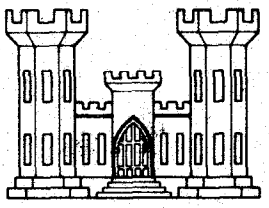


DREDGED MATERIAL RESEARCH PROGRAM

MISCELLANEOUS PAPER D-74-13

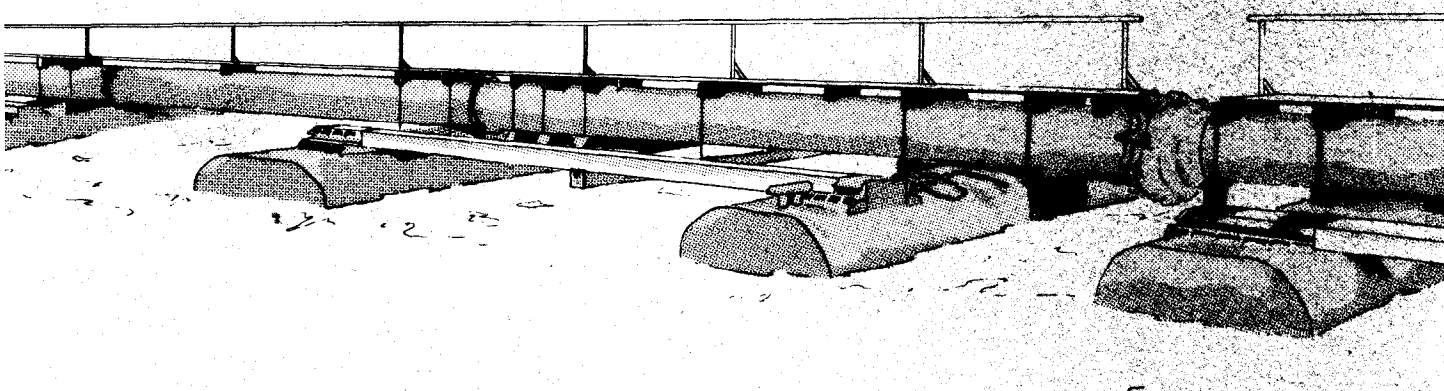
EFFECTS OF OPEN-WATER DISPOSAL OF DREDGED MATERIAL ON BOTTOM TOPOGRAPHY ALONG TEXAS GULF COAST

by

David F. Bastian

Hydraulics Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

November 1974
Final Report



Prepared for Environmental Effects Laboratory
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss. 39180

Destroy this report when no longer needed. Do not return it to the originator.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: Miscellaneous Paper D-74-13
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE *(and Subtitle)*: EFFECTS OF OPEN-WATER DISPOSAL OF DREDGED MATERIAL ON BOTTOM TOPOGRAPHY ALONG TEXAS GULF COAST

5. TYPE OF REPORT & PERIOD COVERED: Final report

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): David F. Bastian

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
U. S. Army Engineer Waterways Experiment Station
Hydraulics Laboratory
P. O. Box 631, Vicksburg, Miss. 39180

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:

11. CONTROLLING OFFICE NAME AND ADDRESS:
U. S. Army Engineer Waterways Experiment Station
Environmental Effects Laboratory
P. O. Box 631, Vicksburg, Miss. 39180

12. REPORT DATE: November 1974

13. NUMBER OF PAGES: 34 (plus 37 overlays in pocket)

14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*:

15. SECURITY CLASS. *(of this report)*:

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT *(of this Report)*:
Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*:

18. SUPPLEMENTARY NOTES:

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*:
Disposal areas
Dredged material
Dredge spoil
Hydrographic surveys
Ocean bottom
Spoil disposal
Submarine topography

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*:
Analysis of hydrographic surveys of hopper dredge disposal areas in the Gulf of Mexico off the coast of Texas indicated that dumping at these sites had little effect on bottom topography. Apparently there are no definitive, discrete mounds of dredged material formed as a result of open-water disposal.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

PREFACE

The study reported herein was the outgrowth of interpretations of data collected during a special survey of selected Corps of Engineers coastal dredged material disposal sites conducted and managed by the Environmental Effects Laboratory (EEL), U. S. Army Engineer Waterways Experiment Station (WES), as part of the Corps of Engineers' Dredged Material Research Program (DMRP).

The hydrographic surveys and dredging described herein were conducted from 1962 to 1973 by the U. S. Army Engineer District, Galveston. Mr. V. C. Keesecker, Galveston District, provided the information from the surveys. Data were analyzed by Messrs. R. E. Black, J. E. Lee, G. W. Hughes, and D. F. Bastian, WES, under the supervision of Mr. Bastian. Mr. Bastian prepared this report under the supervision of Dr. J. W. Keeley, Project Manager of the Aquatic Disposal Research Project, DMRP, EEL.

Director of WES during the preparation and publication of this report was COL G. H. Hilt, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

	Page
PREFACE	1
CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT	3
PART I: INTRODUCTION	4
Background	4
Purpose of Study	4
Study Method	4
PART II: DISPOSAL OPERATIONS AND SEDIMENT TRANSPORT	7
Determination of Required Dumping Distances	7
Fate of Disposed Dredged Material	8
PART III: SURVEYS OF DISPOSAL AREAS	12
Freeport	12
Port Aransas-Corpus Christi	14
Brazos Island Harbor	14
Matagorda Ship Channel	17
Port Mansfield	19
PART IV: SUMMARY	21
REFERENCES	22
TABLES 1-3	
PLATES 1-7	
OVERLAYS 1-37	

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
cubic yards	0.764555	cubic meters
square yards	0.836127	square meters
feet	0.3048	meters
miles (U. S. statute)	1.609344	kilometers
inches	0.0254	meters

EFFECTS OF OPEN-WATER DISPOSAL OF DREDGED MATERIAL ON BOTTOM TOPOGRAPHY ALONG TEXAS GULF COAST

PART I: INTRODUCTION

Background

1. Interest in the effects on ocean-bottom topography of open-water dredged material disposal has resulted in extensive research. Of basic concern is what happens to the dredged material once it is dumped from the hopper dredges into the open water. Pertinent records are sparse. Because geometry, hydraulic forces, meteorological conditions, and dredging requirements vary according to disposal site and time, any changes in bottom site topography are highly variable.

Purpose of Study

2. The purpose of the study reported herein was to analyse site survey data to yield information on the stability and growth rate of hopper dredge disposal areas along the Texas coast. Attention was focused on (a) the net change in bottom topography after a single disposal season and after several disposal seasons and (b) whether or not a definitive disposal mound was produced.

Study Method

3. Since the 1960's, the U. S. Army Engineer District, Galveston, has made hydrographic surveys of most of their hopper dredge disposal areas primarily to insure sufficient draft for the hopper dredges. Generally, the surveys were made prior to dredging operations and were in conjunction with surveys made to determine the condition of navigation channels. Fathometers were used and readings were corrected for tides. The disposal areas discussed herein are at Brazos Island, Port Mansfield, Matagorda, Freeport, and Port Aransas (Figure 1) on the Texas Gulf Coast, within the Galveston District.

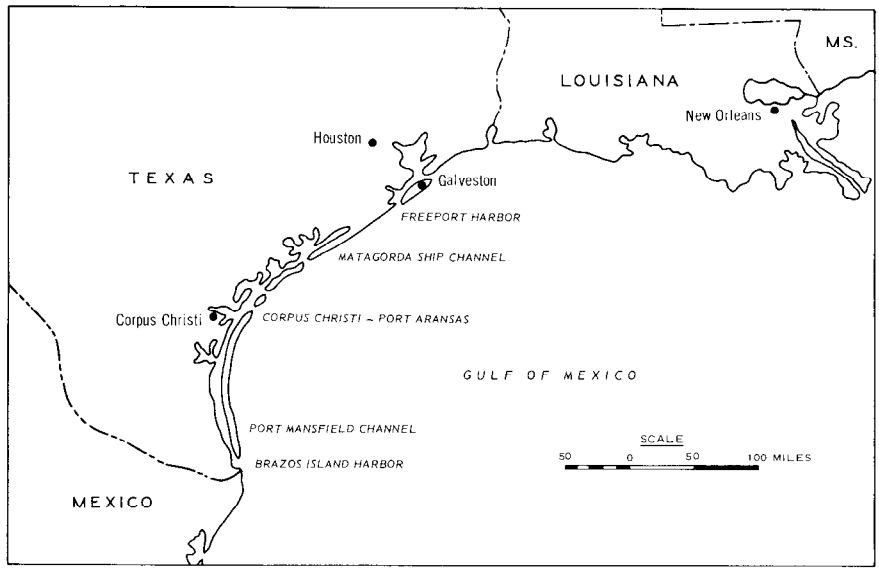


Figure 1. Hopper dredge disposal areas

4. Since the disposal areas along the Texas coast were of particular interest, contours of the five areas mentioned above were made at WES from survey data furnished by the Galveston District. Because the Galveston District usually marked only the shore-side and channel-side boundaries of the disposal areas, the other two sides had to be selected to obtain a basis of comparison between surveys. The selection was an arbitrary one, determined by the extent of the hydrographic survey. An effort was made to establish a comparable disposal area that was as large as possible. Occasionally this required extrapolation of contours.

5. Comparisons were made of changes of the average elevation of the disposal area with time. These comparisons are more significant when "before" and "after" dredge surveys are compared rather than when "after" and "after" surveys are compared (which is the most common case) because of the time intervals involved.* One difficulty in working with

* Normally hydrographic surveys were conducted soon after dredging was completed to insure adequate channel depth as required by contract. These surveys are referred to as "after" surveys by the Galveston District. On occasion, hydrographic surveys were conducted just prior to the initiation of dredging. These surveys are referred to as "before" surveys.

this method of comparison was that there were no records of the hopper dredge route as it dumped the dredged material. Therefore, the possibility exists that some portion of the material was dumped in an area outside of the boundaries shown in this study, due to the limited size of the areas contoured and the distance of travel required by the hopper dredge to empty its bins.

6. The survey was made by soundings taken from a boat operating in zigzag patterns perpendicular to the channel. In the few cases where an additional sounding-survey path was run in a zigzag pattern normal to the previously mentioned survey pattern the intersecting soundings were found to vary as much as 2 ft.* These additional survey patterns were not used.

---

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

PART II: DISPOSAL OPERATIONS AND SEDIMENT TRANSPORT

Determination of Required Dumping Distances

7. The two hopper dredges operating regularly in the Galveston District are the MacKENZIE and the McFARLAND. On occasion, the LANGFITT has also been operated in the District. Facts about these dredges pertinent to this report are tabulated below.

Name	Rated Speed fps		Hopper Capacity cu yd	Draft Loaded ft
	Loaded	Light		
LANGFITT	17.6	23.2	--	--
MacKENZIE	17.6	19.5	1656	21
McFARLAND	20.4	22.2	3140	23

8. The dredges operate up and down the channel. When the bins are full or when the dredge has obtained an optimum load, the dredge is taken to the disposal area, the bottom doors of the hopper bins are opened, and the dredged material falls from the bins while the speed of dredge as it moves through the disposal area remains the same (i.e., the material is expelled from the hopper while the dredge is moving). Whether or not, or how much of, the material is dumped while the dredge is over the disposal area is unknown.

9. The path that a dredge takes while dumping is not recorded, but records are available from which the average length of the dumping path can be determined.

10. Data from a collection of charts entitled "Report of Operations - Hopper Dredges" allowed for various calculations which are presented herein as Table 1. Assuming that the maximum speed attained by the dredge during dumping is equal to or less than the average speed calculated for the dredge traveling to and from the dump (based on personal correspondence and observation), the maximum distance that the dredge would travel while dumping can be expressed as

$$D_{max} = \overline{V} \times \overline{T}_d \qquad (1)$$

where

D_{max} = maximum distance dredge travels while dumping, miles

$\overline{V}$ = average velocity of dredge to and from dump site, mph

$\overline{T}_d$ = average time dumping per load hauled, hr

11. This calculation for each project gives an idea of the size of disposal area needed to correspond to the operation of the hopper dredge. From Table 1 the average maximum distance the dredge would travel while dumping is 2.2 miles at Brazos, 1.4 miles at Port Mansfield, 1.9 miles at Matagorda, 1.9 miles at Corpus Christi, and 2.2 miles at Freeport. However, this tells nothing about the path of the dredge.

Fate of Disposed Dredged Material

12. In attempting to determine the fate of the dredged material once it is dumped from the dredge, there are two basic considerations. First, when and where does the material reach the sea bed. Second, once at the bed, how long and what percentage of the material reaching the bottom will remain in place.

Initial release

13. Corps of Engineers records for dredging at the study areas in the Galveston District excluding Freeport show that over 80 percent of all the material handled by hopper dredges is sand (see Table 2). Upon release from the bin, this sand drops in bulk with an imparted horizontal velocity equal to that of the hopper dredge. How far the sand has to fall from the hopper dredge and through what currents are important factors relating to the initial lateral transport of the sand.

14. Due to turbulence and shear stresses, the sand falls in a combination of three forms: solid bulk, slurry, and particulate. As the sand falls, the bulk material moves fastest with the surrounding slurry moving as a distinct density current. Eddies are formed and particulate matter is sheared from the slurry. Particles fall the slowest. The fall velocity W of various sizes and shapes of sand

particles is well documented. In the present situation, according to Graf,[1] this is complicated since

> If more than a single sphere moves through an unbound fluid system, a mutual interaction will be noticed. It has been observed that the settling velocity increases if only a few closely spaced particles move, and that the fall velocity is reduced (i.e. the drag increased), if many particles are dispersed throughout the fluid.

15. By making the gross assumption that given no ocean current, the particulate matter would observe its empirically determined fall velocity. From sieve analysis of samples taken aboard hopper dredges while dredging, the extreme low value for 20 percent finer by weight d_{20} and the extreme high value for the 80 percent finer by weight d_{80} for all study areas except Freeport are 2.35×10^{-3} in. and 1.56×10^{-1} in., respectively. The following tabulation presents the fall velocities and the expected time for these particles to reach the ocean floor, assuming that the hopper dredge has a draft of 21 ft and the water depth is 36 ft.

	$\frac{d_{20}}{2.35 \times 10^{-3}}$	$\frac{d_{80}}{1.56 \times 10^{-1}}$
Particle size, in.		
Fall velocity W , fps	0.008	0.2
Time of fall, sec	1888	75

The larger sand grains would reach the bottom in about 1 min, whereas the smaller sand would take up to 30 min.

16. Both the speed of the dredge and the velocity of the ocean currents impart a horizontal component to the falling sand, which prescribes a nonvertical path. Still ignoring turbulence, without knowing the vertical velocity distributions, prediction of the final target is difficult to pinpoint.

17. The final problem in predicting when and where the sand will fall is turbulence. Turbulence counterbalances the settling tendency of the particles. Depending upon the turbulence, the sand can remain suspended and be transported great distances.

18. In summary, the material released from the dredge falls in a combination of three forms: particulate, slurry, and bulk. The larger particles and that material falling in bulk and slurry can be expected to hit the bottom within a few minutes.

Suspension due to impact

19. As the sand hits the sea bed, turbulence and rebound occur. Some of the material is undoubtedly resuspended. Depending upon the concentration of the suspensions and local currents, this suspended material can be transported away from the disposal area.

Erosion of dredged material banks

20. The erosion of material from a dredged material bank is dependent upon the type and degree of compaction of the material, bed form, water viscosity, and magnitude of local currents. As the sand size under consideration (for all sites except Freeport) is greater than 7.48×10^{-3} in., the effects of special properties of shape, packing, and cohesiveness are negligible.[2] Thus, there is no armoring effect (Reference 3, p 152) as is observed with silts and clays. However, research has been able to show that in some situations benthos can stabilize the dredged material mound surface.[4]

21. By neglecting the stabilizing effect of benthos, the erosion of the sand can be studied from strictly a fluid velocity standpoint. Simply stated, critical shear velocity is required to move bottom particles. Sediment motion is of two forms: bed load and suspended load.

22. To help evaluate what effect known currents will have upon the stability of the mound of dredged material it is necessary to know the size of particles, water viscosity, and bottom currents. With this information various competency curves (i.e. Shields Diagram) exist which can be used to determine if the material will be transported and in what form. By knowing the duration of current equal to or greater than the critical shear velocity, the amount of time the material will move can be predicted. But this tells nothing about the volume of material which would be transported; this requires the use of equations of motion and continuity for both water and sand. Unless the bank is large enough to change the local current patterns, material will be eroded

not only from the bank but also from the surrounding area. If the bank is composed of sands different from those of the surrounding area, then the bank will be subject to a different rate of attack. Some of the bank material will move and will be replaced simultaneously to some degree.

23. According to Morris and Wiggert,[5] ordinary wave activity can move sand to depths of about 30 ft below the water surface. Since most of the disposal areas under consideration are in greater depths, ordinary wave activity should have little effect on the disposal area. Studies by Smith and Hopkins (Reference 3, p 172) and by Sternberg and McManus[6] show that storm-generated currents have a pronounced effect on sediment movement even in depths greater than 200 ft. A logical conclusion is that storms in the Gulf of Mexico generate enough energy to produce pronounced effects on the bottom topography. The critical erosion velocity measured about 3 ft above the bed for sand ranging from 2.76×10^{-3} to 1.57×10^{-2} in. is about 1.5 fps with the cessation of movement velocity being even less.

