The First Annual Report Submitted To N.A.S.A

by

The University of Southern Mississippi
for the project entitled

REMOTE SENSING STUDY OF LAND USE AND SEDIMENTATION IN THE ROSS BARNETT RESERVOIR JACKSON, MISSISSIPPI, AREA

(NASA Grant No. NGL 25-005-007)

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W. T. Mealor, Jr., D. L. Wertz, et. al.

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SECTION I
INTRODUCTION

A. Objectives

The Ross Barnett Reservoir Remote Sensing Project is designed as a multi-year study that is focused on the recognition of sediment and other culturally induced affluents in the Reservoir and their spatial linkages and relationships with land use and site characteristics. In the December, 1971, proposal accepted by NASA, the University of Southern Missisisippi remote sensing research team states that the principal objectives of the Ross Barnett Reservoir study are the determination through remote sensing techniques of (1) land use types, (2) effect of land use on erosion within the immediate vicinity of the Reservoir, (3) the suspended sediment within the Reservoir, and (4) correlation of suspended sediment with land use in the immediate Reservoir vicinity.

The project does not focus on the entire Reservoir or its watershed, nor does it attempt to accomplish all objectives in less than three years. However, it does attempt to study a small but characteristic portion of the Reservoir and to accomplish certain goals within prescribed time tables.

1. Selection of the General Test Site Region

The Ross Barnett Reservoir is located approximately ten miles northeast of downtown Jackson, Mississippi, in the Jackson Prairie sub-province of the East Gulf Coastal Plain Province (Fig. 1). The Reservoir contains approximately 30,000 acres and has a shoreline elevation of 296 feet. Its average maximum depth is 30 feet. The Reservoir and most of the land surrounding it is owned by the Pearl River Valley Water Supply District.

Because of the size of the Reservoir, the limited number of investigators, and budget restraints, it was deemed impossible to study the entire Reservoir. Therefore, the focus of the project was and is on a small area representative of land use typologies and their relationship with near-shore water conditions. Therefore, the first step for implementing the project was selection of the study area. Criteria for selection of a representative study area was based on the following:

(1) Is the study area large enough to be representative of all land utilization typologies within the vicinity of the Reservoir?

(2) Is the study area small enough to permit efficient use of research team manpower and resources?

(3) Is the study area (and selected field training sites and sampling points) reasonably accessible?

Selection of the study area was accomplished prior to the June, 1972, overflight. Based upon November, 1971, 1:120,000 and 1:60,000 scale color and color infrared imageries of the Reservoir area (furnished by NASA-MTF),

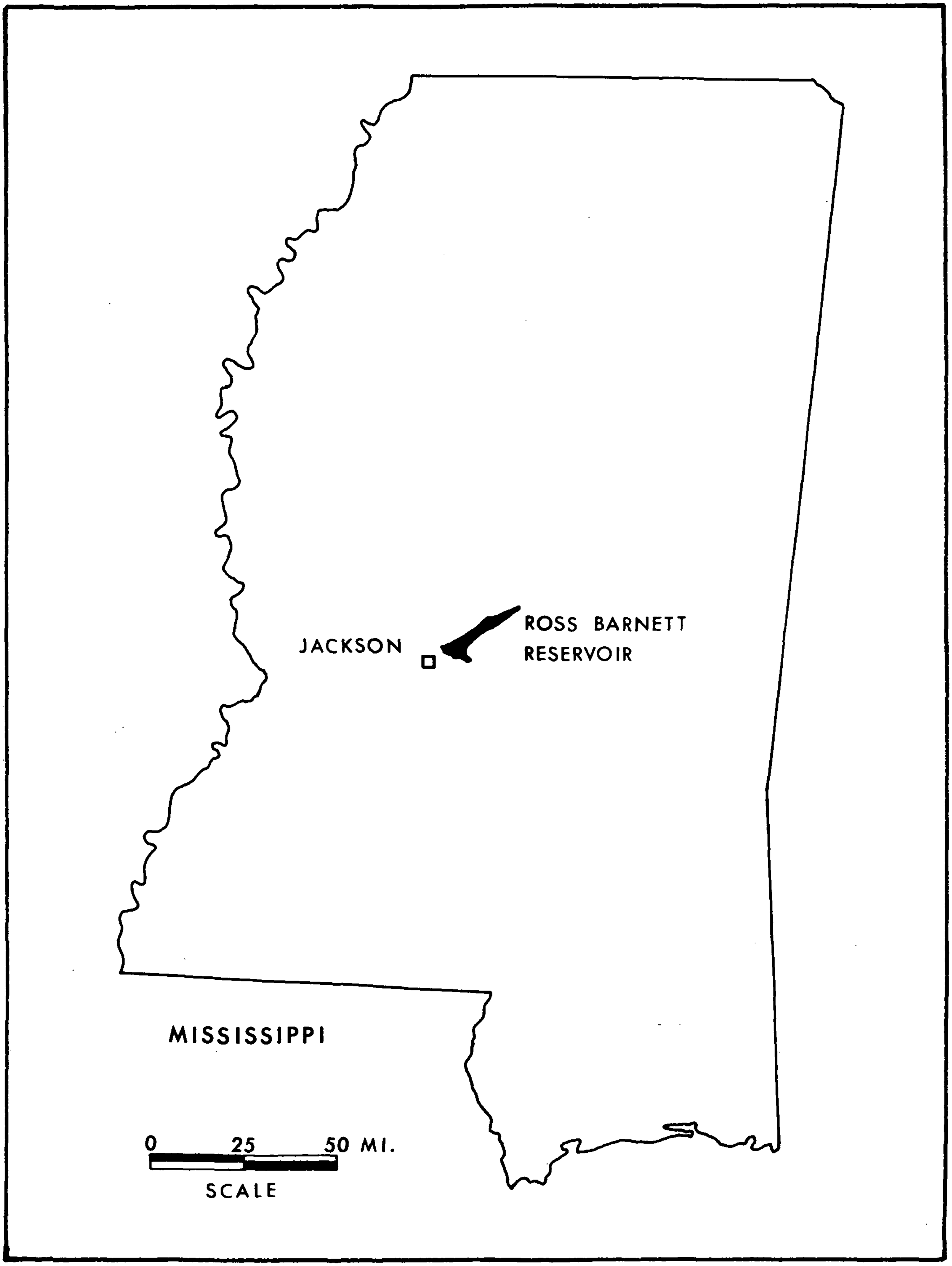

ROSS BARNETT
RESERVOIR
JACKSON
MISSISSIPPI
0
25
50 MI.
SCALE

Figure 1

several sites were selected as possible areas of study. Typological sketch maps of each potential test site were compiled from the November, 1971, imagery for use in field reconnaissance. The final selection was based upon the maps and on four lengthy field excursions which indicated that landforms, drainage networks, vegetation associations and cultural modifications on the landscape of the selected test site were generally characteristic of the entire Reservoir area.

The selected test site contains approximately forty square miles (Fig. 2). It is bounded on the south by state road 468, on the east by state road 471, on the west by an imaginary line approximately one-quarter mile off shore in the Reservoir, and on the north by an imaginary line connecting the northern portion of Mill Creek north drainage basin with state road 471. Roughly 39 per cent of the area is in forest, approximately 25 per cent in open land, cu. 29 per cent in water, and approximately 7 per cent in residential and recreational usages.

The focal area of the test site is a seven mile long shoreline strip. Its physical characteristics (terrain and vegetation) and its cultural traits expressed in land use forms are representative of the Reservoir area as a whole. Near-shore water sampling points are representative of the Reservoir's land-water interface association.

The primary objectives for the first year were (1) to select representative study target areas in water and on

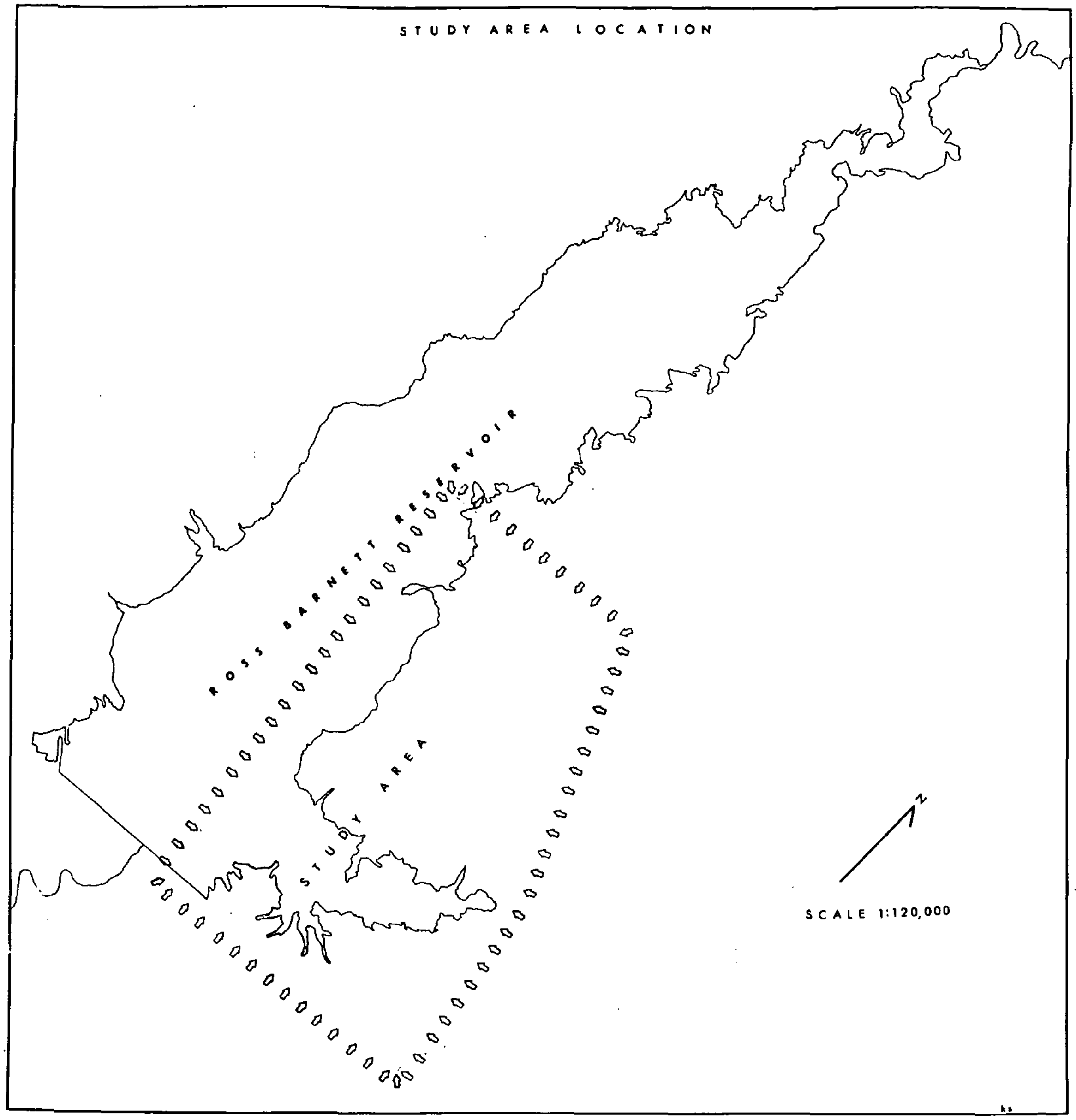

STUDY AREA LOCATION
ROSS BARNETT RESERVOIR
STUDY AREA
N
SCALE 1:120,000

Figure 2

land, (2) to collect ground truth data from these areas, and (3) to correlate ground truth data with I^2S multi-band imagery. Although the relationships between land use as source areas for sediment and water as the recipient of sediment were observed, this was not the primary objective of the first year's study. At this point it should be understood that this is a unified project studying a specific ecological-environmental system. However, in order to approach the system its components must be recognized and studied. Therefore the first year of the study has been devisive in that two separate studies--one focused on water and the other on land--have been conducted. The two studies will be joined together during the second and third years as each places more emphasis on linkages between sediment source areas and sediment collection areas.

The following synopsis of the first-year's work may seem methodologically disjointed. However, two approaches were necessary because of the nature of the phenomena studied. In order to establish correlation of water quality with I^2S multi-band imagery tonal registrations, sample sites had to be closely monitored. An inductive approach was followed in establishing relationships between water quality and imagery. Water was first analyzed for sediment and then correlated with the imagery. The deductive method was used in determination of land use and physical site characteristics. This approach was necessitated because specific unit areas of land, i.e., source areas of sediments, had to be identified from the imagery. Therefore the I^2S multi-band imagery was analyzed for significant tonal registration and then correlated with known land use parameters.

B. Imagery

1. Flight plan and imagery acquisition, June, 1972.

Six flight lines at an altitude of 10,000 feet and one flight line at 3,000 feet were requested for the June, 1972, mission. The 10,000 foot altitude lines were planned to provide complete overlapping coverage of the test site. The 3,000 foot altitude line was designed to cover only the shoreline along the southeast shoreline of the Reservoir. Imagery systems requested included color infrared film exposed through both 40 mm and 250 mm Hasselblad cameras, multi-band imagery acquired through the I^2S four-band camera, and thermal imagery from the RS-18 scanner (Appendix I).

Imagery received from the June, 1972, mission did not cover the prescribed test site. Flight lines at 10,000 feet were not flown as planned and as a result gaps in coverage exists in some areas while other areas have double and triple coverage. Lack of coverage negated water sampling sites at the northern portion of the study area (flight line terminated prematurely, and prevented analysis of several primary land use sites near the center of the study area. Multiple coverage over the southern portion of the study area, however, was beneficial for comparative purposes (Appendices I and II).

2. Imagery quality, June, 1972.

I^2S multi-band imagery was satisfactory for both water and land use studies. Imagery from the RS-18 scanner was complicated by tonal discontinuities or streaking apparently caused by a power drain when the I^2S camera shutter was triggered. The MTF support group has since eliminated this problem. The Hasselblad imagery, for the most part, was excellent. However, the 250 mm imagery, particularly, has been of little use and therefore was not requested for the November, 1972, mission (Appendix III).

The appearance of sunspots on several frames of I^2S imagery made correlation of imagery tonal qualities with sample water data impossible. Sunspots did not affect imagery correlation with land use studies.

3. Imagery request and acquisition, November, 1972.

Seven 10,000 foot altitude flight lines and four 3,000 foot flight lines, to provide complete coverage of the study area and multiple coverage of certain segments of the study area, were requested for a morning mission during November, 1972. Furthermore, the 3,000 foot flight lines and selected 10,000 foot flights were to be reflown in the afternoon. Both I^2S and RS-18 imagery were requested for each flight line.

Only the four 3,000 foot flight lines of the morning mission were actually flown. The remainder were aborted due to excessive cloud cover and high winds. That the four low altitude flight lines were flown was an achievement for the MTF support group. These lines were flown as requested.

4. Imagery quality, November, 1972.

Duplicates of the November, 1972, imagery have not been made available to the U.S.M. research team. However, a quick-look examination of the original I^2S imagery and of processed RS-18 thermal imagery indicates that it is probably acceptable.

SECTION II
LAND USE STUDY AND IMAGERY ANALYSIS

A. Introduction

1. Objectives

The objectives of the land use study of the Ross Barnett Reservoir area are focused on the following: (1) the development of land use classification keys based upon I^2S multi-band imagery, (2) application of the classification keys, in concert with other remotely sensed imagery, for identification of source areas and site characteristics of sedimentation, and (3) identification of possible transport patterns of sediments from source areas to the Reservoir. The primary thrust of the first year has been the development of land use classification keys based upon June, 1972, I^2S multi-band imagery. The second goal of the first year's study was the application of the classification scheme as a tool for identification of sediment source areas. Although the investigation of linkages between sediment source areas and the Reservoir was not a primary aim of the first year's study, it was undertaken in a cursory manner. A detailed examination of progress and goals accomplished is presented elsewhere in this paper.

