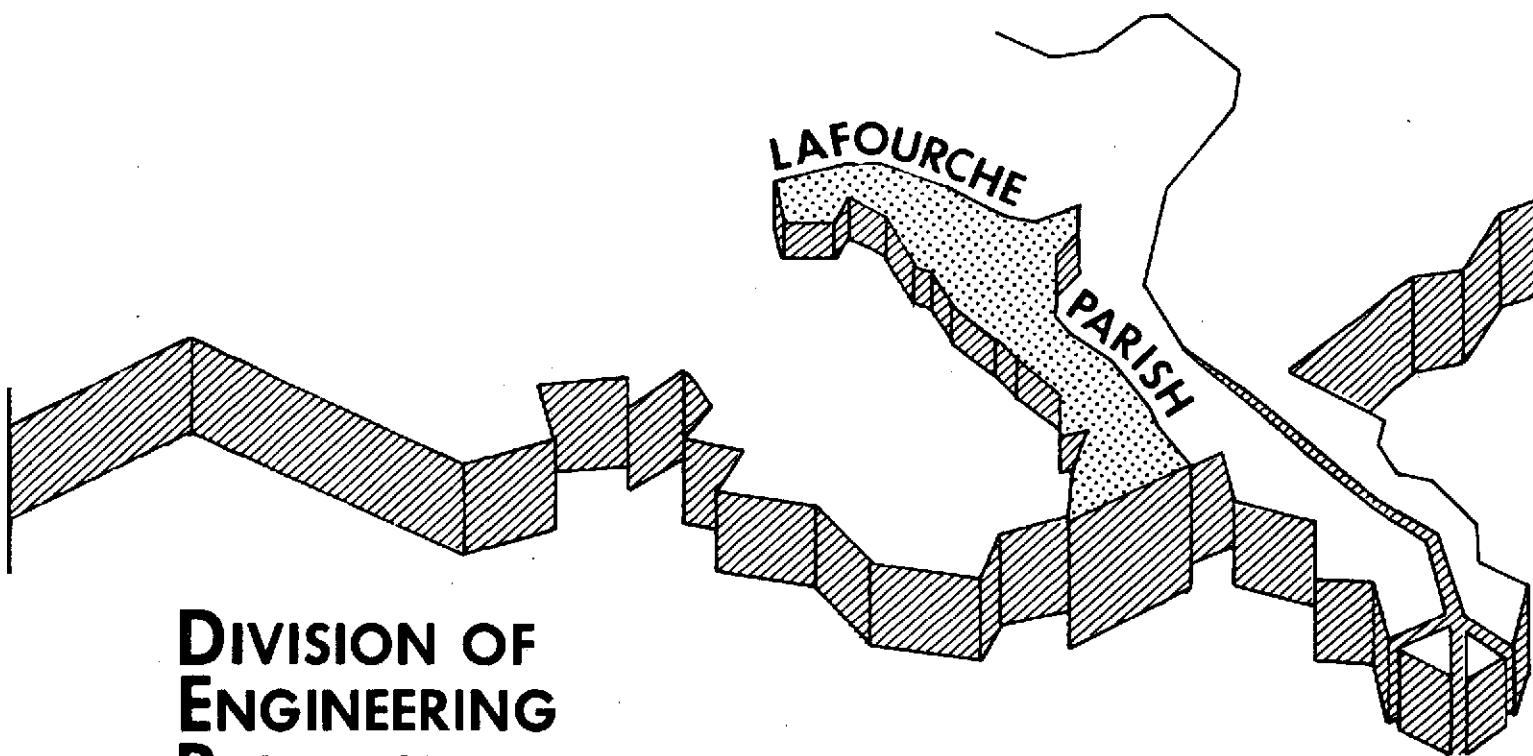


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SEDIMENT TRANSPORT AND EROSION IN THE FOURCHON AREA

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EROSION IN THE FOURCHON AREA OF
LAFOURCHE PARISH (Louisiana State Univ.)

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SEDIMENT TRANSPORT AND EROSION IN
THE FOURCHON AREA OF LAFOURCHE PARISH*

by

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March, 1974

*This project was supported by the National Aeronautics
and Space Administration, Office of University Affairs,
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SEDIMENT TRANSPORT AND EROSION IN THE
FOURCHON AREA OF LAFOURCHE PARISH

SYNOPSIS

NASA aerial photography in the form of color infrared and color positive transparencies is used as an aid in evaluating the rate and effect of erosion and sediment transport in Bay Champagne Louisiana.

1. Introduction

During the summer of 1972, studies of the marshlands of South Louisiana were initiated, using airborne infrared and multispectral imagery. This study, under the sponsorship of the National Aeronautics and Space Administration is a joint effort of the Division of Engineering Research, Louisiana State University, and Nicholls State University.

In 1973, work continued in the Fourchon area, between Leeville and Grand Isle, (Figure 1) in Lafourche Parish, Louisiana, and was extended to the brackish marsh in the Pointe au Chien area, south of Houma in Terrabonne Parish.

This report deals only with that portion of the study related to the Fourchon-Belle Pass area. The results from other study areas will be submitted in later reports.

The Fourchon study area is bound by the Gulf of Mexico on the south, Lake Champagne on the east, Pass Fourchon on the west and the canal leading to Belle Pass on the north. It encompasses an area slightly greater than one square mile and is typical of the coastal environment of South Louisiana.

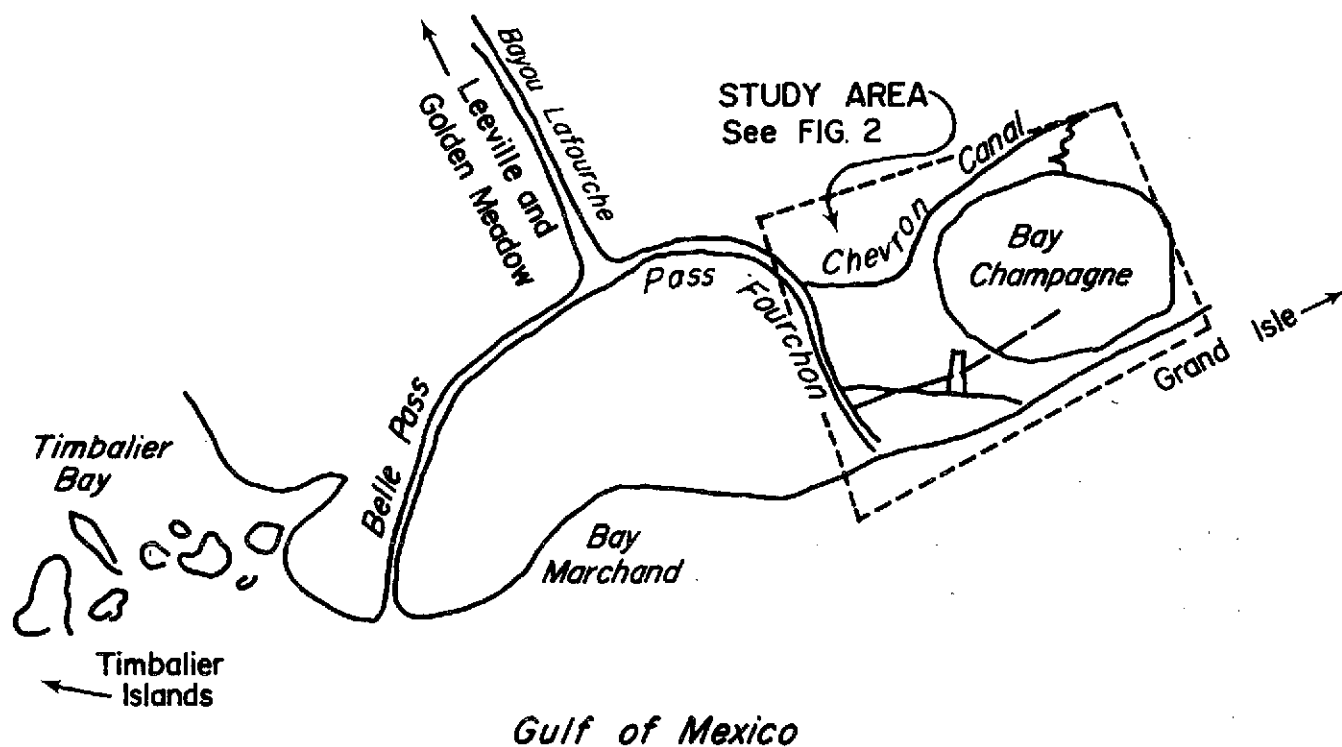


FIGURE 1.-- Map of western margin of eastern lobe of Old Lafourche Delta showing study area (Fourchon). Dashed line marked P.S.L. shows present shoreline. Map taken from Shepard & Wanless, 1971, and is based on USDA aerial photographs taken in 1953. No scale is given.