Littoral drift

24. Littoral drift is the major classification of nearshore sediment movement. Disposed dredged material can be part of the littoral drift process, depending on location. If not directly, then it can be influenced by its proximity to the jetties and channel which interrupt the littoral process and result in topographical changes. Brunn and Lackey[7] have concluded that up to about 400,000 to 500,000 cu yd a year pass a given point on part of the Texas shore.

PART III: SURVEYS OF DISPOSAL AREAS

Freeport

25. Hopper dredges operating at Freeport use the two disposal areas (A and B) shown in Figure 2. These areas are along both sides of the entrance channel and reach from sta -20+00 to sta -110+00. They parallel the channel 500 ft from the channel sides. There is no defined outside border (away from the channel). The northern disposal area, A, is used when the current is from south to north and the southern disposal area, B, is used when the current is from north to south.

26. The exterior boundary for both areas A and B was chosen such that the area of each measures 1,135,000 sq yd.* The results of only three surveys (Plate 1, Overlays 1 and 2)** were available; these surveys cover the period 1964-1966.† Between the first and third surveys, a total of 1,771,889 cu yd of dredged material was dumped. Despite this dumping, the average elevation of both disposal areas decreased about 0.5 ft. Table 3 presents the dates of the surveys and the corresponding disposal area bottom elevations, as well as the dates of dredging and the corresponding volume of material dumped.

27. The areas chosen for study are 5000 ft long and lie parallel to the channel. From records for 1968-1972 (see Table 1), the average length of travel required by the hopper dredge to empty its bins was calculated to be about 1.1 miles, which corresponds well with the modified length of the disposal area.

28. It is obvious that the disposal areas do not reflect the amounts of dredged material being dumped but instead show a tendency for the disposal areas to be scoured.

29. Two possible reasons for the lack of buildup are (a) the

---

* The study areas had to be shortened to sta -70+000 because of the data available from the surveys.

** Transparent overlays for the disposal area maps are in the pocket on the inside back cover of this report.

† The disposal area contour maps were developed using Galveston District hopper dredge survey maps. The contouring was done at WES.

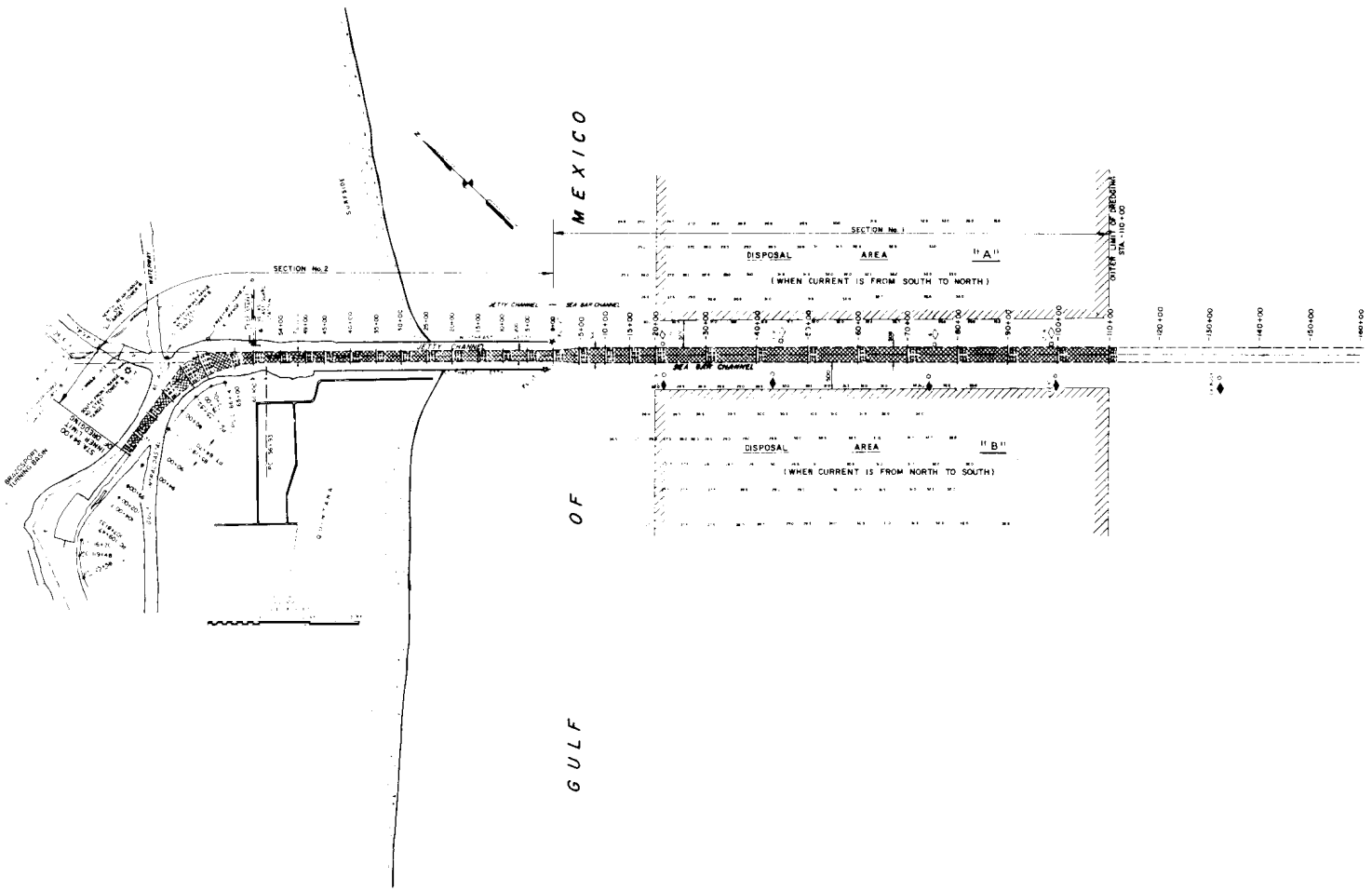


Figure 2. Freeport Harbor hopper dredge disposal areas

dredged material was 80 percent silt according to Galveston District maps and (b) there was a long time period between dredging and surveys. Once dumped from the bins, any material that remained particulate would stay in suspension for relatively long periods. This material could easily come to rest outside the disposal area. The material that reached the disposal area is erodible, and the rate of erosion is related to the cohesion, compaction, and water content of the disposed material. The second reason for lack of buildup may be attributed to the 6-month to 1-yr lapse of time between dredging and subsequent surveys, during which time equilibrium of the bottom topography in the disposal area was probably achieved. However, neither reason explains the net deepening of the disposal area.

Port Aransas-Corpus Christi

30. At Port Aransas, hopper dredging is done in the jetty and outer bar channel. The dredged material is dumped in the designated disposal area bounded between sta 80+00 and sta 145+00 and 800 ft south of the south side of the outer bar channel (Figure 3). The area of analysis coincides with the District's boundaries set above. The width of the disposal area was chosen to be 1500 ft.

31. Data in Table 3 indicate a definite accretion trend in the area of study. From 1961 to 1973 the disposal area bottom elevation rose about 5 ft. Contoured areas can be compared by study of Plate 2 and Overlays 3-10.

Brazos Island Harbor

32. Hopper dredges at Brazos Island Harbor utilize a dump area north of the sea bar channel (Figure 4). The District has defined the southern channel and western shore boundaries of the disposal area. The southern boundary remained constant at 800 ft from the center line of the channel; the western boundary was extended seaward from sta -10+200 to sta -13+000 in 1966 to sta -15+00 in 1967.

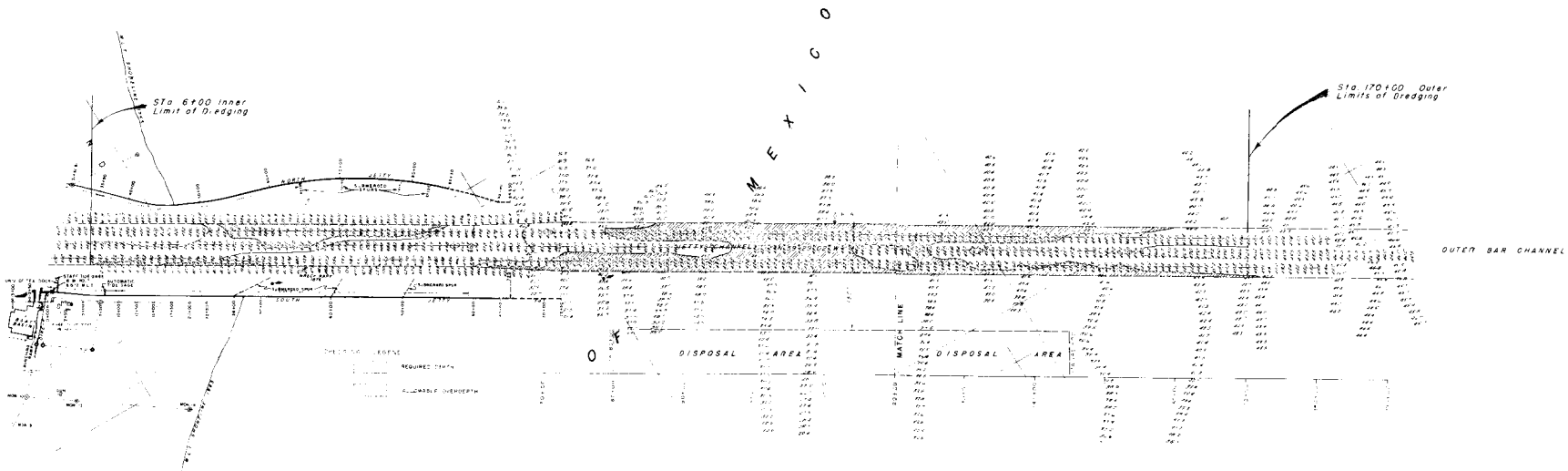


Figure 3. Port Aransas-Corpus Christi waterway hopper dredge disposal area

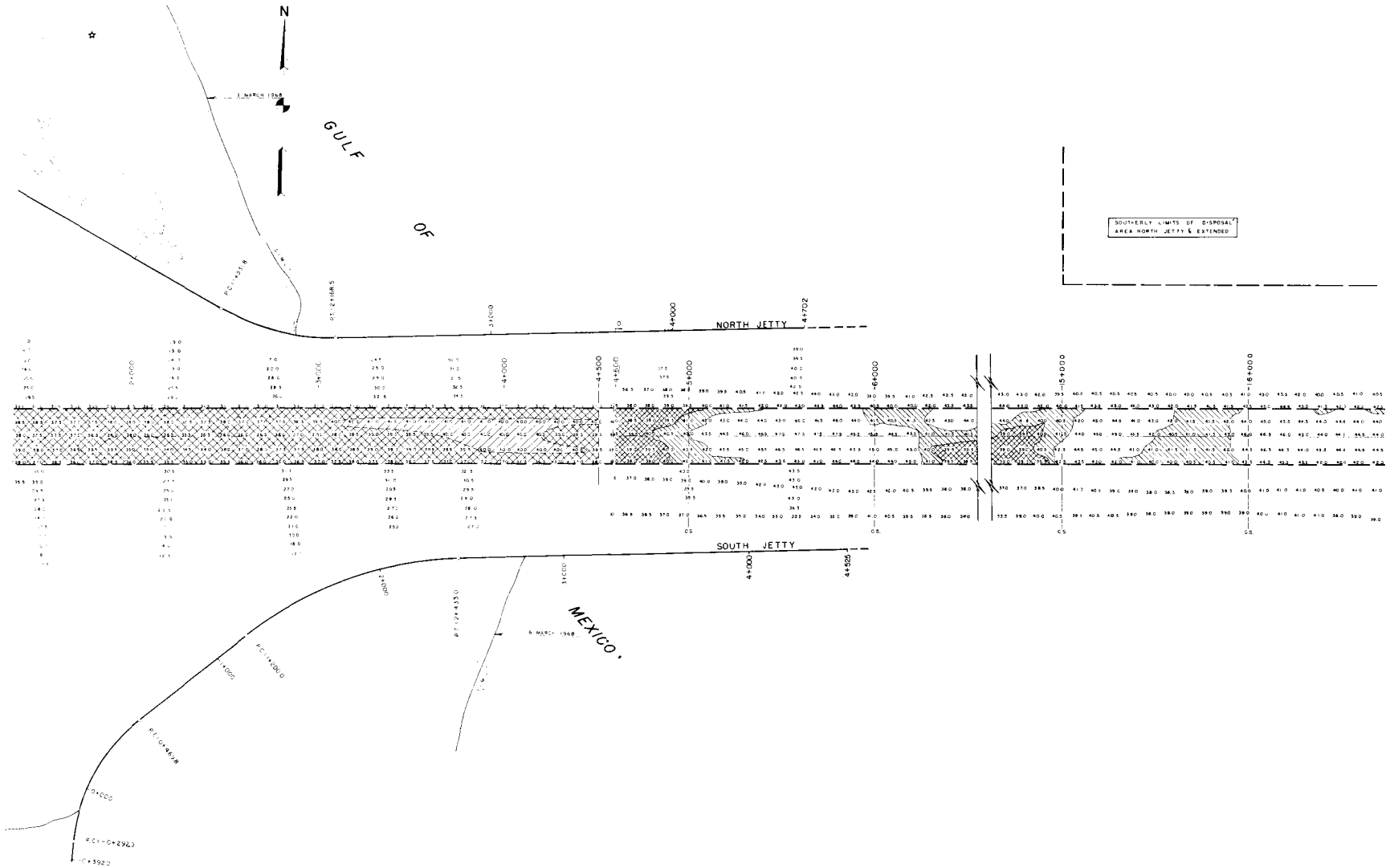


Figure 4. Brazos Island Harbor hopper dredge disposal area

33. Because the western (shoreside) boundary was moved seaward twice during the period of study and because of the extent of soundings, two areas were defined for comparative study. The first area chosen (covering dredging from 1964 to 1967), designated Brazos I, was applied to Plate 3 and Overlays 11-15 because the disposal area was shifted as shown by Plate 4 and Overlays 16-18. This area is 5000 ft long starting at sta -10+200, and is 2000 ft wide. Table 3 presents the dates of surveys and the corresponding disposal area bottom elevations and the dates of dredging and the corresponding volume of material dumped. This area remained relatively stable during the period of study and showed no positive trend toward buildup of the disposal area.

34. The second area chosen, designated Brazos II (Plate 4, Overlays 16-18), covers the period of dredging from 1968 to 1970. Brazos II disposal area starts at sta -15+000 and extends 3200 ft seaward and is 2000 ft wide. Average hopper dredge dumping distances for the period 1969-1972 were calculated and found to be 1.2 miles, which is about twice the length of the chosen study area. Table 3 presents the dates of the survey and the corresponding disposal area bottom elevations and the dates of dredging and the corresponding volume of material dumped. The fathometer survey of 5 June 1968 yielded an average bottom elevation of -54.7 ft from 14-30 June; 228,103 cu yd of dredged material were dumped, but the 2 July fathometer survey shows an average bottom elevation of -55.4 ft. If the results of these surveys are correct, there was a net scour of 166,000 cu yd during this 18-day period. Subsequent surveys show a buildup trend.

