian erosion as do all coasts; it is, however, somewhat more complex in this area because of a unique low topographic profile, an intensive proximate cultural development (towns and coastal roads), and heavy recreation beach use. For these reasons, aeolian erosion, which is a natural part of the beach coastal cycle, takes on added dimensions of significant economic impact and concern for human health and safety.

Because of the heightened local concern with the economic and environmental impact of aeolian erosion and inland deposition, the use of Landsat data to identify areas of blowing sand was investigated. With the successful establishment of the limits of these areas, a study of the mechanics and processes of aeolian erosion suggested that certain types of features and structures could be combined into site designs. The site design areas would function to concentrate human activity, diminish stress and erosion throughout the full extent of the beach, and trap blown sand and alleviate erosion.

Collectively, these designed sites, separated by expanded or additional access-prohibited Least Tern nesting and low-use areas, should have the effect of materially reducing erosion. This decrease in erosion at the design sites would occur because unstable, exposed sand surfaces will be replaced with relatively stable areas planted with shrubs and trees. These designed areas would also provide sand trapping and wind-reducing surfaces. Within the larger, whole-beach context, reduced erosion in out-site areas would result from the natural sand stabilization in the areas of prohibited access, and the lessened population pressure in the low use areas.

Footnotes

1) Beach Erosion Report on Cooperative Study of Harrison County, Mississippi, Division Engineer, C of E. South Atlantic Division, Atlanta, GA, 1947.

2) Russell Rich Joel, "Physiography of Lower Mississippi River Delta," Louisiana Geological Bulletin No. 8, 1936.

3) Howe, H. U. Louisiana Petroleum Stratigraphy. American Petroleum Institute, Division of Prod., Paper 901-12B, 1936.

4) Congressional Document No. 682, 8th Congress, 2nd Session, 1948, pg. 16, paragraph 30.

5) "Behavior of Beach Fill and Borrow Area at Harrison County, Mississippi," Technical Memorandum No. 107, Beach Erosion Board.

6) Short note "Behavior of Beach fill Harrison County, Mississippi, December 1975.

7) Udden, J. A. The Mechanical Composition of Wind Deposits, 1898.

8) Bagnold, R. A. The Physics of Wind Blown Sand and Desert Dunes. 1941.

9) NASA Technical Memorandum, The ERTS-1 Investigators (ER-600), Volume II-ERTS-1, Coastal/Estuarine Analysis, NASA LBJ Houston, TX, 77058, July 1976, TMX-58118, JSC-085474, A-19-A24.

APPENDIX A

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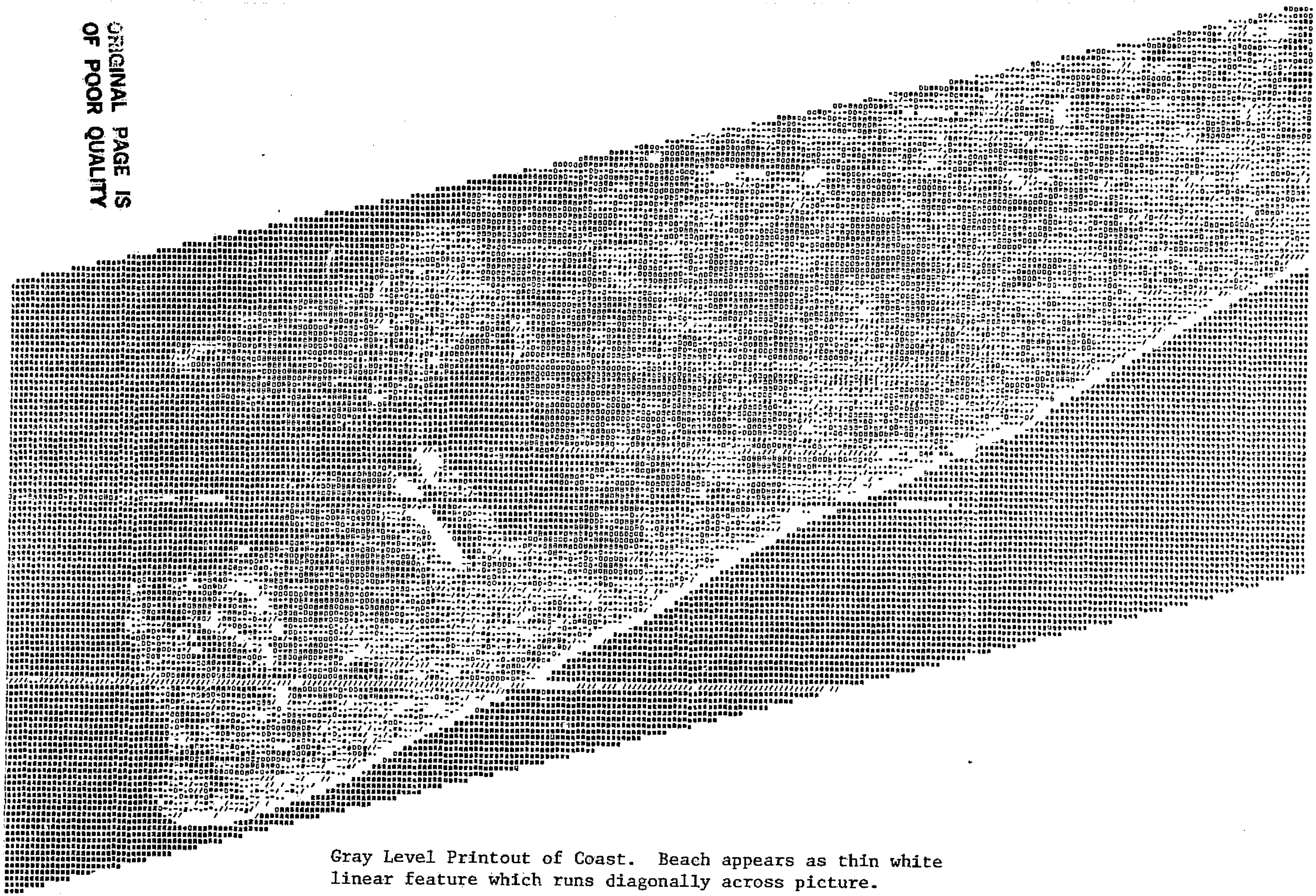
APPENDIX B

GRAY LEVEL PRINTOUT, BAND 5, OF STUDY AREA



Gray Level Printout of Coast. Beach appears as thin white linear feature which runs diagonally across picture.

APPENDIX C

HISTOGRAMS

HISTOGRAM

FIELD 1

(NO. SAMPLES : 11)

CHANNEL 1

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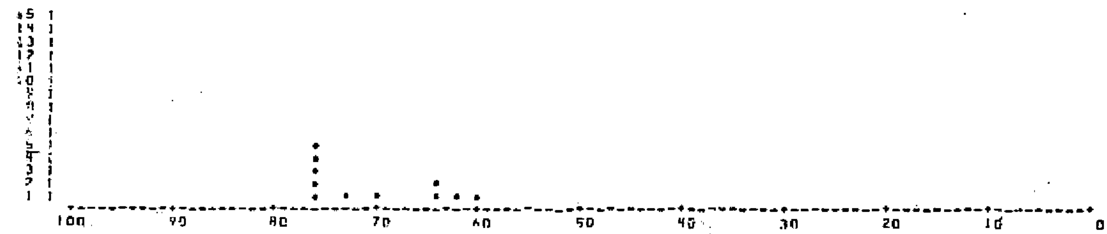

CHANNEL 2

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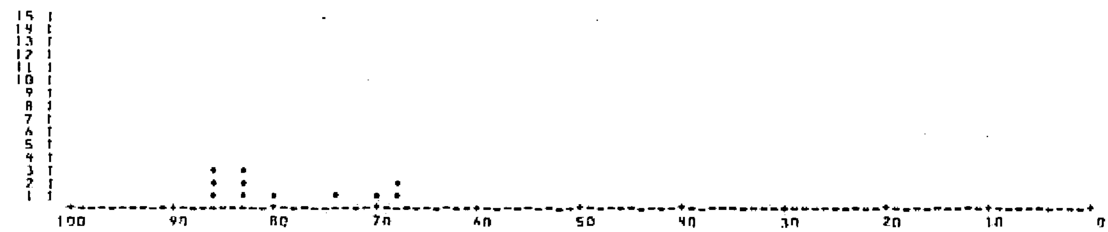

CHANNEL 3

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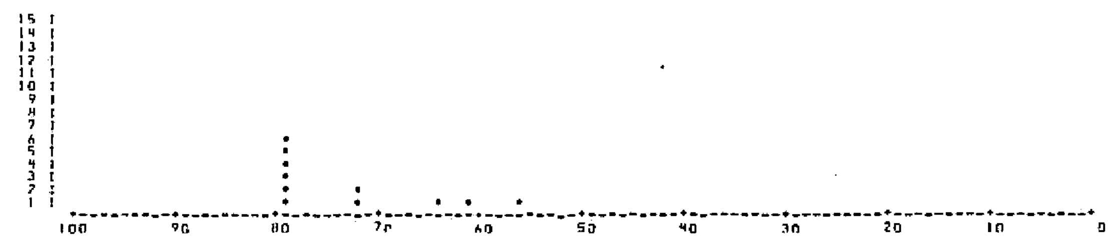

CHANNEL 4

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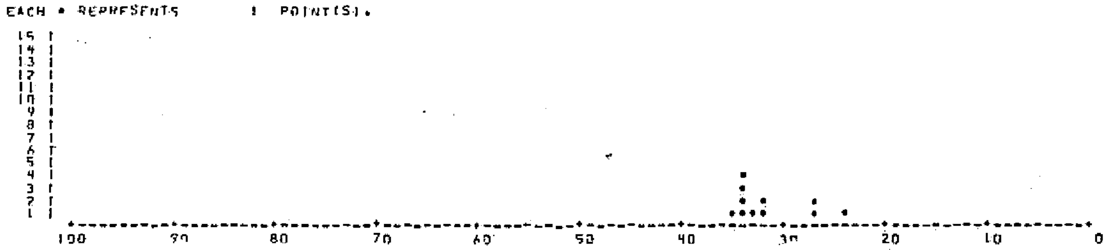

DATA BLOCK(S) HISTOGRAMMED

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2 5	1	2	1	1	(768, 541) (778, 561)
3 6	1	2	1	1	(768, 541) (778, 561)
4 7	1	2	1	1	(768, 541) (778, 561)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND − 3 STD DEV)	
1	60.0	76.0	72.3	6.2	51.6	88.9
2	68.0	86.0	78.8	7.0	57.7	99.9
3	56.0	79.0	72.6	8.1	48.2	97.1
4	24.0	35.0	31.5	3.5	20.9	42.0

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OF POOR QUALITY

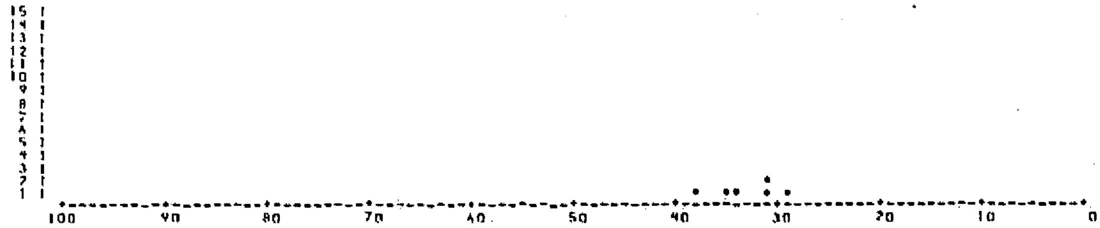
HISTOGRAM

FIELD 2

(NO. SAMPLES : 6)

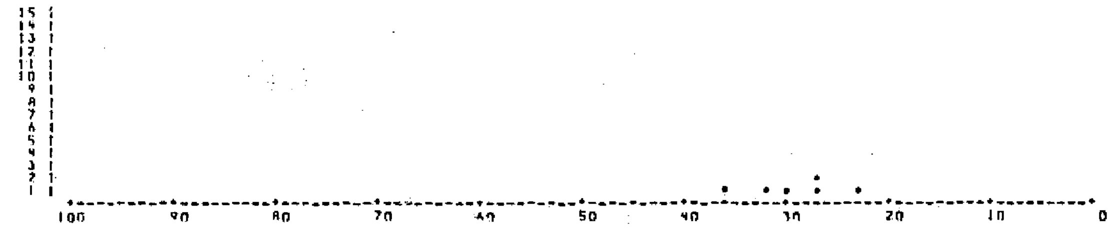
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



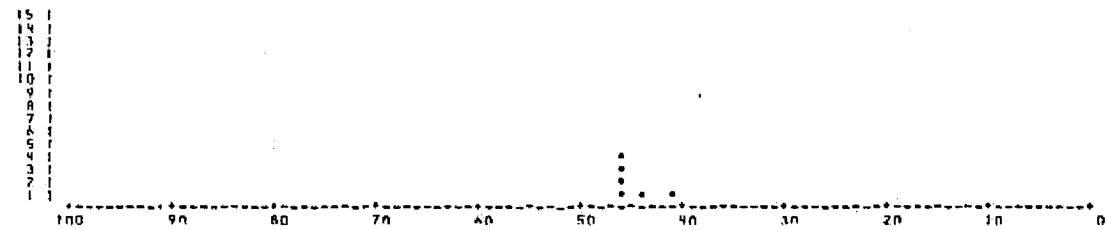
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



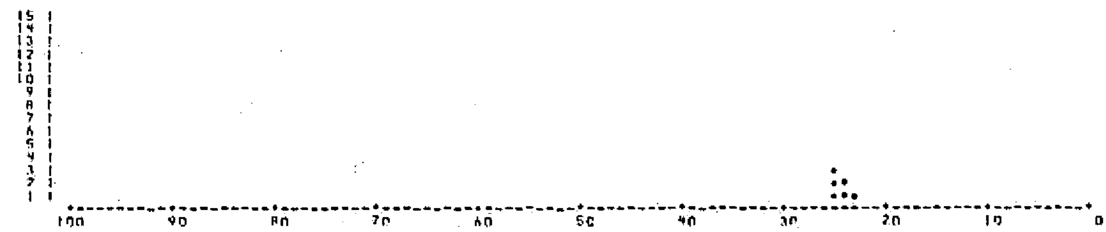
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	2	2	1	1	(769, 560)	(774, 560)
2	2	2	1	1	(769, 560)	(774, 560)
3	2	2	1	1	(769, 560)	(774, 560)
4	2	2	1	1	(769, 560)	(774, 560)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	29.0	38.0	33.0	3.0	24.0	42.0
2	23.0	36.0	29.2	4.1	16.7	41.6
3	41.0	46.0	44.8	1.9	39.2	50.4
4	23.0	25.0	24.3	.7	22.1	26.6

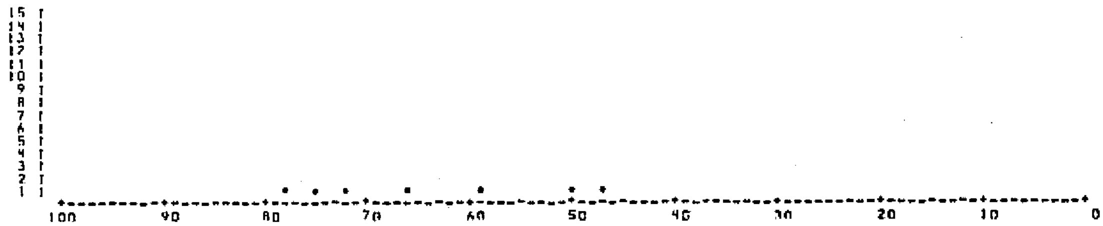
HISTOGRAM

FIELD 3

(NO. SAMPLES : 71)

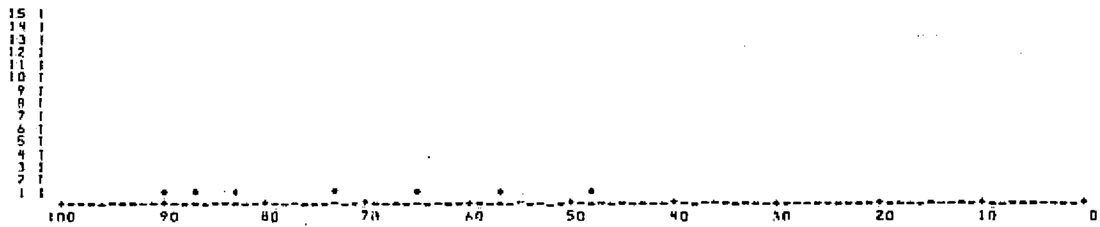
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



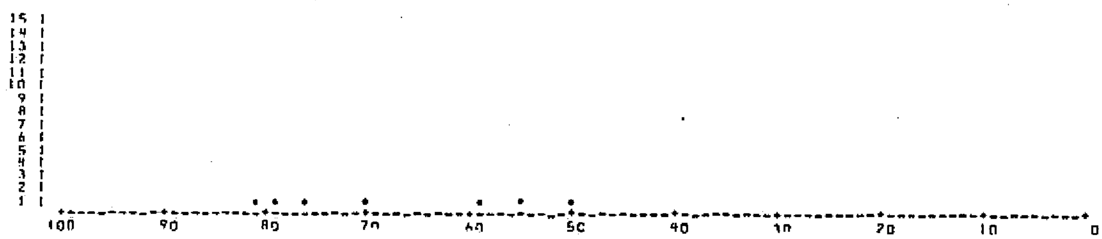
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



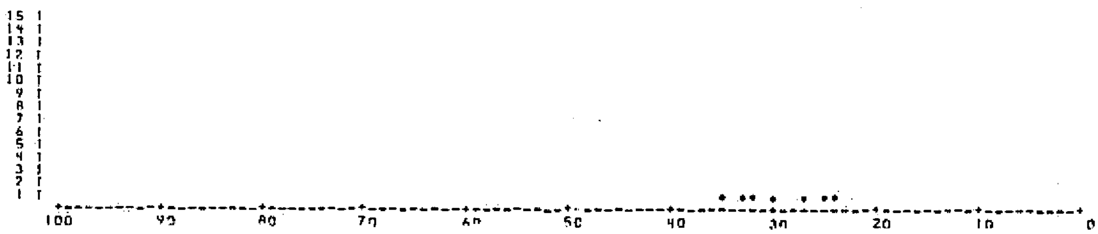
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	3	2	1	1	(776, 560)	(782, 560)
2	3	2	1	1	(776, 560)	(782, 560)
3	3	2	1	1	(776, 560)	(782, 560)
4	3	2	1	1	(776, 560)	(782, 560)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	47.0	78.0	63.9	11.3	29.9	97.8
2	48.0	90.0	71.9	14.7	27.6	116.1
3	50.0	81.0	67.1	11.5	32.6	101.7
4	24.0	35.0	29.4	3.9	17.8	41.1