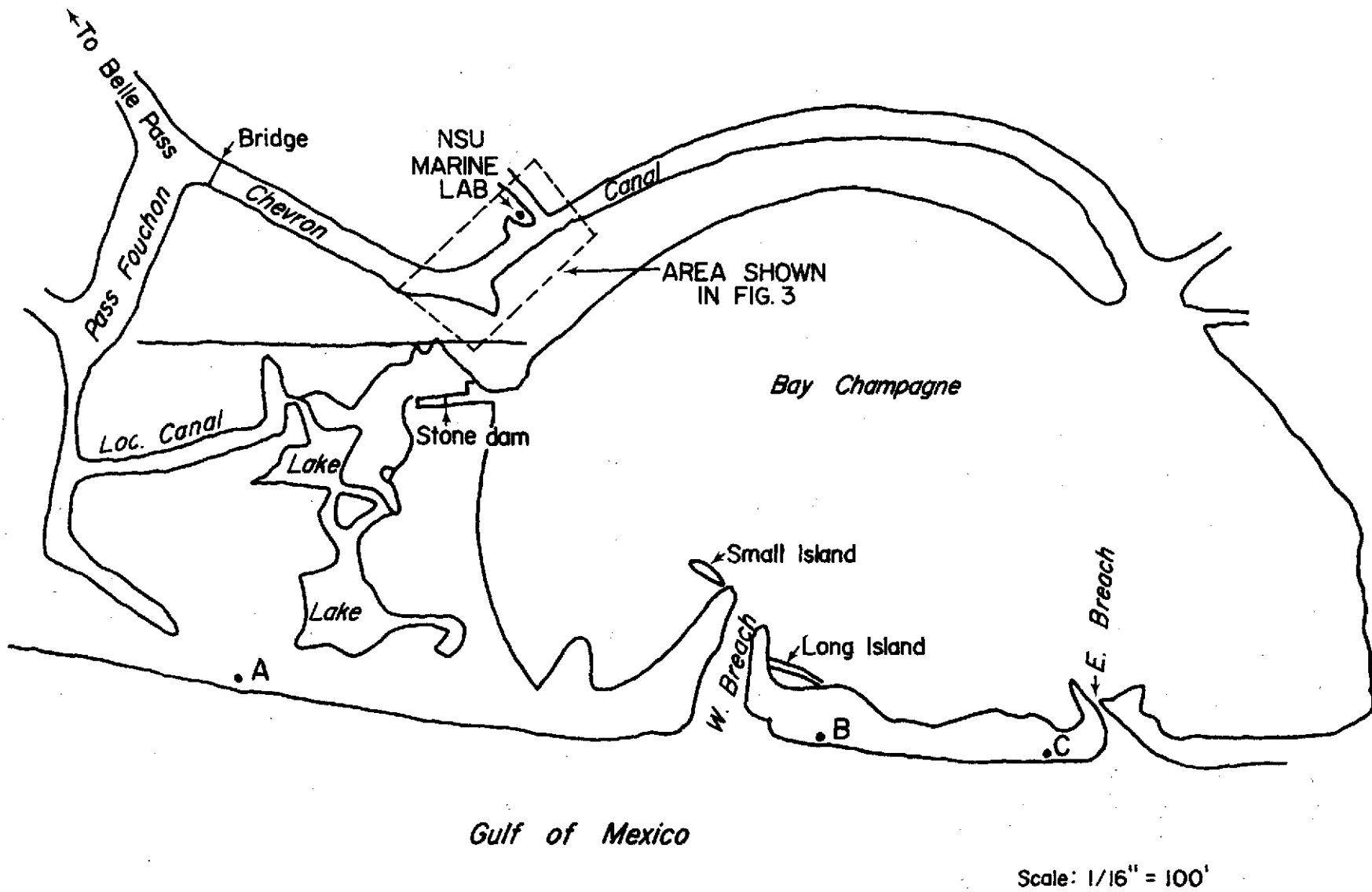


FIGURE 2.-- Location map of Fourchon area, June 1973 photographs

PURPOSE

The original purpose of the particular project was to define the biological, geological and hydrological environments in the Bayou Lafourche area of South Louisiana and to relate the ground truth data to data obtained from remote sensors, notably color infrared, I²S and RS-18 imagery. The research teams were to provide "ground truth" upon which the interpretation of the imagery was based. A specific objective was to use remotely sensed data in the planning activities of the local port and harbor commission and to provide this commission with environmental protection recommendations.

The basic environments in the salt water marsh of the Fourchon area were delineated in 1972 when the chemical composition and texture of the surface sediments were determined. The 1973 efforts were designed to see if any changes especially erosion of beaches and canals had occurred between the overflights of August, 1972, and May, 1973.

Techniques

The dimensions of several man-made objects which would remain constant over a long period of time were measured in the Fourchon area. These included the bridge across Chevron Canal (Figure 2) and a small stone dam (Figure 2) which were used to scale the photographs. The original widths of canals and beaches and erosion factors were measured from photographs taken by Earth Resources Laboratory aircraft, NASA Mississippi (Table I). In addition, profiles across Chevron Canal and current velocities and directions were obtained and compared with data from 1972. All maps in this report were taken directly from aerial photographs of the study area.

Results--Fourchon

There are four distinctive sedimentary environments in the study area: (1) beach, (2) marsh, (3) spoil banks, (4) channels. These environments are easily distinguished with I²S, infrared and normal aerial photography.

TABLE I
MEASUREMENTS FROM AERIAL PHOTOGRAPHS

<u>Location</u>	<u>Aug. 1973</u>	<u>May 1973</u>
Width of Chevron Canal at Wing Net	247.3 ft	244 ft
Width of Chevron Canal at Lab	195.3 ft	195.6
Max. width of beach near lake	400	397
From beach on bar to W. tip of ?? long I.S.	759	over-rode by spit on E. side of W. beach
From beach on bar to E. end of long I.S.	505	423
Backside of bar to E. end of long I.S.	165	over-rode
From beach to E. tip of small I.S.	1009	over-rode (see below)
Length of spit on W. side of W. breach	-	1124
Length of E. side of breach	-	645
Max. width of bar	354	40> (293 ft at 1972 Max.)

<u>Location</u>	<u>Aug. '72</u>	<u>May '73</u>	<u>June '73</u>
Table I -- continued			
Width of breach	-0-	456 ft	416 ft
Narrowest part of a breach	-0-	260	182
Width of E. breach*	-0-	157	112
Narrowest part of E. breach	-0-	58	49

* Closed by newly constructed spoil bank (by dragline) Aug. 1973

(locations of all points mentioned above are shown in Fig. 2.)