Matagorda Ship Channel

35. The hopper dredge operating at Matagorda utilizes a disposal area south of the entrance channel as shown in Figure 5. This area is bounded on three sides, 1000 ft south of the south side of the channel and by sta -11+000 and sta -17+000. Since 1963, the disposal area shoreside limit has moved seaward from sta -8+000 because of shoaling off the ends of the jetties. During the 1960's, the project area was

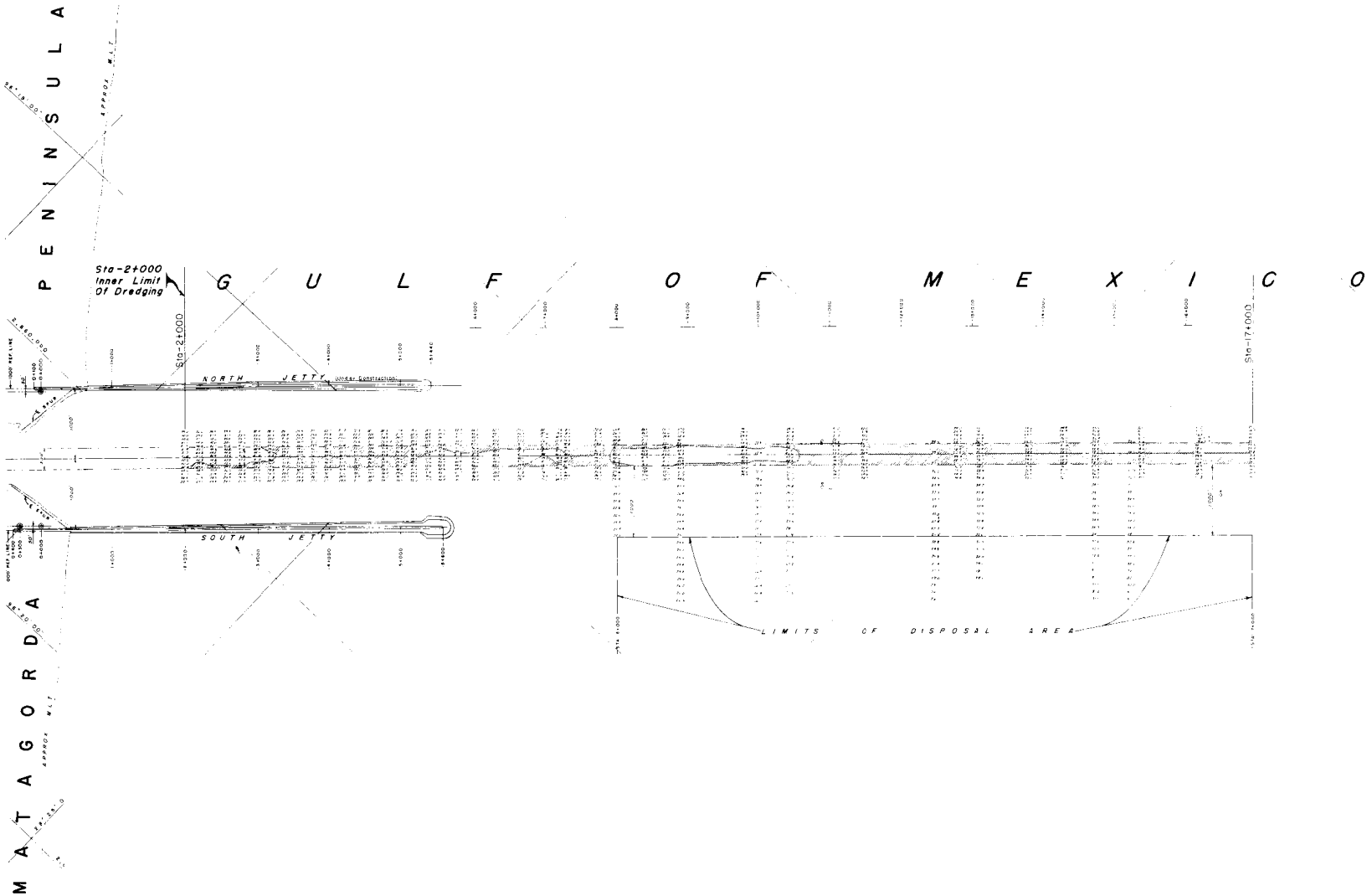


Figure 5. Matagorda Ship Channel hopper dredge disposal area

going through a period of adjustment because of the cut made through the Matagorda Peninsula for the Matagorda Ship Channel. Whether or not it has stabilized is not known. The comparative study area is 6000 ft by 1000 ft as shown in Plate 5 and Overlays 19-26 and Plate 6 and Overlays 27-33. This agrees with the average computed required dumping distance of 1.2 miles.

36. The study area has had a buildup of about 7 ft between 1963 and 1971 as shown in Table 3. (Unexplainable is the survey of March 1968 immediately after disposal, which shows a net scour; a survey three months later, during which time there was no dredging, shows an accretion.)

Port Mansfield

37. At Port Mansfield the hopper dredge used two disposal areas until 1967, after which a single disposal area was used (see Figure 6). As defined by the District, these areas are on either side of the entrance channel, 825 ft from its center line; they start at sta 3+200 and there is no seaward limit. Only five surveys were available (Plate 7 and Overlays 34-37). Of these, only two show the south disposal area. For purposes of the study a common area of comparison was defined in the north disposal area shown in Figure 6. This area is 2000 by 1500 ft. The average required dumping distance calculated from available records shown in Table 1 indicates that the chosen study area is too small. However, because of the limited extent of some of the surveys, the small size of area was necessary for comparison. The study area remained stable over the period of record from 1965 to 1970 with an average bottom elevation of -30 ft.

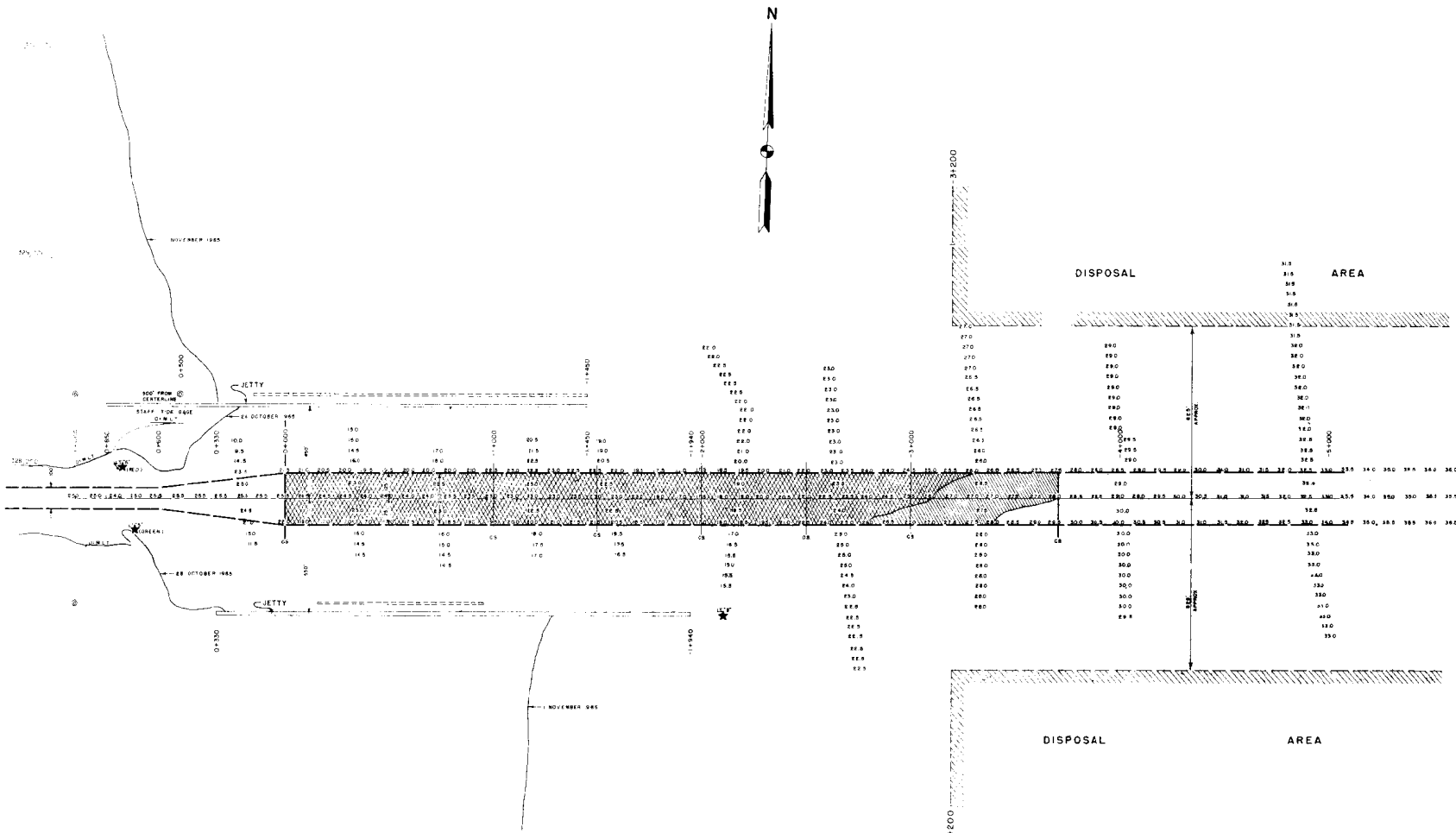


Figure 6. Port Mansfield Channel hopper dredge disposal areas

PART IV: SUMMARY

38. Three of the six navigation project hopper dredge disposal areas studied showed accretion, two were stable, and one showed a slight scour tendency. The Matagorda area showed the greatest change with about a 7-ft bottom elevation rise during a 9-yr period. The rise is attributed not only to dredge disposal but to adjustment of the area to the cut through Matagorda Peninsula. Because the studies focused only on the disposal areas nothing can be said about the surrounding areas. In all probability the surrounding areas experienced the same net change in bottom elevation. It appears that net changes in the bottom elevations are strongly related to the dynamics of the area involved. In addition, disposal areas are not physically marked resulting in a low probability of coinciding repetitive dumping paths of the hopper dredges. Because the dredging process takes such a long time, hydrodynamic forces tend to smooth out each individual disposal. In terms of significance, dumping has had little effect on bottom topography for the sites surveyed. There does not appear to be definitive disposal banks of dredged material.

REFERENCES

1. Graf, W. H., Hydraulics of Sediment Transport, McGraw-Hill, 1971, p 56.

2. Sternberg, R. W., "Predicting Initial Motion and Bedload Transport of Sediment Particles in the Shallow Marine Environment," Shelf Sediment Transport: Process and Pattern, Dowden, Hutchinson, and Ross, Inc., Stroudsburg, Pa., 1972, pp 76-77.

3. Smith, J. D. and Hopkins, T. S., "Sediment Transport on the Continental Shelf Off of Washington and Oregon in Light of Recent Current Measurements," Shelf Sediment Transport: Process and Pattern, Dowden, Hutchinson, and Ross, Inc., Stroudsburg, Pa., 1972, pp 143-180.

4. Rhoads, D. C. and Young, D. K., "The Influence of Deposit-Feeding Organisms on Sediment Stability and Community Trophic Structure," Journal of Marine Research, Vol 28, 1970, pp 150-178.

5. Morris, H. M. and Wiggert, J. M., Applied Hydraulics in Engineering, Ronald Press, 1972, p 585.

6. Sternberg, R. W. and McManus, D. A., "Implications of Sediment Dispersal from Long-Term, Bottom-Current Measurements on the Continental Shelf of Washington," Shelf Sediment Transport: Process and Pattern, Dowden, Hutchinson, and Ross, Inc., Stroudsburg, Pa., 1972, p 193.

7. Brunn, P. and Lackey, J. B., "Engineering Aspects of Sediment Transport," Reviews in Engineering Geology, Vol 1, 1963, p 83.

Table 1

Determination of Required Hopper Dredge Dumping Distances

Dredge	Date of Operation	No. of Loads	Average Distance miles	Time to and from Dump hr	Total Distance miles	Average Speed mph	Dumping Time hr	Time per Dump hr	Dumping Distance miles	Average Load cu yd
				Freeport						
A. MacKENZIE	Oct-Nov 68	589	1.0	155	1178	8.0	67	0.11	0.88	1,205
	Apr-May 69	502	1.6	168	1606	9.6	43	0.09	0.82	1,315
	Dec 69	399	0.9	72	718	10.0	37	0.09	0.90	1,410
	May-Jun 70	399	2.2	73	1931	26.5	33	0.08	2.19	1,511
	Dec 70	430	1.5	102	1410	12.8	36	0.08	1.01	1,438
	Feb-Mar 71	154	3.7	140	1140	8.1	25	0.16	1.31	1,510
	Apr-May 71	539	1.3	135	1401	10.4	45	0.08	0.87	1,429
	Oct-Nov 71	348	0.6	64	418	6.5	32	0.09	0.60	983
	Apr-May 72	488	1.0	83	976	11.8	43	0.09	1.04	1,269
	Nov-Dec 72	310	1.1	63	682	10.8	31	0.10	1.08	1,329
				Port Aransas-Corpus Christi						
	May-Jul 69	509	1.4	164	1465	8.69	102	0.20	1.74	1,633
	Jul 70	368	1.3	73	957	13.11	50	0.10	1.29	1,540
	8-12 Feb 71	114	3.4	95	730	7.68	21	0.18	1.41	1,406
	May-Jul 71	802	1.4	291	2246	7.72	164	0.20	1.58	1,064
McFARLAND	1-22 Jul 72	175	1.5	48	525	10.94	30	0.17	1.88	1,465
A. MacKENZIE	Jul-Sep 72	686	0.5	153	686	4.98	148	0.22	0.97	1,332
McFARLAND	Sep-Dec 72	925	1.3	252	2405	9.54	78	0.08	0.80	1,421
				Brazos Island Harbor						
A. MacKENZIE	Jan 67	208	2.2	69	915	13.3	36	0.17	2.26	1,637
McFARLAND	Aug 68	107	2.3	55	501	9.1	11	0.10	0.91	1,488
A. MacKENZIE	Aug 70	426	2.7	195.2	2300	11.8	65.6	0.15	2.12	736
	Aug-Sep 71	360	1.1	195	792	7.3	65.5	0.18	0.74	981
	Jun-Jul 72	379	0.3	125	227	1.8	79.5	0.21	0.38	1,602
				Matagorda Ship Channel						
	Sep-Oct 68	479	0.9	163.4	862	5.28	1.02	0.21	1.11	1,363
	Feb-Apr 69	414	1.9	198.55	1573	7.92	98.37	0.24	1.90	1,507
	Oct-Nov 69	710	0.7	130	994	7.65	128	0.18	1.38	1,559
	Apr-May 70	385	0.6	77.55	462	5.96	65.25	0.17	1.01	1,545
	Oct-Nov 70	571	1.7	233	1941	8.33	101.15	0.18	1.01	1,446
	Jul-Aug 71	179	0.9	57.15	322	5.63	32.55	0.18	1.01	1,360
	Mar-Apr 72	392	0.2	80.45	1568	1.94	67.35	0.17	0.33	1,429
				Port Mansfield						
	Jun 69	195	0.9	32.15	351	10.92	24.50	0.13	1.42	1,492
	Jun 70	255	0.6	44.05	306	6.95	24.05	0.09	0.63	1,157
	May-Jun 72	494	0.3	82.10	296	3.61	41.35	0.08	0.29	1,252

Table 2

Grain-Size Distribution of Dredged Material

Period of Sampling	Grain Size, mm d_{20}	Grain Size, mm d_{80}
Freeport		
7 Oct-11 Nov 68	0.007	0.05
14 Apr-11 May 69	0.001	0.08
1-30 Dec 69	0.001	0.07
18 May-7 Jun 70	0.001	0.067
30 Nov-27 Dec 70	0.001	0.08
22 Feb-7 Mar 71	0.001	0.026
19 Apr-16 May 71	0.001	0.072
14 May 71	0.001	0.64
29 Oct-28 Nov 71	0.001	0.061
15 Nov-10 Dec 72	0.001	0.058
Port Aransas-Corpus Christi		
12 May-4 Jun, 16 Jun-3 Jul 69	0.08	0.17
8-15 Jun, 30 Jun-19 Jul 70	0.08	0.17
8-21 Feb 71	0.048	0.18
17 May-25 Jul 71	0.11	0.18
1-22 Jul 72	0.09	0.17
24 Jul-24 Sep 72	0.09	0.15
Brazos Island Harbor		
6-17 Aug 68	0.09	0.17
4-31 Jul 69	0.067	0.17
27 Jul-30 Aug 70	0.085	0.158
9 Aug-19 Sep 71	0.088	0.17
26 Jun-17 Jul 72	0.09	0.388
Matagorda Ship Channel		
10 Feb-13 Apr 69	0.085	0.17
29 Jul-6 Oct 69	0.09	0.2
3 Oct-30 Nov 69	0.081	0.27
20 Apr-17 May 70	0.11	0.37
11 Oct-29 Nov 70	0.085	0.171
25 Jul-8 Aug 71	0.078	0.163
20 Mar-16 Apr 72	0.081	0.171
Port Mansfield		
5-15 Jun 69	0.06	0.22
16-29 Jun - 20-26 Jul 70	0.065	0.224
15 May-22 Jul 72	0.063	0.226

Table 3

Survey and Dredging Data

Date of Survey	Date of Dredging	Volume of Dredged Material cu yd	Average Elevation of Disposal Area ft, mlt	
			Area A	Area B
		Freeport		
7 Jan 1964			-30.22	-29.31
	5 Oct-15 Nov 1964	806,689		
Oct 1965			-30.24	-29.66
	24 Oct-19 Nov 1965	965,200		
Jul 1966			-30.68	-30.07
		Port Aransas-Corpus Christi		
14 Aug 1961			-36.55	
26 Sep 1961			-39.07	
18 Dec 1962				
	Dec 1964-Jan 1965	266,041		
	Dec 1965	51,906		
	Feb 1966	398,478		
17-20 May 1966			-34.33	
	Jun-Aug 1966	498,279		
	Aug-Dec 1967	1,264,972		
	Apr-Jun 1968	489,132		
10-21 Apr 1969			-33.94	
	May-Jul 1969	898,568		
11-25 May 1970			-33.07	
	Jun-Jul 1970	570,010		
	Feb 1971	157,500		
Apr 1971			-32.58	
	May-Jun 1971	571,147		
Jun 1972			-32.60	
Feb 1973			-31.96	
		Brazos I		
Apr 1964			-46.72	
Jan 1965			-47.76	
	Feb 1965	112,089		
5 Mar 1965			-47.08	
	Apr-Jun 1965	309,338		

(Continued)