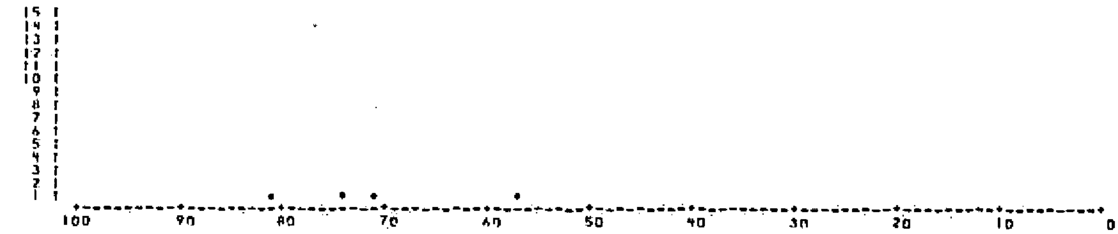
HISTOGRAM

FIELD 4

(NO. SAMPLES : 4)

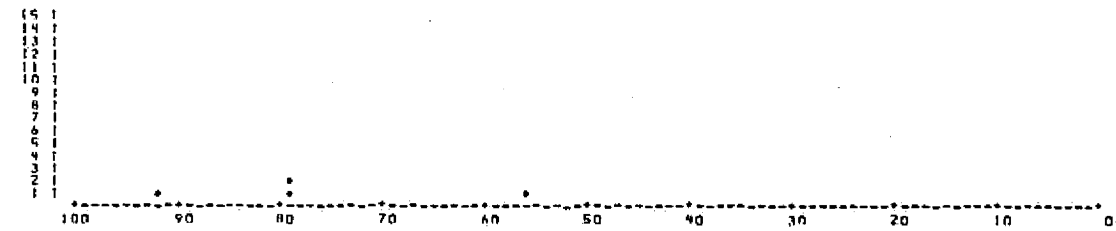
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



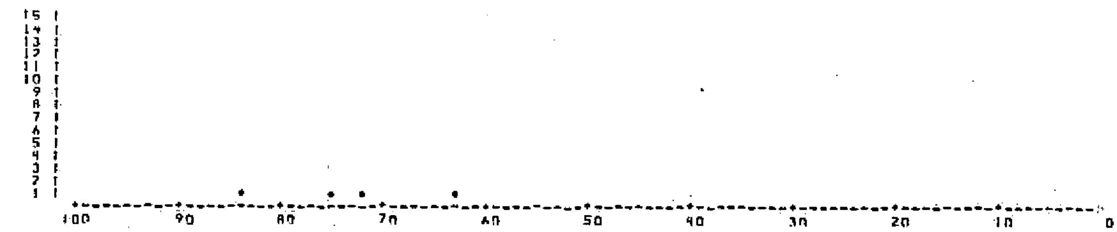
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



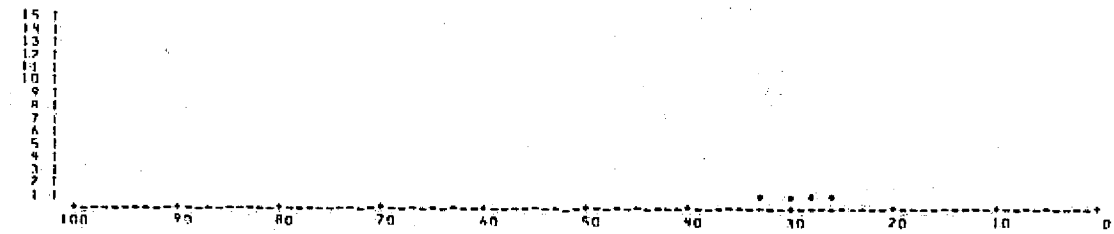
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	4	2	1	1	(783, 559)	(786, 559)
2	4	2	1	1	(783, 559)	(786, 559)
3	4	2	1	1	(783, 559)	(786, 559)
4	4	2	1	1	(783, 559)	(786, 559)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	57.0	81.0	73.7	8.7	44.6	96.9
2	56.0	92.0	76.5	13.0	37.6	115.4
3	63.0	84.0	73.5	7.5	51.0	96.0
4	26.0	33.0	29.2	2.6	21.5	37.0

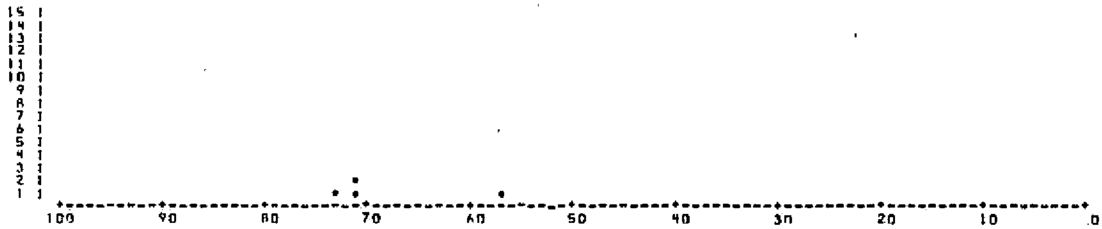
HISTOGRAM

FIELD 5

(NO. SAMPLES : 4)

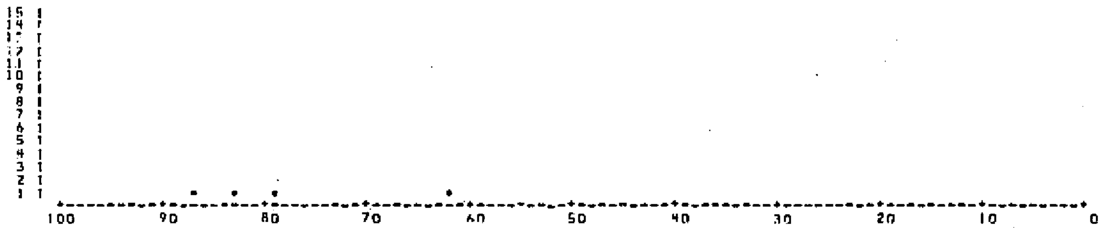
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



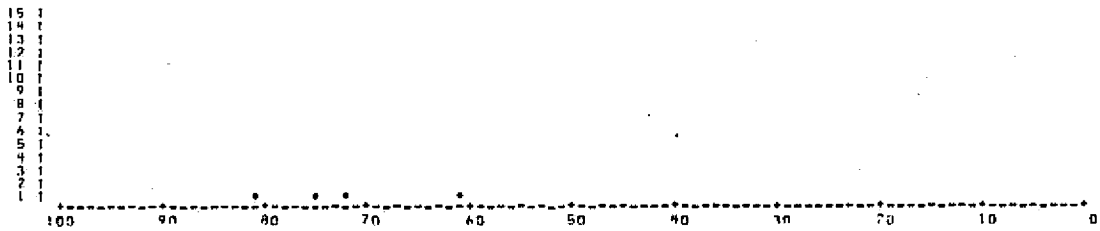
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



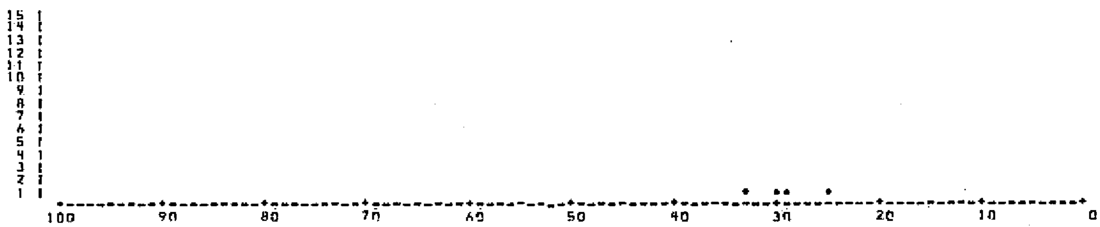
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	5	2	1	1	(786, 558)	(789, 558)
2	5	2	1	1	(786, 558)	(789, 558)
3	5	2	1	1	(786, 558)	(789, 558)
4	5	2	1	1	(786, 558)	(789, 558)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	57.0	73.0	68.0	6.4	48.8	87.2
2	62.0	87.0	77.7	9.5	49.2	106.3
3	61.0	81.0	72.2	7.3	50.5	94.0
4	25.0	33.0	29.2	2.9	20.7	37.8

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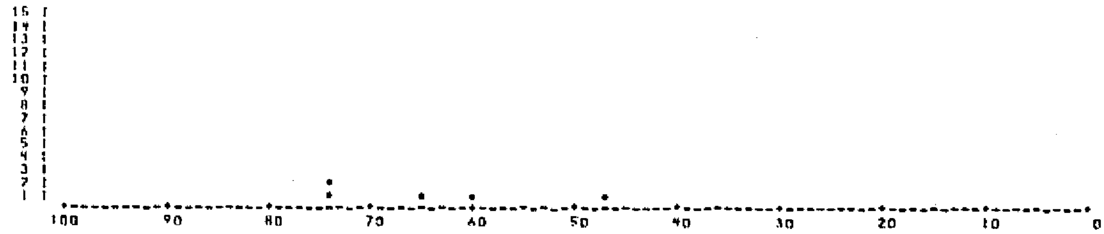
HISTOGRAM

FIELD 6

(NO. SAMPLES : 5)

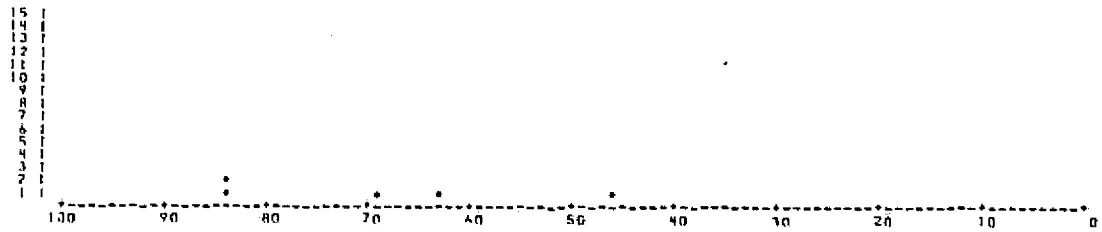
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



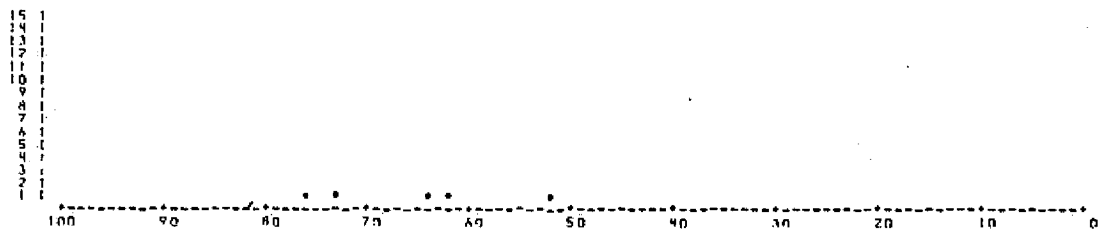
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



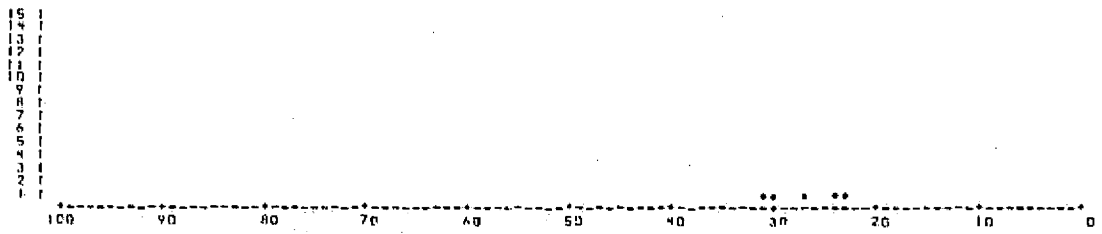
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	6	2	1	1	(789, 557)	(793, 557)
2	6	2	1	1	(789, 557)	(793, 557)
3	6	2	1	1	(789, 557)	(793, 557)
4	6	2	1	1	(789, 557)	(793, 557)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	47.0	75.0	64.3	10.1	33.8	94.2
2	46.0	84.0	69.2	14.2	26.5	111.9
3	52.0	76.0	65.4	8.5	39.8	91.0
4	23.0	31.0	27.0	3.2	17.5	36.5

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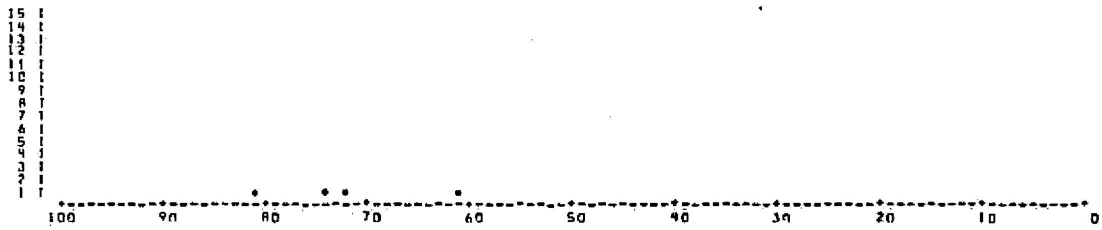
HISTOGRAM

FIELD 7

(NO. SAMPLES : 4)

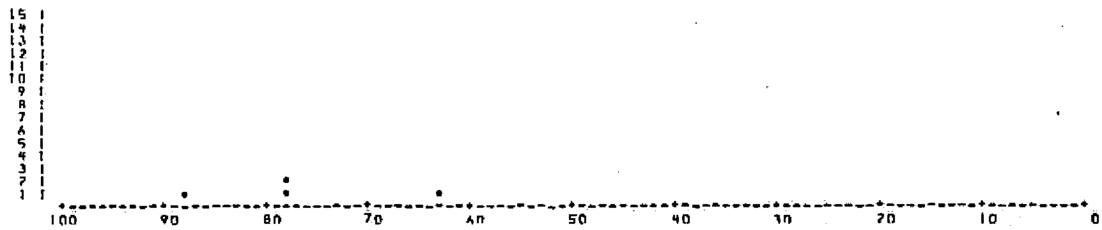
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



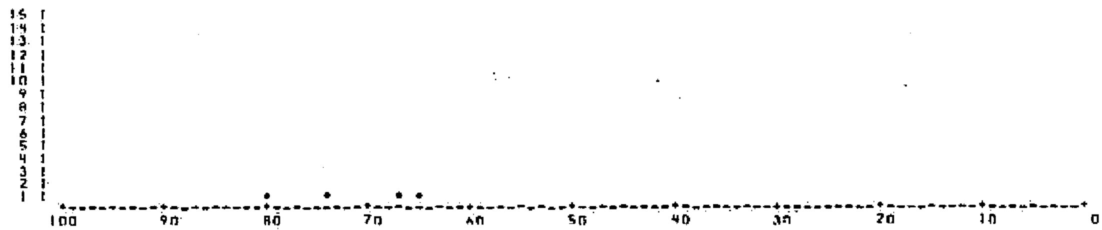
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



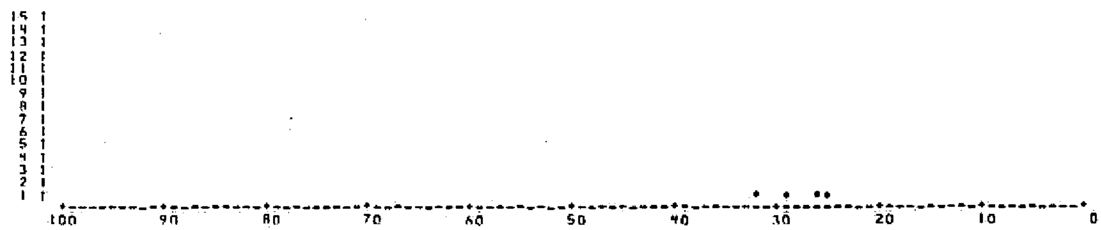
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	7	2	1	1	(793, 556)	(796, 556)
2	7	2	1	1	(793, 556)	(796, 556)
3	7	2	1	1	(793, 556)	(796, 556)
4	7	2	1	1	(793, 556)	(796, 556)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	61.0	81.0	72.0	7.2	50.5	93.5
2	63.0	88.0	76.7	8.9	50.0	103.5
3	65.0	82.0	71.5	5.9	53.7	89.3
4	25.0	32.0	28.0	2.7	19.8	36.2

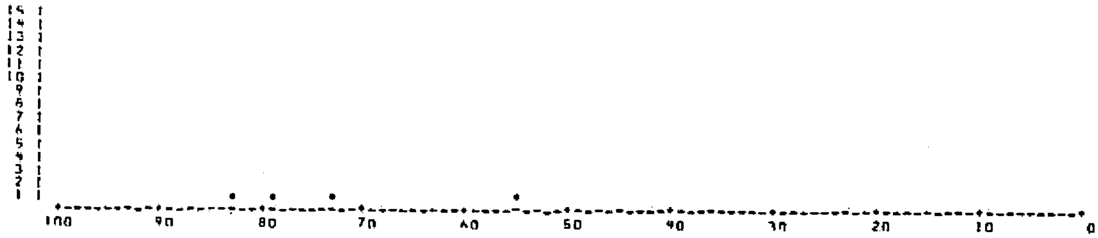
HISTOGRAM

FIELD 8

(NO. SAMPLES : 4)

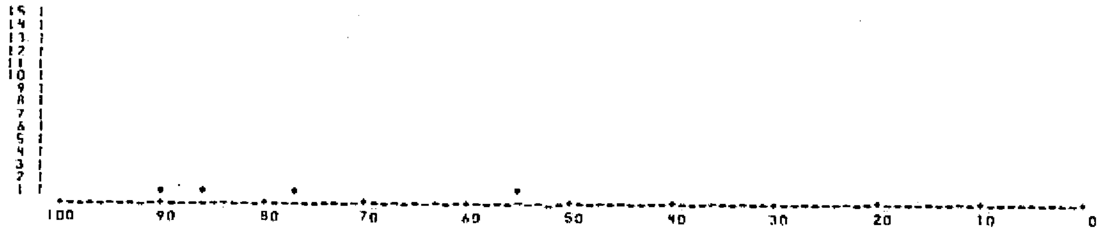
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



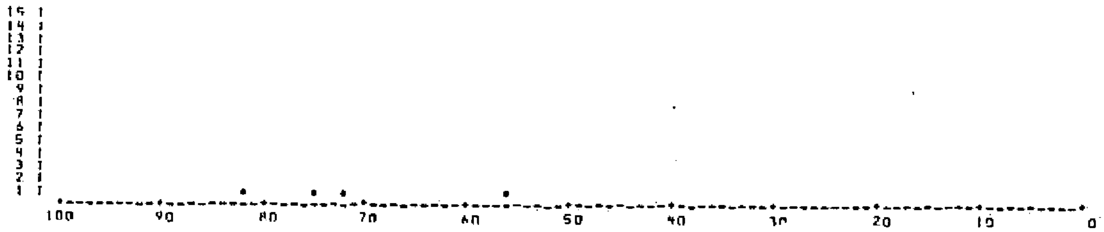
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



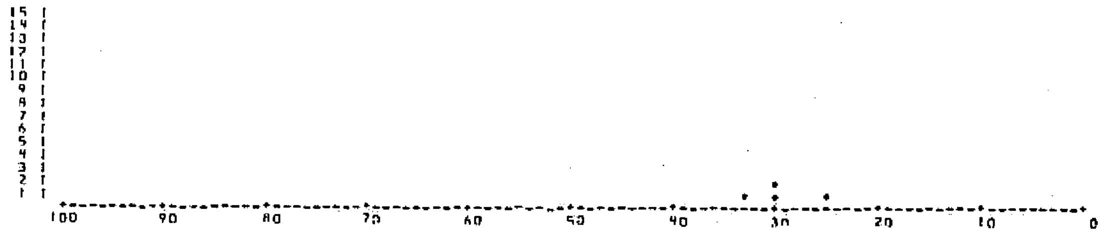
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	8	2	1	1	(795, 555)	(798, 555)
2	8	2	1	1	(795, 555)	(798, 555)
3	8	2	1	1	(795, 555)	(798, 555)
4	8	2	1	1	(795, 555)	(798, 555)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND − 3 STD DEV)	
1	55.0	83.0	72.5	10.7	40.4	104.6
2	55.0	90.0	77.0	13.5	36.4	117.6
3	56.0	82.0	71.2	9.5	42.7	99.8
4	25.0	33.0	29.5	2.9	20.9	38.1

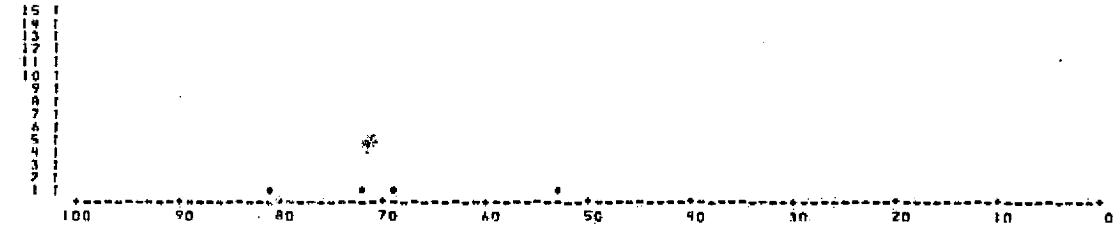
HISTOGRAM

FIELD 9

(NO. SAMPLES : 4)

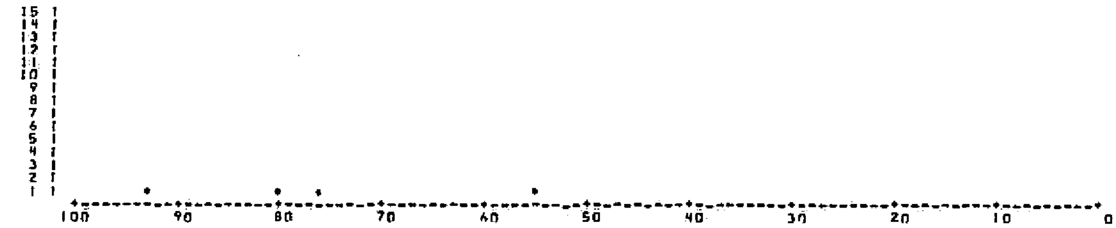
CHANNEL 1

EACH * REPRESENTS POINT(S).