- Beach* The beach consists of fine grained sand with very little clay or silt. In some areas a shell gravel is present. Water content is low, ranging from 10 to 20% of the sand by weight. The beach sands have higher concentrations of Mn and Ma than the adjacent marsh environment. The beach is depleted in Al, Fe^{3+} , K, and PO_4 . The sand has a basic pH (8.2).
- Marsh The marsh contains the finest grain sediments ranging from clay and mud through clay loam and silty sand mud (using two classifications, standard sediment and standard soil classifications). The coarser material is found around the edge of the marsh near spoil banks and beaches while the finer material is located primarily in the center of the marsh. The pH is basic (8.0-8.2). Al, PO_4^- and NO_4^{2-} are concentrated in the marsh more so than in the other environments. It has low amounts of Fe^{3+} , Ca, Mn, and SO_4^- . The surface temperatures are the coolest in the marsh with temperatures not exceeding the seawater temperature. The marsh contains a large Spartina grass and mangrove population. As a results, there is much organic material and a reducing environment is found. Marsh sediments contain 50-70% water by weight which is due to the fact that these areas are flooded by seawater from a depth of a few inches to three feet, depending on tides and wind condition.
- Spoil Banks Spoil banks represent the highest elevation in the study area and are usually restricted to the edges of canals. The banks are dry and have clearly defined bands of vegetation from top to bottom. Surface temperatures are more variable than in other areas and range from highs of 100°F. on a hot afternoon to lows of 80° during summer nights or rainy periods. Thin salt crusts are found along the back side of the banks adjacent to the marsh in some areas. The spoil bank sediments have a pH of 6.5-7.5 which is the most acidic of all the environments. The sediment grain size is intermediate between the marsh and beach with subequal amount of sand and silt (silty or sandy loam for the soil classification and sandy silty to silty sand). The soil bank has concentrations of SO_4^- , Ca, Fe^{3+} , Al and Mn with the Fe^{3+} and Al usually found at the higher elevations. The banks are depleted in Cl and NO_4^{2-}
- Channels A series of winding tidal channels lead out of marsh into Pass Fourchon and also connect Lake Champagne to Pass Fourchon. Pass Fourchon leads into the industrial canal to the north which in turn leads to Belle Pass and the Gulf. The channel sediments are slightly coarser than the marsh sediment and approach the spoil banks in grain size. The portion of Pass Fourchon near the beach and the industrial canal east of Pass Fourchon may be sandy. They are chemically similar to the marsh sediments except for Fe^{3+} which is more concentrated in the channels. The tidal channels extend outward from a lake near the beach. Living oyster beds were found in this region.

*The above definitions are based on "ground truth".

The chief difference between these environments is elevation. The marsh, being the lowest in elevation, is flooded with seawater and is stagnant with decaying vegetation. The result is a condition where Ferric iron (Fe^{3+}) is reduced to ferrous (Fe^{2+}), and where SO_4^- is reduced to sulphur and released as H_2S . In addition Ca^{2+} and Mn are dissolved and removed from the marsh, and the decaying vegetation contributes PO_4^- and NO_4^- to the marsh. The beach, and especially the spoil banks are high, rarely flooded, and have a more oxidizing environment. The spoil banks have the most characteristic oxidizing conditions, contain Ferric iron (Fe^{3+}), Al, and SO_4^- , and are depleted in NO_4^- and to a lesser extent PO_4^- due to a rapid oxidization of decaying organic material. This results in a lower pH. The beach which is flooded during extremely high tides contains high amounts of Cl, Mg and Mn, the minerals found in seawater, and are deficient in other constituents. The spoil banks have the most variable surface temperature (very nearly that of the air) due to their elevation. At mid-day in August, spoil bank temperatures reached their highest value whereas the beaches remained somewhat cooler. The marsh always exhibited the coolest temperatures and were very seldom higher than the seawater values. Table II shows typical values for chemical data obtained in the different environments of the Fourchon area during the study period.

Energy is the chief consideration in determining grain size and water content. The beach is considered to be a high energy environment and the marsh the lowest. Therefore, the coarsest grains are found on the beaches and only during storms or high tides when the beach is breached and seawater flows into inland areas, do the coarser particles settle out around the margins of the marsh. Fine grain materials

TABLE II

Chemical Data --- Fourchon Area

	<u>Fourchon Spoil Bank</u>	<u>Fourchon Marsh</u>	<u>Fourchon Btm. Smpl.</u>	<u>Fourchon Beach</u>
pH	6.5-7.5	>8.0	>8.0	>8.0
Soil Moist	30-40%	50-70%	50-70%	10-20%
Al	100-200 ppm	>200 ppm	>200 ppm	0-25 ppm
K	300- 400 lb/acre	300- 400 lb/acre	300- 400 lb/acre	200- 300 lb/acre
Fe ³⁺	25-5- ppm	<2 ppm	25-50 ppm	<2 ppm
Ca	1200 ppm	350-700 ppm	350-700 ppm	750-1000 ppm
Mg	20-80	40-80 ppm	0-20 ppm	100 ppm
Mg	10-40 ppm	T	T	10-20 ppm
Cl	2000- 2400 ppm	2500- 3000 ppm	2500- 3000 ppm	2500- 3000 ppm
PO ₄	100-150	200 ppm	150 ppm	Q-50 lb/acre
SO ₄	150- 200 ppm	0-50 ppm	0-50 ppm	100- 150 ppm
Nitrate	10 lb/acre	20-40 lb/ac	20 lb/acre	10 lb/acre
Nitrite	T - 1 ppm	T - 1 ppm	T - 1 ppm	T - 1 ppm
Texture Sediment Class	Sdy-Silt to Silty-sd.	Mud, Silty mud Silty sdy mud	Sandy silt	Sand

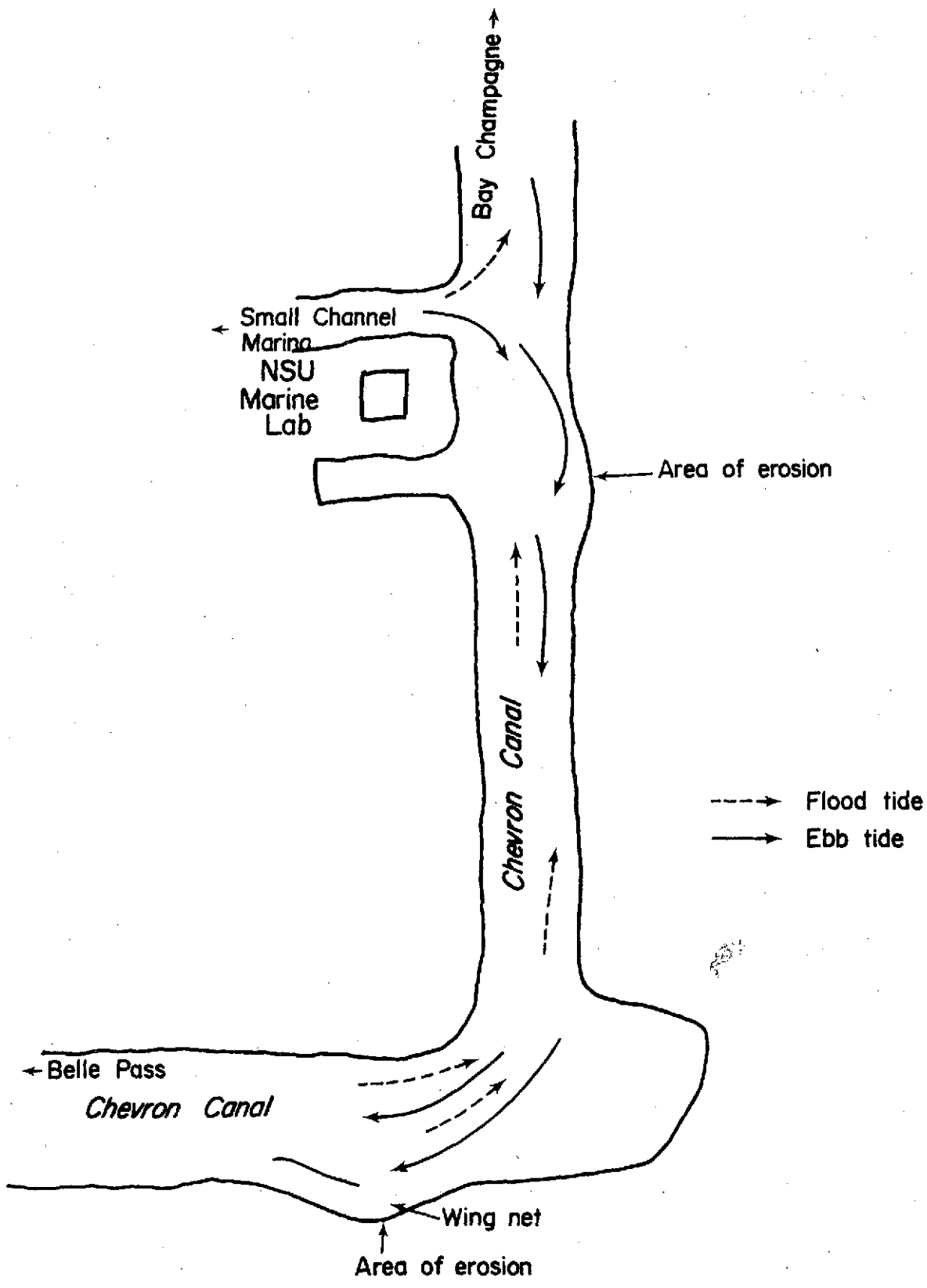


FIGURE 3.-- Erosion in Chevron Canal (no scale)

(clay or very fine silt) are usually found at points in the marsh fartherest from the beaches. Due to flow characteristics, slightly higher energies are found in the channels and therefore slightly coarser sediments. The spoil banks which are formed by material dredged from canals contains mixtures of all grain sizes. Fine grained deposits are usually found just below the surface of these banks.