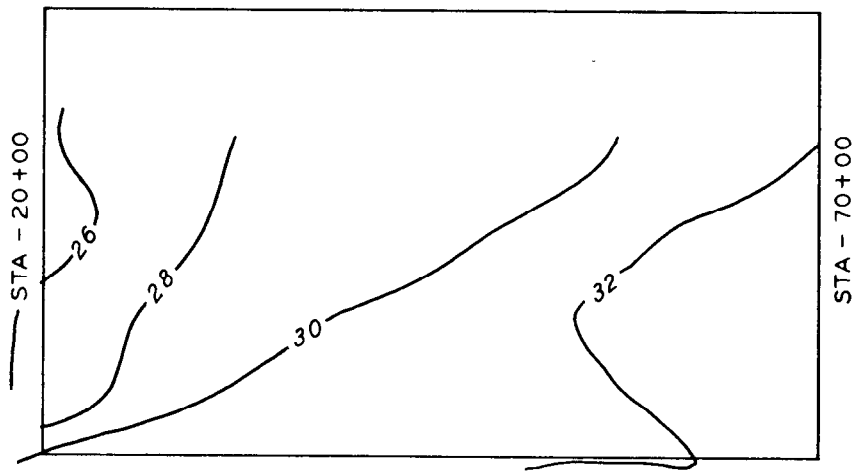
Table 3 (Continued)

Date of Survey	Date of Dredging	Volume of Dredged Material cu yd	Average Elevation of Disposal Area ft, mlt
	Brazos I (Continued)		
11 Mar 1966			-47.69
	Apr-May 1966	247,903	
10 May 1967			-47.98
30 Sep 1967			-46.86
	Oct-Nov 1967	337,870	
	Brazos II		
5 Jun 1968			-54.72
	14-30 Jun 1968	228,103	
2 Jul 1968			-55.40
	Jul 1969	217,940	
Jun 1970			-52.64
	Jul-Aug 1970	341,593	
Feb 1971			-52.58
	Matagorda		(msl)
7 Mar 1963			-33.2
8 Jul 1963			-35.9
12 Oct 1963			-33.3
11 Jun 1965			-32.9
	Aug-Oct 1965	1,712,285	
	Nov-Dec 1965		
	Feb 1966		
16 Feb 1966			
	Mar-Apr 1966	536,212	-33.0
28 May 1966			-30.8
	Jul, Sep-Oct, Dec 1966	728,300	
13 Feb 1967			-30.1
	Mar-Apr 1967	381,500	
27 Jan 1967			-31.0
	Jul-Aug 1967	537,100	
1 Oct 1967			-29.2
	Oct 1967	448,364	
23 Jun 1968			-29.5
	Jan-Mar 1968	661,000	

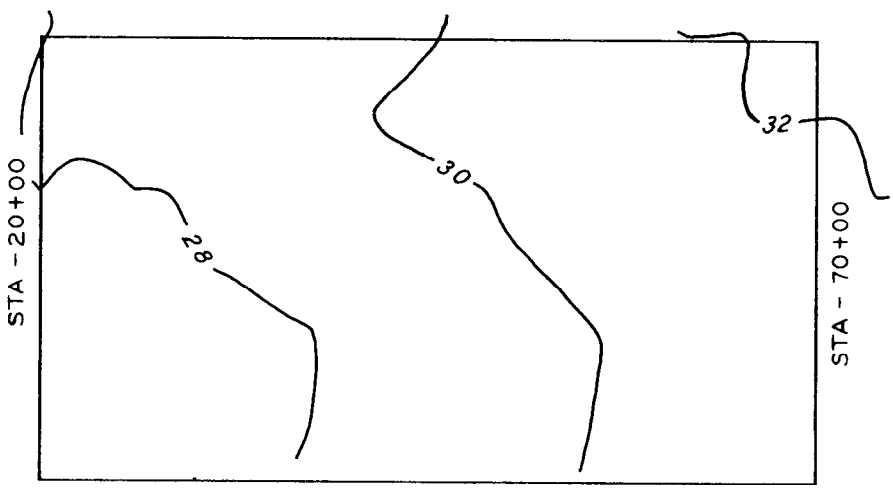
(Continued)

Table 3 (Concluded)

Date of Survey	Date of Dredging	Volume of Dredged Material cu yd	Average Elevation of Disposal Area ft, mlt
	Matagorda (Continued)		
26 Mar 1968			-29.8
30 Jul 1968			-28.83
	Jul-Oct 1968	683,664	
	Feb-Apr 1969	711,000	
Jul 1969			-29.0
	Oct-Nov 1969	1,003,000	
12 Mar 1970			-27.8
	Apr-May 1970	492,087	
24 Aug 1970			-26.5
	Oct-Nov 1970	906,785	
Feb 1973			-26.82
	Port Mansfield		
20 Oct 1965			-30.4
22 Aug 1966			-31.4
	Jul 1968	261,461	
Apr 1969			-29.8
	Jun 1969	161,110	
May 1970			-30.6



CENTER LINE OF CHANNEL



NOTE: DASHED LINES INDICATE THAT CONTOURS WERE ESTIMATED.

CONTOURED DISPOSAL AREAS

FREEPORT HARBOR

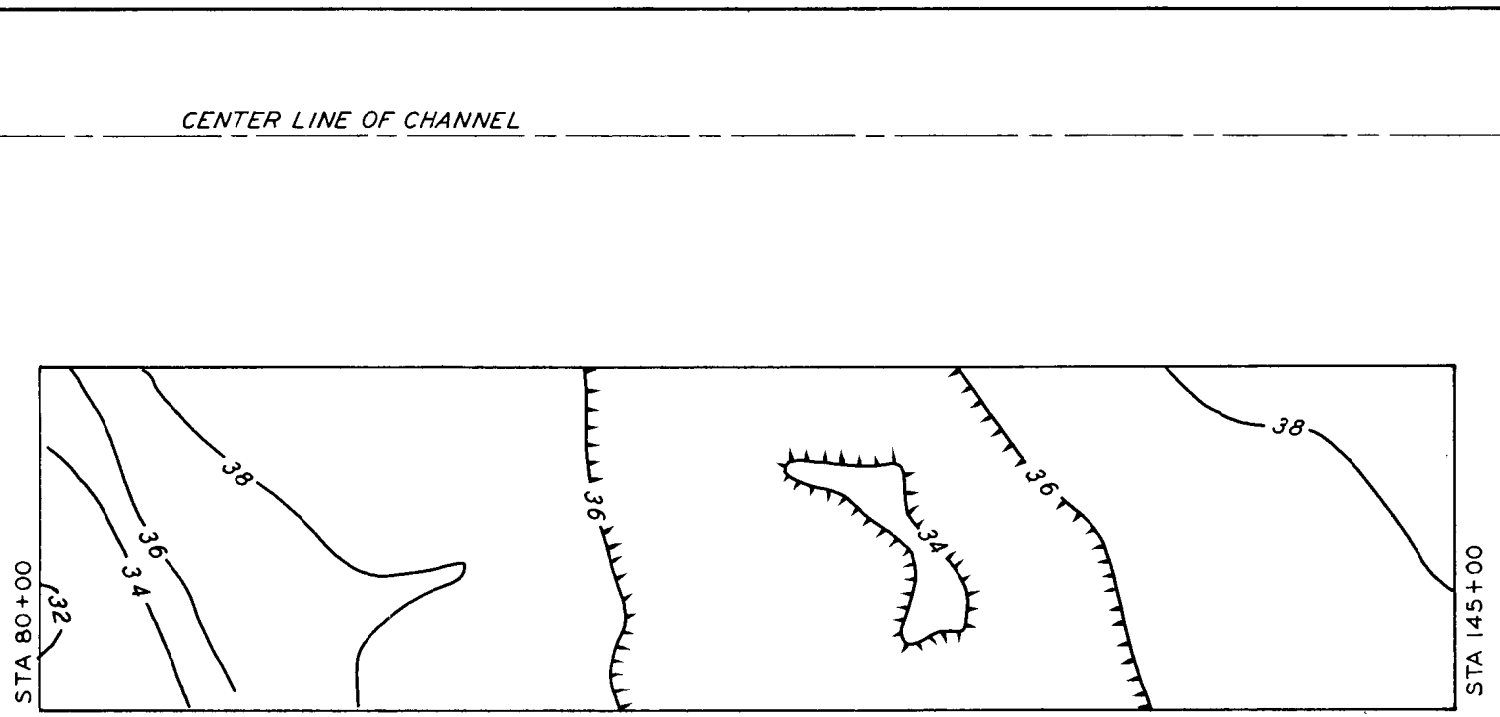
JAN 1964

SCALE

1000 0 1000 2000 FT

PLATE 1

PLATE 2



NOTE: DASHED LINES INDICATE THAT CONTOURS WERE ESTIMATED.

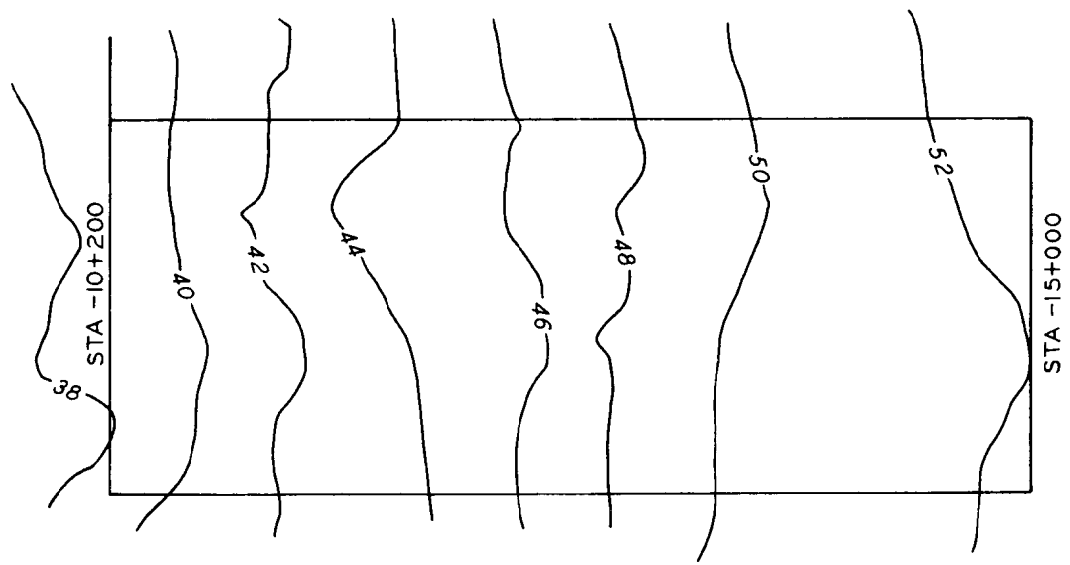
CONTOURED DISPOSAL AREAS

PORT ARANSAS CORPUS CHRISTI

AUG 1961

SCALE

500 0 500 1000 FT



CONTOURED DISPOSAL AREAS

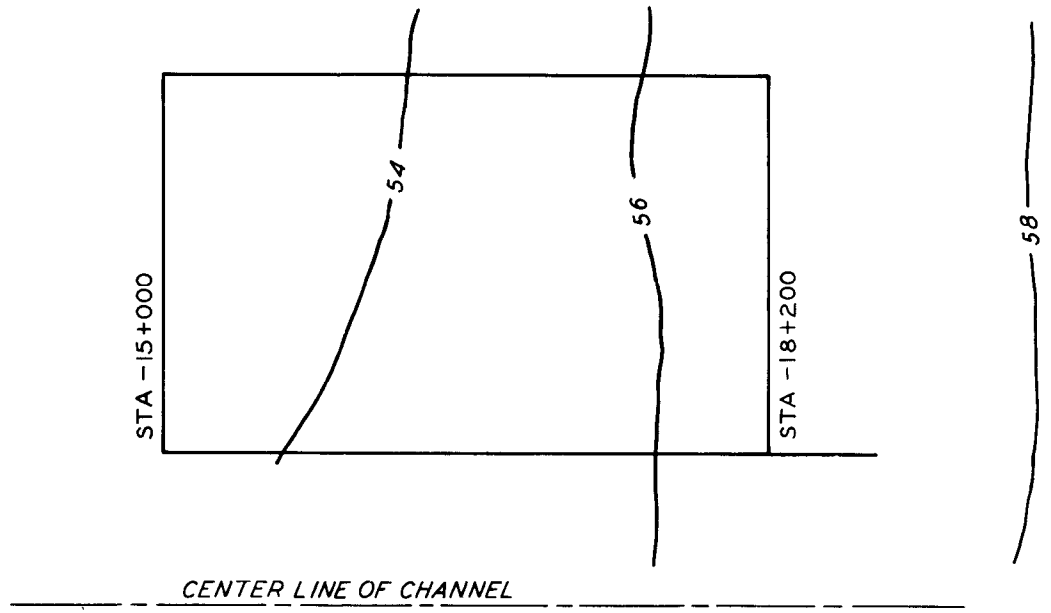
BRAZOS I
APR 1964

SCALE

500 0 500 1000 FT

PLATE 3

PLATE 4



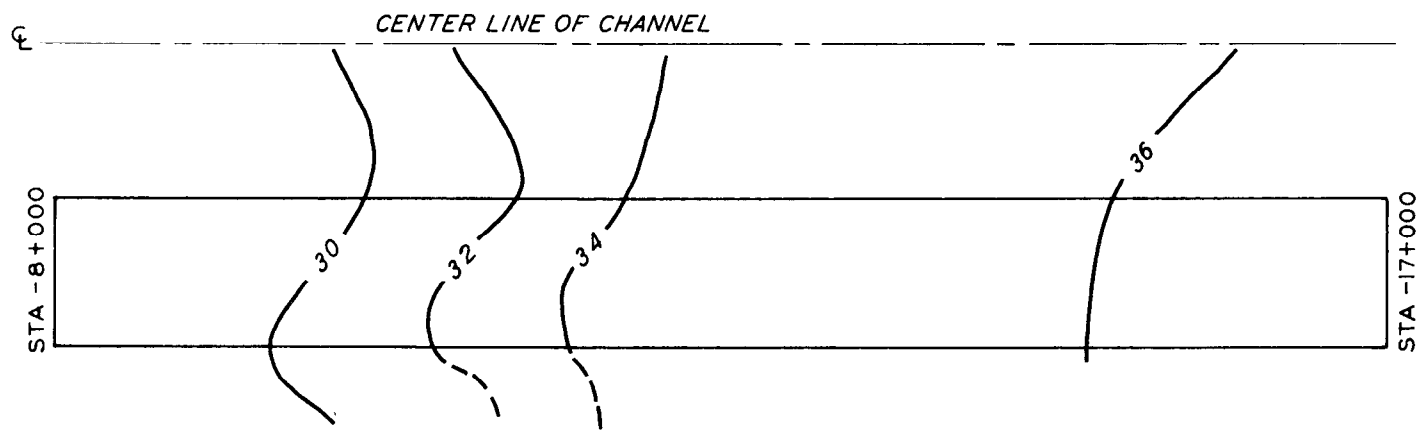
CONTOURED DISPOSAL AREAS

BRAZOS II

JUN 1968

SCALE

500 0 500 1000 FT



NOTE: DASHED LINES INDICATE THAT CONTOURS WERE ESTIMATED.

CONTOURED DISPOSAL AREAS

MATAGORDA SHIP CHANNEL

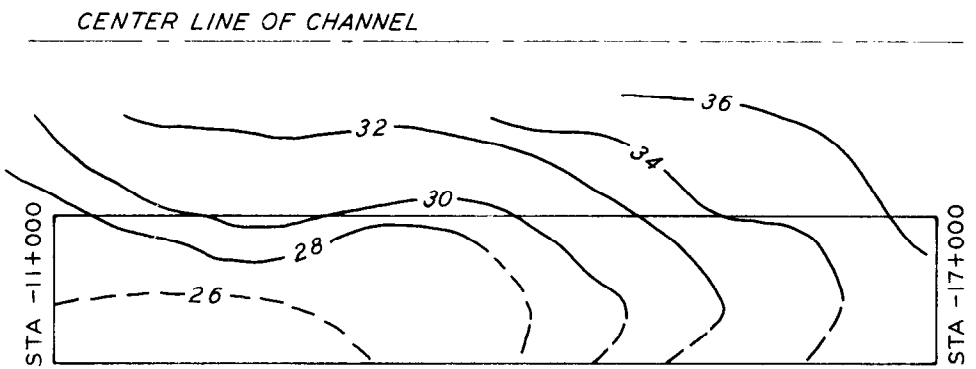
MAR 1963

SCALE

500 0 500 1000 FT

PLATE 5

PLATE 6



NOTE: DASHED LINES INDICATE THAT CONTOURS WERE ESTIMATED.