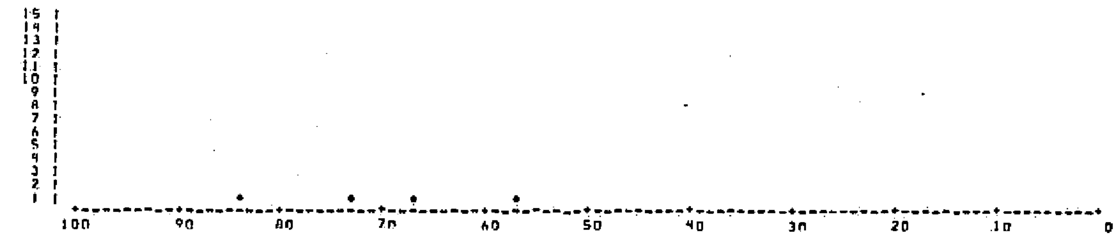
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



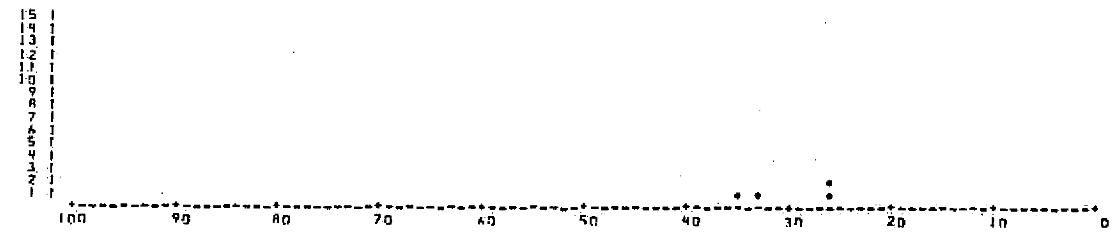
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	9	2	1	1	(798, 554)	(801, 554)
2	9	2	1	1	(798, 554)	(801, 554)
3	9	2	1	1	(798, 554)	(801, 554)
4	9	2	1	1	(798, 554)	(801, 554)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	53.0	81.0	68.8	10.1	38.4	99.1
2	55.0	93.0	76.0	13.7	35.0	117.0
3	57.0	84.0	70.2	9.8	40.9	99.6
4	26.0	35.0	30.0	4.1	17.8	42.2

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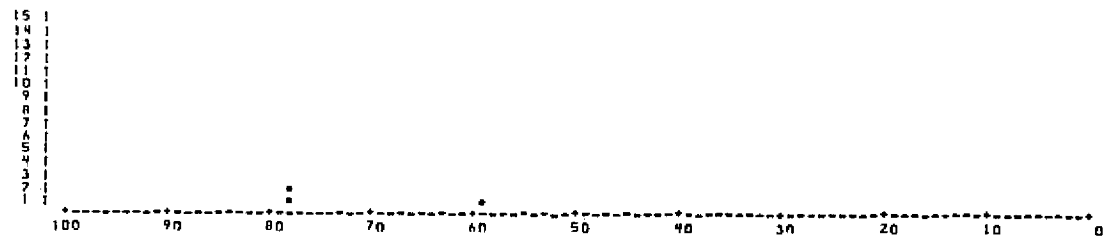
HISTOGRAM

FIELD 10

(NO. SAMPLES : 3)

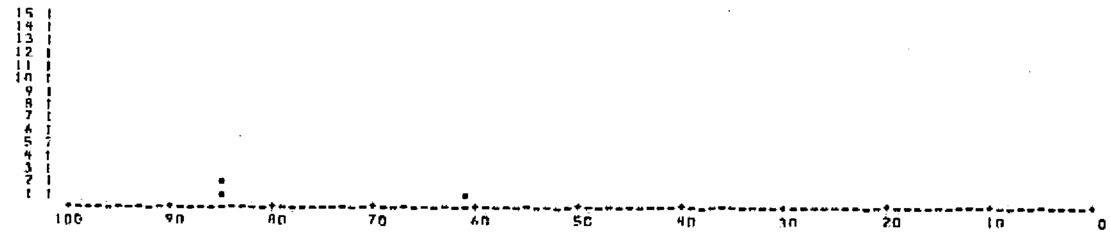
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



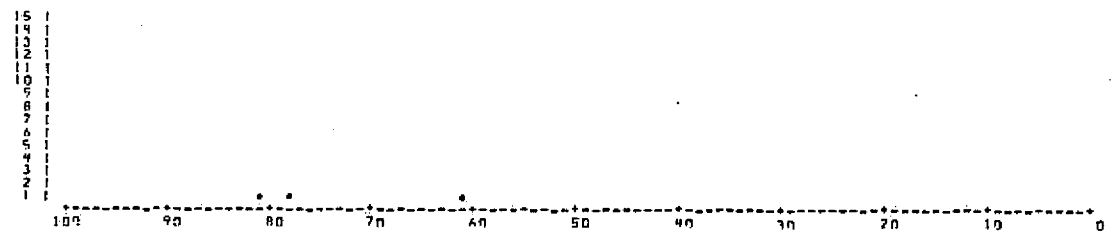
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



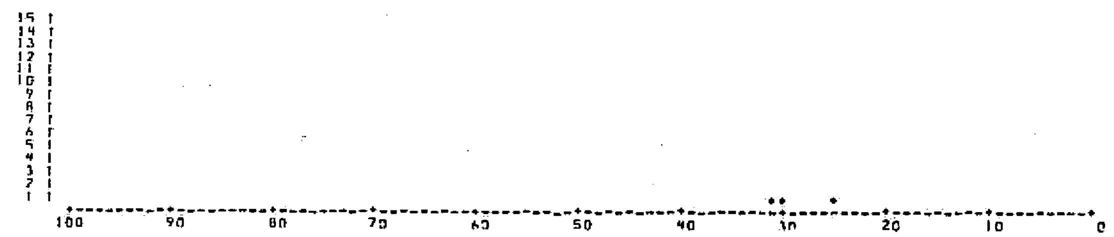
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	10	2	1	1	(801, 553)	(803, 553)
2	10	2	1	1	(801, 553)	(803, 553)
3	10	2	1	1	(801, 553)	(803, 553)
4	10	2	1	1	(801, 553)	(803, 553)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	59.0	78.0	71.7	9.0	44.8	98.5
2	61.0	85.0	77.0	11.3	43.1	110.9
3	61.0	81.0	73.3	8.8	46.9	99.8
4	25.0	31.0	28.7	2.6	20.8	36.5

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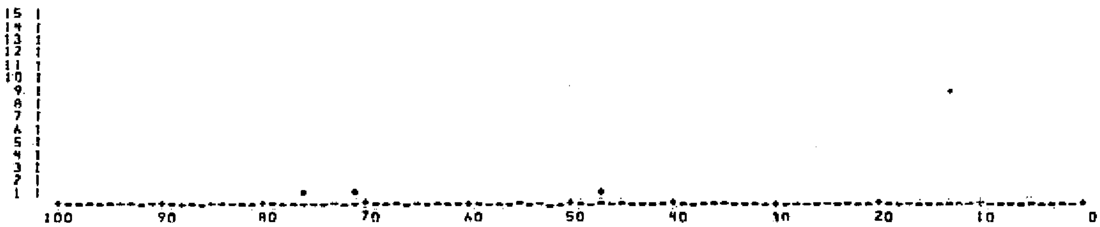
HISTOGRAM

FIELD 11

(NO. SAMPLES : 3)

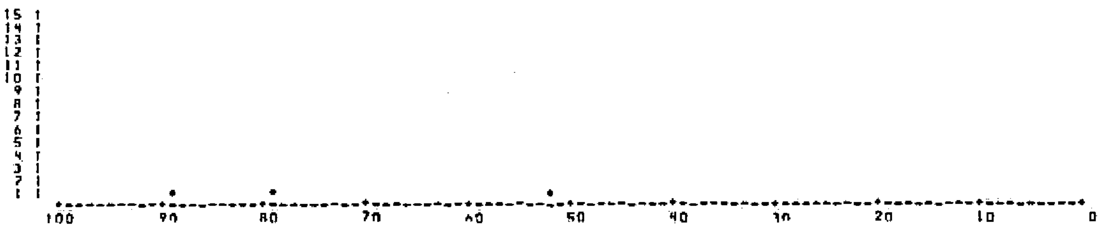
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



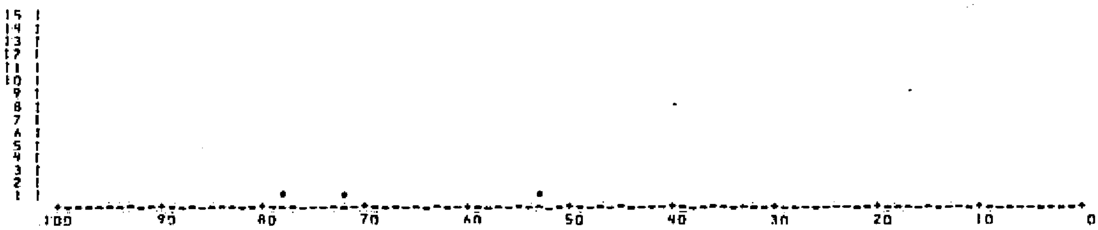
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



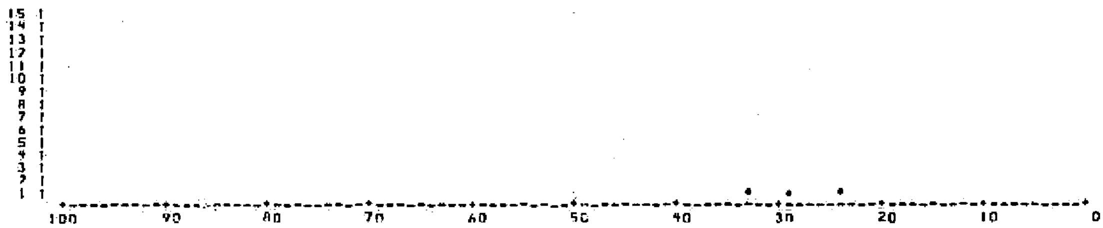
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	11	2	1	1	(803, 552)	(805, 552)
2	11	2	1	1	(803, 552)	(805, 552)
3	11	2	1	1	(803, 552)	(805, 552)
4	11	2	1	1	(803, 552)	(805, 552)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	47.0	76.0	64.7	12.7	26.7	102.6
2	52.0	89.0	73.3	15.6	26.5	120.2
3	53.0	78.0	67.7	10.7	35.7	99.6
4	24.0	33.0	28.7	3.7	17.6	39.7

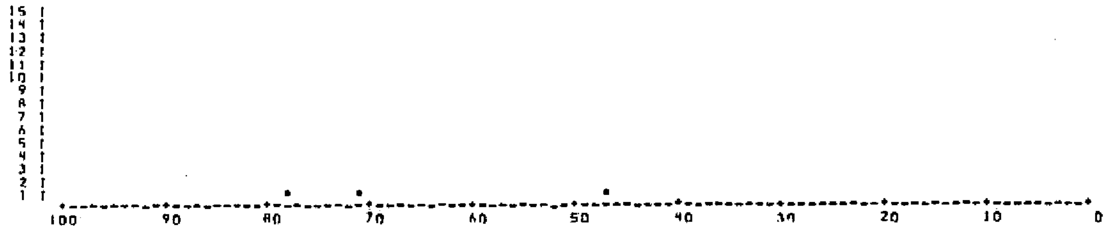
HISTOGRAM

FIELD 12

(NO. SAMPLES : 3)

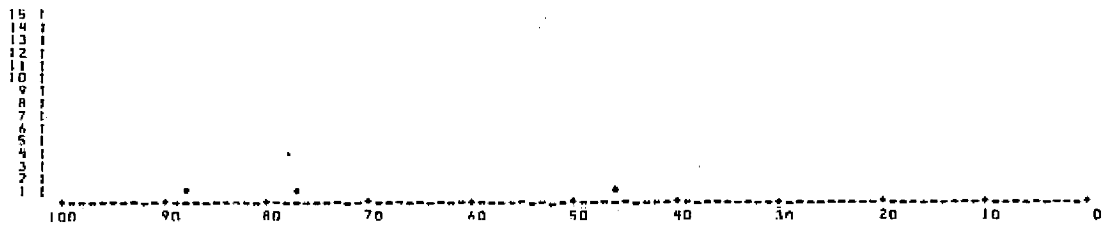
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



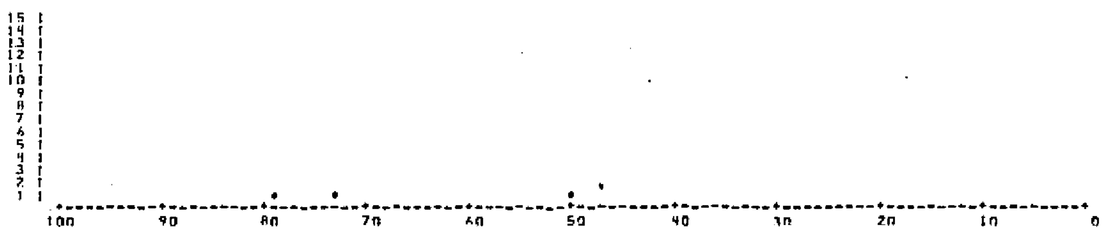
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



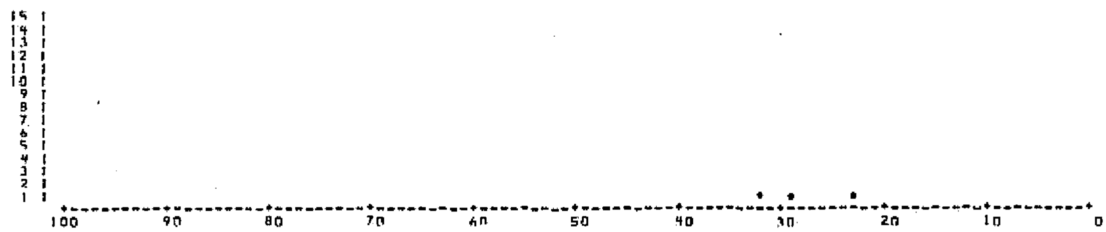
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)
1	12	2	1	1	(805, 551) (807, 551)
2	12	2	1	1	(805, 551) (807, 551)
3	12	2	1	1	(805, 551) (807, 551)
4	12	2	1	1	(805, 551) (807, 551)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	47.0	78.0	65.3	13.3	25.5	105.2
2	46.0	88.0	70.3	17.8	17.0	123.7
3	50.0	79.0	67.3	12.5	29.8	104.8
4	23.0	32.0	28.3	3.7	16.8	39.2

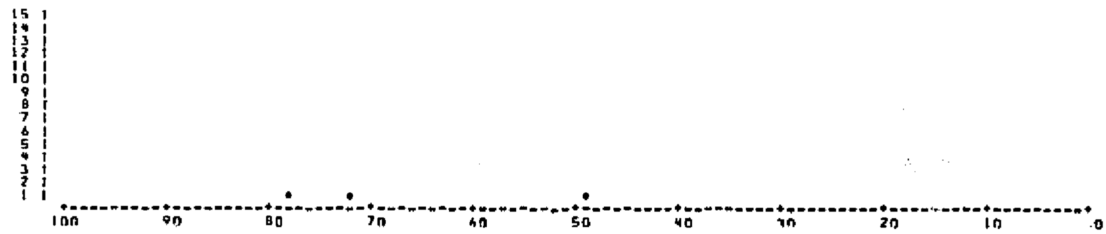
HISTOGRAM

FIELD 13

(NO. SAMPLES : 31

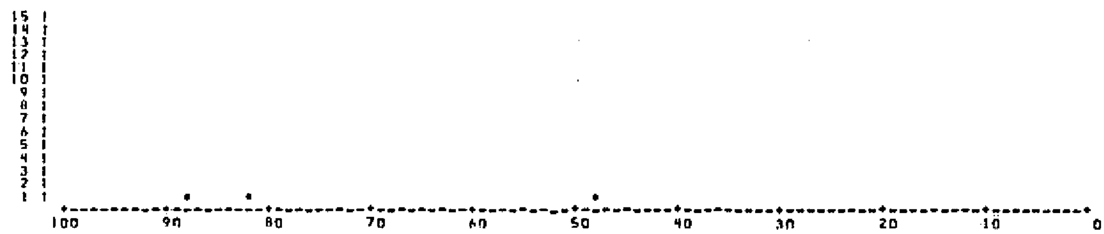
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