Grain size determines the water content. The coarser the grain size the less the water content, thus the highest water content is found in the marsh and the lowest on the beaches.

Studies in the Fourchon area were focused on a section of the Chevron Canal between Nicholls State University Marine Laboratory and the bridge over the canal (Figures 2 and 3) and a section of beach between Pass Fourchon and the eastern side of Bay Champagne. Erosion in both places was noticeable from August 1972 to May 1973 (Table III).

In the Chevron Canal erosion was most apparent on the east bank of the canal opposite the marine laboratory and immediately west of a right angle turn south of the laboratory (Figure 3). These areas of erosion are clearly distinguished in the aerial photographs as indentations in the bank. At the site directly opposite the laboratory, the spoil bank is completely breached allowing marsh water to drain into the canal. In addition, the eroded area is subject to high velocities from a boat channel which connects with Chevron Canal at a point adjacent to the laboratory property. High velocities in the channel deflect tidal currents toward the eroding bank. The constant use of these channels by high speed motor boats contributes to the total amount of erosion. The situation is shown in Figure 3.

The second area occurs 200 yards south of the laboratory where Chevron Canal takes a right angle turn. Erosion at this site has caused

TABLE III
 VELOCITY AND DISCHARGE DATA - FOURCHON
 A. CHEVRON CANAL

<u>Location</u>	<u>Velocity and Discharge</u>	<u>Tides and Current Direction</u>
Chevron canal at wing net	0.75 ft/sec 1531 cfs.	Flood tide at high stage N.E.
Chevron Canal at wing net	1.19 ft/sec 2206 cfs	ebb tide W.
Chevron Canal in front of lab	1.05 ft/sec 1250 cfs.	flood tide at high stage N.E.
Chevron Canal in front of lab	2.03 ft/sec 2093 cfs	ebb tide SW
Small channel at side of lab	1.13 ft/sec 328 cfs	flood tide at high stage SE
Small Channel at side of lab	1.45 ft/sec 355 cfs	ebb tide SE

B. LONGSHORE CURRENTS*

<u>Location**</u>	<u>Velocity</u>	<u>Wind & Current Direction</u>
A	0.15 - 0.25 mi./hr	NE wind SW current
B	0.19 - 0.33 mi/hr	NE wind SW current
C	0.23 - 0.37 mi/hr	NE wind SW current
B	0.19-0.58 mi/hr	S wind -- NE Current.
C	0.24 - 0.28 mi/hr	S wind -- NE current
A	NOT OBTAINABLE	

** Locations are located on Fig. 2.

the collapse of a wing net and dock which were originally anchored to the spoil bank. The net and docks have collapsed into Chevron Canal.

Cross-sectional profiles obtained for Chevron Canal during the summer of 1972 and again in 1973 (Figure 4) show a net deposition of sediment on the north side and net erosion on the south side. Several results are noted: (1) there has been a net loss of 52 square feet for the entire profile, (2) the northern side of the canal has shallowed while the southern side has deepened, and (3) the channel has widened by about 11 feet during the year. The right angle turn in the channel generates velocities which are quite strong (see Table III) and the effect is the same as that which occurs in meandering rivers. Erosion occurs on the outside of the curve and deposition on the inside, and as a result, the north bank appears to have migrated as much as 24 feet southward. Due to lack of fixed points and scale differences in photos, this measurement is difficult and is considered only approximate. Although approximately 30 feet of the bank has been eroded at this time, the spoil bank has not been breached.

The data shows that ebb tide velocities are greater than flood tide velocities and that ebb tide currents flow west to southwest while flood tide currents flow east to northwest. Hence, the areas of erosion are displaced to the south and west of the bend in the canal and the mouth of the smaller channel.

The spoil banks along the south side of Chevron Canal are being undercut by the wakes from motor craft as well as strong currents during high tides are responsible.