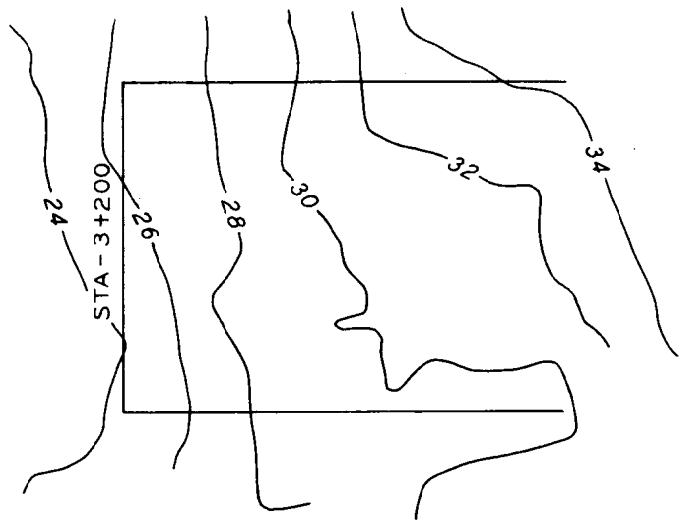
CONTOURED DISPOSAL AREAS

MATAGORDA SHIP CHANNEL

JAN 1968

SCALE

500 0 500 1000 FT



℄ CENTER LINE OF CHANNEL

NOTE: DASHED LINES INDICATE THAT CONTOURS WERE ESTIMATED

CONTOURED DISPOSAL AREAS

PORT MANSFIELD

OCT 1965

SCALE

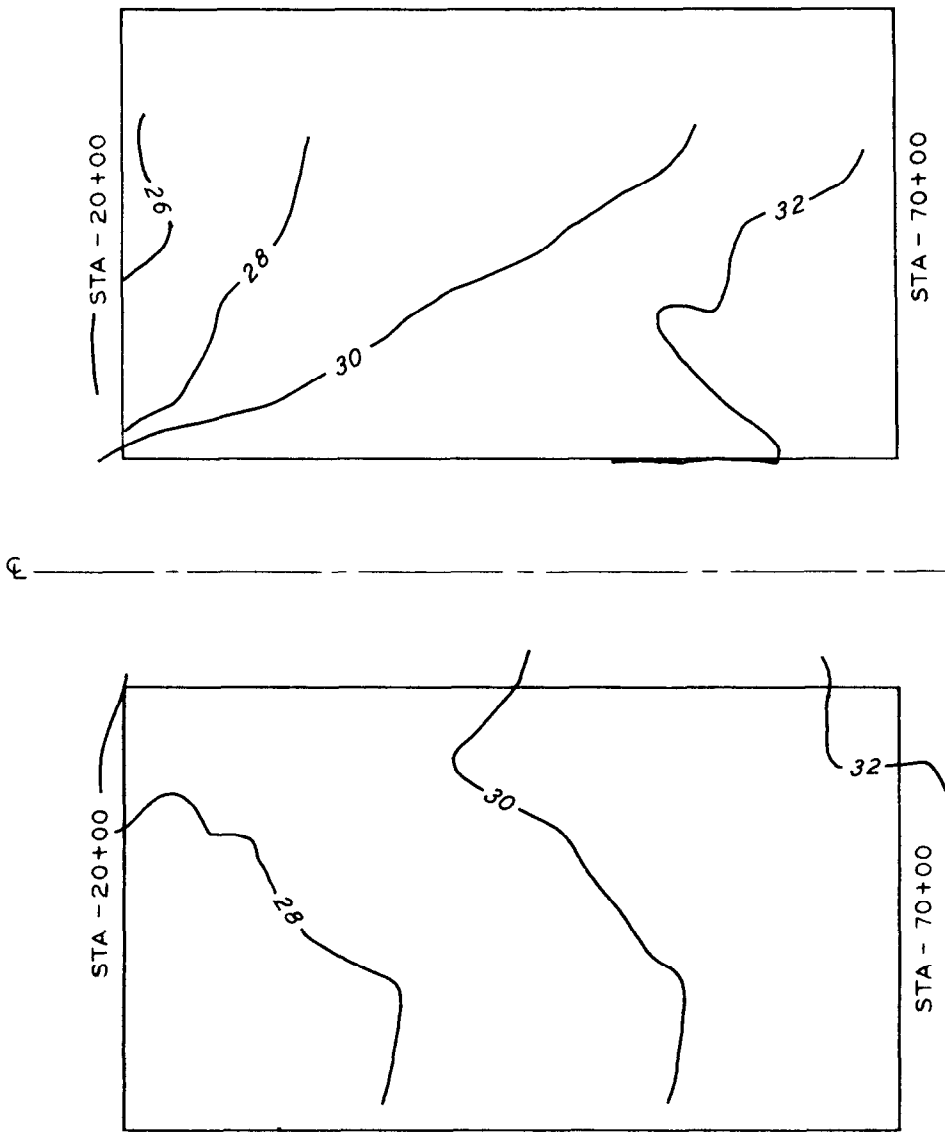
500 0 500 1000 FT

PLATE 7

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

Bastian, David Fenwick
Effects of open-water disposal of dredged material on bottom topography along Texas Gulf Coast, by David F. Bastian. Vicksburg, U. S. Army Engineer Waterways Experiment Station, 1974.
1 v. (various pagings) illus. 27 cm. (U. S. Waterways Experiment Station. Miscellaneous paper D-74-13)
Prepared for Environmental Effects Laboratory, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.
Includes bibliography.

1. Disposal areas. 2. Dredged material. 3. Dredge spoil. 4. Hydrographic surveys. 5. Ocean bottom. 6. Spoil disposal. 7. Submarine topography. (Series: U. S. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper D-74-13)
TA7.W34m no.D-74-13