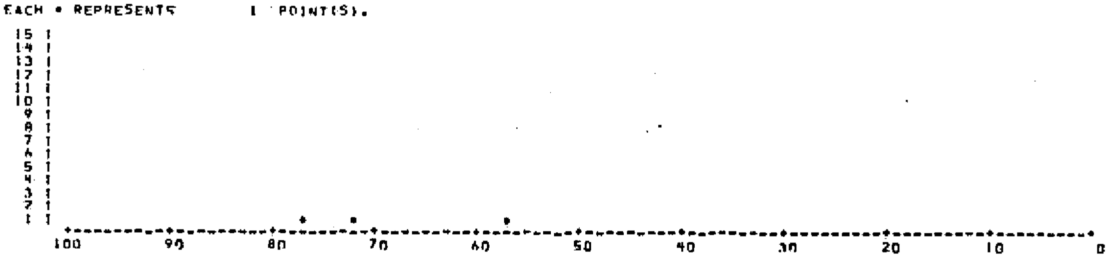
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



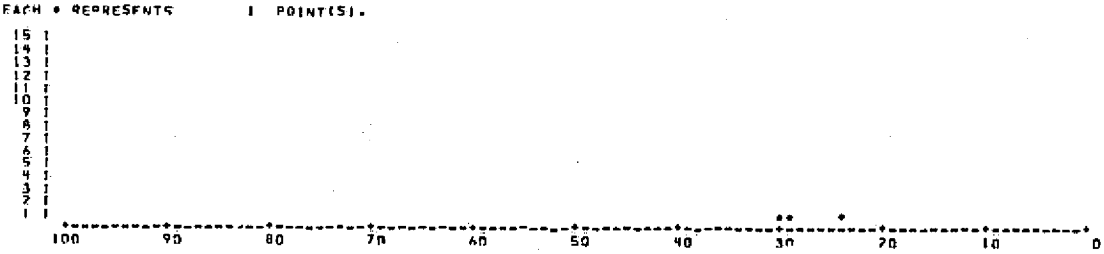
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	13	2	1	1	(807, 550)	(809, 550)
2	13	2	1	1	(807, 550)	(809, 550)
3	13	2	1	1	(807, 550)	(809, 550)
4	13	2	1	1	(807, 550)	(809, 550)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	49.0	78.0	66.3	12.5	28.8	103.8
2	48.0	88.0	72.7	17.6	19.8	125.5
3	57.0	77.0	68.7	8.5	43.2	94.2
4	24.0	30.0	27.7	2.6	19.8	35.5

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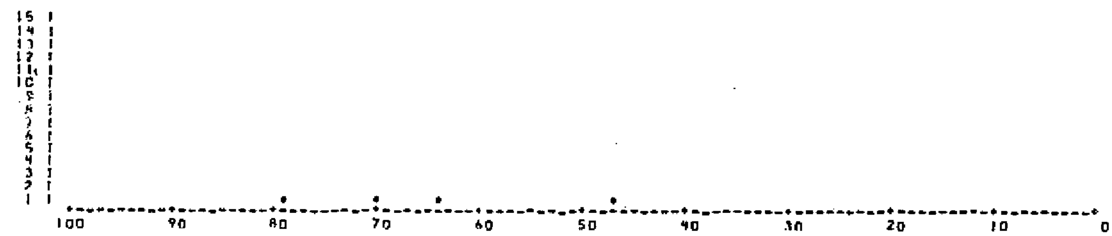
HISTOGRAM

FIELD 14

(NO. SAMPLES : 4)

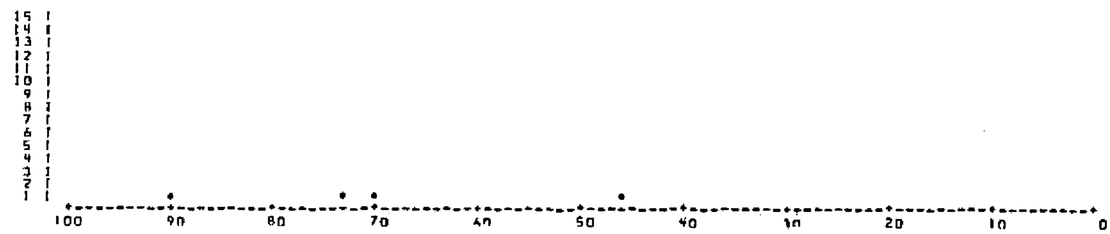
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



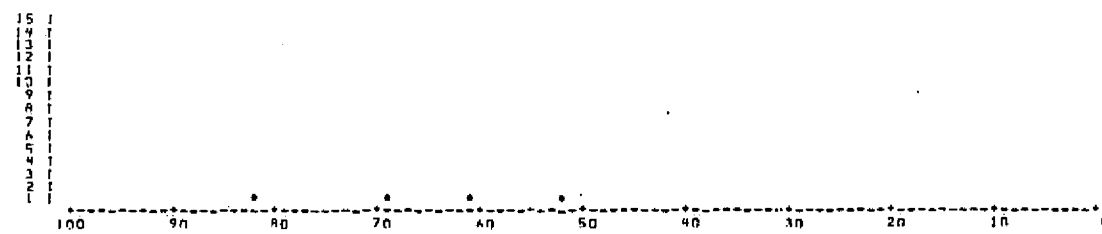
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



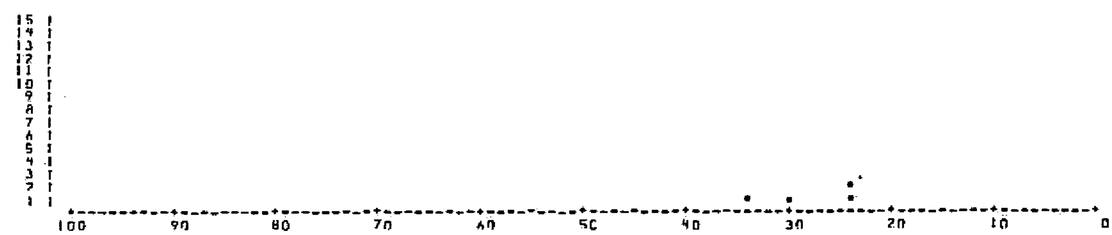
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	14	2	1	1	(808, 549)	(811, 549)
2	14	2	1	1	(808, 549)	(811, 549)
3	14	2	1	1	(808, 549)	(811, 549)
4	14	2	1	1	(808, 549)	(811, 549)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	47.0	79.0	65.0	11.7	30.0	100.0
2	46.0	99.0	69.7	15.7	22.7	116.8
3	52.0	82.0	66.0	11.0	32.9	99.1
4	24.0	34.0	28.0	4.2	15.3	40.7

HISTOGRAM

FIELD 15

(NO. SAMPLES : 4)

CHANNEL 1

EACH * REPRESENTS 1 POINT(S).

```
15 I
14 I
13 I
12 I
11 I
10 I
 9 I
 8 I
 7 I
 6 I
 5 I
 4 I
 3 I
 2 I
 1 I                      *  *         *                        *
     +---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
    100       90        80        70        60        50        40        30        20        10         0
```

CHANNEL 2

EACH * REPRESENTS 1 POINT(S).

```
15 I
14 I
13 I
12 I
11 I
10 I
 9 I
 8 I
 7 I
 6 I
 5 I
 4 I
 3 I
 2 I
 1 I           *     *              *                             *
     +---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
    100       90        80        70        60        50        40        30        20        10         0
```

CHANNEL 3

EACH * REPRESENTS 1 POINT(S).

```
15 I
14 I
13 I
12 I
11 I
10 I
 9 I
 8 I
 7 I
 6 I
 5 I
 4 I
 3 I
 2 I
 1 I                     *     *        *               *
     +---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
    100       90        80        70        60        50        40        30        20        10         0
```

CHANNEL 4

EACH * REPRESENTS 1 POINT(S).

```
15 I
14 I
13 I
12 I
11 I
10 I
 9 I
 8 I
 7 I
 6 I
 5 I
 4 I
 3 I
 2 I
 1 I                                                                 *    **    *
     +---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
    100       90        80        70        60        50        40        30        20        10         0
```

DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	15	2	1	1	(810, 548)	(813, 548)
2	15	2	1	1	(810, 548)	(813, 548)
3	15	2	1	1	(810, 548)	(813, 548)
4	15	2	1	1	(810, 548)	(813, 548)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	40.0	78.0	64.5	14.9	19.7	109.3
2	38.0	89.0	69.5	19.7	10.3	128.7
3	48.0	79.0	66.0	11.7	31.0	101.0
4	24.0	35.0	29.5	3.9	17.8	41.2

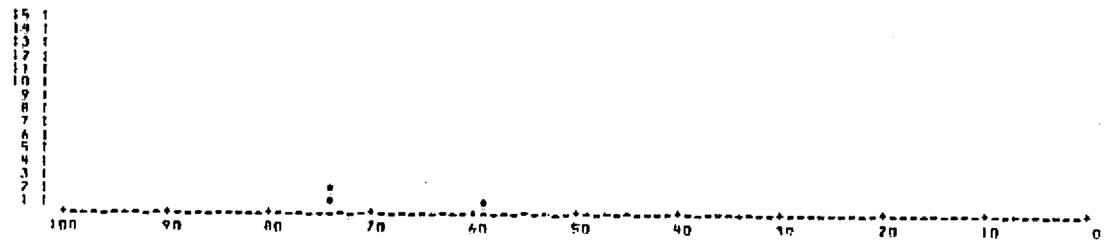
HISTOGRAM

FIELD 16

(NO. SAMPLES : 3)

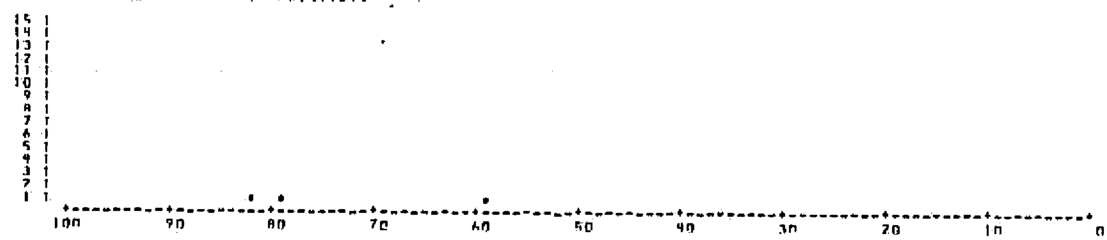
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



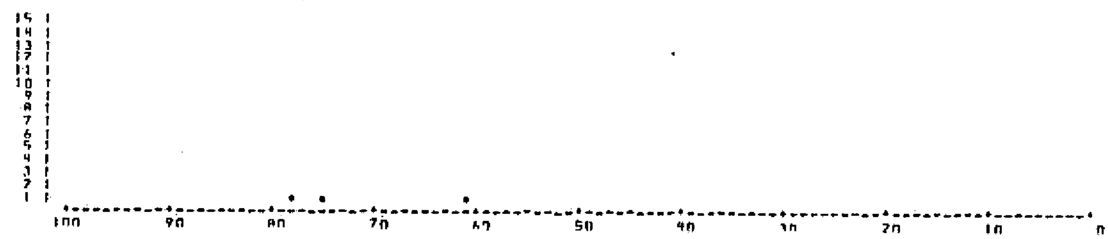
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



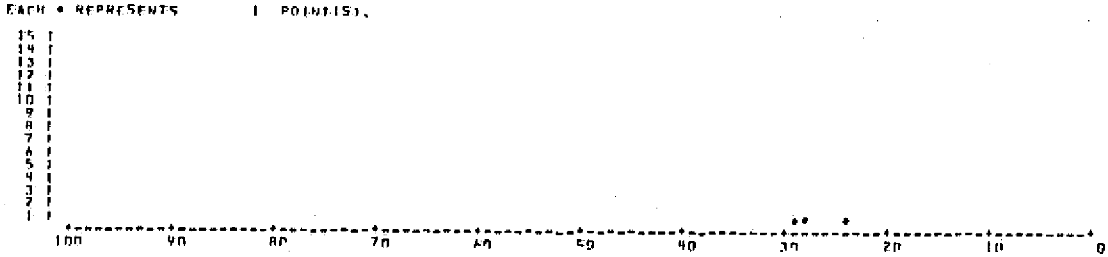
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	16	2	1	1	(813, 547)	(815, 547)
2	16	2	1	1	(813, 547)	(815, 547)
3	16	2	1	1	(813, 547)	(815, 547)
4	16	2	1	1	(813, 547)	(815, 547)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	59.0	74.0	69.0	7.1	47.8	90.2
2	59.0	82.0	73.3	10.2	42.7	104.0
3	61.0	79.0	71.3	7.4	49.1	93.6
4	24.0	29.0	27.0	2.2	20.5	33.5

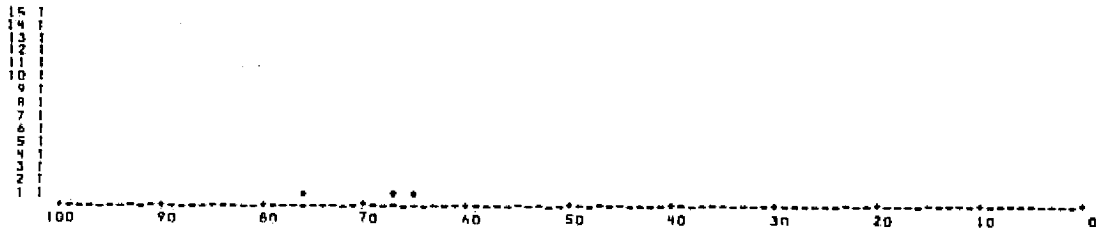
HISTOGRAM

FIELD 17

(NO. SAMPLES : 3)

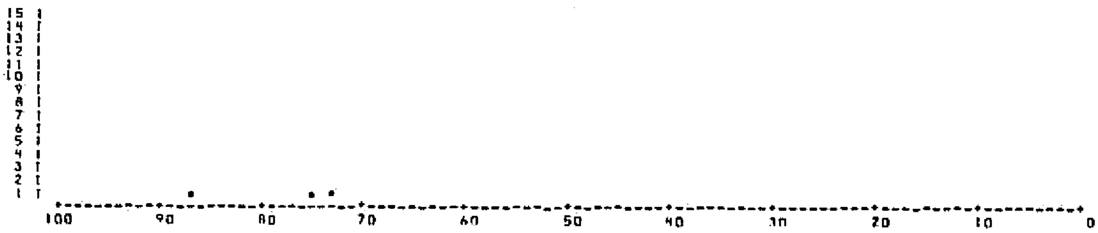
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



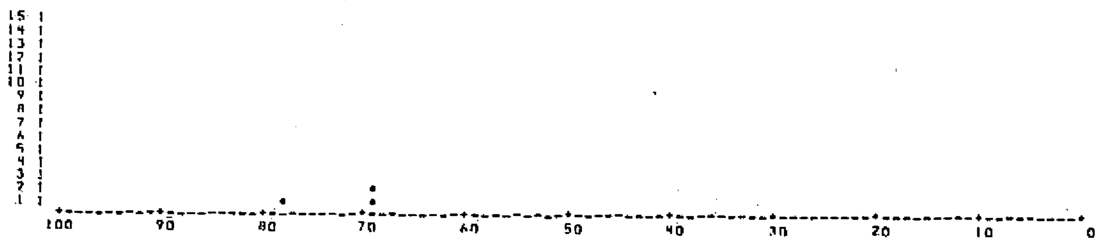
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



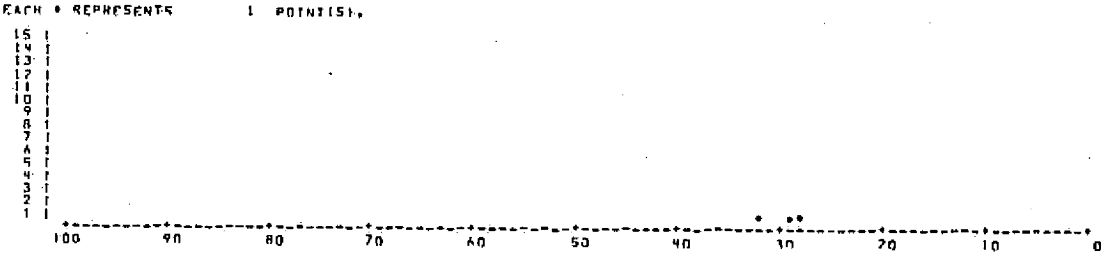
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	17	2	1	1	(816, 546)	(818, 546)
2	17	2	1	1	(816, 546)	(818, 546)
3	17	2	1	1	(816, 546)	(818, 546)
4	17	2	1	1	(816, 546)	(818, 546)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	65.0	76.0	69.3	4.8	55.0	83.7
2	73.0	87.0	78.3	6.2	59.8	96.9
3	69.0	78.0	72.0	4.2	59.3	84.7
4	28.0	32.0	29.7	1.7	24.6	34.8

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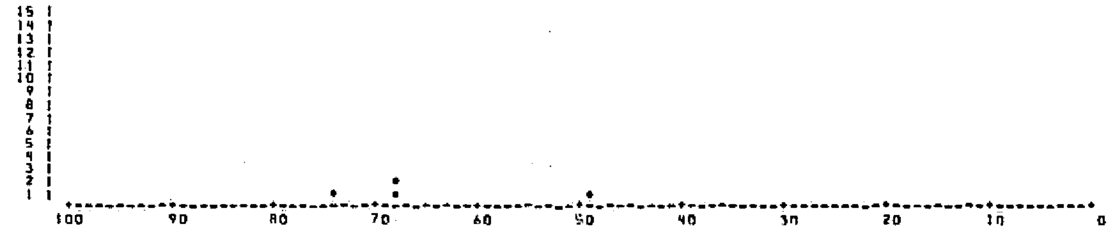
HISTOGRAM

FIELD 18

(NO. SAMPLES : 4)

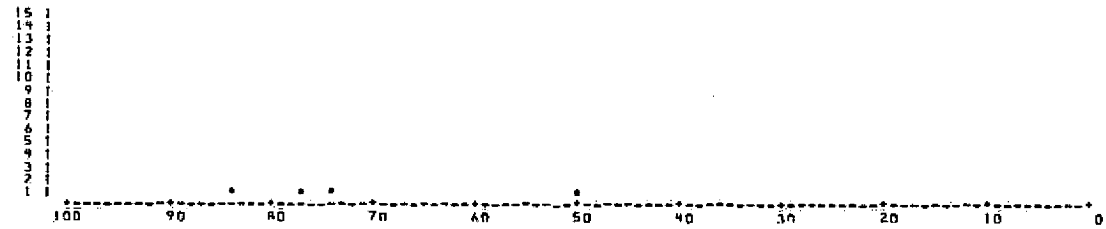
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