Great changes were noted in the beaches of the Fourchon area

DATA SHEET FOR CURRENT METER AT WINGNET

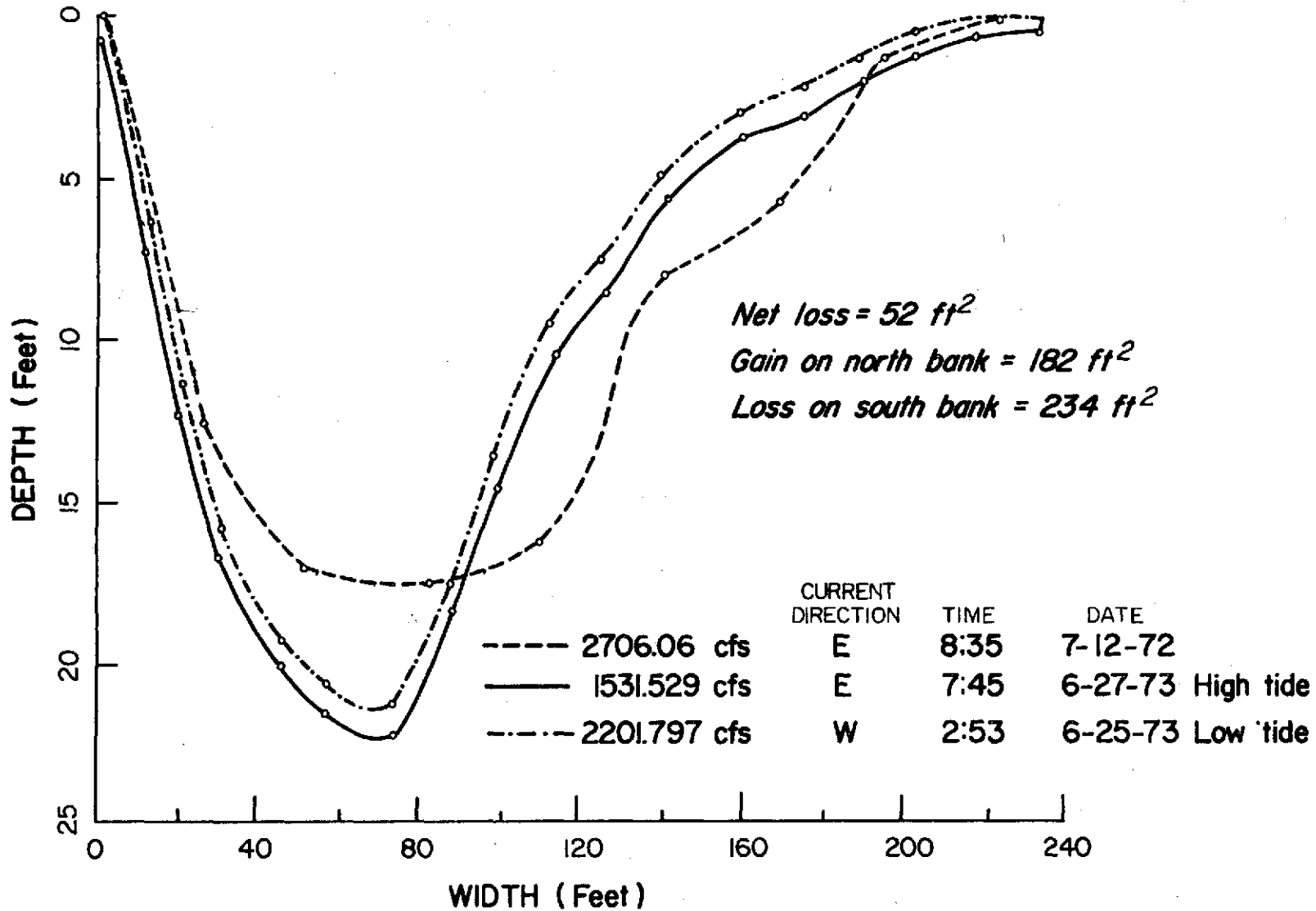


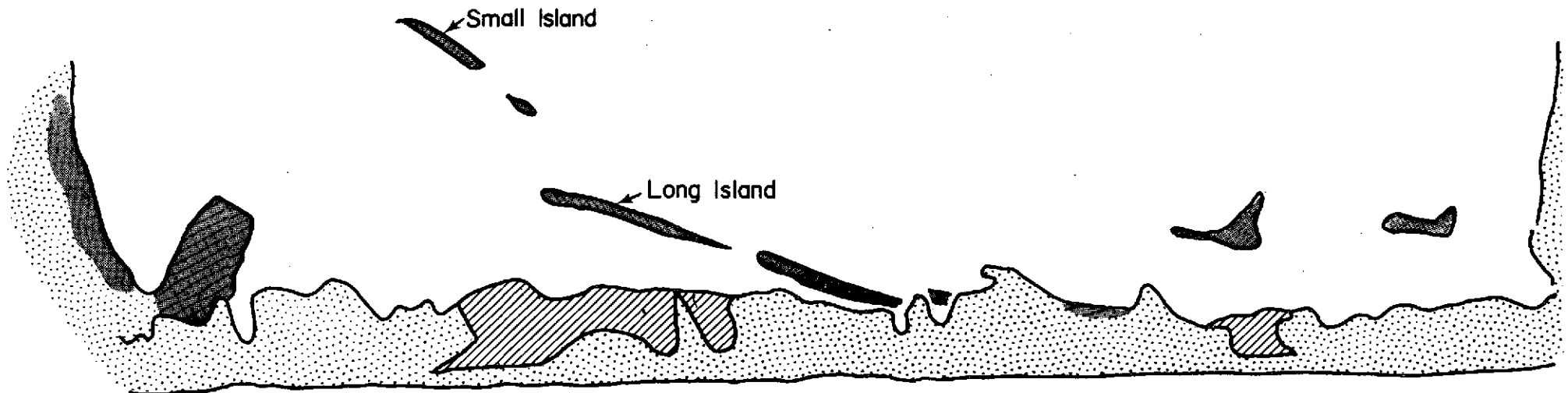
FIGURE 4.-- Profile Across Chevron Canal at Wing Net

especially at the bay-mouth-bar which extends across the mouth of Bay Champagne (Figure 2). Russell (1953) has shown that old Lafourche Delta has retreated 1500 feet in a 20 year period. Gagliano (1971) has suggested that South Louisiana has lost 16.5 square miles of land per year over the last 20 to 30 years. Our study shows that the bar across Bay Champagne has retreated from 80 to 165 feet between August 1972 and May 1973 (Figure 5). Using an average loss of 100 feet per year, we estimate that approximately 560,000 square feet were lost last year along the mouth of Bay Champagne.

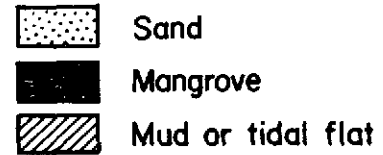
During the year, two breaches were opened in the bar across Bay Champagne. Sand now extends more than 1,000 feet northward into Bay Champagne (Figure 5) where it has obliterated several small mangrove islands. The bar had completely separated Bay Champagne from the Gulf of Mexico, forcing the drainage from the Bay to run through Chevron Canal and several small tidal channels in the marsh. The breaches, however, may have changed the hydrology, and there is now direct communication between the Gulf and Bay Champagne causing current reversals at certain times. This is particularly true during the outgoing tidal periods. The breaches are the result of wave action during high water as the bar was breached from the Gulf side. It is not known when the bar was breached and at the moment, it appears that the breaches are being healed, suggesting that they are temporary. The opening of breaches from time to time can be expected and this would temporarily alter the drainage in the marsh, as shown in Figures 6A, 6B, and 6C and consequently the ecological balance.

The bar across the mouth of Bay Champagne was built by long shore currents. These currents are quite variable, flowing from east to west when the wind blows from the north or from the southeast and the opposite direction when the wind is from the south-southwest. Velocities are slow in

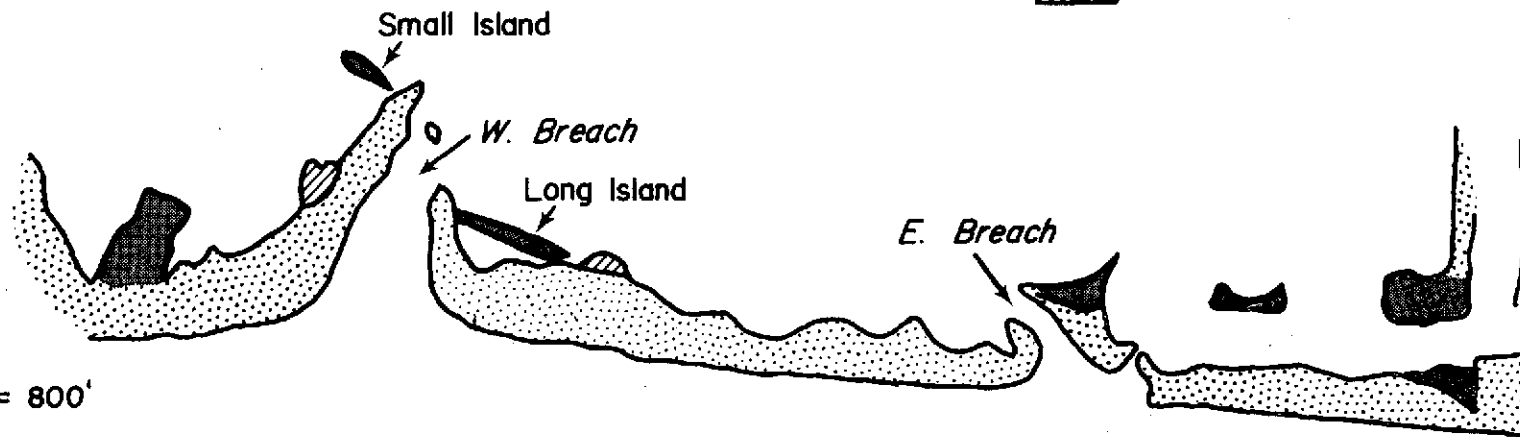
AUGUST 1972



Scale: 1" = 530'



MAY 1973



Scale: 1" = 800'