CONTOURED DISPOSAL AREAS

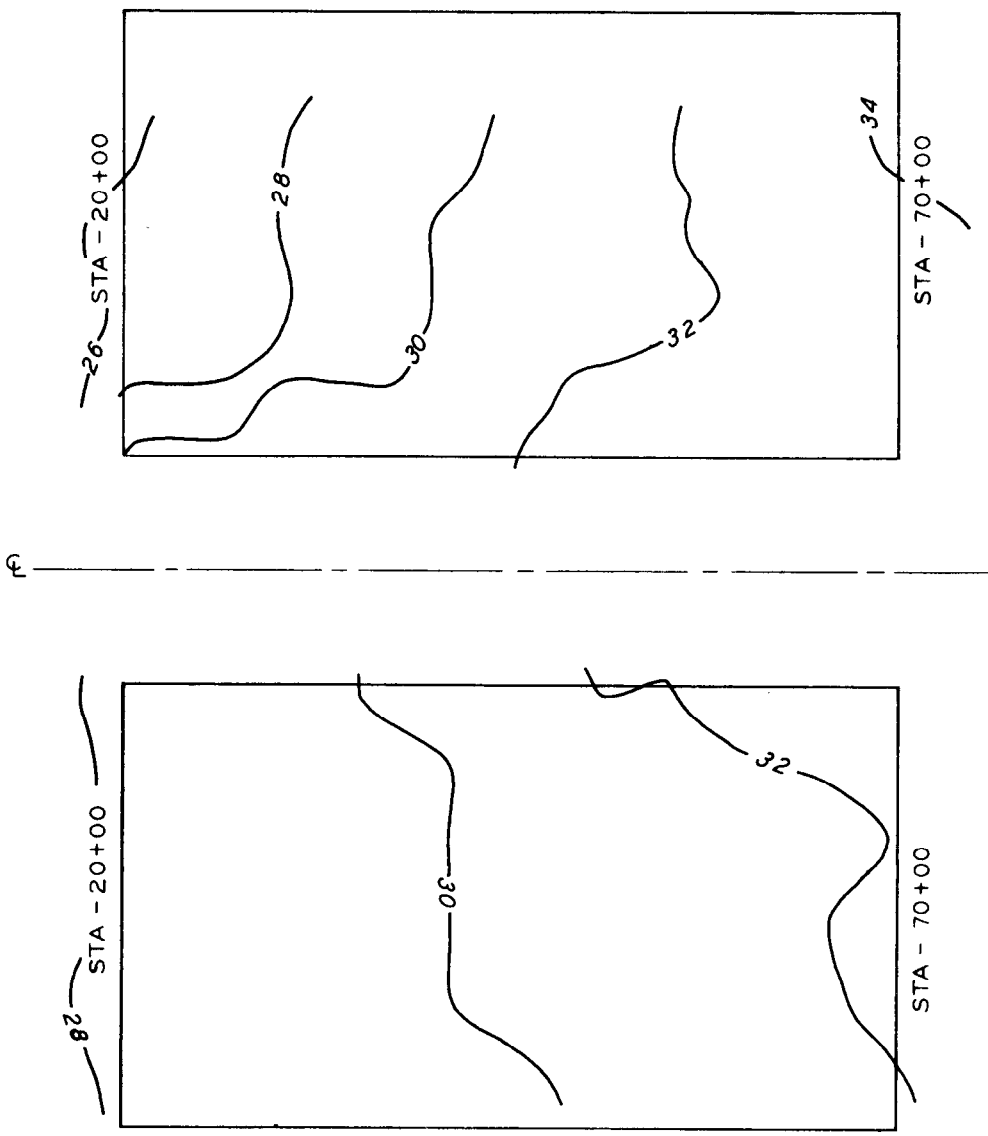
FREEPORT HARBOR

OCT 1965

SCALE

1000 0 1000 2000 FT

OVERLAY 1



CONTOURED DISPOSAL AREAS

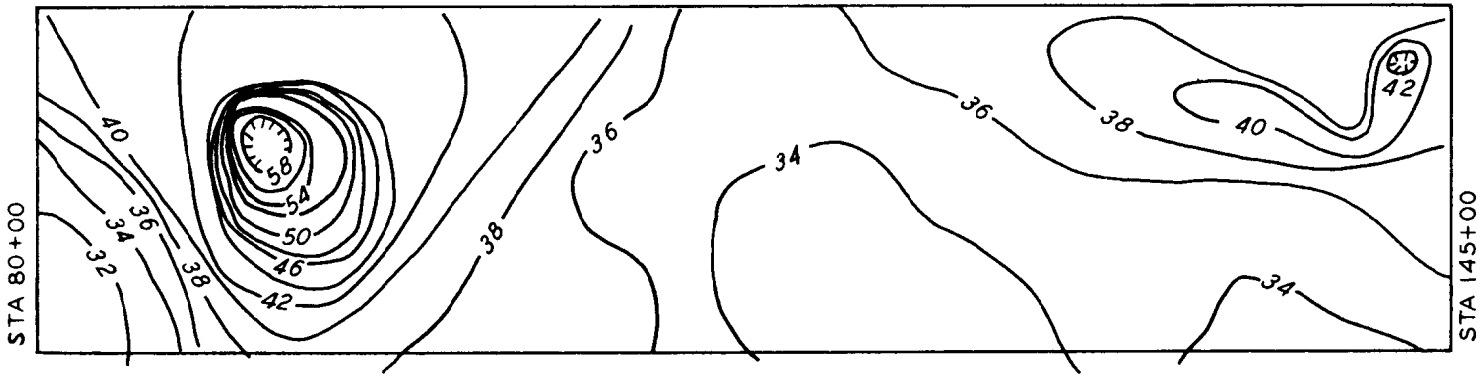
FREEPORT HARBOR

JUL 1966

SCALE

1000 0 1000 2000 FT

OVERLAY 2



CONTOURED DISPOSAL AREAS

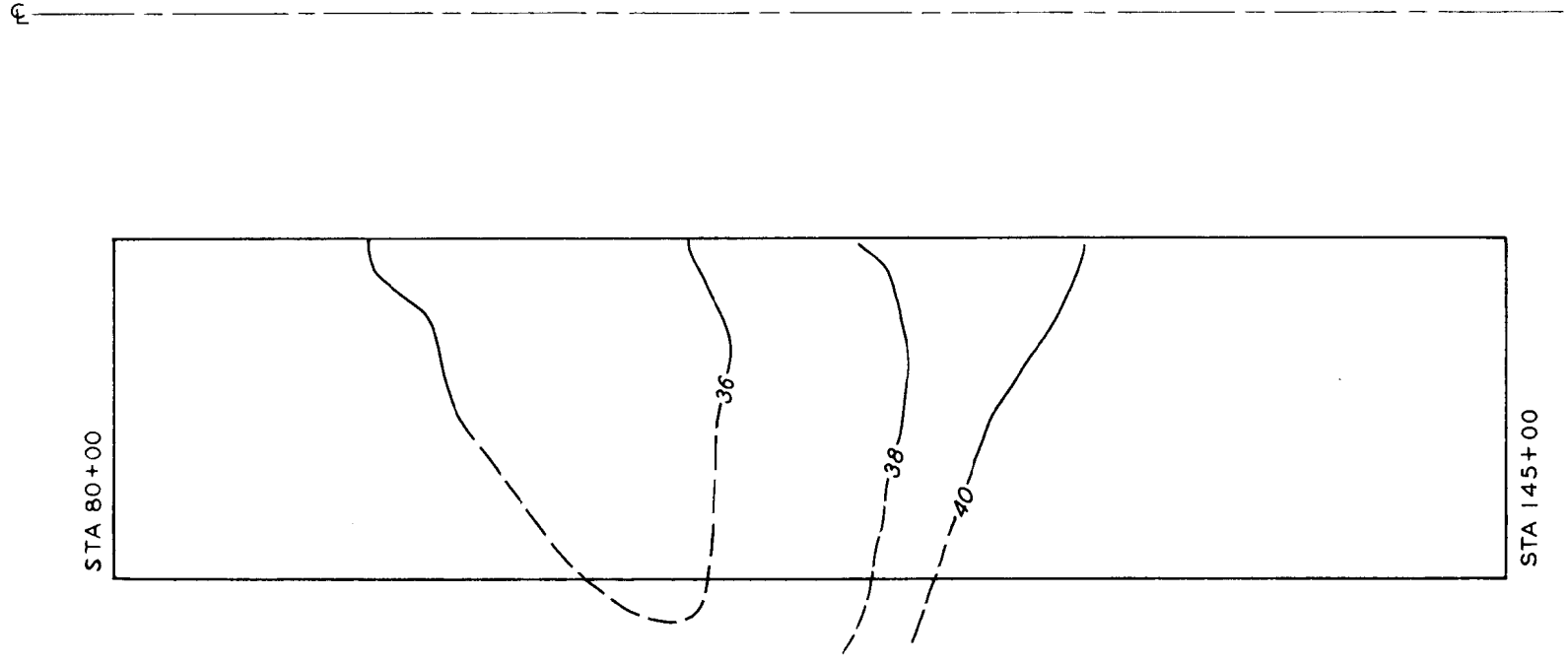
PORT ARANSAS CORPUS CHRISTI

SEP 1961

SCALE

500 0 500 1000 FT

OVERLAY 3



CONTOURED DISPOSAL AREAS

PORT ARANSAS CORPUS CHRISTI

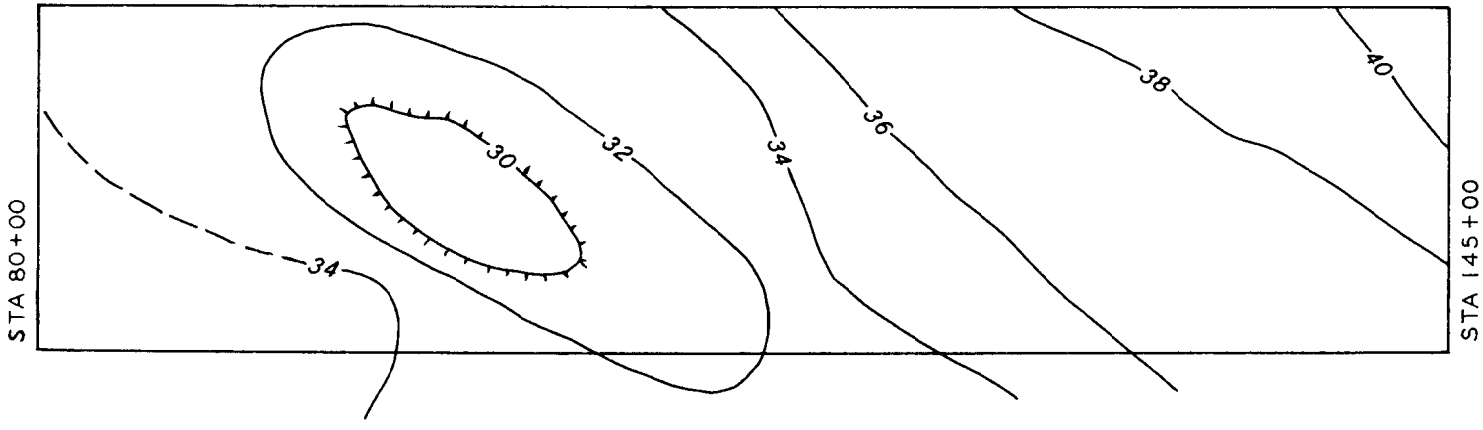
DEC 1962

SCALE

500 0 500 1000 FT

OVERLAY 4

CENTER LINE OF CHANNEL



CONTOURED DISPOSAL AREAS

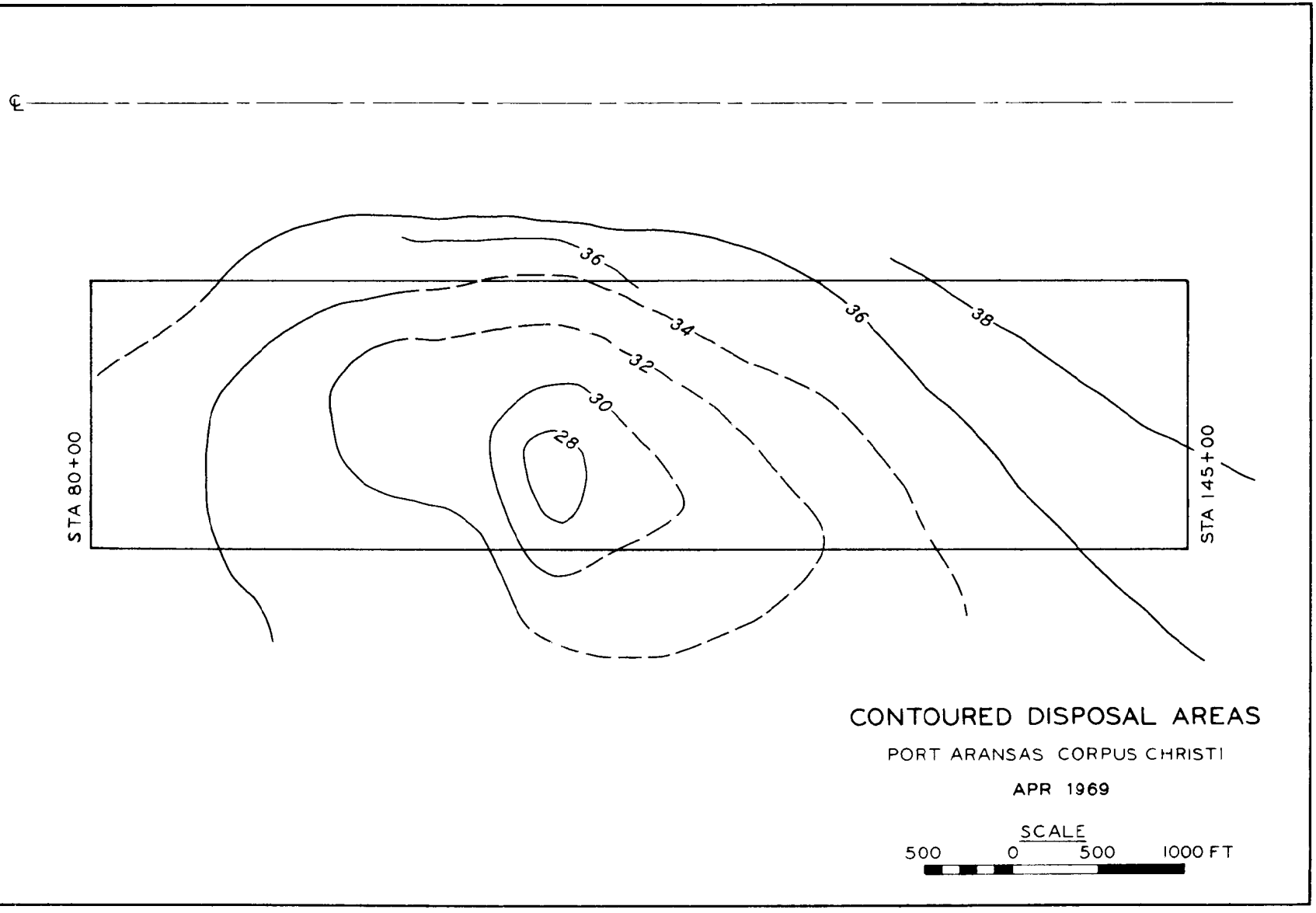
PORT ARANSAS CORPUS CHRISTI

MAY 1966

SCALE

500 0 500 1000 FT

OVERLAY 5



CONTOURED DISPOSAL AREAS

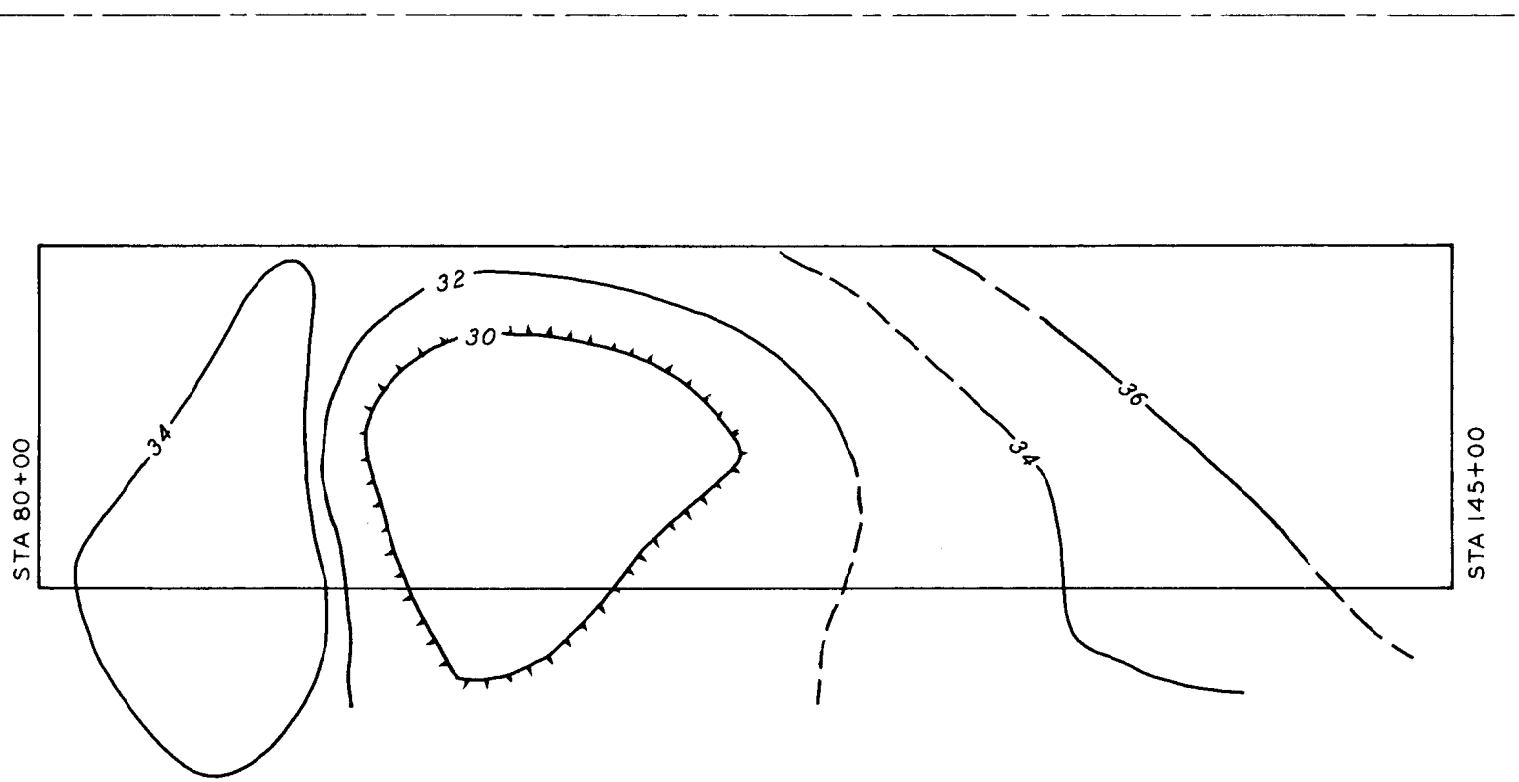
PORT ARANSAS CORPUS CHRISTI

APR 1969

SCALE

500 0 500 1000 FT

OVERLAY 6



CONTOURED DISPOSAL AREAS

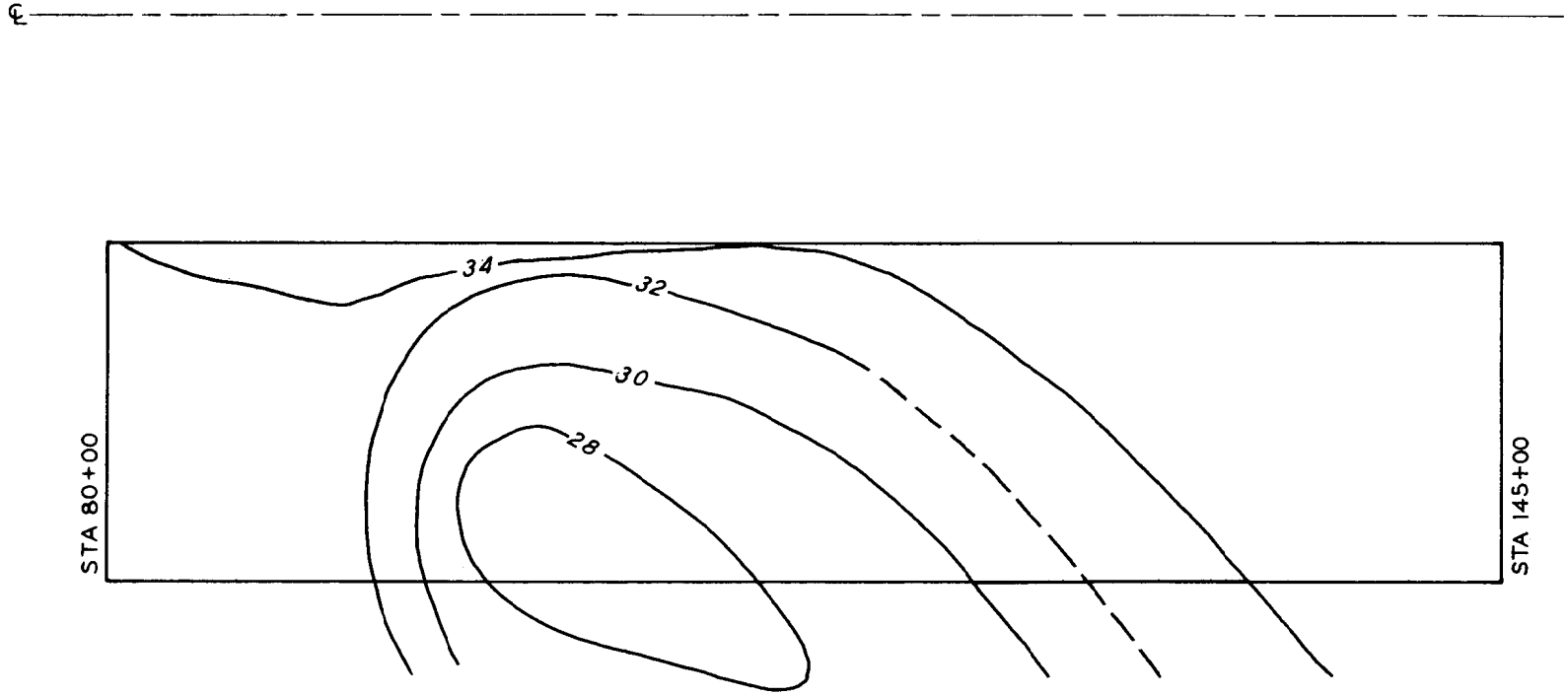
PORT ARANSAS CORPUS CHRISTI

MAY 1970

SCALE

500 0 500 1000 FT

OVERLAY 7



CONTOURED DISPOSAL AREAS

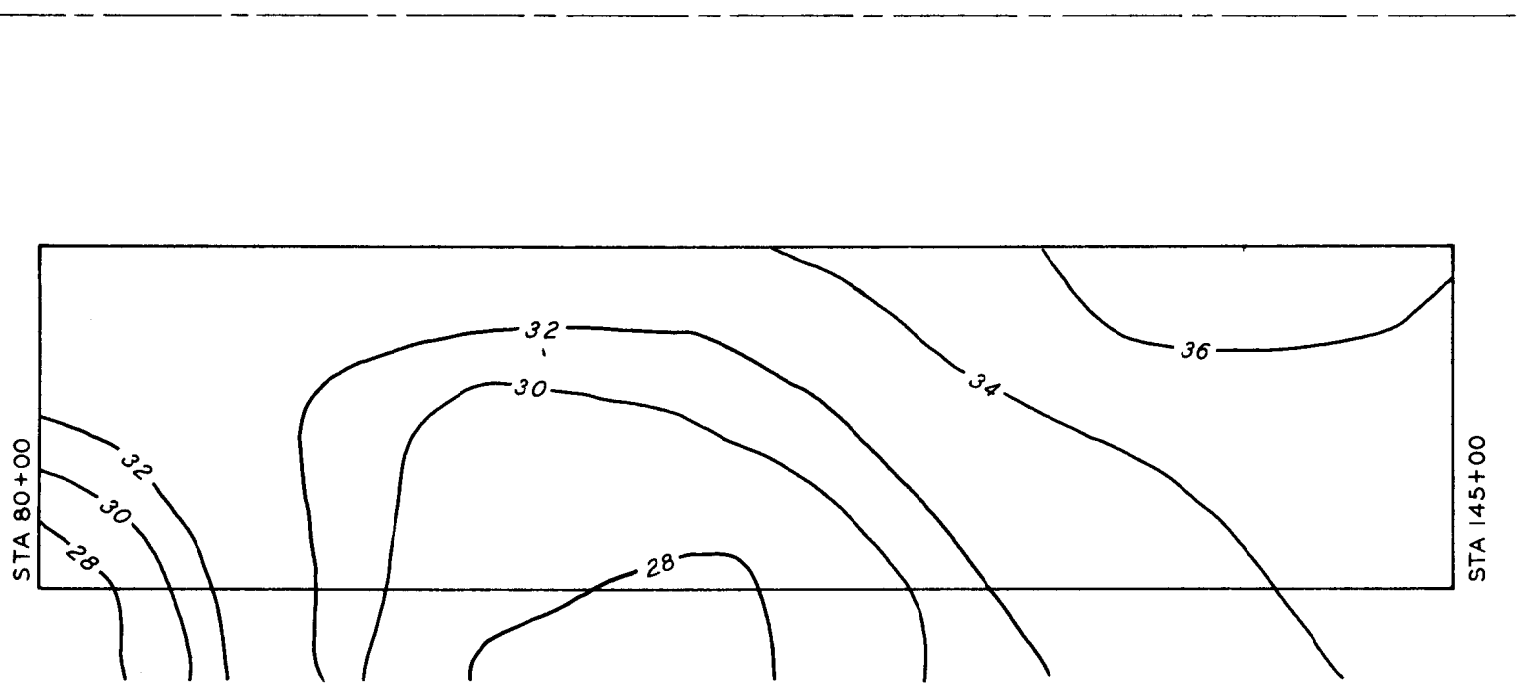
PORT ARANSAS CORPUS CHRISTI

APR 1971

SCALE