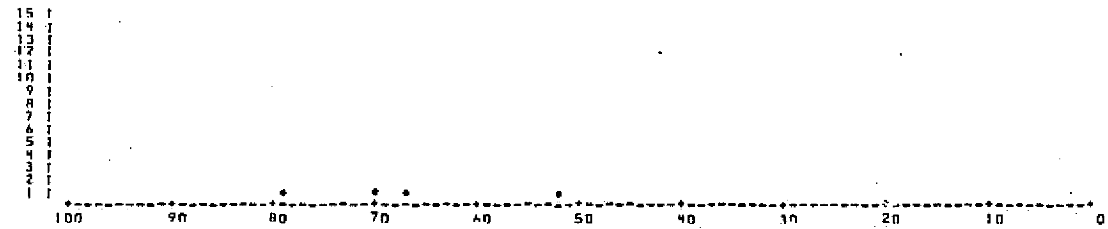
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



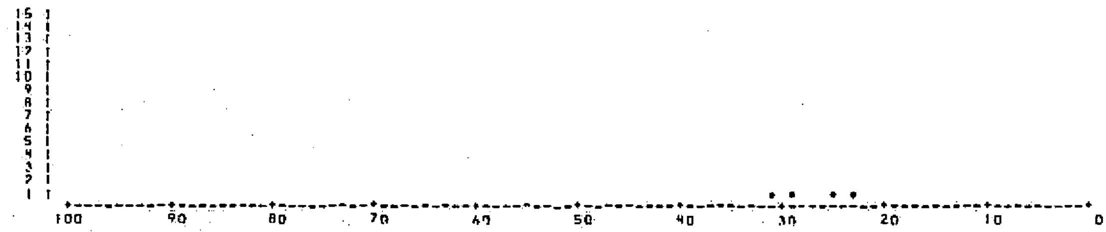
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	18	2	1	1	(818, 545)	(821, 545)
2	18	2	1	1	(818, 545)	(821, 545)
3	18	2	1	1	(818, 545)	(821, 545)
4	18	2	1	1	(818, 545)	(821, 545)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	49.0	[illegible]	64.7	9.4	36.5	93.0
2	50.0	84.0	71.2	12.8	32.9	109.6
3	52.0	79.0	67.0	9.7	37.8	96.2
4	23.0	31.0	27.0	3.2	17.5	36.5

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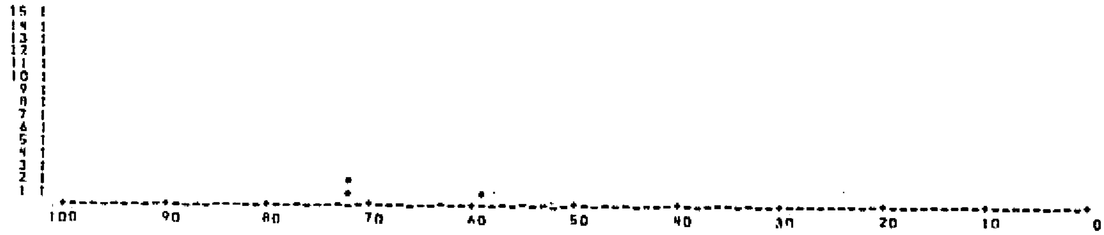
HISTOGRAM

FIELD 19

(NO. SAMPLES : 3)

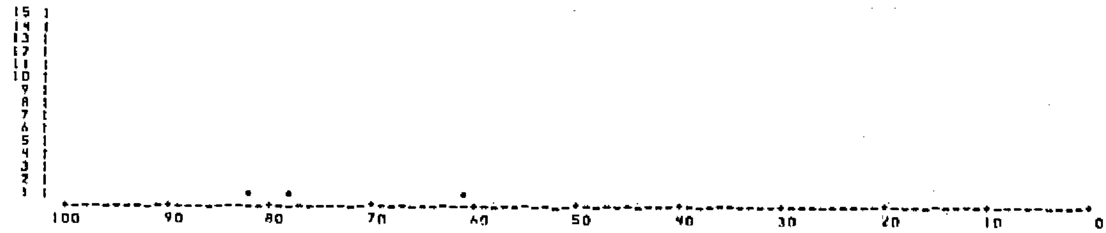
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



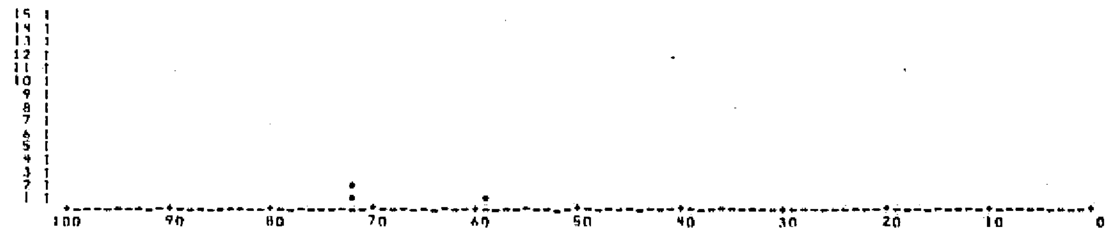
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



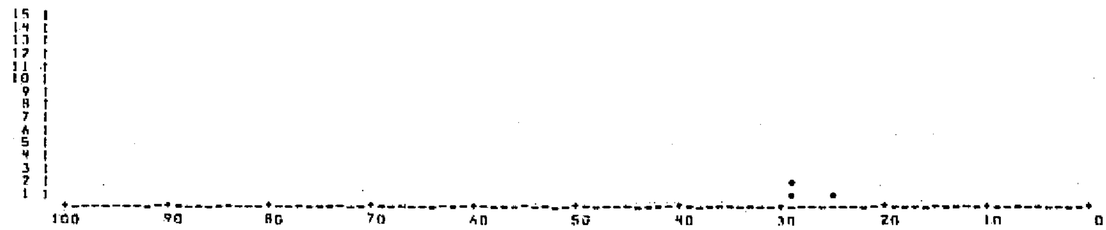
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	19	2	1	1	(821, 544)	(823, 544)
2	19	2	1	1	(821, 544)	(823, 544)
3	19	2	1	1	(821, 544)	(823, 544)
4	19	2	1	1	(821, 544)	(823, 544)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	59.0	72.0	67.7	6.1	49.3	86.1
2	61.0	82.0	73.7	9.1	46.4	101.0
3	59.0	72.0	67.7	6.1	49.3	86.1
4	25.0	29.0	27.7	1.9	22.0	33.3

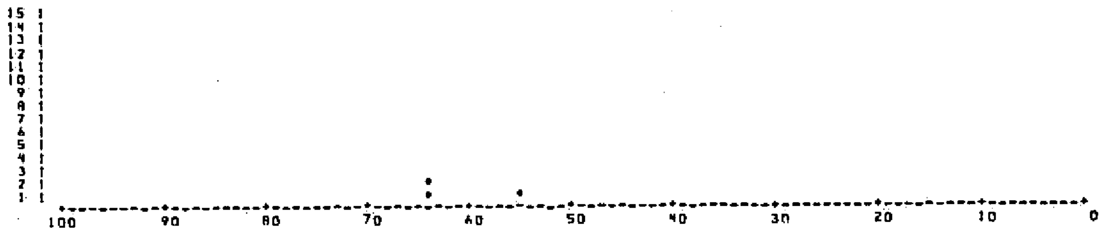
HISTOGRAM

FIELD 20

(NO. SAMPLES : 3)

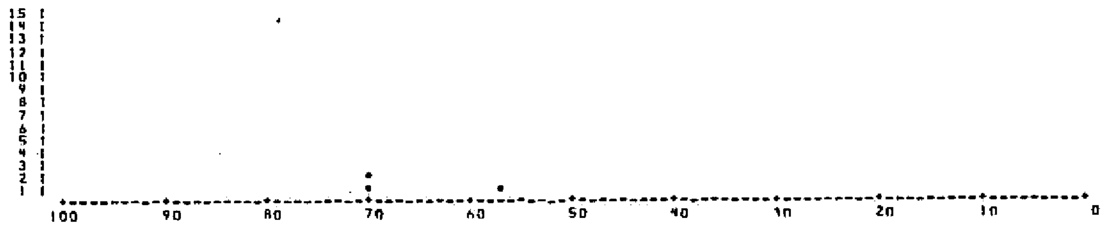
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



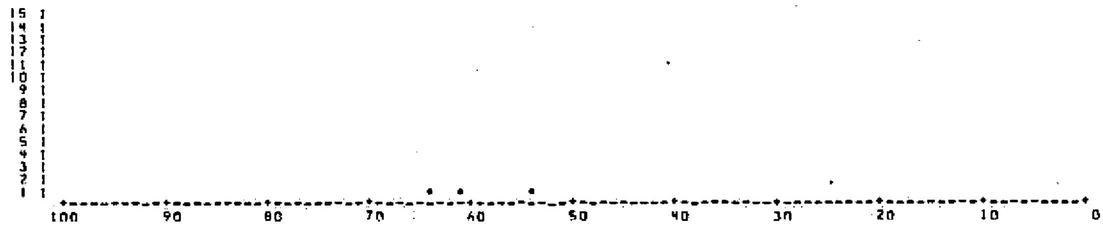
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



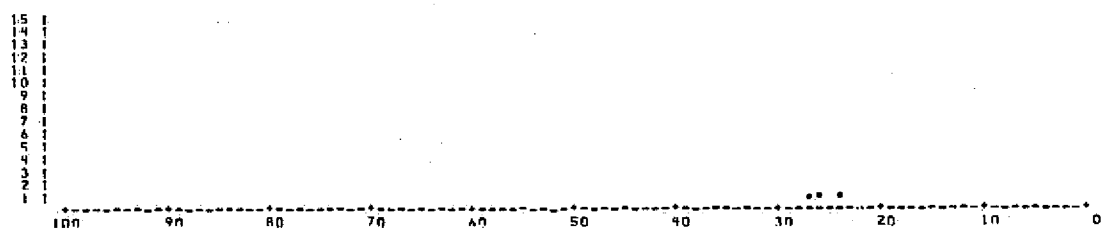
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	20	2	1	1	(823, 543)	(825, 543)
2	20	2	1	1	(823, 543)	(825, 543)
3	20	2	1	1	(823, 543)	(825, 543)
4	20	2	1	1	(823, 543)	(825, 543)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	55.0	64.0	61.0	4.2	48.3	73.7
2	57.0	70.0	65.7	6.1	47.3	84.1
3	54.0	65.0	59.7	4.2	47.1	72.2
4	24.0	27.0	25.7	1.2	21.9	29.4

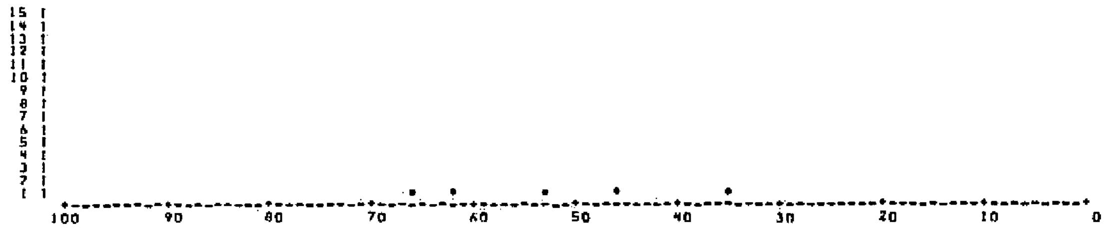
HISTOGRAM

FIELD 21

(NO. SAMPLES : 5)

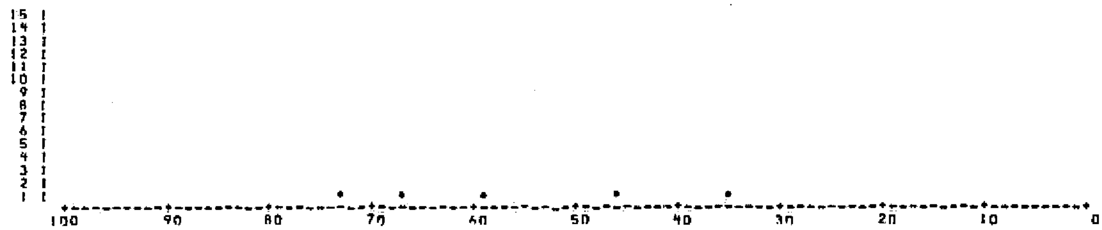
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



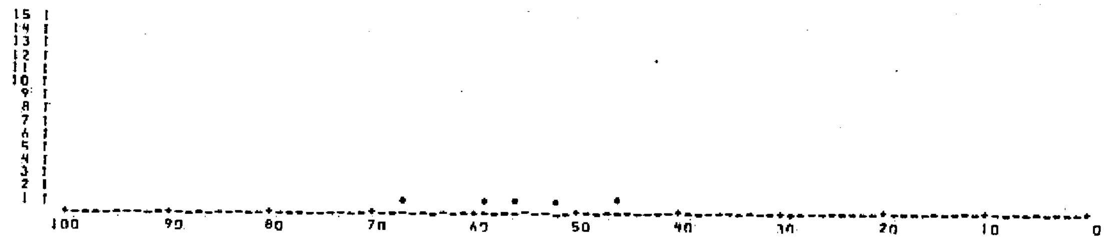
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



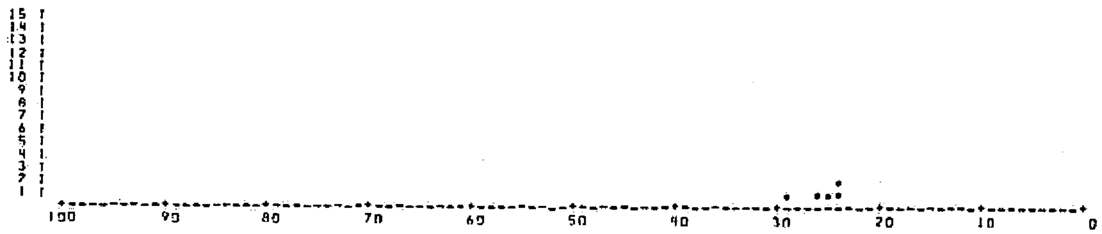
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	21	2	1	1	(824, 542)	(826, 542)
2	21	2	1	1	(824, 542)	(828, 542)
3	21	2	1	1	(824, 542)	(828, 542)
4	21	2	1	1	(824, 542)	(828, 542)

HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	35.0	66.0	52.4	11.1	19.0	85.8
2	35.0	73.0	56.0	13.9	14.4	97.6
3	46.0	67.0	56.0	7.0	35.0	77.0
4	24.0	29.0	25.6	1.9	20.0	31.2

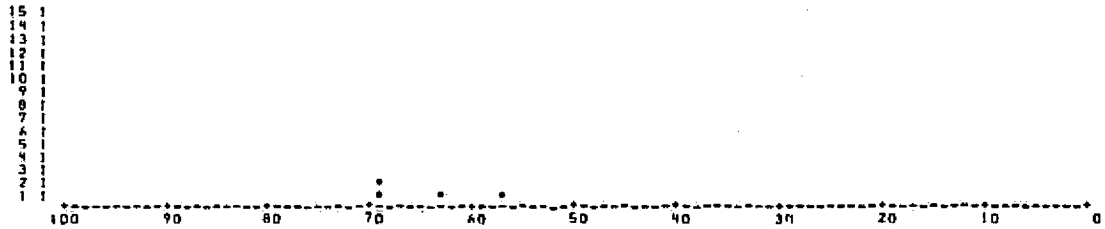
HISTOGRAM

FIELD 22

(NO. SAMPLES : 4)

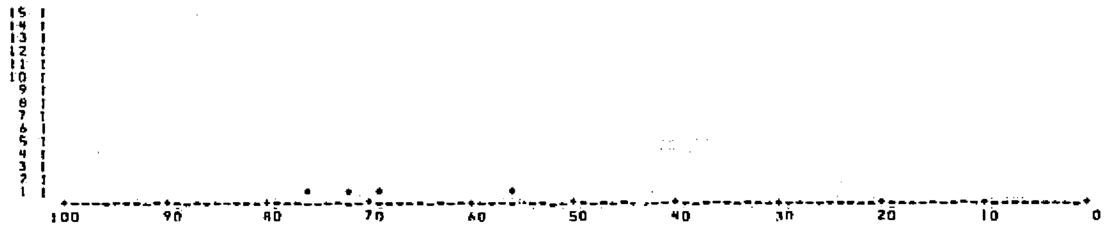
CHANNEL 1

EACH * REPRESENTS 1 POINT(S).



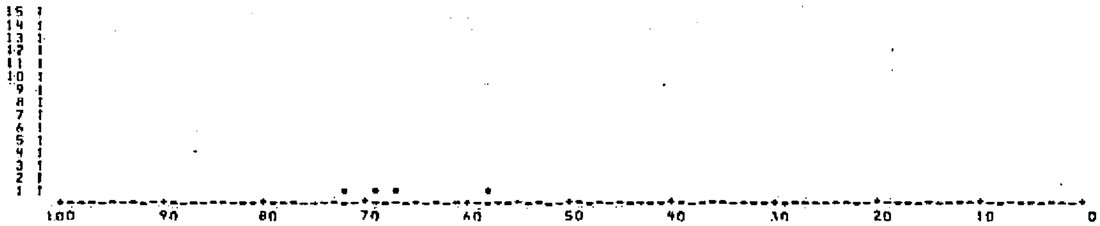
CHANNEL 2

EACH * REPRESENTS 1 POINT(S).



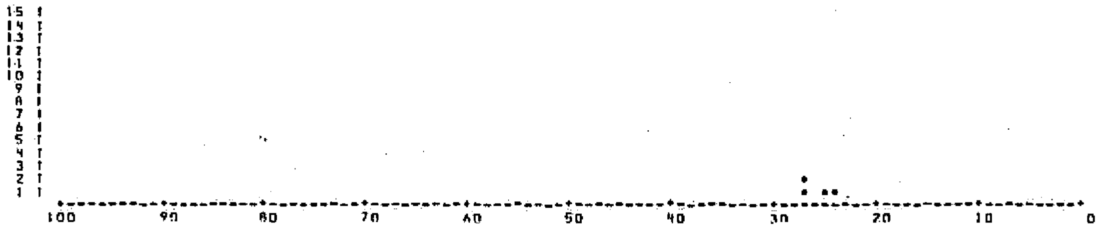
CHANNEL 3

EACH * REPRESENTS 1 POINT(S).



CHANNEL 4

EACH * REPRESENTS 1 POINT(S).