FIGURE 5.-- Erosion of Baymouth -- Bay Champagne

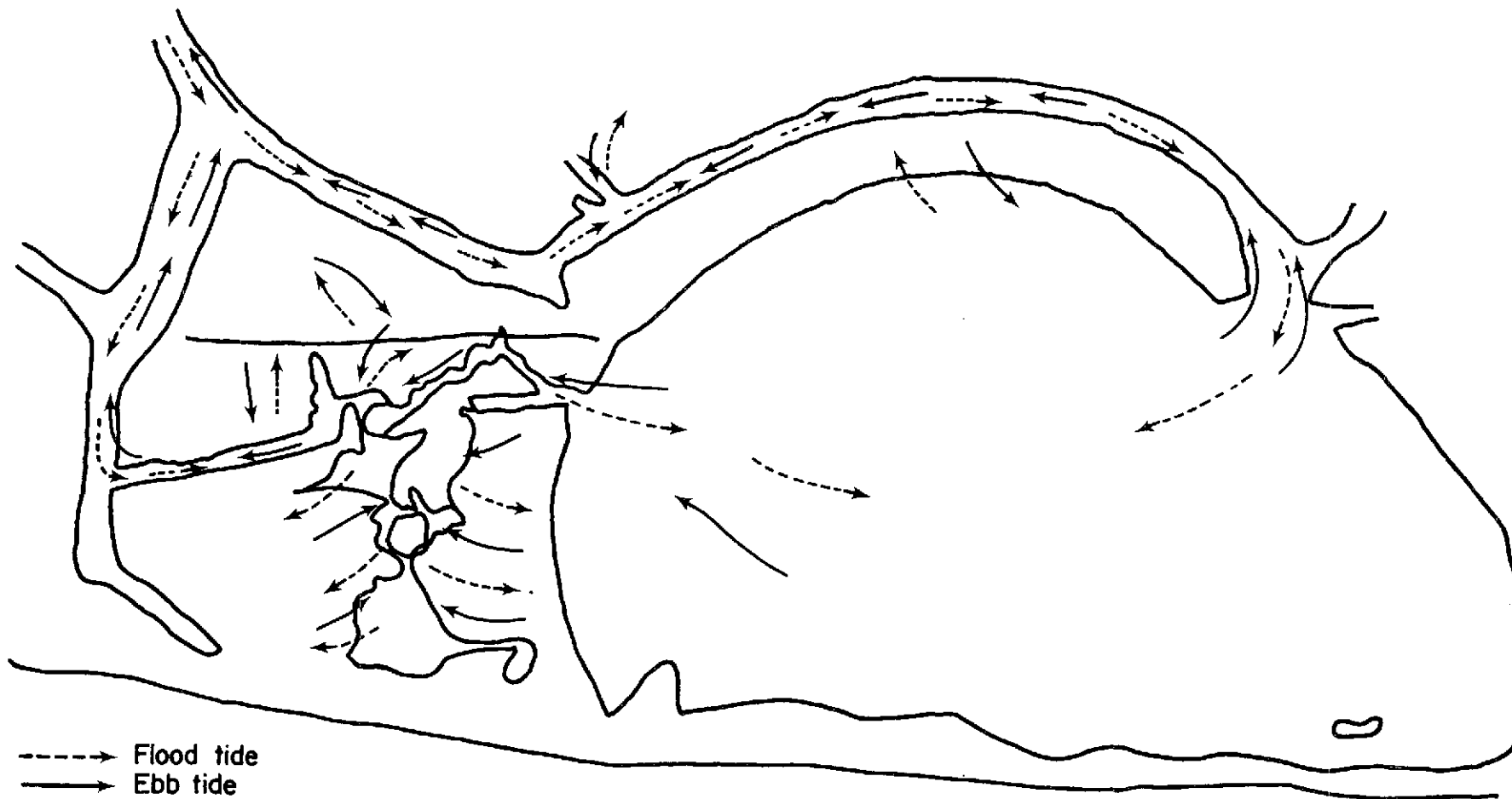


FIGURE 6A.-- Drainage of Bay Champagne and Fourchon Marsh
when breaches are closed