2. Test site characteristics.

Relief in the immediate vicinity (five miles) of the Reservoir study area does not exceed 150 feet. Relief, however, of the primary land test sites (within two miles of the shoreline) is less than forty feet. Pelahatchie Creek, a fourth order stream, Mill Creek south, a second order stream, Mill Creek north, a third order stream, and one other second order stream are the only permanent streams that flow through the study area (Fig. 3). The juncture of Mill Creek south with Pelahatchie Creek has been inundated by the Reservoir, forming Pelahatchie Bay. The rise in base level caused by the Reservoir has resulted in the development of extensive marsh lands along the lower courses of each stream, particularly Pelahatchie Creek and Mill Creek south.

Phytomorphic vegetation associations appear to be related to relief. Upland areas tend to be mixed deciduous hardwoods and conifers or pure stands of conifers. Closed canopies are common. The lowland forests are predominantly closed canopy hardwoods. Agricultural areas and old fields are characteristic of the Barnes Prairie-Fannin Landing area. Old fields on better drained uplands and slopes contain broomsedge and other volunteer scrub plants. Cattails are prevalent along the shore in areas that are periodically inundated. In areas that are subjected to greater flooding more water tolerant species of reeds and grasses are found.

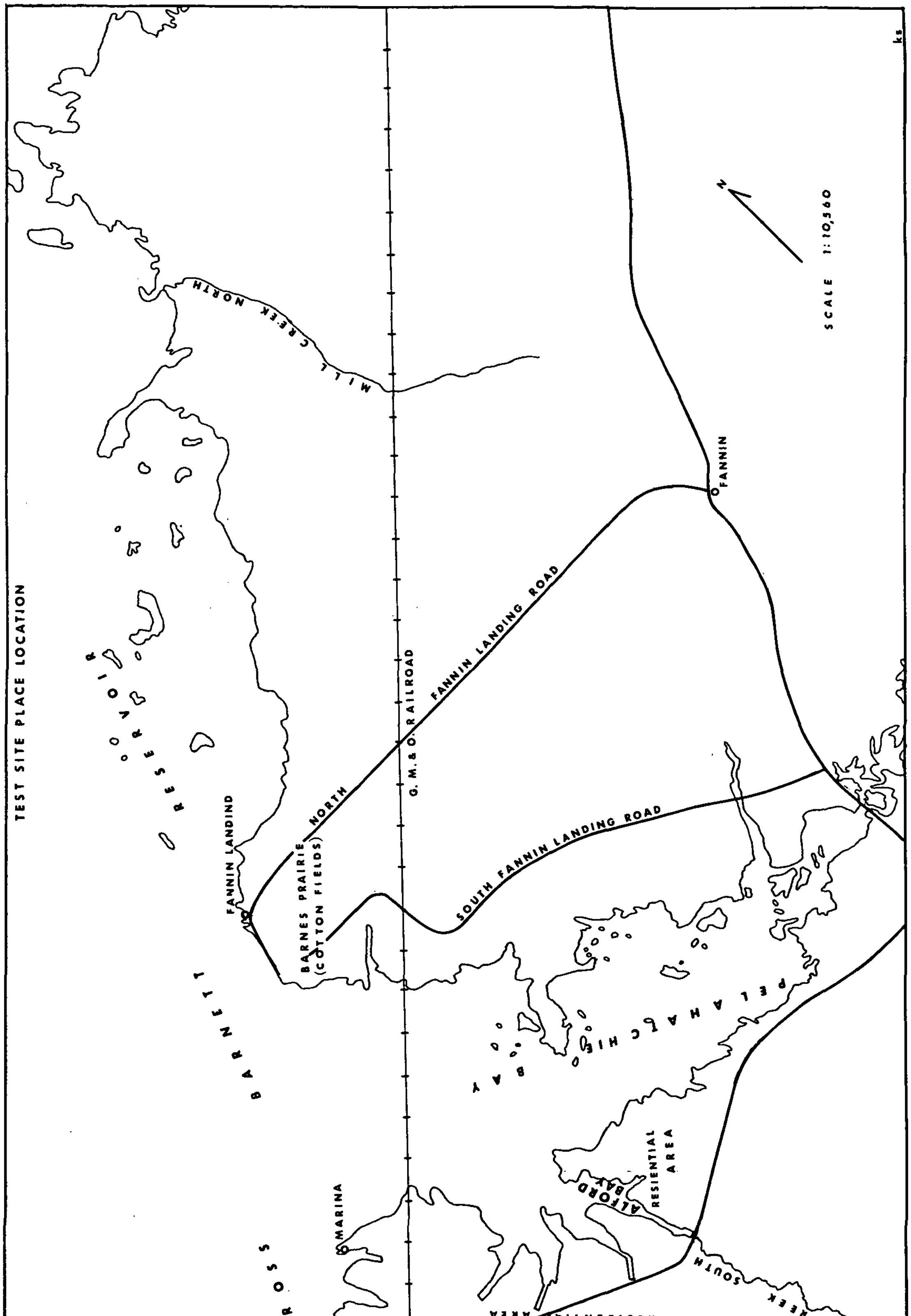

TEST SITE PLACE LOCATION
MILL CREEK NORTH
RESERVOIR
BARNETT
ROSS
FANNIN LANDIND
BARNES PRAIRIE
(COTTON FIELDS)
NORTH FANNIN LANDING ROAD
G. M. & O. RAILROAD
SOUTH FANNIN LANDING ROAD
FANNIN
PELAHATCHIE
BAY
N
SCALE 1:10,560
MARINA
RESIENTIAL AREA
ALFORD BAY
RESIDENTIAL AREA
MILL CREEK SOUTH
ks

Figure 3

Crops, primarily cotton and soybeans, and pasture are found on the interfluves and upland slopes. Within the study area croplands are limited to the Barnes Prairie area between Fannin and Fannin Landing (Fig. 3).

B. Ground Truth

1. Collection of ground truth data.

Establishment of base line land use data is for two purposes. First, general information concerning the test site is needed for accomplishment of the three-year goals. Secondly, more detailed information is needed to support analysis of each overflight. Methods of obtaining land use data in support of the overall project goals and in support of the first (and subsequent) overflights included: (1) analysis of the 1:60,000 and 1:120,000 scale high altitude imagery of November, 1971; (2) ground photographic and mapping traverses; (3) interviews with residents of the test site area and with local agency representatives; (4) soil sampling; and (5) collection of weather information.

Color and color infrared 35mm photographs were taken of a variety of land use activities in the study area on four different occasions prior to the June, 1972, overflight. The photographs were keyed to maps and were one input into the development of a land use classification matrix. A road traverse was made through the study area in June, 1972, prior to the overflight, and land use categories were noted on a sketch map. Selection of "training fields," representative of test site land use, was made based on the road traverse and photographic forrays (including two from boats) in concert with analysis of the November, 1971, 1:60,000 and 1:120,000 scale imageries. Training fields were selected not only for their characteristic admixture of natural and culturally modified land uses, but also for their representative physiographic nature. Test fields were selected for the same reason, however no further ground truth data was gathered on them until after correlation with the I^2S imagery.

Interviews with the owner-operators of cropland training fields verified field boundaries, type of crops in the fields, dates they were planted, and types and amounts of fertilizers and soil amendities applied. Data concerning cultivation practices was not gathered at that time. Additional training fields and test fields were established in residential, recreational and forest areas. Data concerning residential and recreational development and construction were noted. Photographs of training fields and test fields were made during both the June, 1972, and the November, 1972, overflights and on intervening trips to the test site.

In order to preserve the integrity of I^2S imagery interpretation tests, one project graduate student was not permitted in the study area nor allowed access to ground truth data until after partial analysis of the June, 1972, imagery was completed. In this manner interpretational keys developed from the training sites were validated. Ground truth field checks and interviews with test field owner-operators were conducted after interpretation of the I^2S imagery.

To facilitate the collection and analysis of ground truth data in support of the first overflight, the land use data site was divided into target areas. The first target area is located on north Fannin Landing Road one-half mile to one mile east of Fannin Landing. The site borders the Reservoir and is felt to be representative of agricultural, forested, and idle land in the study area. The area, known to the USM research team as the "cotton fields" area, is located on an interfluve between two inlets of the Reservoir. Cultivated and idle land occupy both the flat upland ridge and the gentle slopes. Portions of the "cotton fields" area come within 100 yards of the Reservoir. The "cotton fields" area is well drained. The second target area includes the new residential area south of Pelahatchie Bay and east of the Gulf, Mobile, and Ohio Railroad right-of-way. This area, known as Pelahatchie Bay residential area is undergoing rapid change as land is cleared and new houses are constructed. The relief in this area is slight, less than twenty feet, and much of the surrounding land, associated with the juncture of Mill Creek south with Pelahatchie Creek, is swampy. Dredging in Pelahatchie Bay and along Mill Creek south is evident. A third area, Mill Creek north, was field checked but later eliminated as an active target area for the 1972 overflights. It is a relatively low lying, level area of mixed deciduous forests. The land-water interface region is poorly defined because of extensive marshland.

(a) The Cotton Fields area

The cotton fields target area is the primary agricultural area in the near-vicinity of the Reservoir (Fig. 4). That it is a viable production area is attested to by the fact that one of the two cotton gins in Rankin County is located in Fannin. However, agriculture is not the only activity or land use that occurs in the cotton fields area. A boat landing and an asphalt parking lot are located at Fannin Landing. In this area and along the north side of Pelahatchie Bay, west of the Gulf, Mobile, and Ohio Railroad right-of-way, are unstructured camping and fishing areas. A lodge, owned by a fraternal group, also is located at Fannin Landing. Within the general vicinity of the cotton fields, particularly on central and south Fannin Landing roads, are rural non-farm residences. Planted pines and other natural-growth forests are more prevalent along central and south Fannin Landing roads than along north Fannin Landing Road.

The primary agricultural area parallels north Fannin

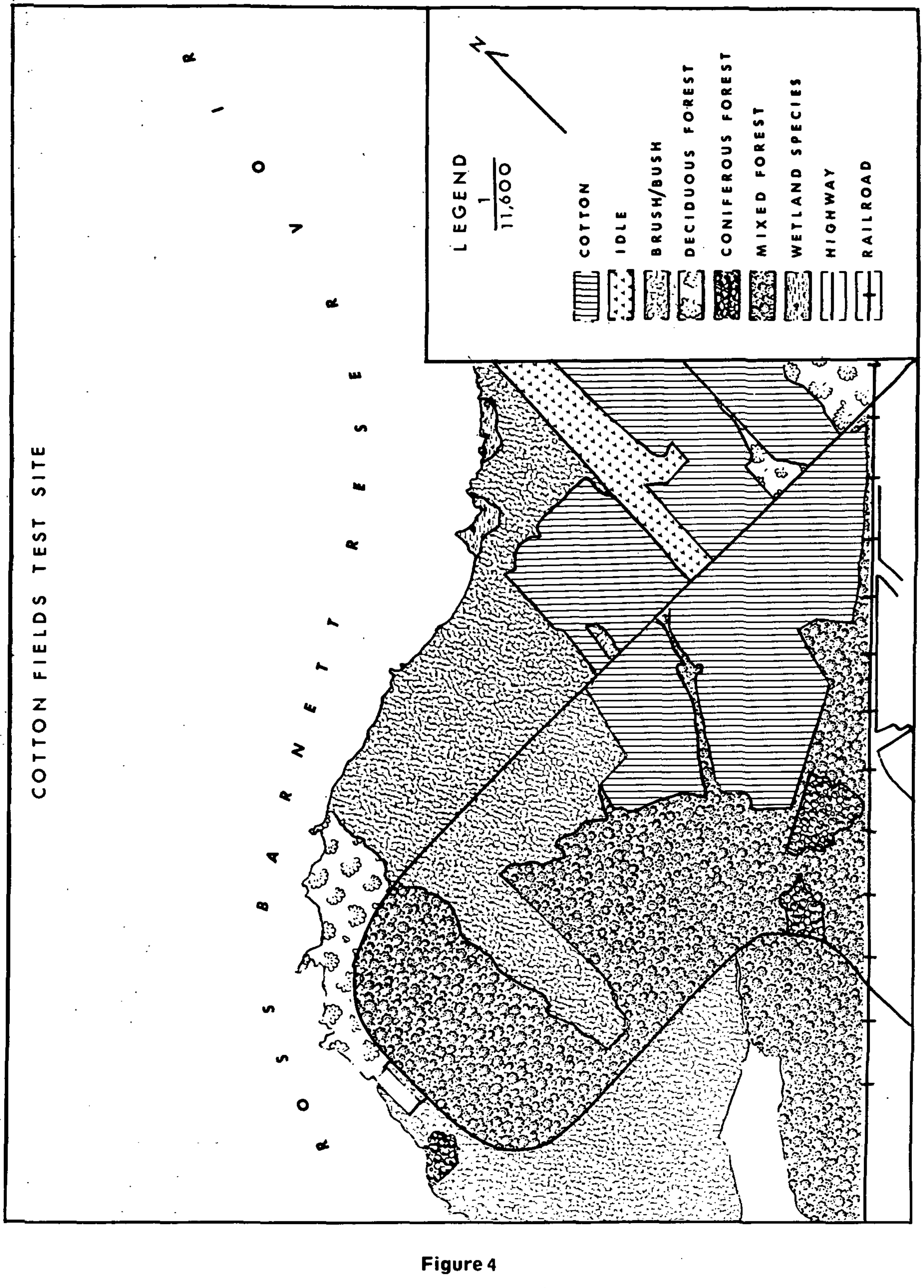

COTTON FIELDS TEST SITE
ROSS BARNETT RESERVOIR
LEGEND
1/11,600
N
COTTON
IDLE
BRUSH/BUSH
DECIDUOUS FOREST
CONIFEROUS FOREST
MIXED FOREST
WETLAND SPECIES
HIGHWAY
RAILROAD

Figure 4

Landing Road from Fannin Landing to Fannin, approximately three and one-half miles. Six farmers owned or leased all cultivated fields in the area. Crops produced in summer, 1972, included corn, cotton, and soybeans. Permanent pastures of varying quality also were found in this area. Idle land was not characteristic of agricultural landholdings. However, former cropland now owned by the Pearl River Valley Water District was idle and in various stages of natural regrowth. Intermixed with the agricultural lands were several non-farm residences, one of which had approximately two acres of luxuriant Bermudagrass.

Interviews with the owner-operators of the agricultural training fields indicated that the first 1972 cotton crop was planted during the third week of April while the last cotton field was planted during the third week of May. Soil amendities applied to the cotton fields included lime, ammonium nitrate, and various admixtures of fertilizers. Soybeans were planted during the last week of May and received both lime and fertilizers but no ammonium nitrate. Planting of corn began during the last week in April and continued into the third week of May. Lime, fertilizers, and ammonium nitrate were applied to each corn field except one in which no ammonium nitrate was spread.

Pastures varied from well maintained, highly improved to poorly maintained. The farmers practiced different cattle rotational systems on pastures, and one farmer maintained his pasture exclusively for hay. Soil amendities and fertilizers ranged from four applications a year to none. Mowing varied from twice a year to none. Pasture grasses included coastal Bermuda, common Bermuda, carpet, and Bahia. Carrying capacity on all pastures was less than one cow to four acres. At the time of the June overflight only two pastures had been cut since the onset of the growing season. One pasture had been planted in ryegrass for haying during winter.