DATA BLOCK(S) HISTOGRAMMED

CHANNEL	FIELDNAME	NO. OF VERTICES	SAMPLE INC	LINE INC	VERTICES(SAMPLE,LINE)	
1	22	2	1	1	(828, 541)	(831, 541)
2	22	2	1	1	(828, 541)	(831, 541)
3	22	2	1	1	(828, 541)	(831, 541)
4	22	2	1	1	(828, 541)	(831, 541)

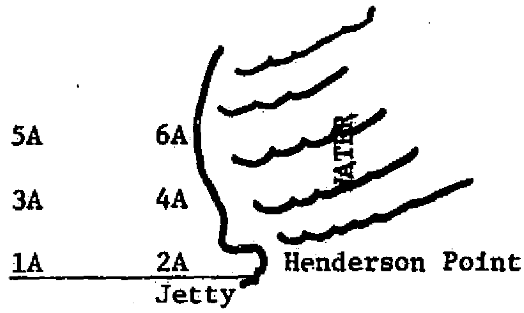
HISTOGRAM STATISTICS

CHANNEL	DATA RANGE		MEAN	STANDARD DEVIATION	NORMALIZED RANGE (MEAN + AND - 3 STD DEV)	
1	57.0	69.0	64.5	5.0	49.6	79.4
2	56.0	76.0	68.2	7.5	45.8	90.7
3	58.0	72.0	66.5	5.2	50.8	82.2
4	24.0	27.0	25.7	1.3	21.9	29.6

APPENDIX D

SAND MOISTURE TABLES

TYPICAL PATTERN



STA. PT.	LOCATION
1A	Henderson Point Jetty
2A	Henderson Point Jetty
19A	Fort Henery Road
20A	Fort Henery Road
23A	Seashore Avenue
24A	Seashore Avenue
40	Island View
41	Island View
44	Beach View
45	Beach View
46	Ronnels Avenue
47	Ronnels Avenue
50	Oak Gardens
51	Oak Gardens
56	West Avenue
57	West Avenue

MULTIPLE PIXELS

Data Collected June 11-12. This sampling exercise only covered vicinity of 5th Avenue to Henderson Avenue in detail (500 ft. intervals) successive miles past Henderson Avenue were covered by ½ mile intervals. (H= closest to highway; L=closest to shoreline)

Location	(Moisture) Wt. Loss	Avg. Wt. Loss	% Moisture Loss	Avg. % Loss
1H	1.396	1.356	2.8	2.7
1L	1.316		2.6	
2H	3.951	2.478	7.9	4.5
2L	1.004		2.0	
3H	3.259	2.192	6.5	3.4
3L	1.125		2.3	
4H	3.203	2.833	6.4	5.6
4L	2.462		4.9	
5H	0.986	2.197	2.0	4.4
5L	3.407		6.8	
6H	1.147	0.953	2.3	1.9
6L	0.758		1.5	
7H	2.716	1.901	5.4	3.7
7L	1.085		2.1	
8H	2.705	2.764	5.4	5.5
8L	2.822		5.6	
9H	1.305	3.031	2.6	6.0
9L	4.757		9.5	
10H	1.494	4.423	3.0	8.9
10L	7.351		14.7	
11H	1.503	3.757	3.0	7.5
11L	6.010		12.0	

Location	(Moisture) Wt. Loss	Avg. Wt. Loss	% Moisture Loss	Avg. % Loss
12H	1.600	4.012	3.2	8.1
12L	6.423		12.9	
13H	4.633	3.053	9.2	6.1
13L	1.472		2.9	
14H	1.419	2.058	2.8	4.1
14L	2.697		5.4	
15H	1.873	3.391	3.7	6.8
15L	4.909		9.8	
16H	1.296	3.086	2.6	6.1
16L	4.875		9.6	
17H	6.952	7.111	13.9	14.2
17L	7.269		14.5	
18H	7.526	7.563	15.1	15.2
18L	7.599		15.2	
19H	7.276	7.150	14.6	14.3
19L	7.024		14.0	
20H	6.789	6.907	13.6	13.8
20L	7.024		14.0	

(Above samples made @ 500 ft. intervals from 5th Ave. to Henderson Ave.; 2 miles)

2A-H	1.473	1.492	2.9	3.0
2A-L	1.510		3.0	
2B-H	2.044	3.730	4.1	7.5
2B-L	5.416		10.8	

Location	(Moisture) Wt. Loss	Avg. Wt. Loss	% Moisture Loss	Avg. % Loss
3A-H	1.001	0.623	2.0	1.3
3A-L	0.244		0.5	
3B-H	6.128	5.821	12.3	11.3
3B-L	5.514		10.3	
4A-H	3.582	2.953	7.2	6.0
4A-L	2.324		4.7	
4B-H	5.385	4.644	10.8	9.3
4B-L	3.902		7.8	
5A-H	3.890	2.369	7.8	4.8
5A-L	0.848		1.7	
5B-H	3.933	2.962	7.9	6.0
5B-L	1.991		4.0	

(The above 16 samples made @ ½ mile intervals from Henderson Avenue on.)

Sample Batch, 7-7-78

Sample No.	Wet Weight of Sample & Container	Wt. After Oven Drying	Change in Wt.	% Change	Wt. of Container	Wt. of Sample After Drying
1A	138.223	138.197	.026	.0002	25.100	113.097
2A	140.877	140.851	.026	.0002	25.239	115.612
3A	129.978	129.930	.048	.0004	25.436	104.494
4A	110.406	110.379	.027	.0003	25.137	85.242
5A	109.521	109.450	.071	.0008	24.900	84.55
6A	109.343	109.320	.023	.0002	24.682	84.638
7A	120.788	120.261	.527	.006	26.022	94.239
8A	107.670	106.979	.691	.008	25.468	81.511
9A	112.111	110.432X	1.679	.019	25.760	84.672
10A	113.891	113.870	.021	.0002	25.555	88.315
11A	121.258	121.217	.041	.0004	24.721	96.496
12A	89.410	89.389	.021	.0003	25.388	64.001
13A	121.270	121.239	.031	.0003	25.622	95.617
14A	120.051	119.988	.063	.0007	25.693	94.295
15A	126.191	126.155	.036	.0003	25.368	100.787
16A	110.350	110.309	.041	.0005	25.372	84.937
17A	133.962	133.932	.030	.0003	25.088	108.844
18A	124.748	124.695	.053	.0005	25.472	99.223
19A	128.753	128.721	.032	.0003	25.539	103.182
20A	128.834	128.801	.033	.0003	24.790	104.011
21A	131.229	131.197	.032	.0003	25.482	105.715

Sample No.	Wet Weight of Sample & Container	Wt. After Oven Drying	Change in Wt.	% Change	Wt. of Container	Wt. of Sample After Drying
22A	122.721	122.699	.022	.0002	24.751	97.948
23A	119.759	119.725	.074	.0008	25.301	94.424
24A	135.959	135.924	.035	.0003	25.624	110.3
25A	137.982	137.939	.043	.0004	25.689	112.25
26A	120.700	120.655	.045	.0005	24.493	96.162
27A	125.520	125.499	.021	.0002	24.871	100.628
28A	110.021	109.965	.057	.0007	24.920	85.045
29A	144.376	144.309	.067	.0006	25.601	118.708
30A					23.943	
31A					25.102	
32A					24.749	
33A	126.068	125.731	.337	.003	25.119	100.612
34A	139.251				25.601	
35A	151.850	151.780	.070	.0006	24.939	126.841
36A	143.973	143.928	.045	.0004	25.940	117.988
37A	122.516	122.407	.109	.001	23.911	98.496
38A	124.756	124.690	.066	.0007	24.709	99.981
39A	130.070	129.941	.129	.001	25.028	104.913
40A	135.720	135.672	.048	.0004	25.189	110.483
41A	143.182	143.120	.062	.0005	24.738	118.382
42A	145.432	145.386	.046	.0004	25.626	119.76
43A	145.698	145.652	.046	.0004	25.762	119.89
44A	144.411	144.383	.028	.0002	24.890	119.493

Sample No.	Wet Weight of Sample & Container	Wt. After Oven Drying	Change in Wt.	% Change	Wt. of Container	Wt. of Sample After Drying
45A	140.805	140.481	.324	.003	25.171	115.31
46A	135.801	135.771	.030	.0003	25.038	110.733
47A	126.250	126.194	.056	.0006	24.410	101.784
48A	134.928	134.899	.029	.0003	25.367	109.532
49A	145.500	145.298	.202	.002	26.053	119.245
50A	107.174	107.151	.023	.0003	25.581	81.57
51A	125.828	125.790	.038	.0004	24.847	100.943
52A	120.594	120.579	.015	.0002	24.860	95.719
53A	125.794	125.773	.021	.0002	25.535	100.238
54A	131.339	131.322	.017	.0002	24.933	106.389
55A	130.839	130.568	.271	.003	25.477	105.091
56A	141.139	141.053	.086	.0007	24.292	116.761
57A					25.429	

Beach Data for July 16

Sample No.	Wet Wt. of Sample & Container	Wt. After Oven-Drying	Wt. of Container	Wt. of Sample	Change In Wt.		% Change	
1A	110.312	109.950	25.100	84.85	0.362		.004	
1B			61.799					
2A	119.755	119.647	25.239	94.408	0.108	0.358	.001	.004
2B	104.930	104.322	25.778	78.544	0.608		.007	
3A	116.952	116.889	25.436	91.453	0.063	0.315	.0007	.004
3B	97.769	97.202	24.843	72.359	0.567		.008	
4A	124.838	124.025	25.137	98.888	0.813	0.563	.008	.006
4B	119.099	118.786	25.172	93.614	0.313		.003	
5A	127.780	127.092	24.900	102.192	0.688	0.399	.007	.004
5B	115.991	115.882	25.111	90.771	0.109		.001	
6A	114.815	114.535	24.682	89.853	0.280	0.418	.003	.005
6B	117.310	116.754	24.981	91.773	0.556		.006	
7A	92.604	92.310	26.022	66.288	0.294	0.423	.004	.006
7B	106.330	105.778	25.873	79.905	0.552		.007	
8A	119.508	119.286	25.468	93.818	0.222	0.308	.002	.003
8B	123.597	123.204	25.379	97.825	0.393		.004	
9A	109.858	109.275	25.760	83.515	0.583	0.340	.007	.004
9B	131.589	131.492	25.388	106.104	0.097		.0009	
10A	113.160	112.361	25.555	86.806	0.799	0.419	.009	.005
10B	113.119	113.080	25.423	87.657	0.039		.004	
11A	116.060	114.861	24.721	90.140	1.199	1.010	.013	.012
11B	99.060	98.248	25.132	73.116	0.812		.011	
12A	118.162	117.285	25.388	91.897	0.877	0.954	.009	.011
12B	105.747	104.716	26.400	78.316	1.031		.013	
13A	107.031	104.150	25.622	78.528	2.881	1.790	.037	.023
13B	104.973	104.259	24.806	79.453	0.714		.009	

Sample No.	Wet Wt. of Sample & Container	Wt. After Oven-Drying	Wt. of Container	Wt. of Sample	Change In Wt.		% Change	
14A	106.403	103.452	25.693	77.759	2.951	1.803	.038	.023
14B	120.439	119.785	24.592	95.193	0.654		.007	
15A	127.545	126.949	25.368	101.581	0.596	1.225	.006	.015
15B	104.873	103.019	25.492	77.527	1.854		.024	
16A	119.451	118.831	25.372	93.459	0.620	1.477	.007	.018
16B	106.369	104.035	25.149	78.886	2.334		.029	
17A	119.932	119.316	25.088	94.228	0.616	1.049	.007	.013
17B	102.408	100.925	25.340	75.585	1.483		.019	
18A	120.511	119.762	25.472	94.290	0.749	0.783	.008	.009
18B	112.192	111.376	25.236	86.140	0.816		.009	
19A	115.837	114.741	25.539	94.202	1.096	1.179	.012	.014
19B	112.312	111.049	25.639	85.41	1.263		.015	
20A	93.424	92.275	24.790	67.485	1.149	1.361	.017	.018
20B	107.072	105.500	25.759	79.741	1.572		.019	
21A	125.430	124.553	25.482	99.071	0.877	0.685	.009	.008
21B	114.469	113.976	24.779	89.197	0.493		.006	
22A	104.873	103.130	24.751	78.379	1.743	1.435	.022	.018
22B	114.617	113.491	25.576	87.915	1.126		.013	
23A	106.670	105.358	25.301	80.057	1.312	1.272	.016	.016
23B	105.627	104.395	25.741	78.654	1.232		.016	
24A	119.100	117.715	25.624	92.091	1.385	1.140	.015	.012
24B	118.411	117.521	25.211	92.31	0.890		.009	
25A	103.082	102.050	25.689	76.361	1.032	1.094	.014	.014
25B	110.304	109.149	25.158	83.991	1.155		.014	

Sample No.	Wet Wt. of Sample & Container	Wt. After Oven-Drying	Wt. of Container	Wt. of Sample	Change In Wt.		% Change	
26A	110.712	109.418	24.493	84.925	1.294	1.099	.015	.012
26B	119.227	118.323	25.111	93.212	0.904		.009	
27A	118.920	118.350	24.871	93.479	0.570	0.691	.006	.009
27B	104.031	103.220	25.609	77.611	0.811		.011	
28A	125.979	124.952	24.920	100.032	1.027	0.875	.011	.010
28B	110.963	110.240	25.274	84.966	0.723		.009	
29A	94.966	94.169	25.601	68.568	0.797	1.004	.012	.013
29B	115.010	113.800	25.006	88.794	1.210		.014	
30A	118.539	117.699	24.750	92.949	0.840	1.259	.009	.013
30B	127.157	125.478	24.846	100.632	1.679		.017	
31A	---	---	---	---	---		---	
31B	123.621	122.730	25.770	96.960	0.891		.009	
32A	113.714	112.470	---	---	---		---	
32B	128.041	127.419	25.171	102.248	1.244		.012	
33A	107.058	104.961	25.119	79.842	2.097	1.066	.026	.013
33B	115.566	115.532	25.119	90.413	0.034		.0004	
34A	123.339	121.741	25.601	96.140	1.598	0.818	.017	.009
34B	132.698	132.661	23.882	108.779	0.037		.0003	
35A	124.046	122.051	24.939	97.112	1.995	1.171	.021	.013
35B	113.670	113.324	24.650	88.674	0.346		.004	
36A	106.792	104.340	25.940	78.400	2.452	1.863	.031	.022
36B	122.179	120.905	26.372	94.533	1.274		.013	
37A	95.642	94.009	23.911	70.098	1.633	3.146	.023	.038
37B	119.853	115.194	25.442	89.792	4.659		.052	
38A	116.181	113.163	24.709	88.454	3.018	3.658	.034	.044
38B	109.987	105.690	25.038	80.652	4.297		.053	

Sample No.	Wet Wt. of Sample & Container	Wt. After Oven-Drying	Wt. of Container	Wt. of Sample	Change In Wt.		% Change	
39A	113.481	109.570	25.028	84.542	3.911	3.254	.046	.039
39B	113.420	110.823	25.521	85.302	2.597		.031	
40A	116.515	112.828	25.189	87.639	3.687	2.771	.042	.032
40B	117.584	115.730	25.081	90.649	1.854		.021	
41A	121.921	119.873	24.738	95.135	2.048	1.710	.022	.020
41B	106.743	105.372	23.939	81.433	1.371		.017	
42A	131.240	130.647	25.626	105.021	0.593	0.369	.006	.004
42B	129.935	129.790	25.027	104.763	0.145		.001	
43A	123.674	120.830	25.762	95.068	2.844	2.897	.029	.031
43B	118.631	115.681	24.760	90.921	2.950		.032	
44A	110.425	108.221	24.890	83.331	2.204	1.782	.026	.020
44B	122.519	121.159	25.358	95.801	1.360		.014	
45A	114.678	114.239	25.171	89.068	0.439	1.615	.005	.019
45B	113.551	110.761	25.639	85.122	2.79		.033	
46A	112.625	111.508	25.038	86.470	1.117	1.704	.013	.019
46B	125.119	122.828	25.818	97.010	2.291		.024	
47A	116.873	114.929	24.410	90.519	1.944	1.547	.021	.017
47B	123.765	122.615	25.451	97.164	1.150		.012	
48A	109.515	108.167	25.367	82.800	1.348	0.724	.016	.009
48B	135.740	135.641	24.821	110.820	0.099		.0009	
49A	106.844	104.083	26.053	78.030	2.761	2.202	.035	---
49B	122.902	121.259	---	---	1.643		---	
50A	110.011	107.005	25.581	81.424	3.006	2.515	.037	.030
50B	118.995	116.971	25.049	91.922	2.024		.022	

Sample No.	Wet Wt. of Sample & Container	Wt. After Oven-Drying	Wt. of Container	Wt. of Sample	Change In Wt.		% Change	
51A	103.441	100.031	24.847	75.184	3.410	3.740	.045	.049
51B	106.180	102.110	24.912	77.198	4.070		.053	
52A	121.235	117.503	24.860	92.643	3.732	2.586	.040	.030
52B	103.910	102.470	24.842	77.628	1.440		.019	
53A	101.062	97.890	25.535	72.355	3.172	1.936	.044	.026
53B	114.228	113.529	25.961	87.568	0.699		.008	
54A	109.582	105.820	24.933	80.887	3.762	2.360	.047	.029
54B	115.867	114.909	24.903	90.006	0.958		.011	
55A	103.870	100.848	25.477	75.371	3.022	2.020	.040	.026
55B	116.155	115.137	25.159	89.978	1.018		.011	
56A	114.552	110.651	24.292	86.359	3.901	3.466	.045	.039
56B	118.523	115.492	24.899	90.593	3.031		.033	
57A	114.440	110.189	25.543	84.646	4.251	8.162	.050	.098
57B	119.841	107.769	24.579	83.190	12.072		.145	
58A	109.350	104.668	24.997	79.671	4.682	5.802	.059	.074
58B	111.262	104.340	25.473	78.867	6.922		.088	
59A	114.018	109.611	24.550	85.061	4.407	6.112	.052	.073
59B	117.290	109.473	25.431	84.042	7.817		.093	
60A	107.372	102.924	24.568	78.356	4.448	7.819	.057	.093
60B	123.599	112.410	24.709	87.701	11.189		.128	
61A	117.300	112.840	25.301	87.539	4.460	3.560	.051	.040
61B	120.574	117.914	25.500	92.414	2.660		.029	
62A	108.584	104.403	25.009	79.394	4.181	3.952	.053	.048
62B	116.140	112.418	25.452	86.966	3.722		.043	

Sample No.	Wet Wt. of Sample & Container	Wt. After Oven-Drying	Wt. of Container	Wt. of Sample	Change In Wt.		% Change	
63A	117.465	113.470	25.770	87.7	3.995	2.523	.046	.0295
63B	110.088	109.037	25.190	83.847	1.051		.013	
64A	111.451	108.165	25.343	82.822	3.286	2.159	.039	.0255
64B	109.741	108.710	26.119	82.591	1.031		.012	
65A	94.304	90.875	25.437	65.438	3.429	3.258	.052	.0455
65B	107.613	104.526	25.490	79.036	3.087		.039	
66A	112.089	107.654	24.668	82.986	4.435	3.473	.053	.041
66B	114.327	111.816	24.536	87.28	2.511		.029	
67A	109.912	105.767	25.099	80.668	4.145	2.825	.051	.0345
67B	109.066	107.561	24.465	83.096	1.505		.018	
68A	108.271	104.160	24.960	79.2	4.111	3.661	.052	.0445
68B	115.059	111.849	25.292	86.557	3.21		.037	
69A	105.997	101.991	25.270	76.721	4.006	5.398	.052	.0675
69B	112.700	105.910	24.314	81.596	6.79		.083	
70A	119.301	113.826	24.678	89.148	5.475	5.804	.061	.0655
70B	119.267	113.134	25.583	87.551	6.133		.071	
71A	110.170	106.310	24.458	81.852	3.86	2.484	.047	.0295
71B	120.078	118.970	25.256	93.714	1.108		.012	
72A	115.049	110.709	24.865	85.844	4.34	2.898	.051	.034
72B	113.069	111.614	24.468	87.146	1.455		.017	
73A	117.814	111.331	25.110	86.221	6.483	4.085	.075	.047
73B	113.395	111.708	24.687	87.021	1.687		.019	
74A	117.399	111.040	24.252	86.788	6.359		.073	
75A	117.151	113.442	24.497	88.945	3.709	2.491	.042	.0285
75B	113.337	112.065	25.181	86.884	1.272		.015	