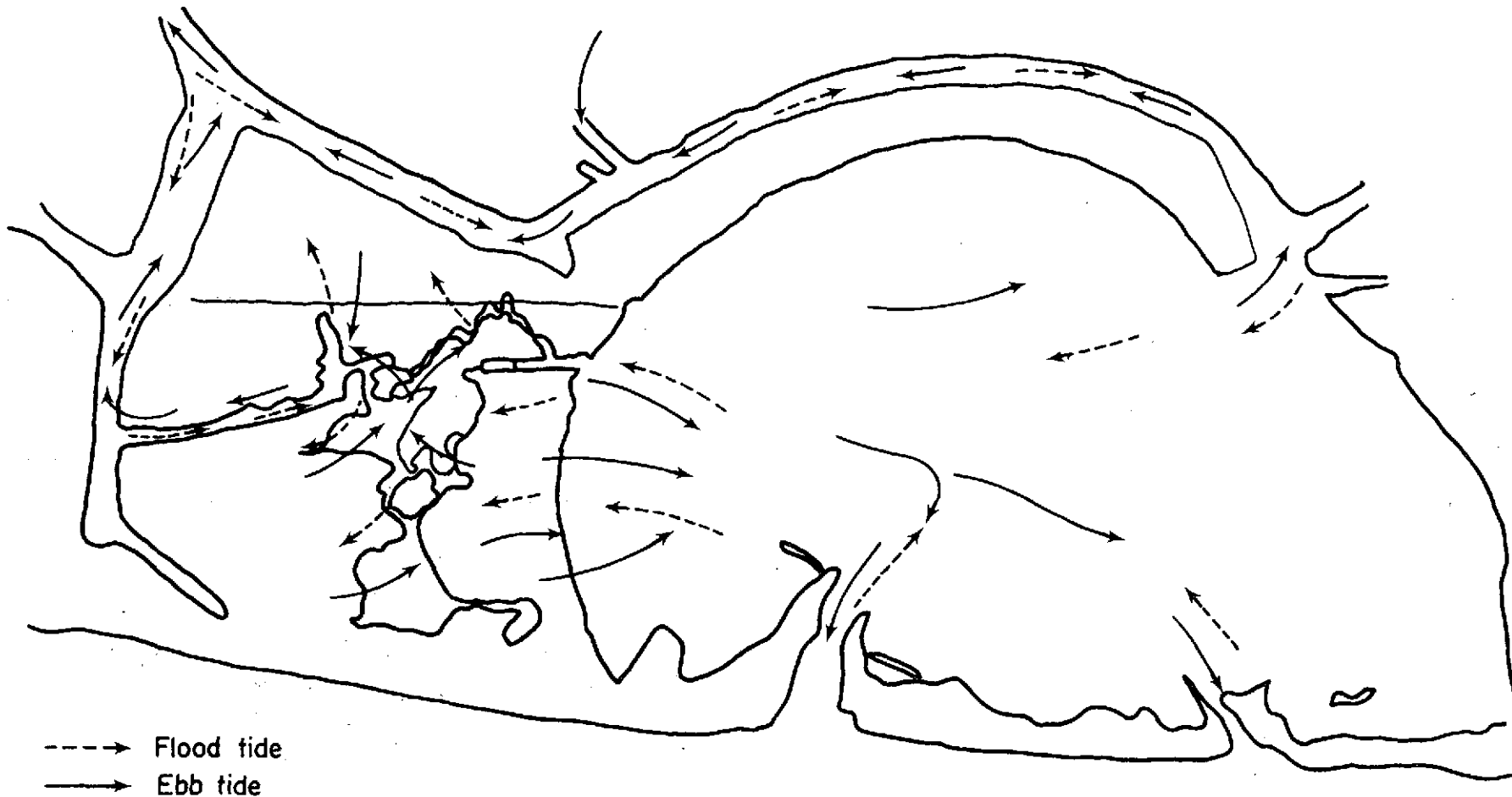


FIGURE 6B.-- Drainage of Bay Champagne and Fourchon Marsh
when Breaches are open

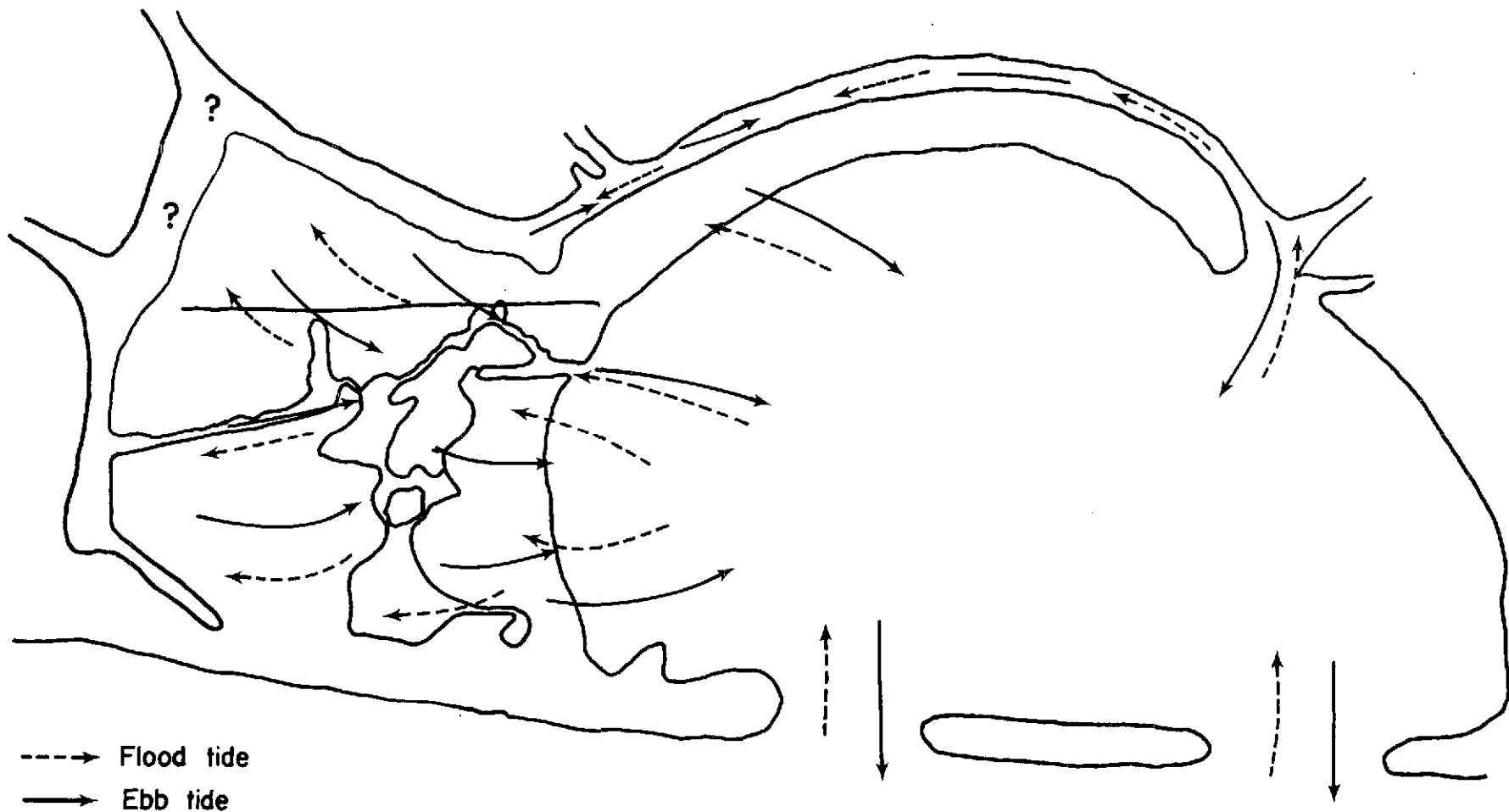


FIGURE 6C.-- Drainage if breaches were widened or deepened or bar disappeared

in both directions (Table III) and are less than one mile per hour.

The beach from the western end of Bay Champagne to Pass Fourchon has been stable over the past year. Comparison with USGS Topographic maps (Belle Pass Quad.) indicate, however, that the area has been cut back tremendously in the last few years. This suggests that areas of erosion shift from year to year along the shoreline, possibly due to changing wave conditions which may reflect changes in bottom configuration due to storms.

Physical characteristics, or patterns within the saline marsh have changed during the year, but the type of sediment has not changed. The changes are due to seasonal (and even shorter time intervals) changes in vegetation in the marsh. Rectangular patterns present in the August 1972 photographs are not present in the May, 1973, photographs.

There are problems in the use of color infrared imagery in sedimentological studies in the marsh areas of South Louisiana. The ground is covered by lush vegetation which obscures the soil and sediments and which may or may not reflect changes in the underlying sediment. Soil differences, especially in texture, are obvious from the ground, but not easily detected from aerial photographs. Some vegetational changes, like the change from grass to mangrove (1972 report) in the Fourchon area are not related to sediment or soil changes while other, such as the *Juncus* in the Pointe au Chien area, may reflect such changes. The sediments or soils were relatively homogenous over the marsh areas which include the vast majority of the acreage under study. Most sedimentological changes were as obvious from the ground

as from the photographs. The photographs do distinguish between spoil banks, channels and marshes and can be used to map large areas of South Louisiana and to locate ancient levees and channels which are not so obvious from the ground.

Sands or sandy soil and sediments usually found on spoil banks, levees and beaches can be easily seen on the color infrared photographs as it shows up as a white or light area. The photographs could be used to explore for sand over a wide area since sand is important as a foundation material and is not widespread in the marsh. Many ancient levees and channels are buried a few feet below the surface so they are not apparent from the ground. The soil over them may be sandy, however, enabling them to be recognized by the remote sensing imagery. The location of surface or near surface sand bodies is important in regional planning (i.e., location of buildings, etc.).

The infrared imagery may be very valuable in the study of sediments suspended in water, the direction of sediment transport and sediment traps by determining discharge patterns. Another project in this series does illustrate the utility of this type imagery in these cases.

This study does not negate the use of infrared and other remote sensing devices in other geological investigations such as the location of oil and gas seeps, salt domes, faults, etc.

The erosion of the South Louisiana coastline due to subsidence (1972) report is serious. The shoreline is being cut back in places at rates ranging from 75 to 100 feet per year. The areas of erosion may move from time to time, possibly in response to changes in offshore bathymetry which effects wave refraction. The bathymetric changes are due to wave erosion during storm periods. It is recommended that, prior to the development of the beaches for recreational or other use, engineering structures such as retaining embankments be placed behind the beach to slow or prevent breaching action.

Erosion is also serious in sections of Chevron Canal. The effected areas show up in aerial photographs as a slight indentation along the bank. Erosion occurs opposite places where fast currents enter the canal and on the outside of sharp turns or curves in the canal. The inside of the curve is becoming more shallow as the outside deepens. The outside bank should be shored up with timbering and inside portion of the canal occasionally dredged if stabilization is desired. A speed limit on motor craft may help reduce bank erosion. The aerial photographs of South Louisiana should be checked for areas of erosion in canals and channels.

Occasionally, breaches are opened in the bay mouth bar separating Bay Champagne from the Gulf of Mexico. This may greatly effect erosion and deposition in Bay Champagne and the surrounding marshes by reversing current flow especially during ebb tide and should be taken into consideration in stabilization programs in the marsh. Erosion would be drastically increased in the marshes around Bay Champagne if the bar were badly breached or disappeared since the bar protects the shore of the bay from wave action.

In addition, several man-made structures and actions were made while this report was in preparation. A dragline was run down the eastern side of Bay Champagne and then along the backside of the bar more than half way across the bay, piling up a bank behind the bar and closing off one breach. This will slow down erosion on the eastern part of the bar, but not the western. This will possibly result in a slight bend in the bar at first followed by a permanent breach which might effect the drainage of Bay Champagne and the surrounding marsh as discussed above. If the bank were extended completely across the backside of the bar, erosion would be slowed down at a uniform rate and the bending and breach would

not occur. Second, a road is being constructed from the bridge to the beach, adjacent to Pass Fourchon. A location canal which normally drains Lake Champagne and the marsh has been completely filled in blocking normal drainage. (Figures 7A and 7B) As a result, the marsh must now drain into Bay Champagne rather than into Pass Fourchon as it formally did. These developments are too recent (within the last two weeks of this report) to evaluate their impact on the surrounding areas, but may result in changes in areas of erosion and deposition within the marsh.

SUMMARY AND CONCLUSIONS

1. Problems exist in the use of color infrared, I²S and RS-18 imagery in sedimentological studies of marshes since vegetational differences do not always reflect sediment differences and the marsh sediments are homogeneous and minute differences do not show on the photographs.
2. Spoil banks, canals, channels, beaches and marshes are easily defined from aerial photographs since each of these environments contain different soils and sediments.
3. Remotely sensed data can be used to explore for and map surficial or near surface sand bodies over wide areas.
4. The shoreline erosion rate is 75 to 100 ft/yr in some places. The areas undergoing erosion shift from time to time due to changes in wave refraction. It is possible that retaining banks and other structures can be placed behind the beaches to deter the erosion problem.
5. Erosion is also occurring at rapid rates in canals and channels, especially where strong currents enter the channel or on the outside of sharp bends. These areas are apparent from aerial data. Reinforcement of the banks in these areas is advisable.