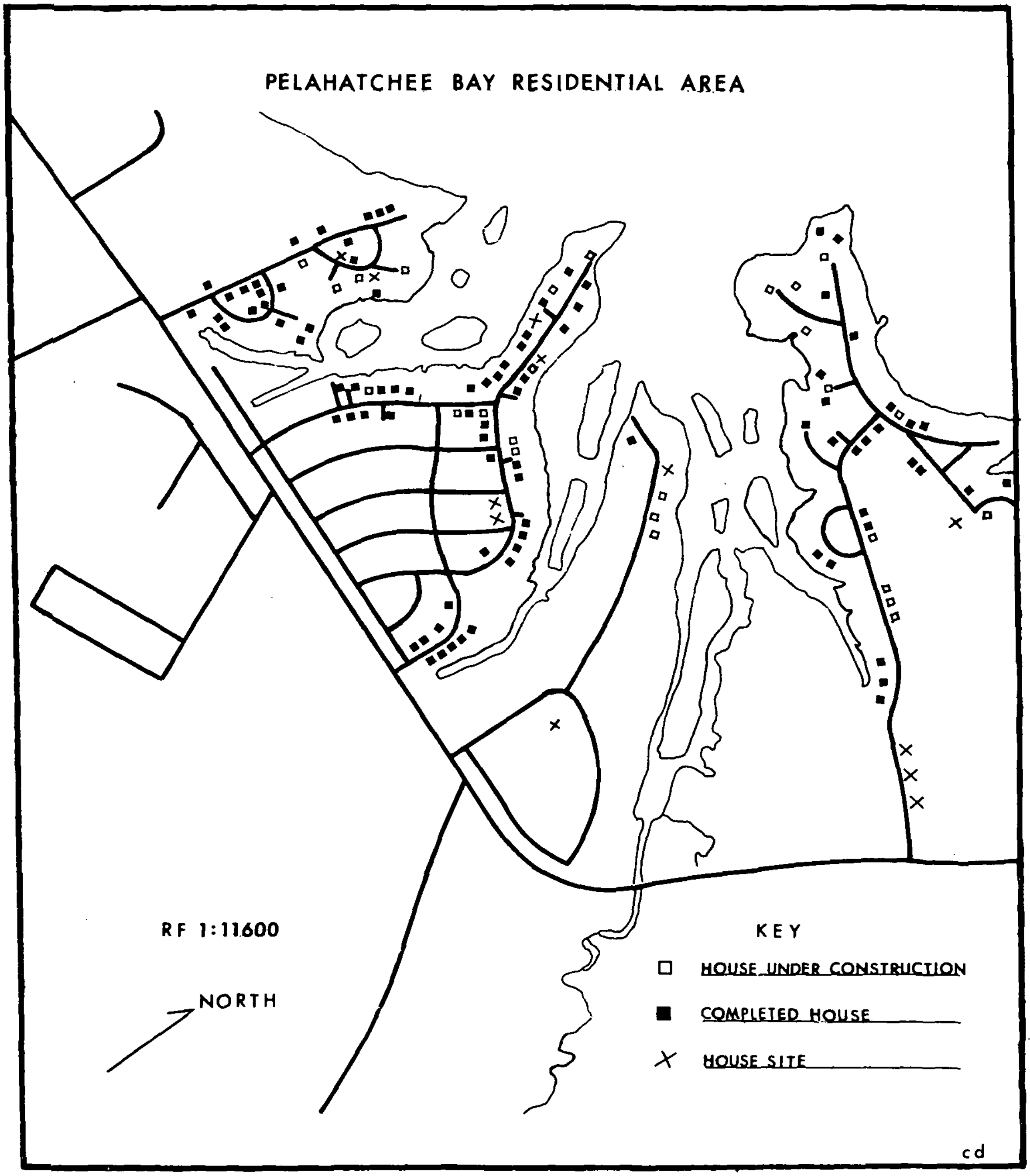
Runoff from the cotton fields agricultural area is in two directions. Those fields on the north side of North Fannin Landing Road discharge directly into the Reservoir via intermittent streams, rills, and sheet run off. Those fields on the south side of North Fannin Landing Road drain southward into a second order stream that enters the Reservoir west of the Gulf, Mobile, and Ohio Railroad grade. Drainage east of the railroad and south of North Fannin Landing Road is into Pelahatchie Creek, while most of the run off north of the road and east of the railroad is in the watershed of Mill Creek north.

The training and test fields, for the most part, are west of the Gulf, Mobile, and Ohio Railroad. More than one-half of the agricultural fields in the study, however, are on the north side of North Fannin Landing Road. None of the fields interface directly with the Reservoir, although one is within 100 yards of the shoreline. Separating the fields from the Reservoir is a buffer zone owned by the Pearl River Valley Water Supply District. Vegetation in the buffer zone ranges from water tolerant species to various types of secondary volunteer species of brushes and grasses to forests. The buffer zone between the Reservoir and the closest cultivated field is characterized by water tolerant plants including cattails but few trees, indicative that the area was at one time open land that is now somewhat boggy.

Whereas the water-land interface in the immediate vicinity of the cotton fields target area is gradual and marshes exist, it is sharp and well defined at Fannin Landing and along the north shore of Pelahatchie Bay. In some areas there is as much as a three foot drop from land to water. Undercutting is prevalent on north and west facing shorelines that exhibit relief of two or three feet.

(b) Pelahatchie Bay Residential area

Pelahatchie Bay residential area is composed of five restricted communities (Fig. 5). Approximately 120 houses, each valued at more than $30,000.00, were either under construction or had been completed at the



PELAHATCHEE BAY RESIDENTIAL AREA
RF 1:11600
NORTH
KEY
HOUSE UNDER CONSTRUCTION
COMPLETED HOUSE
HOUSE SITE
cd

Figure 5

time of the June, 1972, overflight. The land on which the communities are established is owned by the Pearl River Valley Water Supply District and leased to the residents under long term contracts. Construction of homes is by private contractors on both speculative and contract basis. Dredging in Pelahatchie Bay and in Mill Creek south provides water access to the Reservoir and enables many of the residents to maintain docks and boathouses in their backyards. One characteristic of construction within the area has been the lack of clear cutting. Homes are nestled in closed canopy pine forest and the aesthetic nature of the setting is preserved and, for the most part, complimented by housing architecture. Other characteristics of the communities included: underground utilities, asphalt roads (although some roads are yet to be paved), and partially riprapped shorelines.

The Audubon Point residential community was selected as the training field within the Pelahatchie Bay residential target area. Selection of this community was based on the vegetation found in the area (primarily pine, but some hardwoods were evident), its topographic relief, and the quantity and stage of house construction. Houses on water front lots were under construction at the time of the overflight whereas most water front construction had been completed in the other residential communities in the Pelahatchie Bay region. In addition, there was an admixture of completed and unfinished housing units in non-water front locations. Inventories were made of houses completed or under construction, and of land prepared for construction. Data on roof types, roof compositions, roof geometry, conditions of yards, and types of driveways were noted. Access to the Reservoir, types of shoreline, and possible sediment linkages also were noted.

C. Ground Truth Analysis

November, 1971, 1:60,000 and 1:120,000 scale imageries, U.S. Geological Survey 7½ minute quadrangle sheets, U.S. Geological Survey 15 minute quadrangle sheets, and a Pearl River Valley Water Supply District 1:31,680 map were used to prepare base maps for ground truth data collection. Maps were prepared for both land use target areas and near-shore target areas.

From experiences in the test site area prior to and during the June, 1972, overflight, a tentative land use classification matrix was prepared. The scheme was inductively organized, treating the smallest land use type first and then grouping similar types in categories. The resulting matrix is found in Table I. Training fields were classified and located on base maps as were photographic sites and land use information gathered from automobile and boat traverses.

An additional ground truth measurement, not implemented for the June, 1972, mission but utilized in November, was the

ROSS BARNETT RESERVOIR REMOTE SENSING PROJECT
GROUND TRUTH LAND USE CLASSIFICATION SCHEME

TRANSPORTATION
- Paved Roads
- Dirt Roads
- Parking lots
- Rail-roads
- Bridges

COMMERCIAL
- Single Unit Stores
- Multiple Unit Stores
- Storage Facilities
- Processing Plant

HOUSING
- Single Family Housing (non-rural)
- Single Family Housing (rural)
- Apart-ments
- Trailers

AGRICULTURAL
- Cotton
- Soybeans
- Corn
- Pasture
- Idle
- Other

RECREATIONAL
- Picnic Areas
- Marinas
- Swimming Areas
- Boat Docks
- Camping Areas
- Other

FORESTS
- Conifers
- Deciduous
- Mixed
- Cut-over

WET LANDS
- Lakes
- Streams
- dredged
- Marsh
- non-dredged
- Swamp
- Shoreline rip-rapped non rip rapped

TABLE 1

gathering of soil samples and the measurement of soil moisture. Soil data gathered in November has been analyzed but has not been correlated with the November, 1972, I^2S imagery.

Field monitoring of the study area did not cease with the June, 1972, overflight. Several trips were made to the test site during late summer and fall. The nature of these trips were two-fold: (1) to correlate and validate I^2S imagery analysis on both training and test fields; and (2) to determine if any changes were occurring on the training fields that might be significant for the November, 1972, overflight. Several farm-management decisions affecting land use were discovered during these trips. It was noted that approximately one-third of the cotton fields were treated with a pre-harvest chemical defoliant. Also, it was discovered that all cotton and soybeans were harvested mechanically. The latter fact is important because the use of heavy machinery compacts the soil and increases run off. In addition, it was discovered that a forested area of approximately twenty acres was being cleared for development of a subdivision.

D. Imagery Interpretation

1. Method of I^2S Imagery Interpretation

Imagery analysis has been undertaken predominantly with the International Imagery Systems Model 600 color-additive viewer (referred to as I^2S hereafter). The I^2S viewer presents 625 possible wavelength-filter combinations, not including possible variations in these combinations that may be introduced through modulation of light intensities. The complexities of the I^2S viewer necessitated the development of a uniform method of imagery analysis.

Imagery analysis and recording was facilitated by the use of a transparent eight inch by eight inch grid that consisted of sixty-four one inch squares and by especially constructed index record sheets. The transparent grid enabled the investigators to locate and record specific land use features found on the imagery. The index sheets were designed to record image waveband, filter, and light intensity combinations in two ways: (1) by frame and (2) by land use typology (Appendices IV and V). The first method of recording involved comprehensive analysis of each frame. All land use features on a frame were systematically scanned for the best possible settings that enhanced their shape, tone, texture, and contrast. The best settings, with appropriate comments, were recorded on the "frame" index sheets. The second method was similar to the first except that only one land use typology was studied. Once the best settings and appropriate comments were recorded, the next frame was analyzed for the same feature. Land use typology data were recorded on "typology" index sheets.

Recording of imagery data eventually was transferred from the index sheets to maps that had been constructed directly from the I^2S imagery. These maps were no more than line sketches of shoreline, streams, and roads traced on acetate overlays of each I^2S frame. The acetate sheets were composited and a base map at a scale of 1:11,680 was constructed. After an imagery derived land use classification scheme was developed, the acetate overlays were reused to record locations of specific typologies. The typologies were then transferred from the overlays to the base map.

2. I^2S Imagery Analysis

The primary thrust of land use I^2S imagery analysis is to determine and classify the characteristics of land use as sediment source areas. Two types of data must be analyzed in order to determine sediment source site characteristics. The first type of data needed is land use characteristics to include both natural and cultural uses. The second type of data must encompass analysis of the physical characteristics of the landscape regardless of land use. Data of the second type includes drainage, vegetation, and soil characteristics. Although analysis of I^2S imagery during the first year focused on determining land use typologies, physical site characteristics were not completely neglected. Two classification schemes were derived from the I^2S imagery to reflect both land use typologies and site characteristics.

Determination of land use characteristics from I^2S imagery was based on correlation of imagery registration with training field-ground truth information. Identification keys were established from these correlations and applied to the test fields. Verification of interpretation keys was accomplished by field checks and interviews. Based on the interpretation keys and ground truth information (primarily the Ground Truth Land Use Classification Matrix), each I^2S frame was analyzed for land use components. Upon completion of comprehensive analysis of each I^2S frame, a deductive land use classification matrix was devised (Table 2). All subsequent typological identification and classification of I^2S imagery followed this scheme.

The classification scheme is a four level matrix of six broad (Level I) land use typological categories, each of which is composed of a number of sub-categories. Identification of Level I typologies was relatively easy. Although no significant problems were encountered in distinguishing Level II categories, interpretation and classification became more difficult at Levels III and IV. Interpretation of land use components and characteristics was enhanced through a variety of combinations of I^2S waveband, filter, and light intensity settings. Table 3 presents selected examples of settings used to enhance specific land use components at Levels II, III, and IV.

Category 1, agriculture. Separation of cropland (11), pasture (12), and idle land (13) at Level II presented little problems except in the case of idle land. The best settings for enhancement of pastures were: IR band on blue filter with a light intensity of 9.0; Red band on clear filter with a light intensity of 5.0; and both the

TABLE 2

ROSS BARNETT RESERVOIR-REMOTE SENSING PROJECT
LAND USE CLASSIFICATION MATRIX

Level I	Level II	Level III	Level IV
1. Agricultural			
	11 Cropland		
		111 Cotton	1111,1121,1131 Preparation
		112 Soybean	1112,1122,1132 Growth State
		113 Other	1113,1123,1133 Harvested
			1114,1124,1134 Fallow
	12 Pasture		
		121 Improved	
		122 Unimproved	
	13 Idle		
2. Forest Lands			
	21 Planted		
	22 Natural		
	23 Cut over		
3. Recreational			
	31 Picnic areas		
		311 With Swimming Facilities	
		312 Without Swimming Facilities	
	32 Swimming Facilities		
	33 Overnight camping		
		331 Trailers	
		332 Tents	
	34 Marinas		
	35 Boat Landings		

Level I	Level II	Level III	Level IV
4. Built up Areas			
	41 Residential		
		411 Single Family Dwellings-agglomerated	4111,4121,4131 Completed
		412 Multi-Family Dwellings	4112,4122,4132 Under Construction
		413 Rural Single Family Dwellings-non-agglomerated	4113,4123,4133 Land Cleared for Development
		414 Trailers (non-recreational)	
		415 Out Buildings Associated with farmstead	
	42 Commercial		
		421 Single Structure Commercial	
		422 Shopping centers	
	43 Industrial		
		431 Processing	
		432 Storage	
		433 Assembly	
5. Transport Routes			
	51 Roads		
		511 Paved	
			5111 Concrete
			5112 Asphalt
		512 Dirt	
		513 Gravel	
	52 Parking		
		521 Paved	
			5211 Concrete
			5212 Asphalt
		522 Dirt	
		523 Gravel	

Level I	Level II	Level III	Level IV
	53 Railroads		
		531 Mainline	
		532 Side Track	
	54 Pipeline/Powerline Rights-of-way		
6. Water Bodies/ Wet Lands			
	61 Lakes/Farm Ponds		
	62 Shoreline/Marsh		
	63 Streams		

TABLE 2-A

ROSS BARNETT RESERVOIR-REMOTE SENSING PROJECT
PHYSICAL SITE CHARACTERISTICS

THEMATIC OVERLAYS

	Level I	Level II
A Exposed Soil	1A 100% Exposed - (No Vegetation)	
	2A 50-99% Exposed	
	3A 25-49% Exposed	
	4A Less Than 25% Exposed	
B Vegetation		
	1B Cropland/Pasture/Culturally Maintained Grasslands	
	2B Coniferous Forest	2B1,3B1,4B1 More than 75% Crown Cover
	3B Deciduous Forest	2B2,3B2,4B2 50-74% Crown Cover
	4B Mixed Deciduous Forest	2B3,3B3,4B3 25-49% Crown Cover
		2B4,3B4,4B4 Less than 25% Crown Cover
	5B Cut Over Land	
	6B Brush-Bush-Broomsedge	
	7B Wetland Species	
C Drainage System		
	1C 1st Order System	
	2C 2nd Order System	
	3C 3rd Order System	
	4C 4th Order System	

TABLE 3

ROSS BARNETT RESERVOIR REMOTE SENSING PROJECT
LAND USE STUDY
I^2S SETTINGS

TYPE	WAVE BAND, FILTER, INTENSITY				COMMENTS
	IR	RED	GREEN	BLUE	
Pastures	Blue 9.0	Clear 5.0	Off	Off	Register in blue-gray, depending upon cover conditions. Unimproved pastures appear darker in color and have rougher texture.
	Red 4.5	Red 3.0	Green 9.0	Off	
Cotton	Off	Red 6.0	Green 9.0	Blue 6.0	Cotton fields are darker red than adjacent soybean fields. Preparation, growth state, and fallow conditions were hard to determine. More research needed in this area.
	Clear 9.0	Off	Green 9.0	Blue 6.0	Better differentiation was noted between cotton fields and surrounding fields. Field texture is somewhat "smoother" than soybean field.
Soybean	Off	Red 6.0	Green 9.0	Blue 6.0	Soybean fields appear in lighter red tones than adjacent cotton fields.
	Clear 9.0	Off	Green 9.0	Blue 6.0	
Idle Fields	Clear 9.0	Off	Green 9.0	Blue 6.0	Idle fields are hard to identify. Confusion with pastures is a problem.