Sample No.	Wet Wt. of Sample & Container	Wt. After Oven-Drying	Wt. of Container	Wt. of Sample	Change In Wt.		% Change	
76A	113.512	108.898	23.165	85.733	4.614	3.053	.054	.036
76B	111.590	110.099	24.909	85.19	1.491		.018	
77A	124.130	121.408	24.541	96.867	2.722	2.267	.028	.0235
77B	119.662	117.850	24.541	93.309	1.812		.019	
78A	105.510	102.998	25.590	77.408	2.512	1.273	.032	.0162
78B	110.141	110.107	24.553	85.554	.034		.0004	
79A	102.996	100.591	24.987	75.604	2.405	2.039	.032	.0255
79B	116.801	115.129	24.804	90.325	1.672		.019	
80A	115.611	110.762	24.513	86.249	4.849	3.131	.057	.0365
80B	117.099	115.687	24.919	90.768	1.412		.016	
81A	114.490	110.730	25.452	85.278	3.76	2.158	.044	.025
81B	120.875	120.319	24.865	95.454	.556		.006	
82A	117.400	113.251	24.831	88.42	4.149	2.731	.047	.031
82B	121.720	120.408	25.625	94.783	1.312		.014	
83A	115.737	110.629	24.515	86.114	5.108	2.748	.059	.0315
83B	112.279	111.892	25.073	86.819	.387		.004	
84A	120.346	115.792	24.638	91.154	4.554	2.559	.049	.028
84B	110.523	109.960	26.988	82.972	.563		.007	
85A	115.850	113.764	24.922	88.842	2.086	1.499	.023	.017
85B	111.951	111.039	24.692	86.347	.912		.011	
86A	106.252	103.721	25.318	78.403	2.531	1.754	.032	.0215
86B	118.172	117.196	25.485	91.711	.976		.011	
87A	101.640	98.984	25.050	73.934	2.656	1.624	.036	.022
87B	101.430	100.839	24.907	75.932	.591		.008	

Beach Data from August 2

Sample No.	Wt. of Can (Empty)	Wet Wt. of Sample & Can	Oven-Dry Wt. of Sample & Can	Dry Wt. of Sample	Change In Wt.		% Change	
1A	25.100	108.560	108.528					
1B	61.799	102.378	102.360					
2A	25.239	110.072	110.011					
2B	25.778	105.521	105.507					
3A	25.436	105.081	105.639					
3B	24.843	100.450	100.434					
4A	25.137	100.329	100.296					
4B	25.172	104.769	104.730					
5A	24.900	98.801	98.755	73.855	.046	.033	.0006	.0005
5B	25.111	93.720	93.700	68.589	.020		.0003	
6A	24.682	80.270	80.240	55.558	.030	.0255	.0005	.0005
6B	25.102	79.880	79.859	54.757	.021		.0004	
7A	26.022	98.748	98.710	72.688	.038	.0285	.0005	.0004
7B	25.783	90.418	90.399	64.526	.019		.0003	
8A	25.468	102.623	102.575	77.107	.048	.031	.0006	.0004
8B	25.739	90.290	90.276	64.537	.014		.0006	
9A	25.760	91.870	91.830	66.070	.040	.0265	.0002	.0004
9B	25.388	96.501	96.488	71.100	.013		.0002	
10A	25.555	100.577	101.538	75.983	.039	.027	.0005	.0004
10B	25.423	89.569	89.554	64.131	.015		.0002	
11A	24.721	95.930	95.895	71.174	.035		.0005	
11B	25.132	empty	---	---	----		-----	
21A	25.388							
12B	26.400							

Beach Data from August 2

Sample No.	Wt. of Can (Empty)	Wet Wt. of Sample & Can	Oven-Dry Wt. of Sample & Can	Dry Wt. of Sample	Change In Wt.		% Change	
13A	25.622	108.107	108.080	82.458	.027	.0195	.0003	.0003
13B	24.806	79.762	79.750	54.944	.012		.0002	
14A	25.693	109.516	109.485	83.792	.031	.021	.0004	.0003
14B	24.592	76.219	76.208	51.616	.011		.0002	
15A	25.368							
15B	25.492	87.572	87.551	62.059	.021		.0003	
16A	25.372	78.500	78.484	53.112	.016	.0125	.0003	.0003
16B	25.149	79.920	79.911	54.762	.009		.0002	
17A	25.088	73.480	73.450	48.362	.030	.0235	.0006	.0005
17B	25.340	78.982	78.965	53.625	.017		.0003	
18A	25.472	85.131	85.110	59.638	.021	.025	.0004	.0004
18B	25.236	94.368	94.339	69.103	.029		.0004	
19A	25.539	98.929	98.894	73.355	.035		.0005	
19B	25.639							
20A	24.790	96.570	96.546	71.756	.024	.022	.0003	.0003
20B	25.759	99.975	99.955	74.196	.020		.0003	
21A	25.482	96.541	96.500	71.018	.041	.029	.0005	.0004
21B	24.779	91.365	91.348	66.569	.017		.0003	
22A	24.751	86.839	86.801	62.050	.038	.034	.0006	.0005
22B	25.576	96.980	95.950	70.374	.030		.0004	
23A	25.301							
23B	25.741	85.270	85.250	59.509	.020		.0003	
24A	25.624	97.709	97.658	72.034	.051	.0345	.0007	.0005
24B	25.211	90.518	90.500	65.289	.018		.0003	

Beach Data from August 2

Sample No.	Wt. of Can (Empty)	Wet Wt. of Sample & Can	Oven-Dry Wt. of Sample & Can	Dry Wt. of Sample	Change In Wt.		% Change	
25A	25.689	112.380	112.340	86.651	.040	.0305	.0005	.0004
25B	25.158	89.841	89.820	64.662	.021		.0003	
26A	24.493	98.025	97.990	73.497	.035	.0305	.0005	.0005
26B	25.111	81.997	81.971	56.860	.026		.0005	
27A	24.871	97.471	97.441	72.570	.030	.01555	.0004	.0022
27B	25.609	91.282	91.001	65.392	.281		.0040	
28A	24.920	67.711	67.691	42.771	.020	.0205	.0005	.0004
28B	25.274	95.580	95.559	70.285	.021		.0003	
29A	25.601	88.872	88.851	63.250	.021	.023	.0003	.0004
29B	31.848	91.829	91.804	59.956	.025		.0004	
30A	24.750	85.179	85.150	60.400	.029	.0225	.0005	.0004
30B	24.846	83.830	83.814	58.968	.016		.0003	
31A	25.214	108.419	108.361	83.147	.058	.0385	.0007	.0005
31B	25.770	85.310	85.291	59.521	.019		.0003	
32A	24.809	99.670	99.639	74.830	.031	.023	.0004	.0004
32B	25.171	82.330	82.315	57.144	.015		.0003	
33A	25.119	115.081	115.037	89.918	.044	.058	.0005	.0008
33B	25.119	75.361	75.289	50.170	.072		.0010	
34A	25.601	102.511	102.464	76.863	.047	.029	.0006	.0004
34B	23.882	91.271	91.260	67.378	.011		.0002	
35A	24.939	94.961	94.932	69.993	.029	.0205	.0004	.0003
35B	24.650	76.330	76.318	51.668	.012		.0002	
36A	25.940	103.564	103.520	77.580	.044	.036	.0006	.0006
36B	26.372	79.871	79.843	53.471	.028		.0005	

Beach Data from August 2

Sample No.	Wt. of Can (Empty)	Wet Wt. of Sample & Can	Oven-Dry Wt. of Sample & Can	Dry Wt. of Sample	Change In Wt.		% Change	
37A	23.911	74.833	74.809	50.898	.024	.021	.0005	.0004
37B	25.442	80.309	80.291	54.849	.018		.0003	
38A	24.709	87.671	87.649	62.940	.022	.016	.0003	.0003
38B	25.038	69.831	69.821	44.783	.010		.0002	
39A	25.028	97.271	97.240	72.212	.031	.027	.0004	.0004
39B	25.521	89.199	89.176	63.655	.023		.0004	
40A	25.189	86.489	86.468	61.279	.021	.0225	.0003	.0003
40B	25.081	94.064	94.040	68.959	.024		.0003	
41A	24.738	103.959	103.917	79.179	.042	.0315	.0005	.0004
41B	23.939	90.706	90.685	66.746	.021		.0003	
42A	25.626							
42B	25.027	92.110	92.079	67.052	.031		.0005	
43A	25.762	72.786	72.737	46.975	.049	.0375	.001	.0007
43B	24.760	86.248	86.222	61.462	.026		.0004	
44A	24.890	76.164	76.091	51.201	.073	.0475	.001	.0007
44B	25.358	90.041	90.019	64.661	.022		.0003	
45A	25.171	88.799	88.689	63.518	.11	.069	.002	.0013
45B	25.639	83.267	82.239	56.600	.028		.0005	
46A	25.038	73.830	73.777	48.739	.053	.0375	.0010	.0007
46B	25.818	87.770	87.748	61.930	.022		.0004	
47A	24.410	76.002	75.919	51.509	.083	.0545	.0020	.0012
47B	25.451	104.348	104.322	78.871	.026		.0003	
48A	25.367	76.490	76.452	51.085	.038	.0450	.0007	.0009
48B	24.821	69.170	69.118	44.297	.052		.0010	

Beach Data from August 2

Sample No.	Wt. of Can (Empty)	Wet Wt. of Sample & Can	Oven-Dry Wt. of Sample & Can	Dry Wt. of Sample	Change In Wt.		% Change	
49A	26.053	114.417	114.373	88.320	.044	.032	.0005	.0005
49B	24.571	70.742	70.722	46.151	.020		.0004	
50A	25.581	104.650	104.477	78.896	.173	.0955	.0020	.0015
50B	25.049	83.131	83.113	58.064	.018		.0003	
51A	24.847	95.008	94.801	69.954	.207	.1165	.0020	.0012
51B	24.912	87.978	87.952	63.040	.026		.0004	
52A	24.860	99.120	99.060	73.200	.068	.0425	.0009	.0006
52B	24.842	92.690	92.673	67.831	.017		.0003	
53A	25.535	103.318	103.231	77.696	.087	.0505	.0010	.0007
53B	25.961	80.510	80.496	54.535	.014		.0003	
54A	24.933	89.794	89.289	64.356	.505	.2625	.0080	.0042
54B	24.903	85.676	85.656	60.753	.020		.0003	
55A	25.477	52.825	52.811	27.334	.014	.0175	.0005	.0005
55B	25.159	80.702	80.681	55.522	.021		.0004	
56A	24.292	96.589	96.560	72.268	.029	.0155	.0004	.00022
56B	24.899	84.563	84.561	59.662	.002		.00003	
57A	25.543	92.292	92.265	66.722	.027	.0245	.0004	.0004
57B	24.579	77.207	77.185	52.606	.022		.0004	
58A	24.997	87.213	87.185	62.188	.028		.0005	
58B								
59A	24.550	95.148	95.106	70.556	.042	.0305	.0006	.0005
59B	25.431	80.778	80.759	55.328	.019		.0003	
60A	24.568	93.471	93.447	68.879	.024	.022	.0003	.0004
60B	24.709	72.340	72.320	47.611	.020		.0004	

Beach Data from August 2

Sample No.	Wt. of Can (Empty)	Wet Wt. of Sample & Can	Oven-Dry Wt. of Sample & Can	Dry Wt. of Sample	Change In Wt.		% Change	
61A	25.301	102.406	102.380	77.079	.026		.0003	
61B								
62A	25.009	73.933	73.908	48.899	.025	.0235	.0005	.0005
62B	25.452	82.660	82.638	57.186	.022		.0004	
63A	25.770	77.310	77.282	51.512	.028	.029	.0005	.0005
63B	25.190	82.689	82.659	57.469	.030		.0005	
64A	25.343	90.202	90.171	64.828	.031	.0265	.0005	.0005
64B	26.119	68.642	68.620	42.501	.022		.0005	
65A	25.437							
65B	25.490	88.079	88.041	62.551	.038		.0004	
66A	24.668	78.371	78.339	58.671	.032	.030	.0004	.0004
66B	24.536	82.837	82.809	58.273	.028		.0003	
67A	25.099	86.842	86.819	61.720	.023	.0875	.0003	.0012
67B	24.465	86.392	86.240	61.775	.152		.0020	
68A	24.960	76.062	76.048	51.088	.014	.0145	.0002	.0002
68B	25.292	78.355	78.340	53.048	.015		.0002	
69A	25.270	85.880	85.860	60.590	.020	.0225	.0002	.0003
69B	24.314	89.045	89.020	64.706	.025		.0003	
70A	24.678	109.350	109.311	84.633	.039	.028	.0004	.0003
70B	25.583	77.179	77.162	51.579	.017		.0002	
71A	24.458	100.480	100.460	76.002	.020	.0165	.0002	.0002
71B	25.256	83.230	83.217	57.961	.013		.0002	
72A	24.865	74.328	74.309	49.444	.019	.019	.0003	.0003
72B	24.468	77.069	77.050	52.582	.019		.0002	

Beach Data from August 2

Sample No.	Wt. of Can (Empty)	Wet Wt. of Sample & Can	Oven-Dry Wt. of Sample & Can	Dry Wt. of Sample	Change In Wt.		% Change	
73A	25.110	106.630	106.600	81.490	.030		.0003	
73B	24.687	82.245	82.228	57.541	.017	.0235	.0002	.0003
74A	24.252	97.143	97.122	72.870	.021		.0002	
74B	25.071	97.310	97.288	72.217	.022	.0215	.0002	.0002
75A	24.497	77.346	77.324	52.827	.022		.0003	
75B	25.181	84.868	84.847	59.666	.021	.0215	.0002	.0003
76A	23.165	85.853	85.824	62.659	.029		.0003	
76B	24.909							
77A	24.541							
77B	24.541	88.456	88.430	63.889	.026		.0003	
78A	25.590	66.966	66.941	41.351	.025		.0006	
78B	24.553	84.207	84.184	59.631	.023	.024	.0004	.0005
79A	24.987	86.860	86.840	61.853	.020		.0003	
79B	24.804	82.508	82.481	57.677	.027	.0235	.0005	.0004
80A	24.513	82.013	81.991	57.478	.022		.0004	
80B	24.919	85.567	85.534	60.615	.033	.0275	.0005	.0005
81A	25.452	72.355	72.335	46.883	.020		.0004	
81B	24.865	83.711	83.691	58.826	.020	.020	.0003	.0004
82A	24.831	74.714	74.691	49.860	.023		.0005	
82B	25.625	79.419	79.392	53.767	.027	.025	.0005	.0005
83A	24.515	82.669	82.639	58.124	.030		.0005	
83B	25.073	84.323	84.300	59.227	.023	.0265	.0004	.0005
84A	24.638	89.910	88.871	64.233	1.039		.0160	
84B	26.988	77.979	77.960	50.972	.019	.529	.0004	.0082

Beach Data from August 2

Sample No.	Wt. of Can (Empty)	Wet Wt. of Sample & Can	Oven-Dry Wt. of Sample & Can	Dry Wt. of Sample	Change In Wt.		% Change	
85A	24.922	82.103	82.080	57.158	.023	.022	.0004	.0004
85B	24.692	86.381	86.360	61.668	.021		.0003	
86A	25.318	86.161	86.130	60.812	.031	.0285	.0005	.0005
86B	25.485	91.845	91.819	66.334	.026		.0004	
87A	25.050	102.512	102.484	77.434	.028	.0245	.0004	.0004
87B	24.907	91.901	91.880	66.973	.021		.0003	
88A	24.883	77.540	77.515	52.633	.025	.026	.0005	.0005
88B	25.445	79.007	78.980	53.535	.027		.0005	
89A	25.741	99.722	99.698	73.957	.024	.028	.0003	.0004
89B	25.966	87.683	87.651	61.685	.032		.0005	
90A	25.246	98.728	98.698	73.452	.030	.030	.0004	.0005
90B	24.838	82.369	82.339	57.501	.030		.0005	

Dead Cans
11319B
77A 76B

#	HW 90 Cannister "A"	Water Cannister "B"
1.	Henderson Pt	Henderson Pt
10.	Fort Henry Avenue	Sameo Sameo
14.	Lady Mary Ave	Sameo Sameo
19.	Sherman	Sameo Sameo
24.	Cedar Ave	Sameo Sameo
29.	Barkley Ave	Sameo Sameo
35.	Magnolia Ave	Sameo Sameo
38.	Pine Ave	Sameo Sameo
41.	Henderson Ave	Sameo Sameo
44.	Church	
48.	Pass Christ Ch. Commerce (West)	
49.	Pass Christ Harbor (East)	
60.	Seal Ave	
70.	Courtenay Ave	
75.	Long	
81.	Menge	
88.	Scenic Drive (East)	

APPENDIX E
TABLES 1-15
SYNOPTIC WEATHER TYPES -
PERCENT OF HOURS FOR
MOBILE 1977

Table E-1: Synoptic Weather Types in Percent of Hours for Mobile, 1977

	J	F	M	A	M	J	J	A	S	O	N	D	YR
PH		9	5							6	4	3	2
CH	24	29	8	17	14	13			12	36	18	28	15
FOR	50	24	32	6	10		2	4	9	29	29	19	19
CR			5	22	24		6	26	11	6	6	10	10
GR		20	15	27	16	20	15	23	20	6	12	22	17
FGR	19	10	30	16	12	5	11	33	11	4	31	14	16
GH	7	7	4	10	23	48	42		24	12		4	16
GTD						14	23	13	12				5
											100	100	100

Table E-2: Monthly Precipitation by Synoptic Weather Types for Mobile, 1977 (inches measured/percent total).