500 0 500 1000 FT

OVERLAY 8



CONTOURED DISPOSAL AREAS

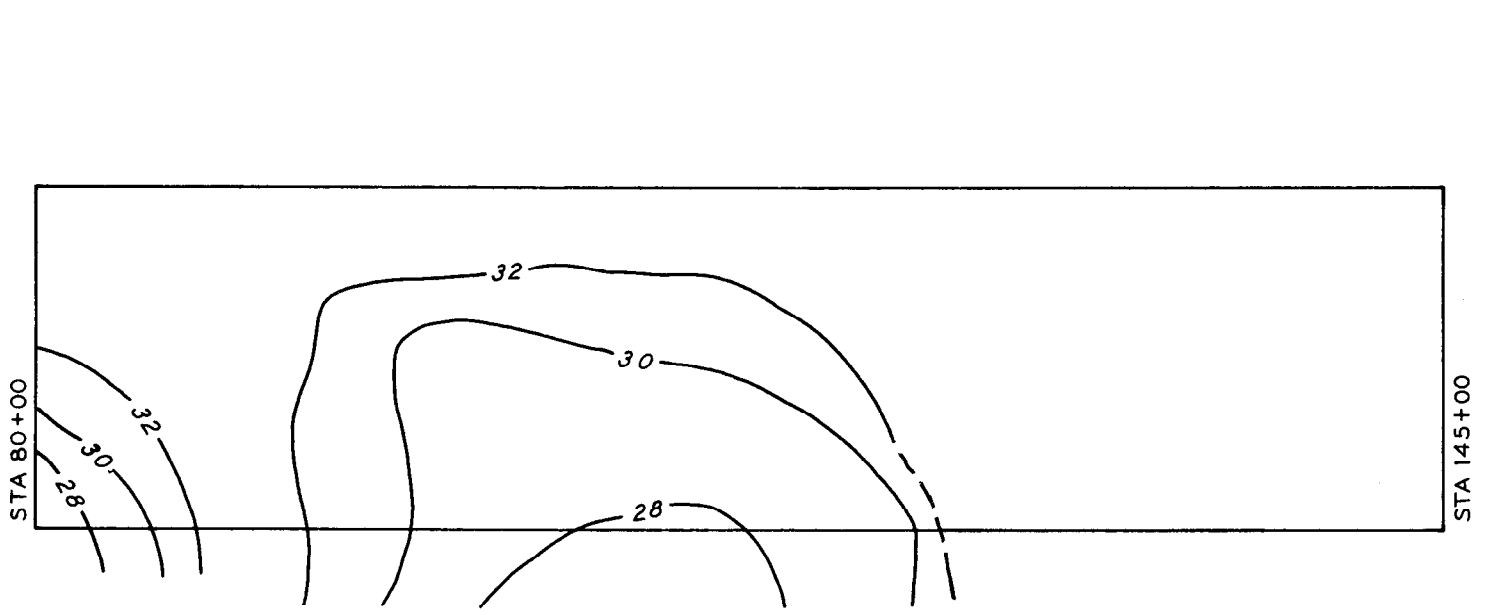
PORT ARANSAS CORPUS CHRISTI

JUN 1972

SCALE

500 0 500 1000 FT

OVERLAY 9



CONTOURED DISPOSAL AREAS

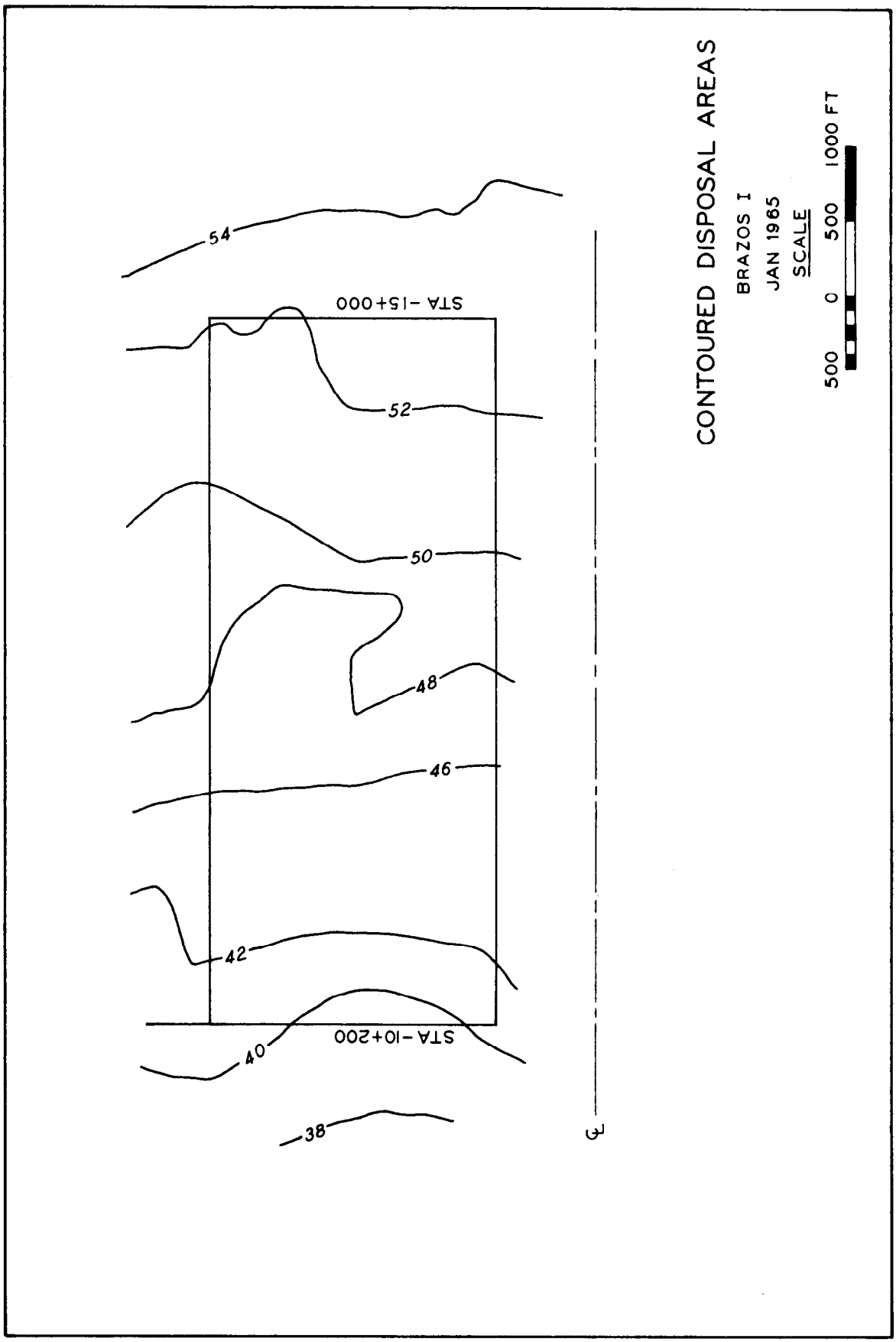
PORT ARANSAS CORPUS CHRISTI

FEB 1973

SCALE

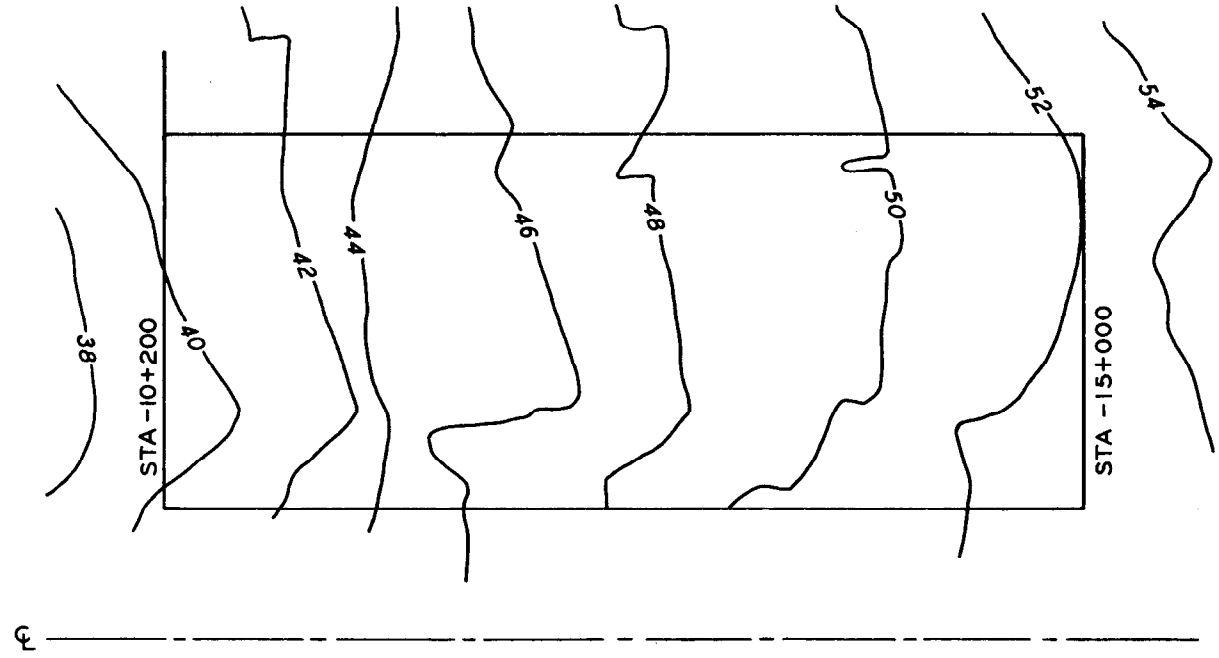
500 0 500 1000 FT

OVERLAY 10


CONTOURED DISPOSAL AREAS
BRAZOS I
JAN 1965
SCALE
500 0 500 1000 FT
54
STA -15+000
52
50
48
46
42
STA -10+200
40
38
℄

OVERLAY 11

OVERLAY 12



CONTOURED DISPOSAL AREAS

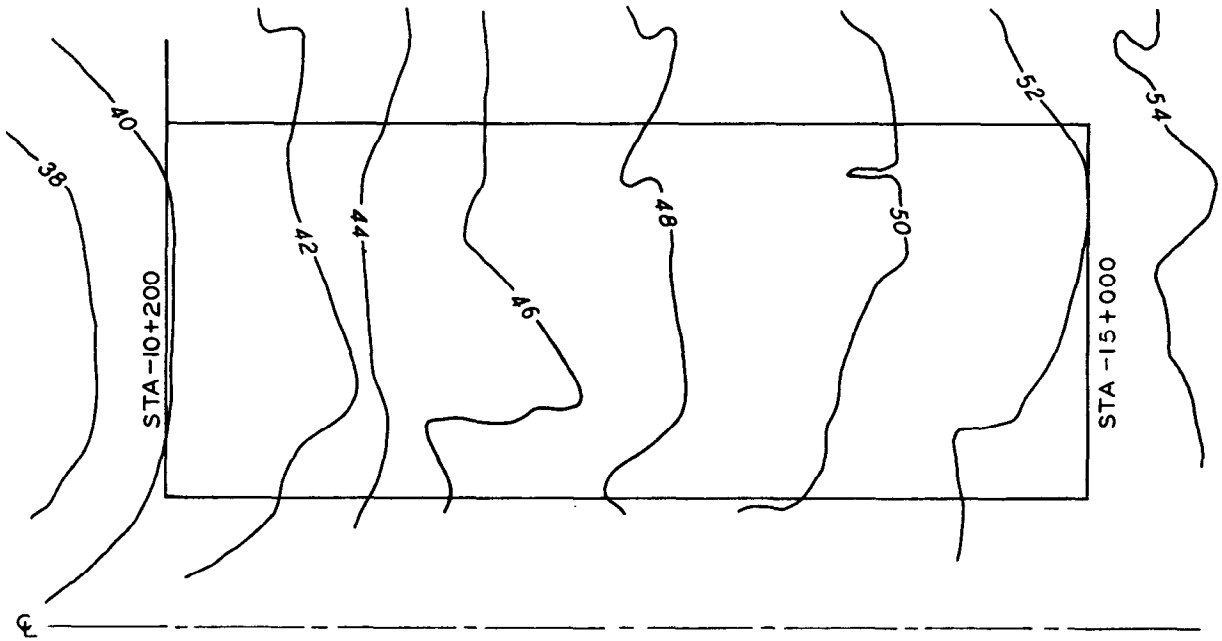
BRAZOS I

MAR 1965

SCALE

500 0 500 1000 FT

OVERLAY 13



CONTOURED DISPOSAL AREAS

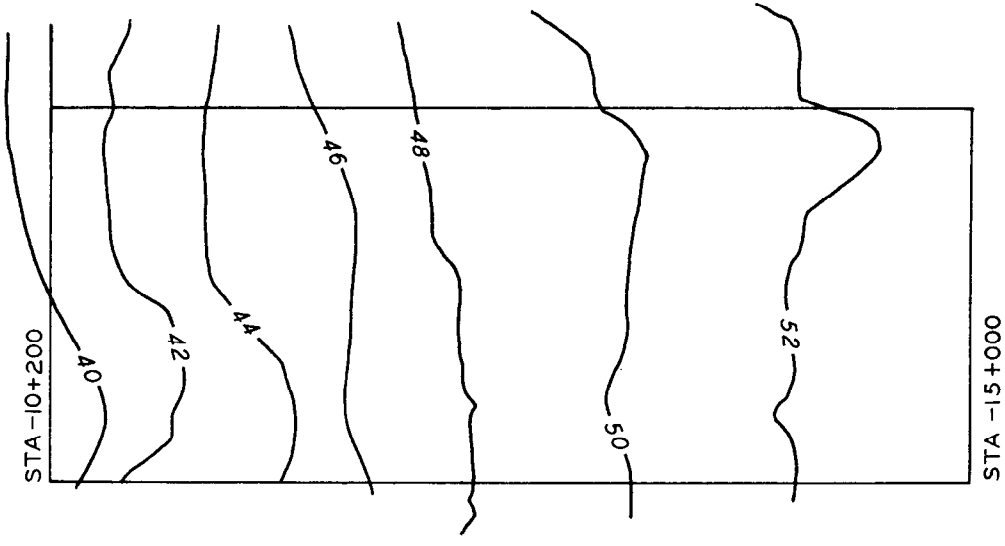
BRAZOS I

MAR 1966

SCALE

500 0 500 1000 FT

OVERLAY 14



CONTOURED DISPOSAL AREAS

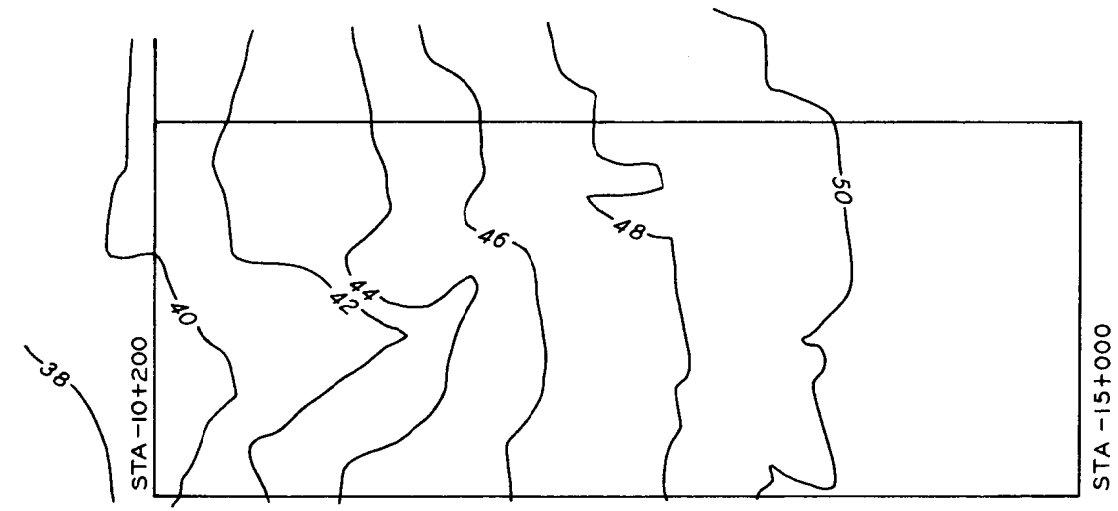
BRAZOS I

MAY 1967

SCALE

500 0 500 1000 FT

OVERLAY 15



℄

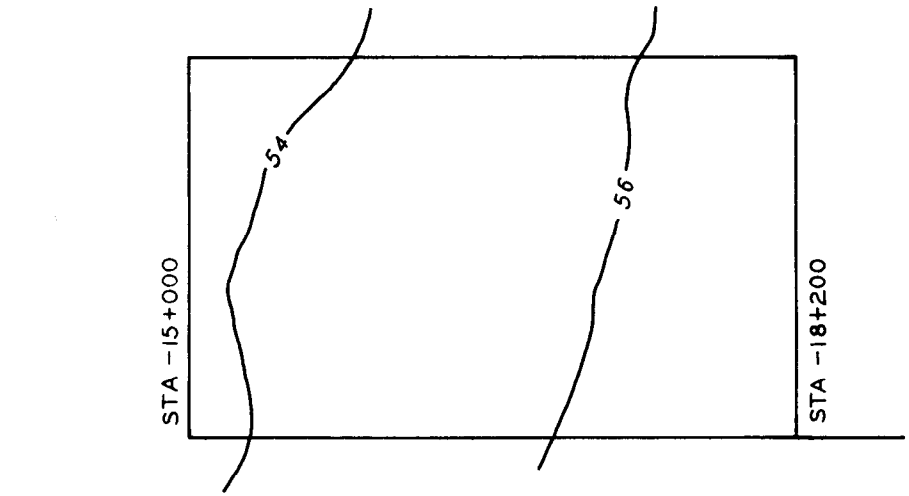
CONTOURED DISPOSAL AREAS

BRAZOS I

SEP 1967

SCALE

500 0 500 1000 FT



CONTOURED DISPOSAL AREAS

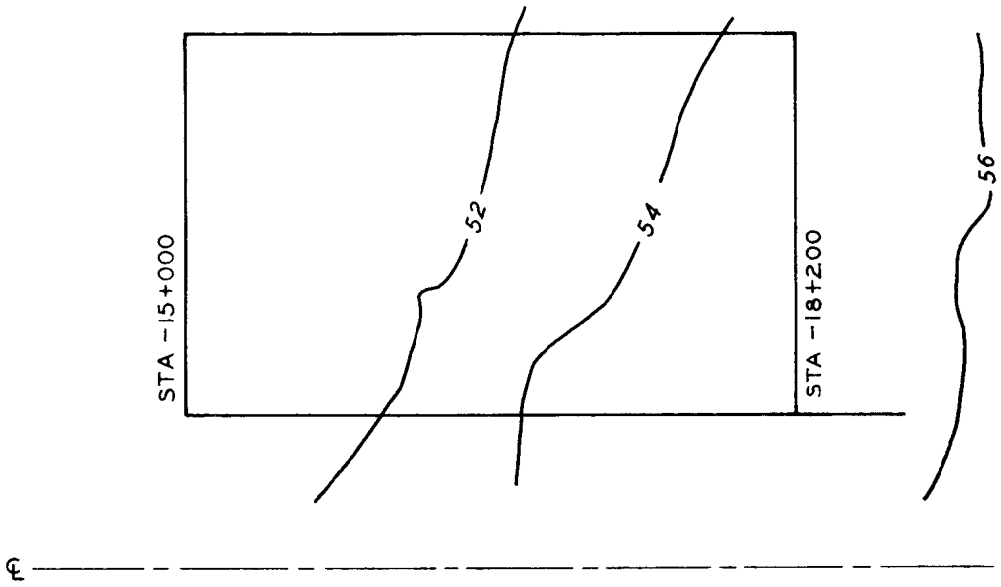
BRAZOS II

JUL 1968

SCALE

500 0 500 1000 FT

OVERLAY 16