TYPE	WAVE BAND, FILTER, INTENSITY IR	RED	GREEN	BLUE	COMMENTS
	Clear 5.0	Off	Green 6.0		
Metallic Roofs	Clear 6.7	Off	Green 8.0	Red 9.0	Metallic roofs appear gray-white.
Housing (Constructed)	Clear 8.0	Off	Off	Off	Constructed buildings appear in black or dark gray tones, based on roof type.
	Off	Red 5.0	Green 9.0	Off	Alternate setting--houses appear red in color. Quality not as good as above setting.
Construction Sites (Cement)	Clear 9.0	Off	Green 8.3	Off	Concrete shows well and, when correlated with shape, is a good indicator of construction taking place.
	Red 8.0	Red 5.0	Green 7.0		
Paved Roads	Clear 9.0	Off	Green 8.3	Off	Paved roads appear green. With different band settings, roads appear in the darkest tones.
	Off	Red 6.0	Green 9.0	Blue 6.0	Paved roads appear light blue.
Dirt Roads	Red 8.0	Red 5.0	Green 7.0	Off	Dirt roads appear red.
	Off	Red 6.0	Green 9.0	Blue 6.0	Dirt roads appear light red.

TYPE	WAVE BAND, FILTER, INTENSITY				COMMENTS
	IR	RED	GREEN	BLUE	
Exposed Soil	Off	Red 6.0	Green 9.0	Blue 6.0	100% exposed soil appears red. As the percent decreases there is a decrease in the darkness of red.
	Blue 9.0	Clear 5.0	Off	Off	
Natural Forest (deciduous)	Blue 9.0	Clear 5.0	Off	Off	Hardwoods stand out in a vivid shade of blue along possible drainage ways.
	Clear 8.0	Off	Off	Off	Deciduous trees appear a dark gray or black in color.
Natural Forest (conifers)	Blue 9.0	Clear 5.0	Off	Off	Conifers appear in a light shade of blue.
	Clear 8.0	Off	Off	Off	Conifers appear gray-white as compared to deciduous appearing a dark gray almost black.
	Clear 4.5	Red 8.5	Green 8.5	Off	Conifers appear light green in color.
Planted Forest					No settings were found that differentiated either planted conifers or hardwoods. Planted trees were noted near the marina--pattern of planted trees is the best method of detection.
Brush-Bush-Broomsedge	Red 3.9	Red 4.5	Green 9.0	Off	Brush and broomsedge appear milky green.

TYPE	WAVE BAND, FILTER, INTENSITY IR	RED	GREEN	BLUE	COMMENTS
Drainage Systems (streams)	Clear 7.0	Red 7.0	Off	Off	First and second order streams are hard to locate in thick brush or forest. Darker tones indicate drainage ways.
Drainage Systems (streams)	Clear 7.0	Off	Off	Blue 8.0	Third and fourth order streams appear dark blue.

Green and Blue bands off (Table 3). Pasture in poor growth state appeared in darker tones than did either improved pasture or idle land.

Difficulty in determining cotton fields from soybean fields was encountered at Level III. However, discernment between the two resulted with the following I^2S viewer settings: IR waveband on clear filter at light intensity of 9.0; red waveband off; green waveband on green with a light intensity of 9.0; and blue waveband on blue filter with a light intensity of 6.0. Cotton appears in darker tones than soybeans at the time of the overflight and for the particular growth state of each crop. Unfortunately, only one soybean field was covered by the June, 1972, overflight, so no comparison of growth states could be made. It appears that there is no variation of I^2S viewer settings that will significantly enhance differences between growth states of cotton. If there is an appropriate setting, it has yet to be discovered.

The Forest Lands category was broken into three classifications at Level II. No further sub-classifications were attempted. It was felt that land use would be expressed best if consideration were given only to the cultural modifications that have (or have not) occurred on the landscape. Therefore, forest as a land use type was considered as planted, natural, or cutover. As might be expected, no combination of mini-addcol settings have been found that differentiate tones between planted and natural growth forests. Traditional photographic interpretation techniques must be used to discern between the two. Distinguishing characteristics of phytomorphic association was identifiable and is discussed under Physical Site Classification elsewhere in this report.

Identification of components of Category 3, Recreational land use, involved adaptation of mini-addcol settings for both agriculture land use (Category 1) and Built Up Areas (Category 4). Recreational areas were characterized by an admixture of the following land uses: (1) buildings of various sizes, shapes, and functions; (2) cleared or thinned forest lands, some with planted improved grasses, for picnicing, camping, or trailer parking; (3) roads and parking lots; (4) rampways for boat launching; and (5) marinas. In most instances recreational areas were recognized because of the characteristic spatial patterns of their component parts, not because of exotic I^2S viewer settings. However, inventory and identification of component parts were facilitated by certain I^2S viewer tonal combinations. The metal roofs of trailers nestled under a pine forest canopy were identifiable by setting the IR waveband on clear at a light intensity of 6.7, turning off the red waveband, placing the green band on green at a light setting of 8.0, and placing the blue waveband on red filter at a setting of 9.0. Measurement of trailer size indicated that the trailers were not large enough to be permanent mobile homes.

Like Recreational land use, Built up areas (Category 4) have certain morphological traits that identify their function regardless of mini-addcol settings. However, I^2S tonal analysis of component land use phenomena in built up areas was significant in classifications at Levels III and IV. An example of the ability of the mini-addcol to enhance imagery is demonstrated at Level IV for single family dwellings (Categories 4111, 4112, and 4113). With settings of IR waveband on clear filter at a light intensity of 8.0 and all other wavebands off, completed buildings or those whose roofs have been constructed register in dark tones against a light grayish background. Building sites, including buildings under construction with no roofs are not easily identifiable with this setting. However, with I^2S viewer settings of IR waveband on clear filter at a light intensity of 4.5, red waveband on red filter at a light intensity of 4.5, and green waveband on green filter at a light intensity of 5.0 building sites, particularly those with concrete slabs poured, become easily recognizable. On the other hand, completed buildings are all but invisible.

Transportation routes (Category 5) are broken into four categories at Level II, each reasonably identifiable based on morphology and photographic interpretation techniques.

At level three, however, discernment of paved roads and parking lots versus those that are unpaved is made possible through I^2S mini-addcol settings. Paved roads registered best with the IR waveband on clear filter at a light intensity of 9.0, the red waveband off, the green waveband on green filter at a light intensity of 8.3 and with the blue waveband off. Concrete roads appear in darker tones than asphalt roads. Dirt roads were enhanced by mini-addcol setting of IR waveband on red filter at 8.0 light intensity, red waveband on red film at 5.0 light intensity, green waveband on green filter at a light intensity of 7.0, and the blue waveband off.

Water bodies have not as yet been investigated in detail. However, it appears that no matter what I^2S setting is used, farm ponds will appear in dark tones. In fact, confusion has occurred between very small ponds and asphalt composition roofs of large buildings. Identification of streams smaller than fourth order has been accomplished through association with vegetation. Shorelines appear to be identified best with a mini-addcol setting of IR waveband on red filter at a light intensity of 8.0, however, only where there is a distinct boundary between land and water. Where marshes are found along the shore other settings must be used to enhance the tonal registration of vegetation. One setting that has been of some use is the IR waveband on red filter with a light intensity of 8.0, red waveband off, green waveband on green filter at a light intensity of 8.0, and the blue waveband off. This setting tends to enhance the infrared reflectivity of the vegetation while allowing the gray tones characteristic of saturated soil to be distinguished. The point where the gray tones disappear and red and pink tones dominate is the upland boundary of the marsh.

Physical characteristics of the landscape detectable on I^2S imagery include exposed soil, vegetation, and drainage systems (Table 2A). These three were analyzed as separate categories and mapped as thematic overlays for the land use map.

Bare ground was analyzed on the basis of percentage of exposed soil in relationship to vegetation in the given area (normally a training or test field, or in association with a specific land use typology). An I^2S viewer setting of IR waveband with a blue filter at a light intensity setting of 9.0, red waveband with a clear filter at 5.0 light intensity, and both the green and blue wavebands off provided the best tonal contrast for recognition of bare soil.

Vegetation types were placed in seven categories and included both culturally maintained species as well as natural species. Since a discussion of culturally maintained crops and pasture (Category 1B) has been given, emphasis will be placed on natural vegetation categories. Two settings have been found satisfactory for discriminating between coniferous and deciduous forest. One setting utilizes only the IR waveband on clear filter at a light intensity of 8.0. The other setting is IR waveband on clear filter at 4.5, Red waveband on red filter with a light intensity of 8.5, Green waveband on green filter with a light intensity of 8.5, and the Blue waveband off. Conifers will register in darker tones than deciduous species with the above settings. A setting of IR waveband on blue filter at 9.0 light intensity and Red waveband on clear filter at a light intensity of 5.0 enhances hardwood detection. Cut over and brush and bush land (idle) are best detected using IR waveband on red filter at a light intensity of 3.9, Red waveband on clear filter at a light intensity of 4.5, Green waveband on clear filter at 9.0, and the Blue waveband off. It has been our experience that identification of cut over and brush and bush lands decreases with increased IR light intensity.

First order drainage systems are difficult to observe, regardless of viewer setting. Recognition of lower order drainage systems is dependent, in part, on vegetational associations, especially in areas of dense overstories. Enhancement of lower order streams has been accomplished best with those settings that enhance deciduous tree species, while higher order streams are observed best with those settings that discriminate shorelines.

It should be noted that site association characteristics will affect tonal registration of certain land use phenomena. For instance, building roofs of the same material will have different spactral characteristics if they are located under or near trees than they will if they are located in the open. Age of the roof also will affect tonal quality. Time of day and sun angle at the time of overflight will have affects on imagery quality. For this reason settings that are satisfactory for identification of a specific phenomena on one I^2S frame may not be satisfactory for the same phenomena on another frame.

I^2S multi-band imagery analysis has progressed satisfactorily since September. However, several problem areas in interpretation of the June, 1972, imagery still exist. Among these are: (1) discrimination of idle land; (2) detection of wetlands; (3) identification of drainage networks; and (4) discrimination of stages of cultivation.

3. Interpretation of Thermal Infrared Imagery

June, 1972, thermal infrared imagery has been of some utility to the project even though primary emphasis has been placed on I^2S imagery interpretation. It has been particularly helpful in examination of shoreline marshes. The use of the I^2S digicol for thermal imagery analysis appears to corroborate information from the I^2S multi-band imagery.

Agricultural land use and forest areas are identifiable and can be classified to the third level, in some instances, from thermal infrared imagery that has been enhanced by eight and sixteen-level density slicing on the I^2S digicol. This technique of thermal imagery density slicing has not been as satisfactory for interpretation of land use phenomena in residential areas. With exceptions of vegetation-site correlation, most physical site characteristics interpretable from the I^2S multi-band imagery were not identifiable on the thermal imagery.

The thermal imagery, when analyzed in concert with I^2S multi-band imagery, is useful and will be relied on more during the next year.

E. Summary

During the first year the land use research team established and regularly monitored two representative target areas--Fannin Landing and Pelahatchie Bay. Correlation of ground truth data with I^2S multi-band imagery has indicated that interpretation keys are satisfactory and that specific land use characteristics can be identified at the fourth order. Also, correlation of ground truth data with I^2S multi-band imagery revealed that certain training and test fields were more meaningful than others, due to physical site characteristics, for accomplishment of the project's three-year goal. It is on these sites that more effort is now being placed.

Interpretation and classification of I^2S imagery via the I^2S viewer has not been without problems. One major disappointment has been the inability to satisfactorily detect growth state of cultivated crops. Other hindrances have included the inability to satisfactorily discriminate between certain vegetational classifications, specifically between idle (brush and bush) and poor quality pasture where I^2S viewer tonal registrations are similar. At present the land use research team is concerned primarily with overcoming problems in imagery land use interpretation. Once these problems are resolved (using both June and November, 1972, imagery), emphasis will be placed on analysis of physical site characteristics.

In the opinion of this investigator, the most exhilarating event of the project's first year was discovering the ability of the I^2S viewer to enhance specific target area phenomena. Significant contribution of the various and exotic I^2S mini-addcol enhancement settings included the following: (1) that construction sites in densely wooded areas were observable and measureable; (2) that apparent differences in soil were noticeable--this, of course, has direct implications for the remainder of the study; (3) that discrimination between vegetation types and enhancement of certain species can give corrolative data necessary for drainage network analysis.

SECTION III

IMAGERY ANALYSIS OF WATER AND WATER-LAND INTERFACES

A. Objectives of the Water Imagery Study.

To relate the I^2S imagery to measurable water parameters was one of two objectives of this portion of the project. The second objective is to utilize the water imagery and its interpretation in support of the land use portion of our overall study. The first year's work has been devoted towards the former task though there has been close correlation between the two divisions within our group in regard to site selections, etc. since the origin of the project. In the future the convergence of the land use divisions and the water division will increase towards the focal points stated in the original proposal: i.e. (1) to evaluate land use types, (2) to determine the effect of land use on erosion in the immediate vicinity of the Reservoir, (3) to determine the suspended sediment load at specific sites in the Reservoir, and (4) to correlate sediment input with land use via the I^2S imagery.

To this end we will be requesting soon a third overflight of the Barnett Reservoir, preferably in late April or early May. At this time we anticipate agricultural lands to be cultivated but the soil to be bare, leading consequently to increased sediment input into the Reservoir. As with our previous flights, we will request that the flight be flown after a moderate-to-large rain. As with the November overflight we will request that the flightlines be flown in the morning and again in the afternoon of the same day. We further anticipate an overflight in August or September, when the crops are up but not harvested.