	J	F	M	A	M	J	J	A	S	O	N	D	YR
PH													0/0
CH					0.1/2								0.1/0
FOR	4.0/56	0.8/42	2.3/38	0.3/11					2.5/26	4.0/88	2.7/28	1.6/33	18.2/28
CR					0.4/8			0.5/9	0.1/1				1.0/2
GR			0.2/3	0.1/4		0.2/17	1.7/21	0.3/6	0.4/4	0.1/2	0.2/2		3.2/5
FGR	3.1/44	1.1/58	3.6/59	2.3/85	3.9/73	0.6/50	0.4/5	3.0/56	2.7/28	0.5/10	6.6/69	3.3/66	31.1/47
GH					0.9/17	0.4/33	4.2/54		1.5/15				7.0/10
GTD							1.5/19	1.6/29	2.4/25				5.5/8
Total Precipitation:	7.1	1.9	6.1	2.7	5.3	1.2	7.8	5.4	9.6	4.6	9.5	4.9	66.1/100

Table E-3: Characteristic Wind Direction*/Speed** for Synoptic Weather Types at Mobile, 1977, 0600 and 1500 Hours CST

	January S		August B		January J		October C	
	0600	1500	0600	1500	0600	1500	0600	1500
CH	34/7	31/11	29/3	34/13			02/5	02/8
PH							33/5	15/11
FOR	02/6	36/8	35/4	31/8	34/5	05/5	07/7	34/7
CR			05/5	13/9	05/3	13/7	09/10	12/8
GR			14/5	16/13	19/3	20/8	15/5	19/11
FGR	22/9	21/12	18/12	18/15	14/5	22/5	25/4	22/10
GH	27/9	31/8	33/4	26/9	22/3	19/9	25/3	28/7
GTD					09/5	13/8		

* direction in azimett x 10
** speed in knots

TABLE E-4. MEAN PROPERTIES OF SWTs, JANUARY, MOBILE, 1977

0600 CST	PH	CH	FOR	CR	GR	FGR	GTD	GH
No. Cases		7	16			6		2
T_A (°F)		24	36			51		25
T_D (°F)		16	26			47		18
RH (%)		73	70			85		75
*Wind Dir.		34	02			22		27
**Wind Sp.		7	6			9		9
***Cloud Cvr.		0	9			9		0
1500 CST								
No. Cases		7	15			7		2
T_A		39	50			55		56
T_D		15	30			41		20
RH		40	51			64		24
Wind Dir.		31	36			21		31
Wind Sp.		11	8			12		8
Cloud Cvr.		0	8			9		0

*Director in azimuth X 10

**Speed in t knots

***Cloud cover scale 0 to 10; 0 = clear; 10 = overcast

TABLE E-5. MEAN PROPERTIES OF SWTs, APRIL, MOBILE, 1977

0600 CST	PH	CH	FOR	CR	GR	FGR	GTD	GH
No. Cases		4	3	7	8	4		4
T_A		50	58	56	62	71		53
T_D		46	53	40	61	67		47
RH		89	84	53	94	86		81
Wind Dir.		29	35	05	14	18		33
Wind Sp.		3	4	5	5	12		4
Cloud Cvr.		1	6	3	6	10		1
1500 CST								
No. Cases		4	2	7	8	5		3
T_A		74	71	81	79	78		78
T_D		38	62	51	57	66		44
RH		29	72	36	49	66		30
Wind Dir.		34	31	13	16	18		26
Wind Sp.		13	8	9	13	15		9
Cloud Cvr.		1	10	1	5	10		2

TABLE E-6. MEAN PROPERTIES OF SWTs, JULY, MOBILE, 1977

0600 CST	PH	CH	FOR	CR	GR	FGR	GRT	GH
No. Cases			1	2	5	3	7	13
T_A			72	76	76	78	75	77
T_D			71	72	73	73	71	74
RH			97	91	92	86	88	91
Wind Dir.			34	05	17	14	09	27
Wind Sp.			5	3	3	5	5	3
Cloud Cvr.			10	7	7	7	7	4
1500 CST								
No. Cases			1	2	4	4	7	13
T_A			92	92	82	87	87	90
T_D			70	70	73	73	73	74
RH			49	49	75	63	63	59
Wind Dir.			05	13	20	22	13	19
Wind Sp.			5	7	8	5	8	9
Cloud Cvr.			6	4	8	8	9	7

TABLE E-7. MEAN PROPERTIES OF SWTs, OCTOBER, MOBILE, 1977

0600 CST	PH	CH	FOR	CR	GR	FGR	GTD	GH
No. Cases	2	12	10	1	2	1		3
T_A	56	50	61	64	73	77		61
T_D	55	46	56	62	68	74		47
RH	94	88	87	93	85	91		88
Wind Dir.	33	02	07	09	15	25		25
Wind Sp.	5	5	7	10	5	4		3
Cloud Cvr.	1	1	9	10	8	3		0.6
1500 CST								
No. Cases	2	11	8	3	2	1		4
T_A	77	72	74	78	84	81		76
T_D	58	44	62	61	67	68		45
RH	52	37	69	57	57	65		35
Wind Dir.	15	02	34	13	19	22		28
Wind Sp.	11	[illegible]	7	7	11	10		7
Cloud Cvr.	2	1	9	4	8	10		2

TABLE E-8. ANNUAL REGIME OF MEAN PROPERTIES FOR PH, MOBILE, 1977

0600 CST	J	F	M	A	M	J	J	A	S	O	N	D
No. Cases	0	2	2	0	0	0	0	0	0	2	1	1
T_A	0	47	55							56	57	43
T_D	0	38	49							55	56	36
RH	0	70	82							94	96	76
Wind Dir.	0	29	31							33	24	25
Wind Sp.	0	8	8							5	3	3
Cloud Cvr.	0	0	2							1	0	0

1500 CST	J	F	M	A	M	J	J	A	S	O	N	D
No. Cases	0	2	1	0	0	0	0	0	0	2	2	1
T_A	0	70	76							77	72	67
T_D	0	34	38							58	59	28
RH	0	28	25							52	62	23
Wind Dir.	0	28	34							15	24	27
Wind Sp.	0	12	7							11	6	6
Cloud Cvr.	0	5	0							2	8	2

TABLE E-9. ANNUAL REGIME OF MEAN PROPERTIES FOR CH, MOBILE, 1977

0600 CST	J	F	M	A	M	J	J	A	S	O	N	D
No. Cases	7	9	3	4	5	4	0	0	4	12	5	10
T_A	24	36	40	50	65	70			70	50	39	33
T_D	16	27	30	46	61	62			66	46	30	27
RH	73	69	69	89	87	79			87	88	70	79
Wind Dir.	34	36	02	29	34	01			04	02	36	34
Wind Sp.	7	7	5	3	5	6			4	5	6	6
Cloud Cvr.	0	2	0	1	2	1			1	1	1	1

1500 CST	J	F	M	A	M	J	J	A	S	O	N	D
No. Cases	7	7	2	4	4	5	0	0	4	11	5	8
T_A	39	57	63	74	85	90			88	72	64	50
T_D	15	24	27	38	60	59			68	44	32	22
RH	38	29	26	29	43	35			52	37	33	33
Wind Dir.	31	36	02	34	05	07			05	02	34	35
Wind Sp.	11	8	9	13	8	7			6	8	11	12
Cloud Cvr.	0	2	1	1	5	1			2	1	5	2

TABLE E-10. ANNUAL REGIME OF MEAN PROPERTIES FOR FOR, MOBILE, 1977

0600 CST	J	F	M	A	M	J	J	A	S	O	N	D
No. Cases	16	7	10	3	3	0	1	2	3	10	9	6
T_A	36	42	55	58	63		72	76	73	61	57	48
T_D	26	34	47	53	54		71	71	69	56	54	44
RH	70	72	76	84	72		97	86	87	87	90	84
Wind Dir.	02	01	03	35	04		34	02	05	07	36	36
Wind Sp.	6	7	8	4	8		5	3	5	7	7	6
Cloud Cvr.	9	8	8	6	10		10	7	10	9	10	9

1500 CST	J	F	M	A	M	J	J	A	S	O	N	D
No. Cases	15	7	11	2	4	0	1	1	1	8	8	7
T_A	50	54	52	71	82		92	83	76	74	66	56
T_D	30	27	42	62	56		70	72	70	62	54	41
RH	51	41	48	72	42		49	70	82	69	69	61
Wind Dir.	36	05	03	31	04		05	01	08	34	33	01
Wind Sp.	8	6	8	8	10		5	4	8	7	7	9
Cloud Cvr.	8	9	9	10	8		6	10	10	9	9	9

TABLE E-11. ANNUAL REGIME OF MEAN PROPERTIES FOR CR, MOBILE, 1977

0600 CST	J	F	M	A	M	J	J	A	S	O	N	D
No. Cases			3	7	8		2	8	3	1	2	4
T_A			42	56	66		75	77	74	64	38	45
T_D			38	40	62		72	72	68	62	31	54
RH			89	53	87		91	86	84	93	76	91
Wind Dir.			07	05	05		05	05	04	09	02	07
Wind Sp.			4	5	4		3	6	6	10	5	4
Cloud Cvr.			3	3	6		7	5	5	10	1	0
1500 CST												
No. Cases				7	7		2	8	3	3	2	2
T_A				81	85		92	88	91	78	58	61
T_D				51	61		70	72	69	61	34	49
RH				36	46		49	60	49	57	41	61
Wind Dir.				13	15		13	09	10	13	7	12
Wind Sp.				9	12		7	10	9	7	7	6
Cloud Cvr.				1	5		4	6	6	4	2	8

TABLE E-12. ANNUAL REGIME OF MEAN PROPERTIES FOR GR, MOBILE, 1977

0600 CST	J	F	M	A	M	J	J	A	S	O	N	D
No. Cases	0	7	4	8	5	6	5	7	4	2	4	6
T_A		52	60	61	68	76	77	77	75	73	56	54
T_D		46	55	61	66	73	72	72	70	68	52	72
RH		81	83	94	92	91	86	86	87	85	85	94
Wind Dir.		16	11	14	17	22	12	12	00	15	13	16
Wind Sp.		6	13	5	3	4	6	6	0	5	6	7
Cloud Cvr.		5	10	6	7	5	4	4	2	8	5	8
1500 CST												
No. Cases	0	5	5	8	4	7	4	7	6	4	4	8
T_A		70	70	79	83	90	82	87	87	76	71	66
T_D		47	50	57	63	72	73	74	72	45	57	54
RH		45	52	49	51	58	75	64	62	35	63	68
Wind Dir.		18	15	16	20	20	20	17	19	28	15	19
Wind Sp.		10	11	13	6	9	8	8	8	7	10	8
Cloud Cvr.		7	7	5	7	6	8	8	6	2	6	7

TABLE E-13. ANNUAL REGIME OF MEAN PROPERTIES FOR FGR, MOBILE, 1977

0600 CST	J	F	M	A	M	J	J	A	S	O	N	D
No. Cases	6	1	8	4	3	2	3	10	4	1	9	
T_A	51	35	69	71	67	69	78	77	74	77	65	
T_D	47	23	62	67	63	65	73	73	71	74	62	
RH	85	62	80	86	86	87	86	86	93	91	90	
Wind Dir.	22	30	16	18	13	20	14	22	14	25	15	
Wind Sp.	9	6	10	12	7	3	5	3	4	4	8	
Cloud Cvr.	9	0	10	10	10	8	7	8	8	3	10	

1500 CST	J	F	M	A	M	J	J	A	S	O	N	D
No. Cases	7	4	11	6	5	1	4	11	5	1	9	
T_A	55	71	74	78	82	92	87	84	81	81	70	
T_D	41	60	64	66	64	71	73	74	71	68	65	
RH	64	68	81	66	58	50	63	72	73	65	83	
Wind Dir.	21	20	18	18	19	24	22	18	24	22	16	
Wind Sp.	12	16	16	15	12	8	5	8	6	10	10	
Cloud Cvr.	9	9	10	10	8	6	8	10	10	10	10	

TABLE E-14. ANNUAL REGIME OF MEAN PROPERTIES FOR GH, MOBILE, 1977

0600 CST	J	F	M	A	M	J	J	A	S	O	N	D
No. Cases	2	2	1	4	7	14	13	0	8	3	0	1
T_A	25	37	36	53	70	76	77		75	61		52
T_D	18	28	29	47	67	73	74		71	47		46
RH	75	70	76	81	91	91	91		89	88		80
Wind Dir.	27	-	-	33	29	25	27		29	25		21
Wind Sp.	9	-	-	4	2	4	3		4	3		10
Cloud Cvr.	0	0	0	1	5	2	4		2	1		0

1500 CST	J	F	M	A	M	J	J	A	S	O	N	D
No. Cases	2	3	1	3	7	13	13	0	7	4	0	1
T_A	56	65	67	78	75	91	90		89	76		50
T_D	20	28	27	44	77	72	74		70	45		27
RH	24	25	24	30	51	54	59		55	35		41
Wind Dir.	31	23	27	26	14	20	19		29	28		19
Wind Sp.	8	12	4	9	6	12	9		6	7		5
Cloud Cvr.	0	0	0	2	6	5	7		7	2		5

TABLE E-15. ANNUAL REGIME OF MEAN PROPERTIES FOR GTD, MOBILE, 1977

0600 CST	J	F	M	A	M	J	J	A	S	O	N	D
No. Cases						4	7	4	4			
T_A						75	75	77	76			
T_D						74	71	71	70			
RH						96	88	81	81			
Wind Dir.						16	09	12	11			
Wind Sp.						6	5	7	10			
Cloud Cvr.						6	7	8	9			
1500 CST												
No. Cases						4	7	4	4			
T_A						90	87	86	84			
T_D						71	73	73	72			
RH						54	63	68	69			
Wind Dir.						18	13	13	14			
Wind Sp.						7	8	10	9			
Cloud Cvr.						6	9	8	9			

APPENDIX F

CONSTRUCTION MATERIAL

Appendix F

Construction Materials. Materials of construction play both an aesthetic and erosive role. Two materials which are traditionally used for wall construction and which are appropriate here are masonry and wood. If masonry is used, footings must be dug and forms must be built. However, these requirements present problems in areas of high water tables and soil with low angles of repose as are typical on the beach. Masonry is also very cold to the eye (concrete) and the touch which is not consistent with a warm recreational atmosphere. Wood piles, on the other hand, require no footings, may simply be driven into the sand, offer a warm feeling when viewed or touched, and provide textures and colors that relate well with the natural setting thus visually tying the wall to the landscape. Treatment of wood piles with appropriate preservative will enable long life and not be harmful to skin or beach.

APPENDIX G

PLANT MATERIAL

Appendix G

Plant Materials. For this design to hold up under heavy pedestrian use, a good turf must be used with irrigation support. Irrigation is expensive initially, but with an automated system designed to deliver the required amount of fresh water at regular intervals the assurance of plant survival is virtually guaranteed. Such a system and plant fertilizer would very likely have prevented the costly loss of palms on the beach. As depicted in the Section of Sheet 6, the planting in addition to the grass turf should consist of trees, shrubs, and groundcover.

By referring to the Relationship Matrix it is possible to evaluate each of these items and arrange and locate each in such a way as to maximize the asthetic as well as the erosion control properties. Groundcover, for instance, should be used sparingly while the others can be used liberally. The implications of the matrix are that the turf could be used extensively, the groundcover may be used to tone down the wharf tie wall and in limited other areas, shrubs could be used along the highway to filter noise and fumes as well as along paths to reinforce direction of movement. Shrubs should be dense at the highway to filter noise and fumes as well as along paths to reinforce direction of movement. Shrub density should diminish as the fore beach is approached to provide a smooth transition into the open beach area. Trees should be used throughout with tropical salt tolerant species supplanting natives as they approach the water.

Selective treatment of sandspur weed, as recommended by the Agronomy Department at Mississippi State University, should be by the use of post emergent MSMA (not harmful to Bermuda Grass) at one pound per acre. The recommended turf is common Bermuda grass with a mowing height of 1-1½ inches. Planting of the seed should be preceeded by incorporation of 15-20 pounds per 1,000 square feet of 13-15-13 fertilizer. Seeding should be done in April as the nightly temperature remains between 40 and 40 degrees F.

Plant materials for the low use areas comprising the balance of the beach are naturally developing species. There development can be facilitated merely by reducing population pressure and altering maintenance practices such that salt organic crust and vegetation are not disturbed and the erosion is reduced.

APPENDIX H

THEORY OF SAND MOVEMENT

Appendix H

1. <u>Large Particle Exclusion Rule</u>. Particle size and movement are governed by the following rules. Generally, large particles tend to be excluded from blowing sand because the size of a particle capable of being transported by the current of a fluid varies as the eixth power of the velocity of the current. The diameter of the particle, therefore, varies as the square of the velocity. If the velocity is doubled, the diameter of particles transported may be increased four times. The range of velocities of sand moving winds, as usually measured, certainly exceeds a doubling of their speed, thus there is some upper limit to the size of wind blown sand and it might be expected that the bulk of the sand in some places at least, should consist of grains many times as large as in others. This is, however, not the general case or the specific case of this beach as size samples of beach sand indicate that this study area consists mainly of sand in the fine to coarse categories.

There appears to be two main reasons why blown sand in general and the beach sand and the eroding and redeposition is not composed of larger particles: 1) there appears to be a scarcity of large grains of sand in the dredge zone from which the beach material was taken, therefore, the beach contains virtually no large particles; and 2) wind velocities are usually measured some distance above the ground but aeolian sand is moved only by the very lowest layer in the atmosphere and the velocity of the current in the lower most layer is much lower and is increased at a very slow rate with an increase in the speed of the layers above it. For this reason, the velocity in the flowing air layers next to the surface on the ground probably seldom reach three miles per hour, a speed at which there is moderate overall movement and only, of course, of finer sized particles. These factors coupled with the fact that as winds increase in speed and pick up a load of suspended material the energy expended by the wind retards the current of air and lessens its carrying power, producing a self-limiting influence on the winds ability to move sand. Thus, larger particles tend to be excluded from wind blown matters and from the beach in general.

2. Small Particle Exclusion Rule. In the case of particles smaller than fine sand, there tends to be a general absence from all filled beaches and most sand areas for two reasons. First, since the sand in this study area as in most filled beaches was dredged, most of the dust and finer particles were suspended in the water and never became part of the beach. This fact of origin coupled with the second factor that evidently the law which governs the separation of the fine admixtures from the aeolian sand implies that materials finer than sand when moved by air are wholly lifted up into swifter air currents and promptly removed from the area results in an absence of small particles. Working in this manner, the transporting power of the wind for smaller material varies more nearly in approximation of its erosive force than to its lifting force. With changes in velocities the latter varies as the sixth power, while the erosive force varies as the square. Thus, small particles are removed completely from the beach environment and the beach tends to consist of only those grains of a middle range of size.

3. Particle Movement. Generally the coarser ingredients are not moved and the finer grains are entirely blown away. Aeolian erosion and redeposition is a problem of mid-sized particles. The mechanics of the movement when studied in detail have suggested that the wind much more rapidly ceases to lift sand grains exceeding one eight of a millimeter in diameter then it ceases to roll grains which become larger than one fourth of a millimeter. In tabular form, the approximate distances of movement are:

Gravel - a few feet

Coarse and medium sand - several weeks

Fine sand - less than a mile

Very fine sand - a few miles

Dust - from 200 miles to around the globe (7, 8).

Table 1-1 summarizes these conditions from the principal sand erosion studies by Udden and Bughold and the gulf coast sand measurement conduced for this research.

These findings have been confirmed in numerous studies where aeolian sand erosion was approached on two fronts: 1) wind tunnel experiments and 2) experimental confirmation in desert and other sand masses. In these works the authors have concluded that:

> After much desert travel, extending over many years which sand storms of varying intensity were frequently encountered, I became convinced that the movement of sand (as opposed to that of dust) is a purely surface effect, taking place only within a metre of the ground; and that large-scale eddy currents within the air stream play no appreciable part in maintaining the grains aloft (8).

In wind tunnel experiments, it has been found that moving sand rarely approaches the height of eighteen inches above the ground and also that sand moves by the "ping-pong ball" effect or saltation. That is, a grain of sand is driven aloft by wind, when the energy of the wind on the surface of the grain exceeds the inertia and gravitational attraction of the grain. Grains tend to be held aloft until the force of gravity exceeds the energy of the wind and pulls them to the surface. This grain strikes other grains on the surface and sends them aloft into the stream of air where by the processes is repealed. This "saltation" is complemented by another mode of transport surface creep where the grains are rolled along under the force of the wind (where wind energy is greater than inertia but not greater than gravity and inertia together). Thus, this study is concerned with coarse to fine sized grains of sand whose movement is purely a surface effect limited largely to the first 18 inches of atmosphere.