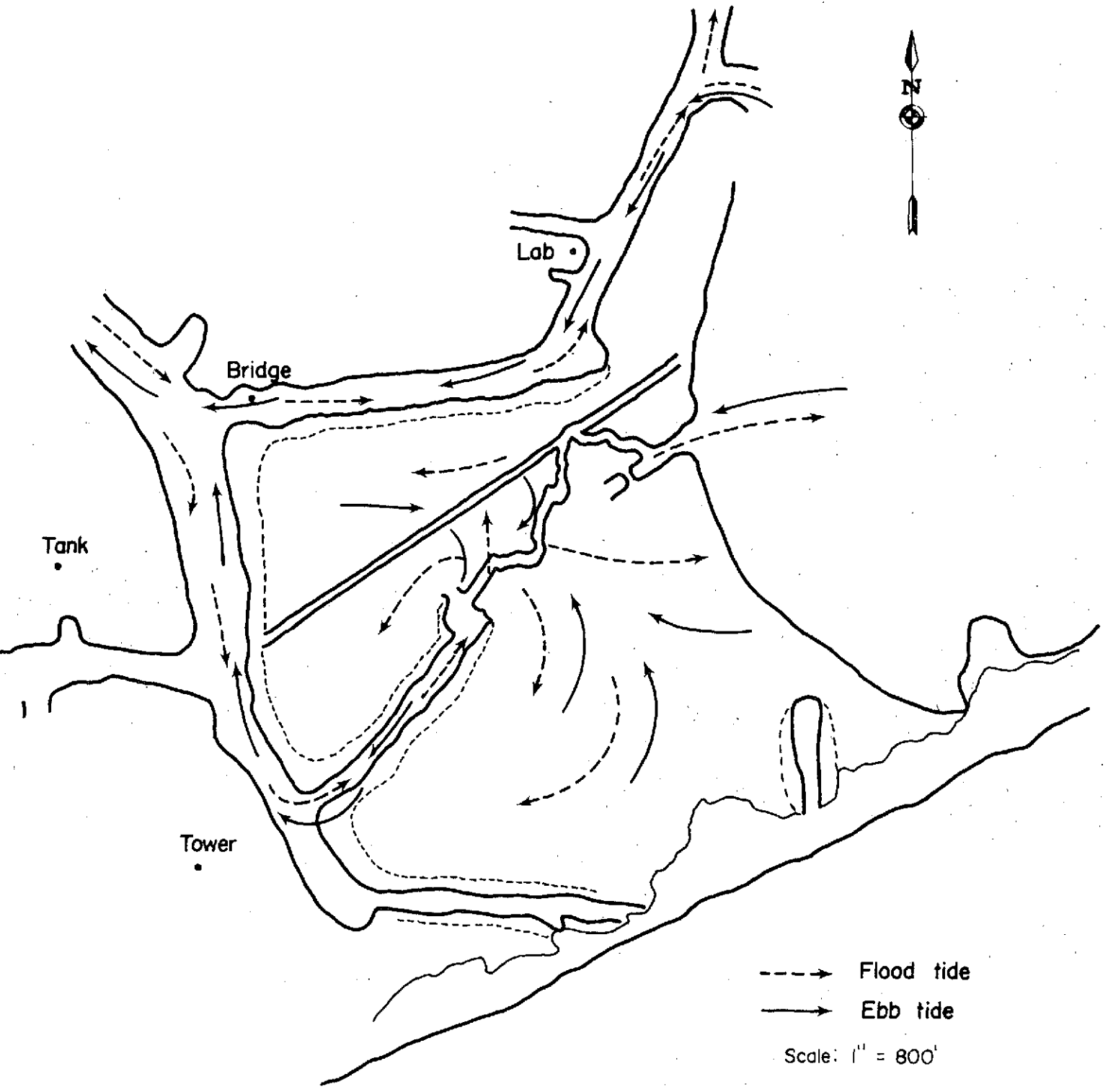


FIGURE 7A.-- Normal Drainage Fourchon Marsh

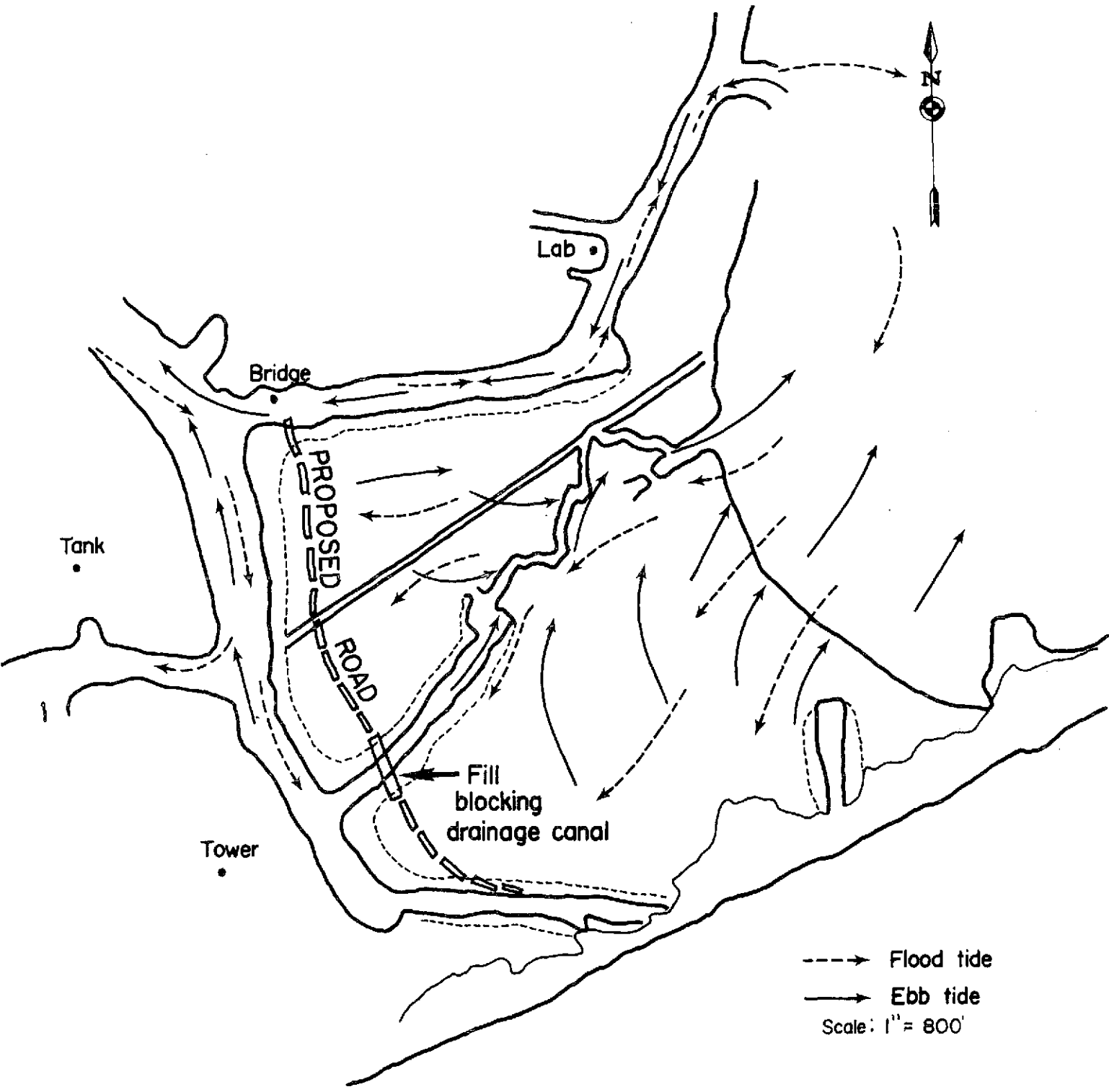


FIGURE 7B.-- Blockage of Location Canal and Resulting Drainage

6. Breaches in bay mouth bars may open and close from time to time greatly effecting local drainage near Bay Champagne. Drainage patterns in the marsh should be studied before any permanent breach is made. The bay mouth bars protect the marshes in back of them from erosion and should be preserved. Man-made changes may reverse drainage in the Bay Champagne area.

Recommendations

1. The photos can be used to map areas of marsh, spoil banks, beaches, and channels in the coastal areas of South Louisiana.
2. The photographs may be used to explore large areas for sand bodies which make better foundation materials than the mud in the surrounding marsh.
3. Engineering structures, such as goins and retaining embankments may be placed on or behind beaches prior to development. This may slow down or prevent excessive erosion.
4. Aerial photographs can be used to check canals and channels for areas of excessive erosion. These areas should be reinforced.
5. A speed limit on motor craft may help reduce bank erosion along channels and canals.
6. Care should be taken not to block tidal channels and other areas which affect tidal drainage.
7. The barrier islands or bars across the mouth of bays should be preserved since they protect the marsh from waves and hence prevent erosion of the marsh.
8. Seasonal changes in vegetation can be studied by use of the photo.

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