B. Target Area and Site Selections.

We have chosen five target areas to examine experimentally in an attempt to relate our findings to the imagery obtained <u>via</u> the overflight. These are:

Target Area 1. Off-shore near Alford Cove

Target Area 2. Off-shore in the Marina area

Target Area 3. Off-shore near Fannin Landing

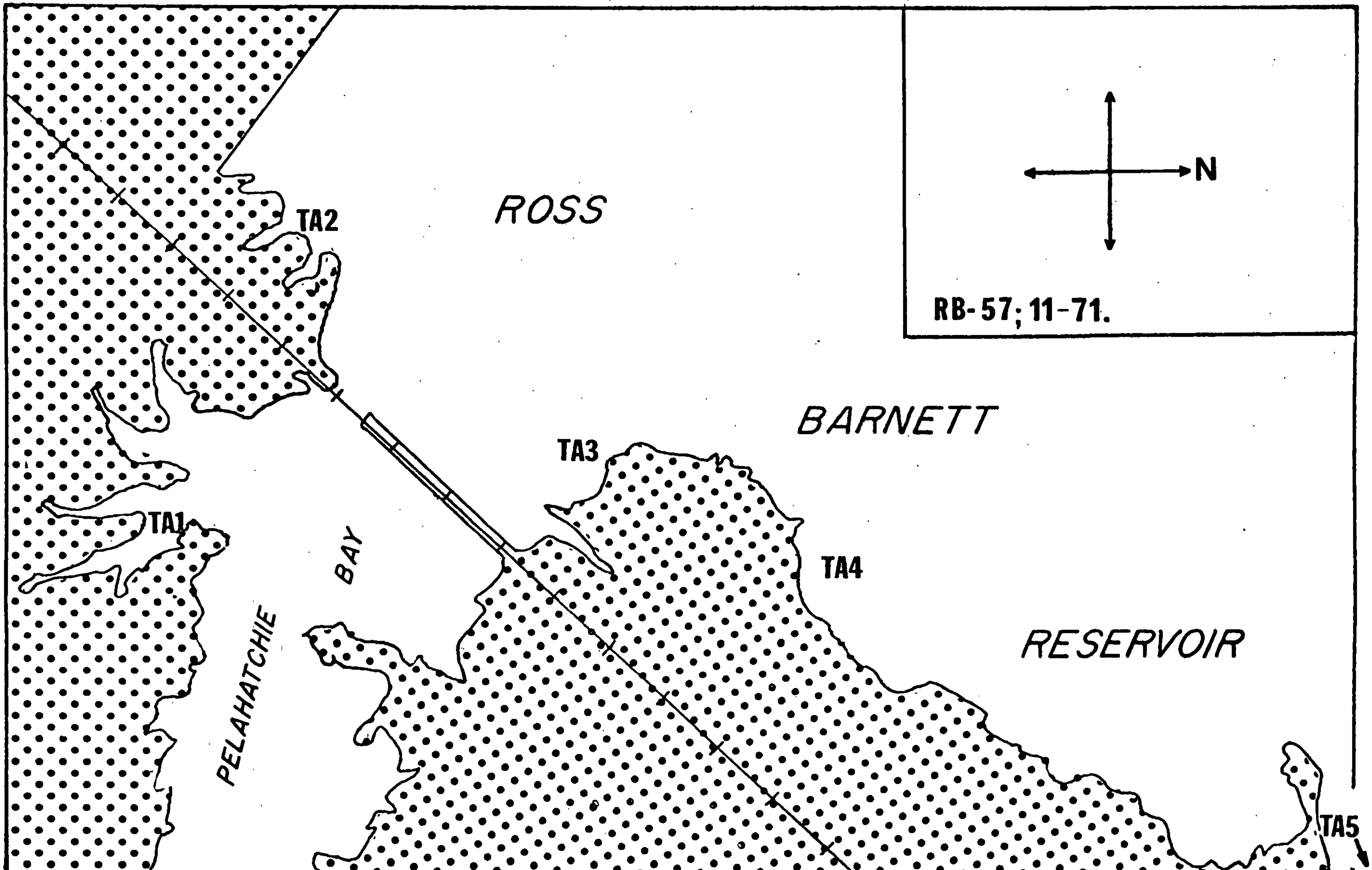
Target Area 4. Off-shore near the cotton fields

Target Area 5. Off-shore near Mill Creek North

These target areas (TA's) are illustrated in Figure 1 of this section.

The target areas differ significantly with regard to their geological, geographical, and utilization characteristics.

Alford Cove, at the south end of Pelahatchie Creek is in the center of a rapidly developing suburban usage area. Consequently, sediment input from housing and road development was anticipated to be large. Further, the various fingers of the cove and other coves in this region have recently been dredged. The area is protected, <u>via</u> its location, from weather-wind effects pertinent to the main body of the Reservoir.



N
RB-57; 11-71.
ROSS
BARNETT
RESERVOIR
PELAHATCHIE
BAY
TA1
TA2
TA3
TA4
TA5

Fannin Landing, a peninsula into the Reservoir, is exposed to weather-wind effects.

The cotton fields target is located in a region where considerable agricultural land usage is present. Within this target area we have examined sites adjacent to freshly planted fields (re. June 21 overflight) and grasslands.

The Mill Creek North target area is of interest because it represents a region adjacent to a natural drainage path and because in close proximity to the mouth of Mill Creek North is an extensive marsh. One significant problem with this target area is that it is ca. 8 miles from the nearest other target area. The area is stable re. land use aspects. The land adjacent to the target area is heavily forested though there are easily traced drainage patterns to the Reservoir via Mill Creek North.

The marina target area is characterized by extensive but stabilized recreational development. At specific sites in this area there is considerable land erosion. There has been considerable construction in this area in the immediate past.

Our selection of the target areas has been dictated not only by the land use patterns noted above but also by their reasonably close proximity to one another. Consequently, we may sample these sites in some semblance of real time in relation to the overflights if the Mill Creek North sites are not sampled.

C. Water Measurements

We have conducted extensive on-site and laboratory measurements on water samples taken at the Reservoir. We have undertaken extensive sampling trips on June 21, 1972, on September 16, 1972, and on November 27, 1972. The June 21 and the November 27 trips were in support of the overflights. For the November 27 trip each site was sampled twice, once in the morning and once in the afternoon, with a time interval of _ca_. 6 hours.

The on-site water sample measurements included:

1. turbidity
2. apparent water color
3. conductivity
4. dissolved oxygen (DO)
5. water temperature
6. pH

Uncertainties in the on-site measurements are probably _ca_. ±10%.

The subsequent laboratory measurements of the water samples included:

1. suspended sediment
2. total carbon analysis
   a. inorganic carbon
   b. organic carbon
3. total nitrate
4. total phosphate

Results of these measurements, along with test descriptions, are listed in Appendix VI.

We have also made visual examinations of extensive vegetation in the water and have extensively photographed each site with 35 mm color and color IR photography from the boats.

D. General Correlations, Water Sampling

On the basis of on-site and laboratory analyses, it is our contention that there is a near linear relationship between apparent water color, water turbidity, and suspended sediment load at any particular sample site at a particular time (Figs. 2, 3, and 4). Data to support this contention are shown in Appendix VI.

In comparing changes in these parameters with time, it is noted that the turbidity at a site in September or November is *ca*. 50% of the corresponding value obtained at that site in June. However, the apparent water color change from June to November (or September) is significantly less. This is interpreted to indicate that the light absorbing species in the water (dispersed clays, etc.) are relatively constant but that the concentration of light scattering species (*i.e.* plankton, etc. as well as dispersed clays) changes from season to season to a far greater extent. Such an interpretation accounts for two phenomena noted in our data.

1. Only at sites #47 and #49 in June are water turbidities noted to be excessive. This is probably indicative of a high plankton concentration. These particular sites are

adjacent to cultivated fields, and in June it is anticipated that nutrient levels from over-fertilization could support such plankton levels.

2. The turbidity and the apparent water color of each sample taken in June were measured on-site and ca. two weeks later in the laboratory. Before the laboratory measurements, each sample was thoroughly stirred. The measured apparent water color of each sample remained constant (within experimental error) over the two week period but the turbidity of the sample decreased by ca. 50%. For all other samples except samples #47 and #49, the turbidity decreased 30 - 40%.

In general, all three parameters were considerably lower in September and November than in June.

The secchi disc visibilities and/or water depth values obtained were not inversely proportional either to suspended sediment load, to apparent water color, or to water turbidity at each site.

There are no apparent temperature or dissolved oxygen effects noted in the sampling data.

It is of interest to note that while the conductivity data is heavily dependent upon temperature effects, the conductivity at a particular site is inversely related to the sediment load, i.e., dispersed sediment removed ionic species from the water. This effect is exactly opposite to that observed in salt water, where dispersed solids enhances electrical conductivity.

The chemical analyses, total carbon, total phosphate, total nitrate, etc., are not anticipated to correlate directly with the imagery and its interpretation. Rather, we anticipate correlating these to suspended sediment and/or turbidity since we believe that the major input of chemicals to the natural water is via adsorption (or absorption) onto clay. Independent tests in our laboratories indicate that anions such as nitrate and phosphate indeed readily and strongly adhere to clays.*

Only at site #47 during the June measurements were the total nitrate and total phosphate levels in the water measurable. It is interesting to note that, at this site where high suspended sediment load was also found, a well delineated drainage pattern to the Reservoir, and recently cultivated fields are also found.

E. Correlation of Imagery With Water Analysis.

1. Target Area 3

For the purposes of illustration of our success to date, Figure 2 (frame 116 of our I^2S imagery) will be discussed. The frame was taken at 10,000 feet altitude on flightline B and is imagery of the Fannin Landing target area.

The frame is uncomplicated by extensive sun reflection. Because we have not been able to reproduce the artificial

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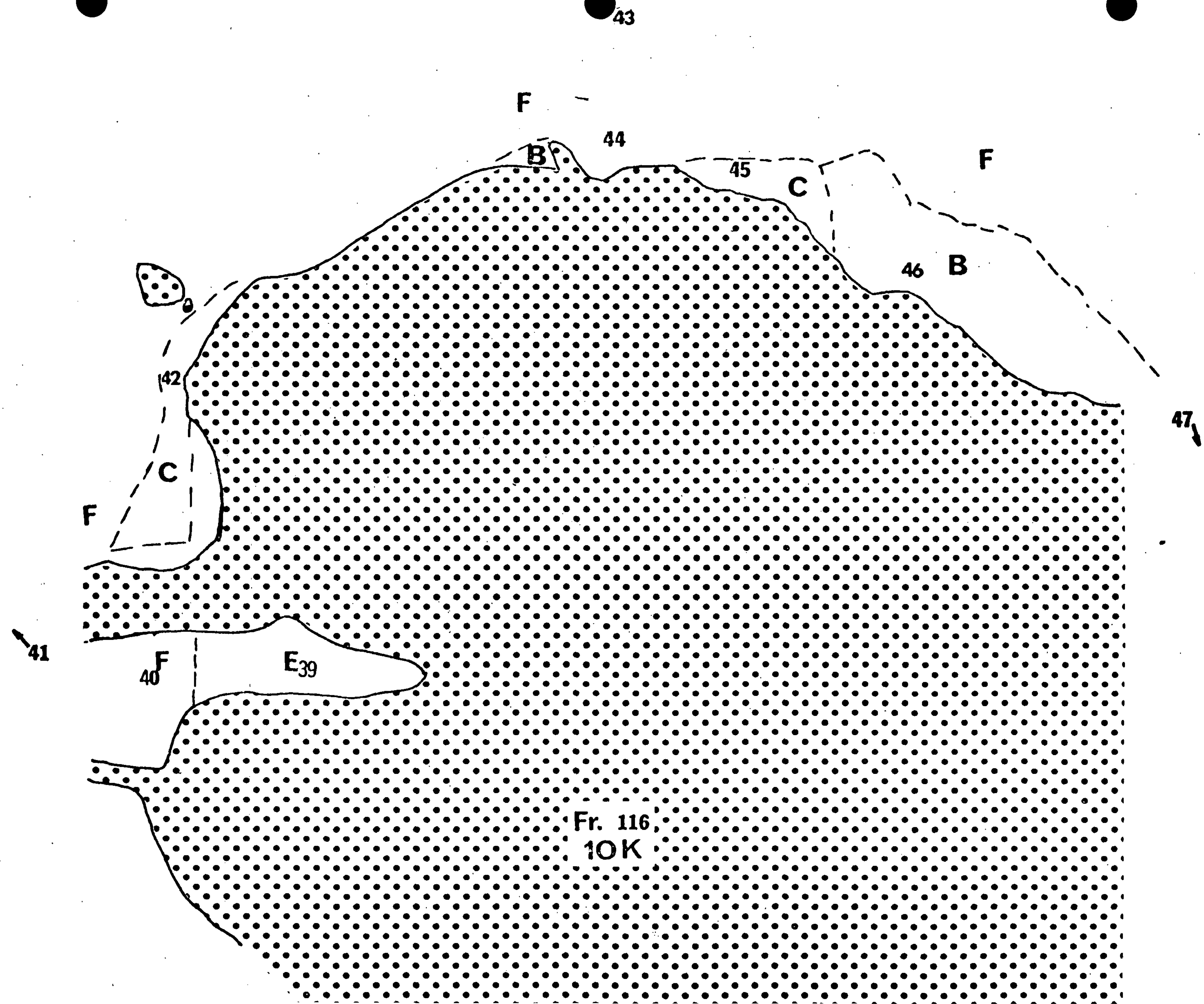
*Miss Joy Alford, a senior in the University's Honors Program, has made a study of the adherence of radioactive chloride onto clays and sediment as her Senior Research Project.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Fr. 116
1OK

tonal registrations available with the I^2S viewer, we have chosen to represent the tonal graduations *via* a numerical code at this time. This coding system is listed in Table I.

At setting 1 on the I^2S viewer described in Table II, the off-shore water mass is opaque (brown), but significant coloration along the water-land interface is present. The target area was thoroughly sampled on June 21 by our team in real time relation to the overflight.

In the well-protected cove at the lower left of Figure 2, the I^2S imagery indicates a color discontinuity. Within the cove the water, when viewed *via* I^2S setting 1, is purple; but at the mouth of the cove the water is brown. Site 39, at the center of the cove, and site 40, at the mouth of the cove, were points where extensive water analysis was undertaken on June 21. As seen in the Tables in Appendix VI, the apparent water color and the water turbidities, both measures of water quality and suspended sediment load, are significantly different. At site 39 both the water turbidity and the apparent water color were *ca*. twice the corresponding values at site 40. As noted above, the imagery of the water at these sites is significantly different. Though we unfortunately did not collect samples for suspended sediment analysis at these sites, the proportional correspondence between apparent water color (or turbidity) and suspended sediment load also indicates

TABLE I. I^2S* SETTINGS AND RESULTING TONAL GRADATIONS

IA. Optimum I^2S Settings

1. Optimum For Interpretation Of 10,000 Foot Imagery

Dial	Filter	Intensity
I	blue	5 1/2
II	green	7 1/2
III	red	6
IV	clear	4 1/2

2. Optimum For Interpretation Of 3,000 Foot Imagery

Dial	Filter	Intensity
I	blue	5
II	green	6
III	clear	6
IV	red	5

IB. Tonal Response Code

A. Silver-Grey
B. Cream
C. Rose
D. Magenta
E. Purple
F. Brown
G. Dark Grey
H. Black (Opaque)
I. Sun Spot

*International Imagery Systems Model 600 Color Additive Viewer.

TABLE II
CORRELATION OF I^2S IMAGERY WITH WATER ANALYSES, JUNE 21, 1972

10,000 foot altitudes, I^2S imagery (setting 1) applied frames 116, 123, 128, 138, and 139. Registration response analysis on other frames is similar

Site No.	Imagery Registration	AWC	TURB	S.S.
39	E (purple)	70	44	no data
40	F (brown)	40	22	no data
41	no imagery	42	46	no data
42	C (rose)	110	64	no data
43	F (brown)	19	14	no data
44	F (brown)		no sampling data	
45	C (rose)		no sampling data	
46	B (cream)		no sampling data	
47	B (cream)	325	196	135

that the suspended sediment load is significantly higher at site 39 than at site 40.

That there is tonal difference is not due to either water temperature, water depth, or water visibility effects is borne out from examination of the Tables of Appendix VI. Water depth at site 40 is ca. 26 inches but at site 39 the depth is ca. 54 inches. Thus the brown coloration, characteristic of the deeper off-shore water as well as the water at the mouth of the cove cannot be attributed to depth effects. The secchi disc visibilities and the water temperatures at these two sites, 39 and 40, are quite similar.

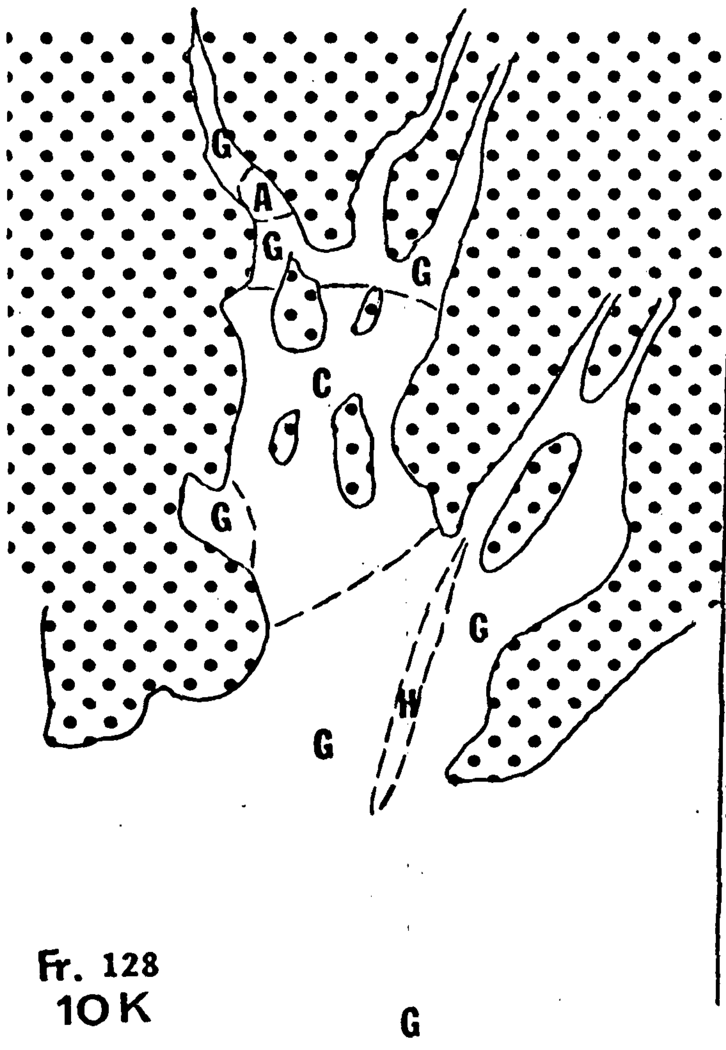
The second and third regions in this frame, where the bright tonal registrations are pronounced, are rather large and diffuse. These regions, designated as rose tinted and which include sites 42 and 45 are characterized by having high apparent water color and turbidity.

The brilliant cream-tinted region is adjacent to the cotton fields target area and our sample site 47. At site 47 the turbidity of the water, its apparent color, and the suspended sediment load are the highest values we have measured and are ca. 200% higher than values obtained at any other sites. The suspended sediment load is ca. 300 ppm.

2. Target Area 1.

Target Area 1, because of its extensive coverage on flightlines D and E and the various differences in the tonal registration of the water imagery, now represents a region of prime importance to our study. In this target area, the I^2S imagery exhibits distinct tonal variations as may be seen in Figure 3. Consequently, on our second and third sampling trips to the Reservoir, we have investigated this area thoroughly. In this target area are offered several advantages: (a) It is possible to set up a grid of sampling sites which include open water in Pelahatachie Bay, open water in the cove, and water adjacent to land interfaces. All of the sites are in close proximity to one another, and consequently travel time from site-to-site is minimal. Shown in Figure 3 are the fifteen sample sites which have been investigated in Target Area 1, and in Appendix VI are the results of our on-site and our laboratory investigations of these sites.

Seen in Figure 3 are portions of frames 128, 138, and 139 of our I^2S imagery at the I^2S setting 1. The imagery was obtained at an altitude of 10,000 feet. Though because of the sun reflection angle the I^2S imagery is not exactly equivalent in the three frames, the tonal demarcation patterns in the water are equivalent. Unfortunately, we obtained no water analyses of Target Area 1 on the day of the overflight. Thus we cannot correlate our imagery



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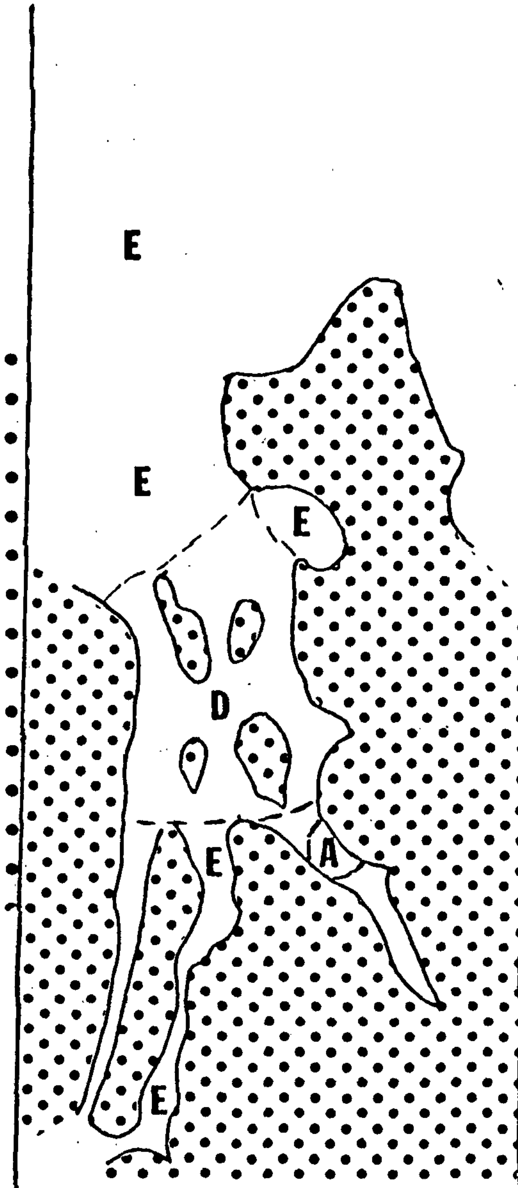
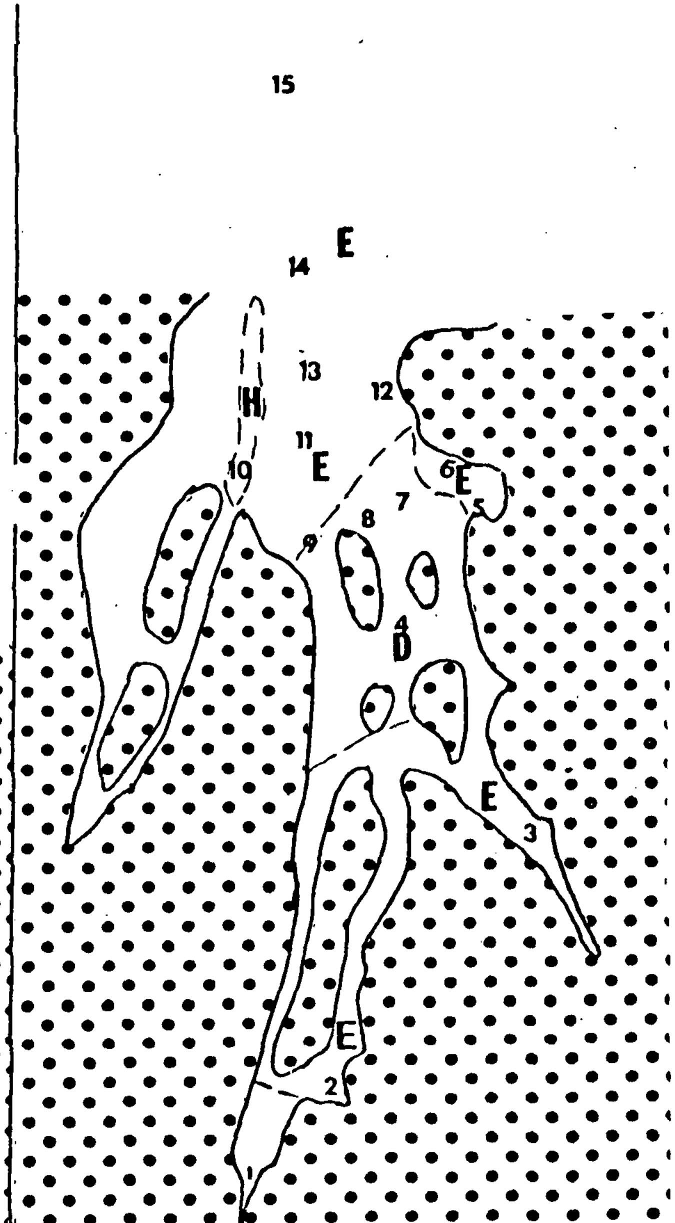


Fr. 138
10 K



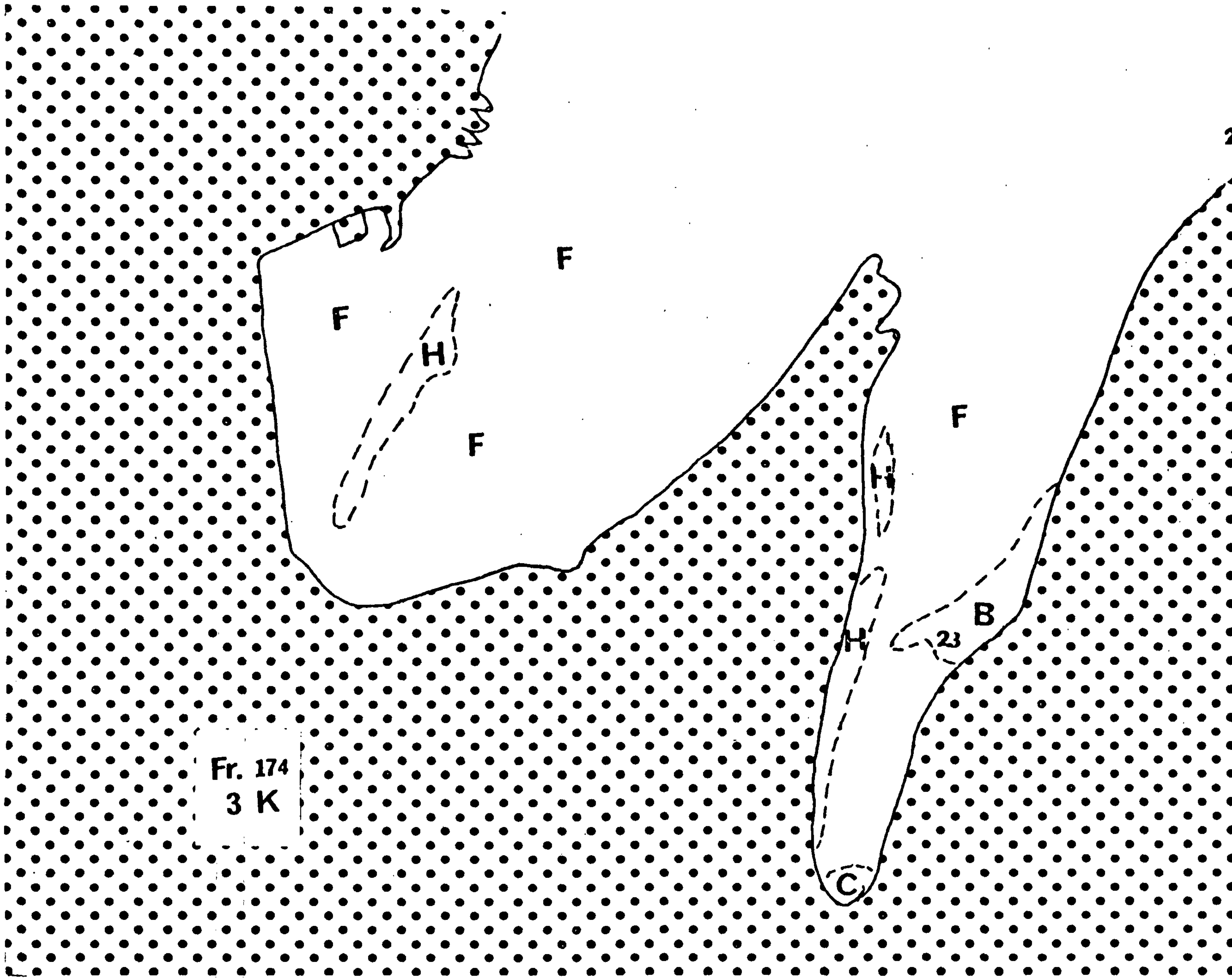
Fr. 139
10 K

with documented on-site measurements of the water parameters. This region was sampled extensively for the November overflight.

Of note in the imagery are the magenta tonal registrations surrounding sample sites 4, 7, and 8; the purple registration characteristic of the open water but also of the enclosed regions, i.e. at sites 2, 3, and 6 and the opaque streak at site 10 on frames 128 and 139. The same demarcation lines of variation in tonal registration are appropriate for frames 128, 138 and 139 except that the spectral response has been slightly shifted in frame 128 relative to that observed in frames 138 and 139. We attribute this to the sun-surface-aircraft angle. Furthermore in frames 128 and 138, a bright silver-greyish region, i.e. in the vicinity of site 3, is noted but this bright spot is not apparent in frame 139 at any I^2S setting we have utilized.

Subsequent on-site analysis has shown that the apparent water color, the turbidity of the water, and the suspended sediment load at site 4 is somewhat higher than these corresponding parameters for sites 1, 2, 3, 11 and 15 re. the September 16 sampling trip or at any other sites in Target Area 1 for the November sampling trip.

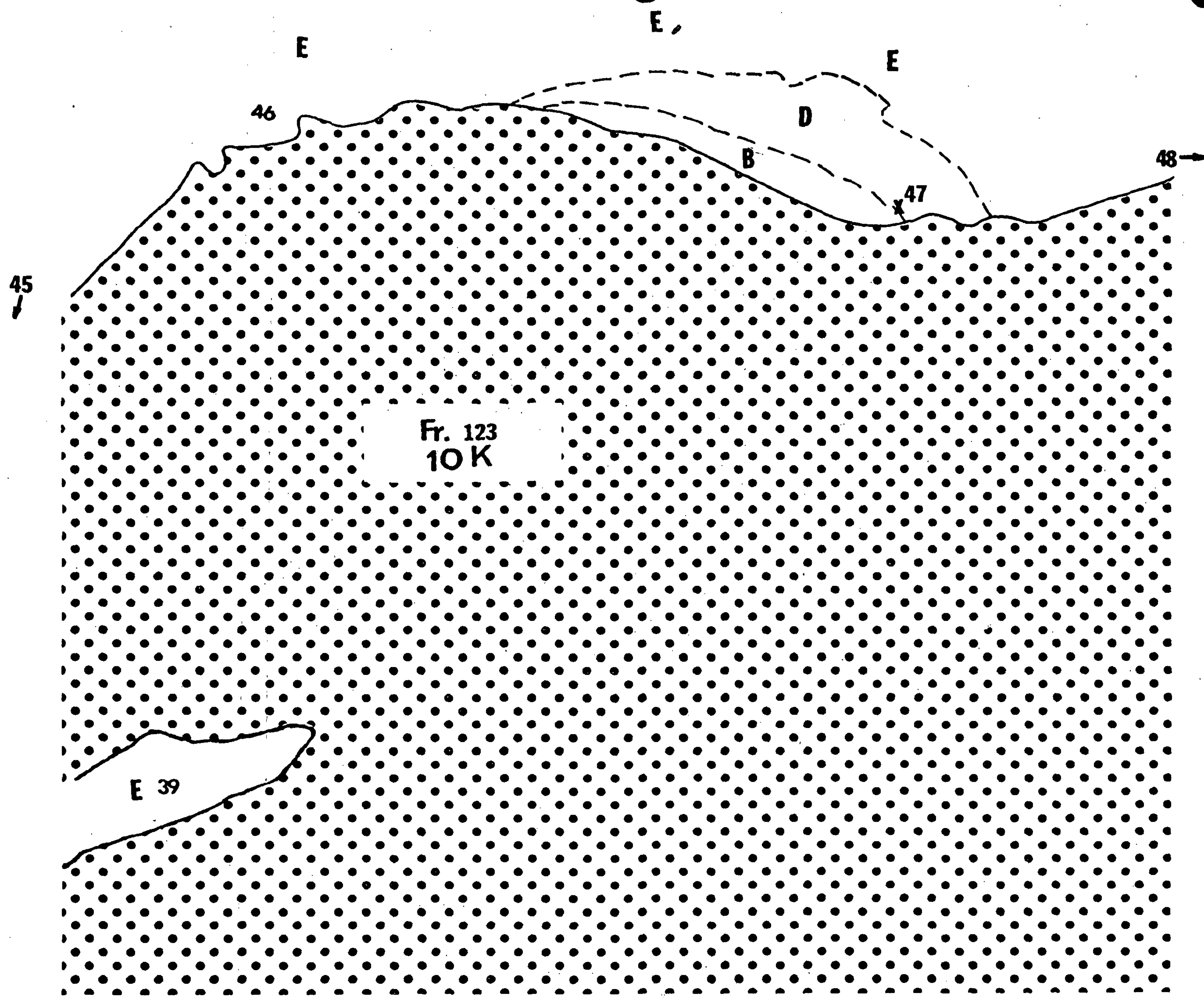
The opaque streaks which appear in frames 128 and 139 in Figure 3 also appear in several other frames. Three such streaks are noted in Figure 4 as well. We have not


F
F
H
F
F
H
H
B
23
C
Fr. 174
3 K

determined the origin of these streaks. Since we were of course unaware of their existence on the day of the June overflight, we did not sample the water within any of the regions where the opaque streaks appear. At this point we have no idea if these streaks are kinetic or inert. If the streaks are inert, then their locations should be the same as viewed by the June and the November overflights. If the streaks are dynamic, then they will not appear as they did on the June imagery (unless by uncontrollable accident). One of the primary purposes of the November overflight was to ascertain the presence and/or location of these streaks re. the June imagery. One purpose of the sequentially scheduled flights requested for November 27, 1972 was to determine the kinetic aspects of such streaks on a much shorter time base, ca. 4-5 hours. Since the afternoon flight patterns were aborted, the I^2S imagery of November will not necessarily answer our queries re. this point.

3. Target Area 4

This region, adjacent to recently cultivated fields and in the vicinity of a well established ditch, gave the brightest tonal registration with I^2S setting 1, as seen in Figure 5. Consistent with this is the fact that at site 47, the suspended sediment load, the apparent water color, and the turbidity were measured to be quite high.


E
E
E
46
D
B
48
47
45
Fr. 123
10 K
E 39

F. Utility of RS-18 Thermal Scanner Imagery.

Use of RS-18 imagery has been fruitful in that it directly distinguishes eddies from other water parameters. The I^2S imagery of frame 116 (Figure 2) shows significant tonal registration in the vicinity of sample sites 39-42. Such tonal registration changes could logically be attributed to eddies and/or to other temperature effects as well as to non-temperature effects, such as apparent water color, turbidity, etc. The RS-18 thermal imagery indicates that the I^2S tonal responses in this region are not related to temperature effects.

Though it has no relation to the June imagery, it should be pointed out that the RS-18 imagery from the November overflight does indicate a significant temperature demarcation zone in going from site 39 to site 42.

G. Problems Encountered.

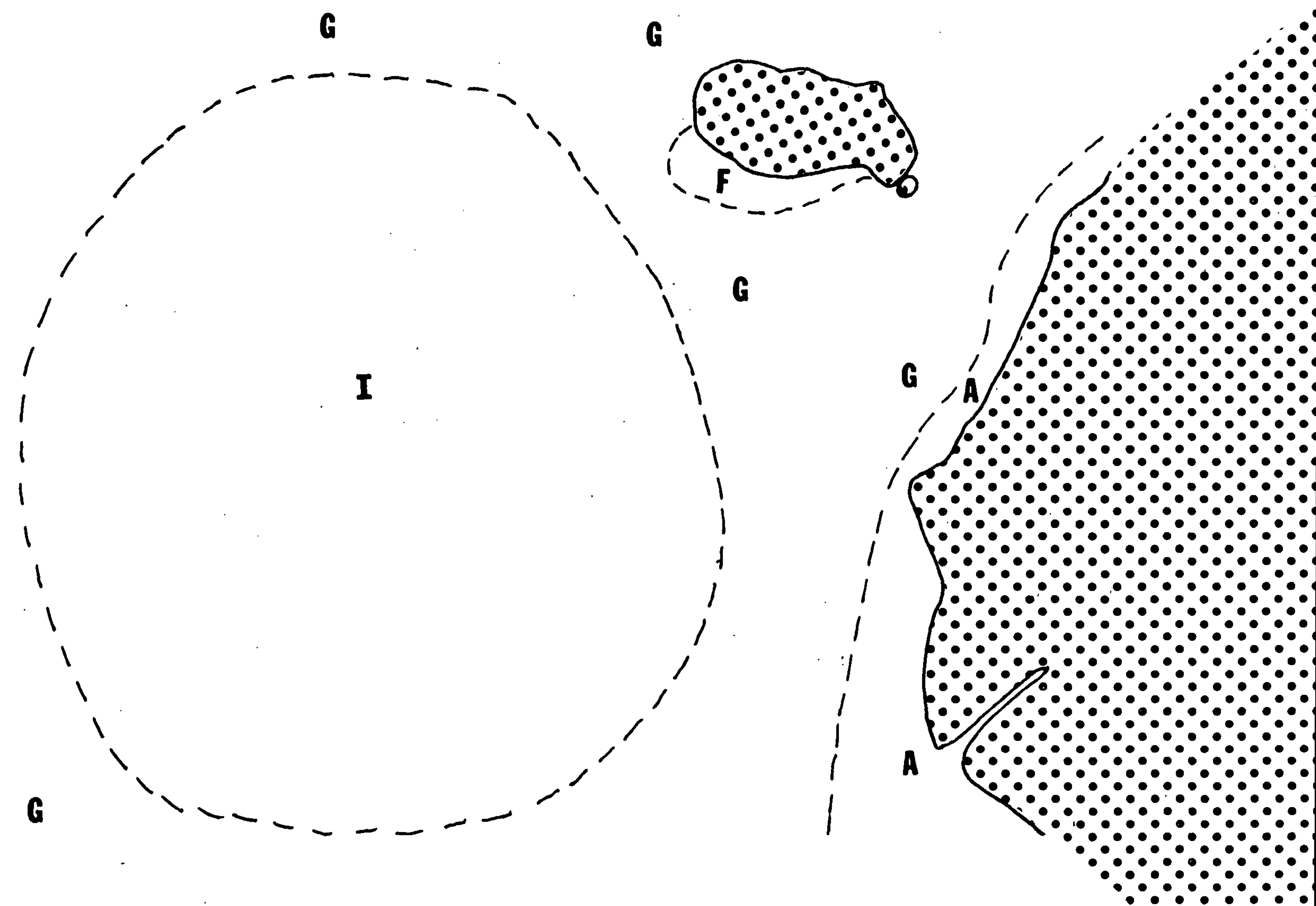
Sun reflection, in many frames, rendered the I^2S imagery useless because it masked the imagery tonal response (Figure 9). It is our understanding that this is a continual problem. On future overflights, we will attempt to minimize this problem.

H. Procedure of Methodology for I^2S Examination of Imagery.

The most significant aspect of the utility of a frame of I^2S imagery is the extent to which sun spots interfere with other measurable tonal registrations.

We have determined that viewing each frame <u>via</u> the black and white infrared channel* gives an excellent indication of

Fr. 166
3 K



the sun spotting in the imagery and consequently the usability of that frame. If there are significantly large regions in the frame where sun spotting is not significant and analysis is considered possible, the I^2S viewer is channeled to setting I or II, and analysis of the imagery is initiated.

I. Summary; water imagery.

It appears that the I^2S imagery of the June 21, 1972 overflight relating to water-land interface regions can now be semi-quantitatively analyzed. As seen in Table II, tonal registration of the I^2S imagery of the frames depicted in Figures 6, 7 and 8, i.e. 10,000 foot altitude I^2S imagery at I^2S viewer setting I, correlates with apparent water color and turbidity measurements at several sampling sites.

The I^2S spectral response at viewer setting I or setting II may be stated as: the higher the apparent water color (or turbidity), the brighter the tonal registration of the imagery. At the present time we are unable to determine the limits of this correlation because insufficient sampling sites were manned during the June overflight and consequently too little water analysis data are available.

It remains to be seen if the optimum I^2S viewer settings for the June imagery are applicable for the November 27 imagery or other overflights or if the tonal response-water parameter

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*I^2S viewer settings for channels I, II, III - off; channel IV is utilized with the clear filter at an intensity of 8-9.

correlations indicated from our analyses of the imagery are applicable for other overflights.

We have been able to show that I^2S imagery response at setting 1 (or setting 2) measures apparent water color and/or sediment load and/or turbidity in a qualitative fashion and the degree of quantization of the imagery with these water parameters should be improved significantly with repetitive investigations and inter-correlations. The correlations are shown in Table II at their present state.

This group's inexperience with both remote sensing capabilities and with water sampling caused us to obtain less than maximum value from the June 21, 1972 overflight. Because of our efforts in preselection of site placements and other fortuitous planning as well as our efforts regarding the current literature we have been able to overcome this inexperience, as our correlations of the November 27, 1972 overflight will signify.

In relation to this aspect of our original proposal, we are far ahead of our forecast. We have shown that water parameters may be measured <u>via</u> remotely sensed aerial imagery.

APPENDIX I.

EARTH RESOURCES LABORATORY

Flight Request for ERL Twin Beech

(A final draft of each flight request is to be coordinated with ERL data acquisition personnel before submission.)

1. Program or Project:

Ross Barnett Reservoir, Mississippi

2. Requesting organization(s) and individual(s):

University of Southern Mississippi
Hattiesburg, Mississippi
Dr. James W. Pinson, et al

3. Date(s) of flight(s):

Week of June 19-23, 1972

4. Flight requirements (Give narrative description of site(s), latitudes and longitudes and attach flight line map. Flight line map should indicate ground track of flight lines, direction to be flown on each line, altitude on each line and sequence of flight lines. Number flight lines numerically in sequence to be flown.)

The site is generally the SE¼ of the reservoir and adjacent terrain. It includes the spillway, SE½ of the dam and the developed area in the Delaware Creek arm of the reservoir.

Flight line map longitude and latitude of flight lines is not given. Flight lines are designated alphabetically in sequence to be flown.

5. Flight Constraints:

Cloud cover: Maximum is 25%.

Sun Angle: Fly between 9 a.m. and 3 p.m. (CST) local time.

Other constraints (Describe other time of flight constraints such as tides, sea state, atmospheric conditions (e.g., rainfall history) vegetation state, river stage, surface measurement coordination, etc.)

Flight should preferably be made within 24 hours after a heavy local rainfall.

6. Communication requirements (describe ground to air or ground to ground communications required and purpose.)

None. Principal investigator will confirm date of flight the preceeding evening by telephone.

7. Sensor requirements [List sensors desired and configuration. For each sensor list sensor designation, film, filter, lens, spectral range, forward overlap, side overlap, flight line to be used on, and any special operation requirements. Fill in summary flight matric (Section 10) and attach.]

Sensor	Film	Filter	Lens	Spectral range (microns)	Forward Overlap	Side Overlap	Flight Lines
Hasselblad #1	Color IR 2443	88A	40 mm		10%	62.5%	A-F
Hasselblad #2	Color IR 2443	Minus Blue	250 mm		10%	none	F
I^2S	B&W 2424	47, 57, 25, 88	100 mm		60%	40%	A-F
RS-18	B&W 2479	-	-	8-14	-	-	A-F
PRT-5				8-14			Back up for RS-18

TEST SITE	AIRCRAFT	FLIGHT DATE
	TWIN BEECH	

FLIGHT LINE NUMBER	FLIGHT ALTITUDE Thou/Ft.	FLIGHT LINE LENGTH	TIME OF DAY	SENSORS (IDENTIFY EACH SENSOR)					
				Hassel-blad #1	Hassel-blad #2	I^2S	RS-18	PRT-5*	
A	10		9a.m. -3p.m.	x		x	x		
B	10		"	x		x	x		
C	10		"	x		x	x		
D	10		"	x		x	x		
E	10		"	x		x	x		
F	3		"	x	x	x	x		

*Back up for RS-18. Operate only if RS-18 is not functioning.

NOTE: COMPLETE A SEPARATE SHEET FOR EACH DIFFERENT TEST SITE OVERFLIGHT REQUIRED.

APPENDIX II.

FLIGHT OPERATIONS REPORT

I. Flight Summary

A. Program or Project

Ross Barnett Reservoir, Mississippi.

B. Requesting Organization and Individuals

University of Southern Mississippi, Dr. James W. Pinson, et al.

C. Date of flight

July 21, 1972

II. Flight Requirements and Flight Description

A. Aircraft performance

1. Altitudes, ground speeds and line start and stop times vs. flight lines

Flight line	Altitude	Ground Speed (KTS.)	GMT Start	GMT Stop
A	10,000	165	16:50:21	16:53:16
B	10,000	165	17:06:08	17:09:15
C	10,000	165	17:15:00	17:18:05
D	10,000	165	17:30:00	17:33:10
E	10,000	165	17:40:55	17:43:26
F	3,000	140	18:03:12	18:06:15

2. Actual flight line map

B. Flight constraints

1. Weather description

Haze, scattered low clouds - 20% estimated (probably too high over reservoir).

2. Site description (conditions as observed from aircraft)

Hazy

C. Communications

None

III. Sensors

A. Configuration

	#1	#2
1. Hasselblad		
a. Film	Color IR 2443	Color IR 2443
b. Filter	88A	Minus Blue
c. Lens	40 mm	250 mm
d. Intervelometer	42 (10,000 ft) 14 (3,000 ft)	2
2. I^2S		
a. Film	B&W 2424	
b. Filter	47, 57, 25, 88	
c. Lens	100 mm	
d. Intervelometer	27 (10,000 ft) 5 (3,000 ft)	
3. RS-18	10,000 ft.	3,000 ft.
a. Velocity to height ratio	.028	.079
b. Gain	4.50	7.25
c. Cal sources	29°C heated, 12°C ambient	33.5°C heated, 23°C ambient

B. Anomalies or malfunctions

1. Hasselblad

   #1 focus soft

2. I^2S

   Blue channel over exposed at 10,000 ft. altitude

3. RS-18

   Scan lines dropped when I^2S shutter operated

4. Data recording system

   None

IV. Calibration Target Information

None

APPENDIX III.

DATA PRODUCT INFORMATION SHEET (1 of 8)

1. Program or project: Ross Barnett Reservoir, Mississippi
2. Sensor: I^2S
3. Site: Ross Barnett Reservoir
4. Date: 6/21/72
5. Mission number: 032
6. Roll number: 3
7. Flight lines on this product: A, B, C, D, E, and F
8. Data start time: 16:50 GMT
9. Data stop time: 18:06 GMT
10. Format: 3½ inches
11. Altitude: 10,000 ft. for flight lines A-E, 3,000 ft. for flight line F
12. Scale of imagery: 1:30,000 A-E; 1:12,000 F
13. Coverage per frame: 1.7 miles by 1.7 miles A-E; .5 miles by .5 miles F
14. Number of frames: 112 through 174
15. Overlap (forward): 60%
16. Overlap (side): varies from 0 to 90%
17. Film: 2424, B&W IR
18. Filter/spectral range: 1) 400 mm - 470 mm 2) 470 mm - 580 mm 3) 580 mm - 700 mm 4) 720 mm - 900 mm
19. Transparency:

    Positive: 2

    Negative: ______

20. Paper

    Positive: ______

    Negative: ______

Number indicates number of copies

Retained at Earth Resources Laboratory Data Lab for use by Principal Investigators.

21. Footage: 63 ft.

22. List of frames/time: See Flight Line map.

23. Processing: $\gamma = 1.7$ on original, $\gamma = 1.$ on dupe

24. Atmospheric corrections: Moderate haze, low scattered clouds

25. Special product: None

Description:

Processing:

26. Quality assessment and anomalies (A general description of product quality and anomalies based on one screening of the product after processing will be provided.)

Blue channel overexposed at 10,000 ft. altitude - flight lines A-E

DATA PRODUCT INFORMATION SHEET (3 of 8)

1. Program or project: Ross Barnett Reservoir, Mississippi
2. Sensor: Hasselblad, 40 mm lens
3. Site: Ross Barnett Reservoir
4. Date: 6/21/72
5. Mission number: 032
6. Roll number: 1
7. Flight lines on this product: A, B, C, D, E, and F
8. Data start time: 16:50 GMT
9. Data stop time: 18:06 GMT
10. Format: 70 mm
11. Altitude: 10,000 ft. for flight lines A through E, 3,000 for flight line F
12. Scale of imagery: 1:80,000 A-E; 1:24,000 F
13. Coverage per frame: 2.8 miles by 2.8 miles A-E; .8 mile by .8 mile F
14. Number of frames: 001 through 034
15. Overlap (forward): 10%
16. Overlap (side): varies from ≈0 to 90%
17. Film: 2443, Color IR
18. Filter/spectral range: E.K. wratten 15/500 mm - 900 mm
19. Transparency:

    Positive: 2

    Negative: ____

20. Paper

    Positive: 1

    Negative: ____

(Number indicates number of copies)

21. Footage: 6.8 ft.

22. List of frames/time: See Flight Line map

23. Processing: E.K. standard E5

24. Atmospheric corrections: Moderate haze, low scattered clouds

25. Special product: none

Description:

Processing:

26. Quality assessment and anomalies (A general description of product quality and anomalies based on one screening of the product after processing will be provided.)

focus soft

DATA PRODUCT INFORMATION SHEET (5 of 8)

1. Program or project: Ross Barnett Reservoir, Mississippi
2. Sensor: Hasselblad, 250 mm lens
3. Site: Ross Barnett Reservoir
4. Date: 6/21/72
5. Mission number: 032
6. Roll number: 2
7. Flight lines on this product: Flight line F
8. Data start time: 18:03 GMT
9. Data stop time: 18:06 GMT
10. Format: 70 mm
11. Altitude: 3,000 ft.
12. Scale of imagery: 1:3,600
13. Coverage per frame: 680 ft. by 680 ft.
14. Number of frames: 035 through 111
15. Overlap (forward): 10%
16. Overlap (side): NA
17. Film: 2443 - Color IR
18. Filter/spectral range: E.K. wratten 15/500 mm - 900 mm
19. Transparency:

    Positive: 2

    Negative: ____

20. Paper

    Positive: 1

    Negative: ____

(Number indicates number of copies)

21. Footage: 15.2 ft.

22. List of frames/time: See Flight Line map.

23. Processing: E.K. standard E5

24. Atmospheric corrections: Moderate haze, low scattered clouds

25. Special product: none

Description:

Processing:

26. Quality assessment and anomalies (A general description of product quality and anomalies based on one screening of the product after processing will be provided.)

DATA PRODUCT INFORMATION SHEET (7 of 8)

1. Program or project: Ross Barnett Reservoir, Mississippi

2. Sensor: RS-18

3. Site: Ross Barnett Reservoir

4. Date: 6/21/72

5. Mission number: 032

6. Roll number: 4

7. Flight lines on this product: A, B, C, D, E, and F

8. Data start time: 16:50 GMT

9. Data stop time: 18:06 GMT

10. Format: 70 mm

11. Altitude: 10,000 ft. for flight lines A-E; 3,000 for flight line F

12. Scale of imagery: N/A

13. Coverage per frame: N/A

14. Number of frames: N/A

15. Overlap (forward): N/A

16. Overlap (side): varies from 0 to 90%

17. Film: 2479, B&W

18. Filter/spectral range: 8-14 microns

19. Transparency:

    Positive: 2

    Negative: ______

20. Paper

    Positive: ______

    Negative: ______

(Number indicates number of copies)

21. Footage:

22. List of frames/time: See Flight Line Map.

23. Processing: Tape to film $\gamma = 1.0$

24. Atmospheric corrections: Moderate haze, low scattered clouds

25. Special product:

Description:

Processing:

26. Quality assessment and anomalies (A general description of product quality and anomalies based on one screening of the product after processing will be provided.)

Scan lines dropped when I^2S shutter operated.

APPENDIX VI
WATER MEASUREMENTS

WATER TURBIDITIES BY SITES
Turbidity
June 21, 1972 Data
September 16, 1972 Data
November 27, 1972 Data

A. Measurements (Turbidity Units)

Site No.	J	S	N	Site No.	J	S	N	Site No.	J	S	N
1		12		19				38			
2		17		20	32		17	39	44	27	25
3		16		21	24		10	40	22		
4		20		22	28		10	41	46	16	16
5			10	23	44		3	42	64		
6			8	24	40			43	14		
7			12	25				44		6	10
8			8	26				45		8	5
9			7	27				46			29
10			4	28				47	196		
11		16	5	29				48	30		
12			4	30				49	80		
13			4	31				50		11	15
14			4	32				51		9	18
15		16	4	33				52			
16				34				53	39		
17				35				54	16		
18				36				55	35		
				37							

B. Test Description. The test measures the light scattering from the sample on-site. The field turbidity meter is pre-standardized with nephelometer against the prescribed formazin turbidity solutions in units from 0 to 500. The test measures the existence of macro- and microscopic particles in the water.

APPARENT WATER COLOR BY SITES

June 21, 1972
September 16, 1972
November 27, 1972

A. Measurements (APC Units)

Site No.	J	S	N	Site No.	J	S	N	Site No.	J	S	N
1		30		19				38			
2		30		20	60		60	39	70	50	80
3		35		21	70		60	40	40		
4		45		22	54		45	41	42	36	50
5			35	23	88		30	42	110		
6			30	24	75			43	19		
7			35	25				44		30	45
8			40	26				45		42	30
9			35	27				46			150
10			30	28				47	325		
11		35	25	29				48	67		
12			25	30				49	87		85
13			25	31				50		33	25
14			20	32				51		32	35
15		38	25	33				52			
16				34				53	110		
17				35				54	57		
18				36				55	100		
				37							

B. Test Description. The test measures the ability of the sample to absorb electromagnetic radiation (in the visible region) against a pre-standardized scale. The test is a measure of both dissolved <u>and</u> suspended matter in the sample on a scale of 0-500. The tests are conducted on-site.

SUSPENDED SEDIMENT LOAD BY SITES

A. Measurements (PPM)

Site No.	J	S	N	Site No.	J	S	N	Site No.	J	S	N
1		31		19				38			
2		32		20			24	39		*	29
3		32		21			15	40			
4		37		22			13	41		*	18
5			12	23			19	42			
6			10	24				43	44		
7			11	25				44		*	
8			19	26				45		*	26
9			8	27				46			81
10			8	28				47	135		
11		32	12	29				48	45		
12			7	30				49	80		40
13			8	21				50		*	25
14				32				51		*	20
15		31	11	33				52			
16				34				53	35		
17				35				54	28		
18				36				55	28		
				37							

*To be Evaluated

B. Test Description. The test measures the level of suspended sediment in the sample. We have run this test in a variety of ways. We have not been satisfied with any of them. The tests are conducted in the laboratory.

ELECTRICAL CONDUCTANCE* BY SITES

(*TEMPERATURE CORRECTED)

A. Measurements (Micromho's cin^{-1}).

Site No.	J	S	N	Site No.	J	S	N	Site No.	J	S	N
1		73		19				38			
2		78		20	58		60	39	52	63	55
3		74		21	59		65	40	47		
4		74		22	58		58	41	57	62	57
5			96	23	58		58	42	55		
6			102	24	60			43	54		
7			98	25				44		57	64
8			97	26				45	53	58	53
9			108	27				46			59
10			112	28				47	54		
11		72	110	29				48	52		
12			108	30				49	60		
13			112	31				50		60	55
14			108	32				51		64	58
15		70	110	33				52			
16				34				53			
17				35				54			
18				36				55			
				37							

On June 21, water temperature was 30.0° ± 1.5°.

On September 16, water temperature was 30.0° ± 1.5°.

On November 27, water temperature was 8.5° ± 1.5°.

B. Test Description. The test measures the concentration of conducting species in the sample. The tests are conducted on-site.

SECCHI DISC VISIBILITY BY SITES (In Inches)

June 21, 1972 Data
September 16, 1972 Data
November 27, 1972 Data

A. Measurements

Site No.	J	S	N**	Site No.	J	S	N**	Site No.	J	S	N
1				19				38			
2				20	26		30*	39	30		18
3				21	12		48	40	26*		
4				22	12		42	41	25		30
5			36	23	24		48*	42	24		
6			36	24	24			43	48		
7			36	25				44			30
8			72	26				45			41
9			48	27				46			12
10			48	28				47	18*		
11			45	29				48	15		
12			24	30				49	14		
13			48	31				50			27
14			48	32				51			24
15			48	33				52			
16				34				53			
17				35				54			
18				36				55			
				37							

*On the Bottom.

**Because of a 30 mph surface wind and poor anchorage, these tests may be as much as 50% too high.

B. Test Description. The test is a reasonably accurate measure of the penetration of visible light into the water.

DEPTH BY SITES

A. Measurements (in inches)

Site No.		Site No.		Site No.	
1	72	19		38	
2	30	20	94	39	60
3	66	21	24	40	26
4	48	22	18	41	54
5	78	23	30	42	45
6	72	24	30	43	102
7	96	25		44	48
8	102	26		45	49
9	78	27		46	18
10	96	28		47	18
11	69	29		48	28
12	60	30		49	24
13	122	31		50	26
14	138	32		51	20
15	126	33		52	
16		34		53	30
17		35		54	42
18		36		55	36
		37			

B. Test Description. No explanation is necessary.

TEMPERATURE BY SITES (DEGREES CENTIGRADE)

June 21, 1972 Data
September 16, 1972 Data
November 27, 1972 Data

A. Measurements

Site No.	J	S	N	Site No.	J	S	N	Site No.	J	S	N
1		31.5		19				38			
2		32.0		20	29.4		9.4	39	29.0	28.5	7.5
3		31.8		21	29.4		8.3	40	29.0		
4		30.8		22	29.5			41	29.4	29.2	8.3
5			8.9	23	29.4		8.9	42	29.4		
6			8.1	24	29.5			43	29.0		
7			7.8	25				44		29.8	8.3
8			7.5	26				45	29.5	30.0	7.8
9			7.8	27				46			10.0
10			8.1	28				47			
11		30.8	8.1	29				48			
12			7.8	30				49			
13			7.8	31				50		29.8	7.8
14			7.8	32				51		31.0	7.2
15		29.8	6.7	33				52			
16				34				53	29.5		
17				35				54	28.6		
18				36				55	28.7		
				37							

B. Test Description. No explanation is necessary.

TABLE IX
DISSOLVED OXYGEN* BY SITES (PPM)

September 16, 1972 Data
November 27, 1972 Data

A. Measurements

Site No.	S	N	Site No.	S	N	Site No.	S	N
1	9.0		19			38		
2	9.1		20		11.2	39	8.5	12.0
3	8.8		21		14.6	40		
4	8.8		22		12.8	41	9.0	13.3
5		12.7	23		13.9	42		
6		14.2	24			43		
7		12.7	25			44	8.8	12.9
8		13.2	26			45	8.8	13.2
9		11.6	27			46		15.4
10		12.6	28			47		12.5
11	8.9	12.4	29			48		
12		12.8	30			49		12.5
13		12.9	31			50	8.8	12.5
14		13.1	32			51	9.1	12.5
15	9.2	11.2	33			52		
16			34			53		
17			35			54		
18			36			55		
			37					

*Temperature Corrected

B. Test Description. The DO content is measured with the use of an excellent DO meter, which has been previously calibrated by the Winkler method.

APC/TURBIDITY RATIOS

June 21, 1972 Data
September 16, 1972 Data
November 27, 1972 Data

Site No.	J	S	N	Site No.	J	S	N	Site No.	J	S	N
1		2.5		19				38			
2		1.8		20			3.5	39	1.6	1.8	3.2
3		2.2		21			6.0	40	1.8		
4		2.3		22			4.5	41	0.9	2.3	3.1
5			3.5	23			10.0	42	1.7		
6			3.8	24				43	1.3		
7			2.9	25				44		5.0	4.5
8			5.0	26				45		6.0	6.0
9			5.0	27				46			5.2
10			7.5	28				47	1.6		
11		2.2	5.0	29				48	2.2		
12			6.2	30				49	1.2		1.9
13			6.2	31				50		2.0	1.6
14			6.0	32				51		3.6	1.9
15		2.4	6.2	33				52			
16				34				53	2.8		
17				35				54	3.6		
18				36				55	2.8		
				37							

APPENDIX IV
FRAME INDEX SHEET

DATE:____________________ FRAME NUMBER _____

AREA	GRID	BAND SETTINGS				COMMENTS
		IR filter intensity	Red Filter intensity	Green filter intensity	Blue filter intensity	

APPENDIX V

TOPOLOGY INDEX SHEET

DATE______________________ TOPOLOGY________________

FRAME	GRID	BAND SETTINGS				COMMENTS
		IR Filter Intensity	Red Filter Intensity	Green Filter Intensity	Blue Filter Intensity	