CONTOURED DISPOSAL AREAS

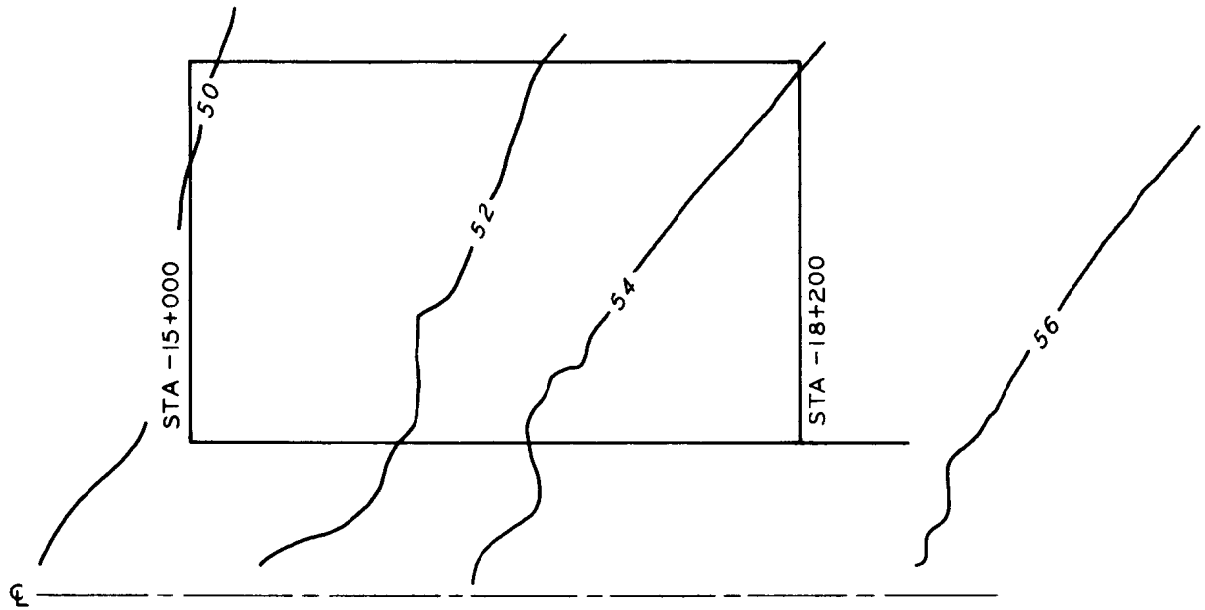
BRAZOS II

JUN 1970

SCALE

500 0 500 1000 FT

OVERLAY 17



CONTOURED DISPOSAL AREAS

BRAZOS II

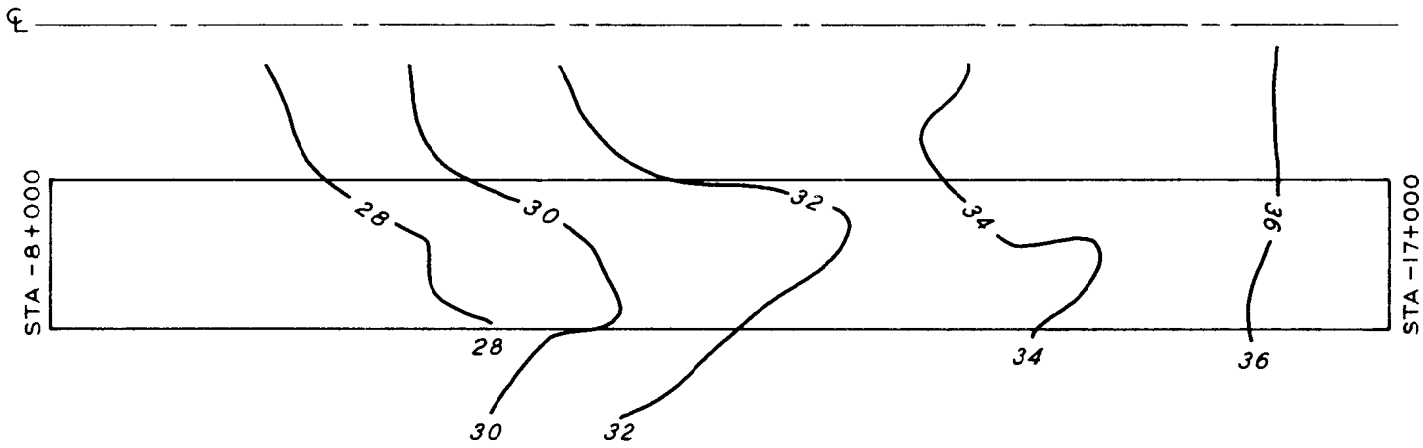
FEB 1971

SCALE

500 0 500 1000 FT

OVERLAY 18

OVERLAY 19



CONTOURED DISPOSAL AREAS

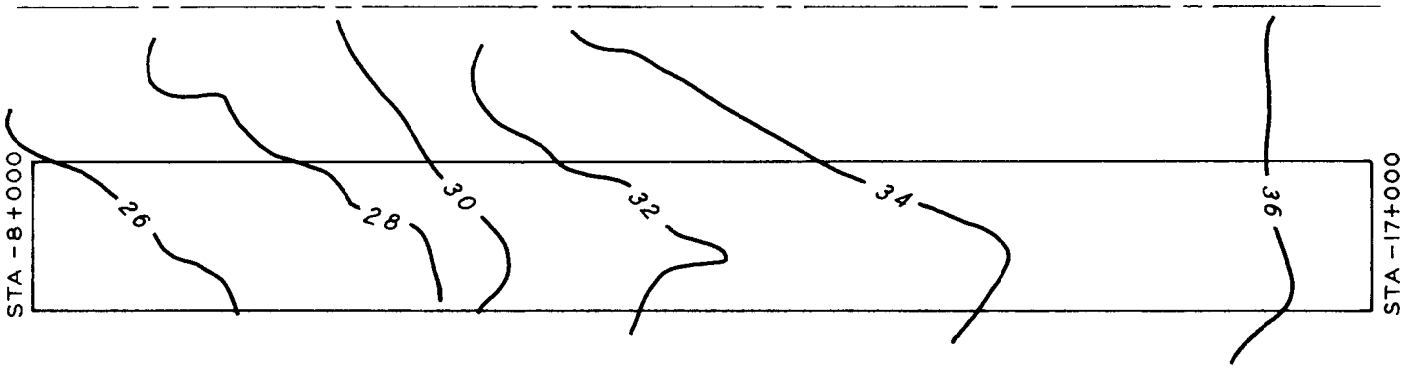
MATAGORDA SHIP CHANNEL

JUL 1963

SCALE

500 0 500 1000 FT

OVERLAY 20



CONTOURED DISPOSAL AREAS

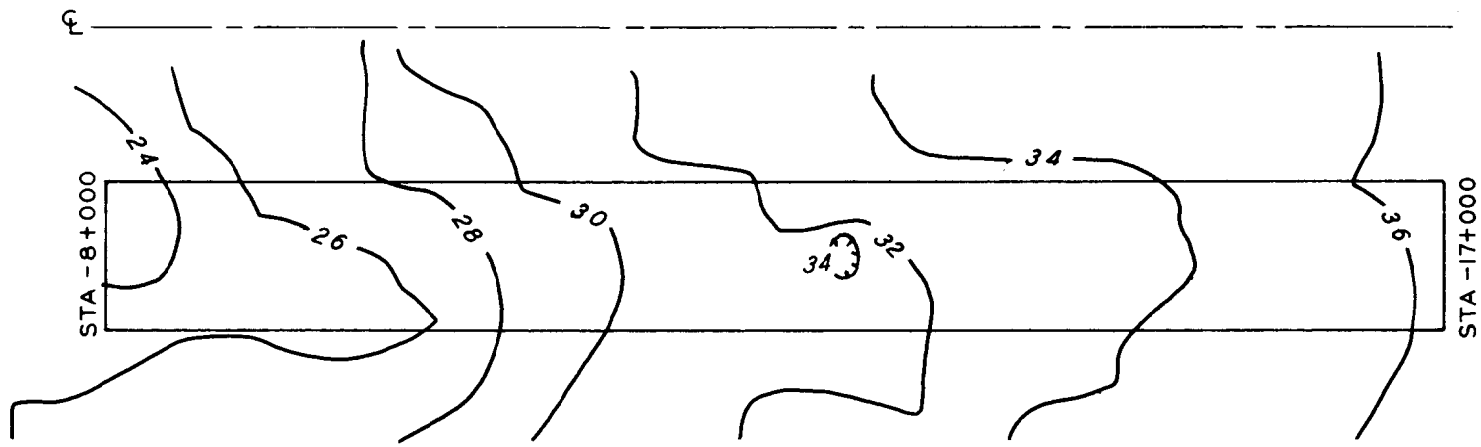
MATAGORDA SHIP CHANNEL

OCT 1963

SCALE

500 0 500 1000 FT

OVERLAY 21



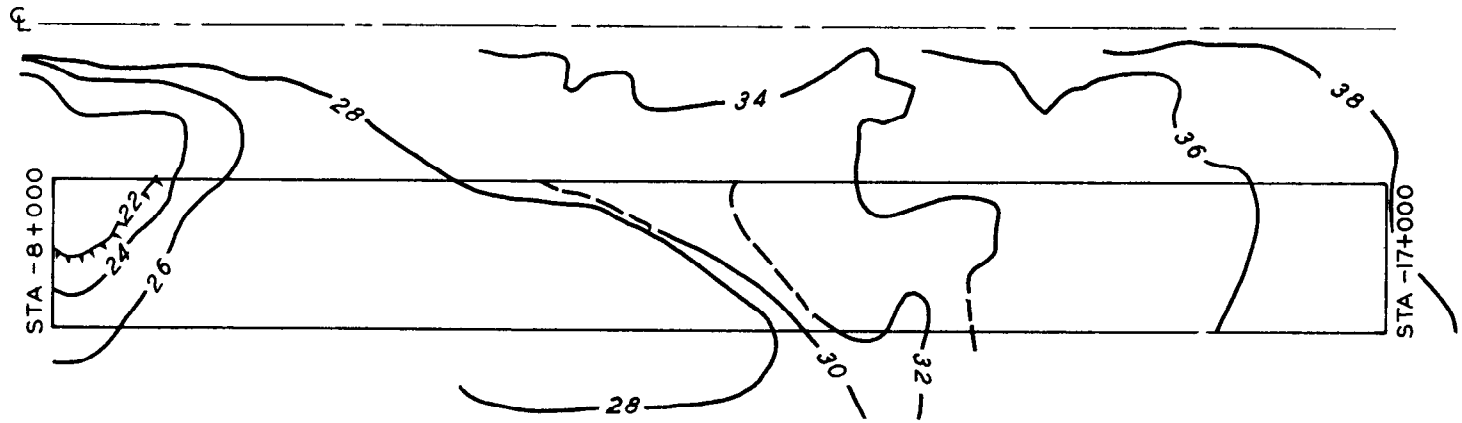
CONTOURED DISPOSAL AREAS

MATAGORDA SHIP CHANNEL
JUN 1965

SCALE

500 0 500 1000 FT

OVERLAY 22



CONTOURED DISPOSAL AREAS

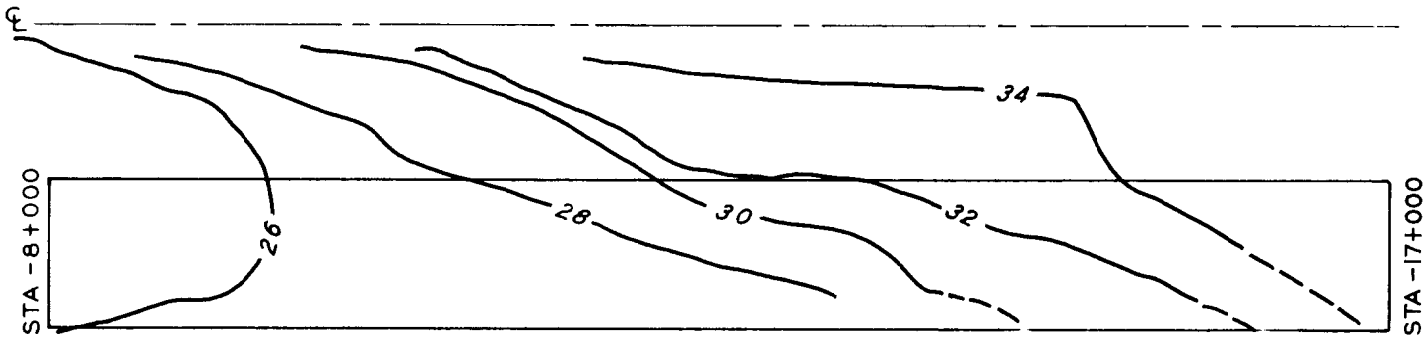
MATAGORDA SHIP CHANNEL

FEB 1966

SCALE

500 0 500 1000 FT

OVERLAY 23



CONTOURED DISPOSAL AREAS

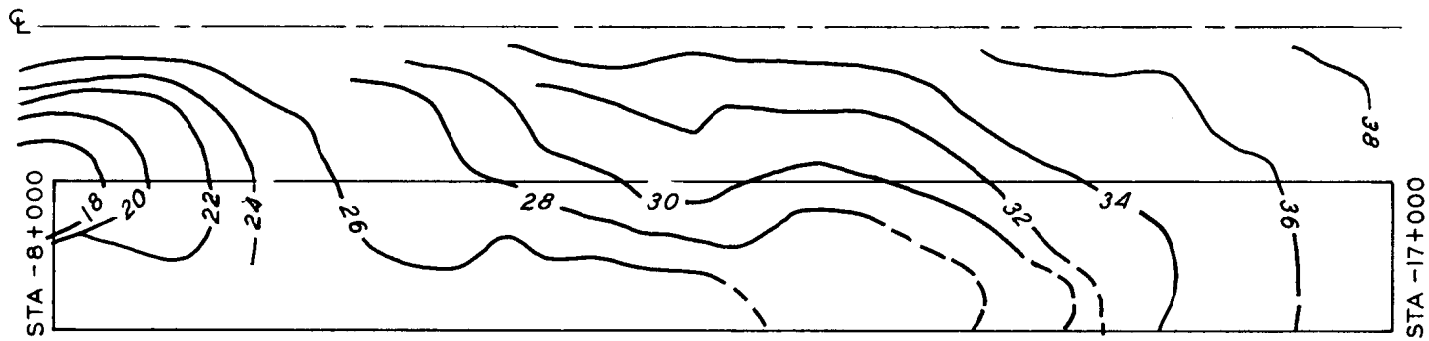
MATAGORDA SHIP CHANNEL

MAY 1966

SCALE

500 0 500 1000 FT

OVERLAY 24



CONTOURED DISPOSAL AREAS

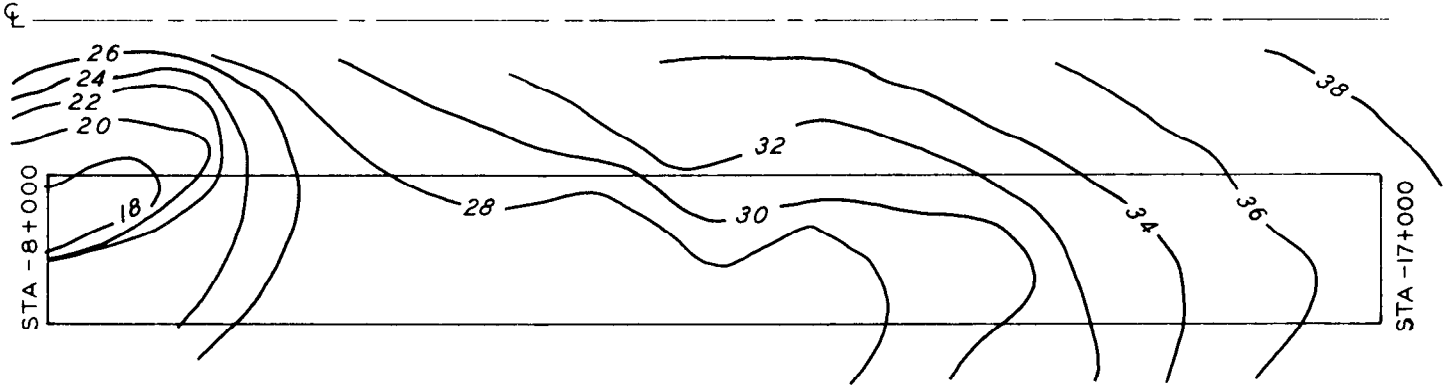
MATAGORDA SHIP CHANNEL

FEB 1967

SCALE

500 0 500 1000 FT

OVERLAY 25



CONTOURED DISPOSAL AREAS

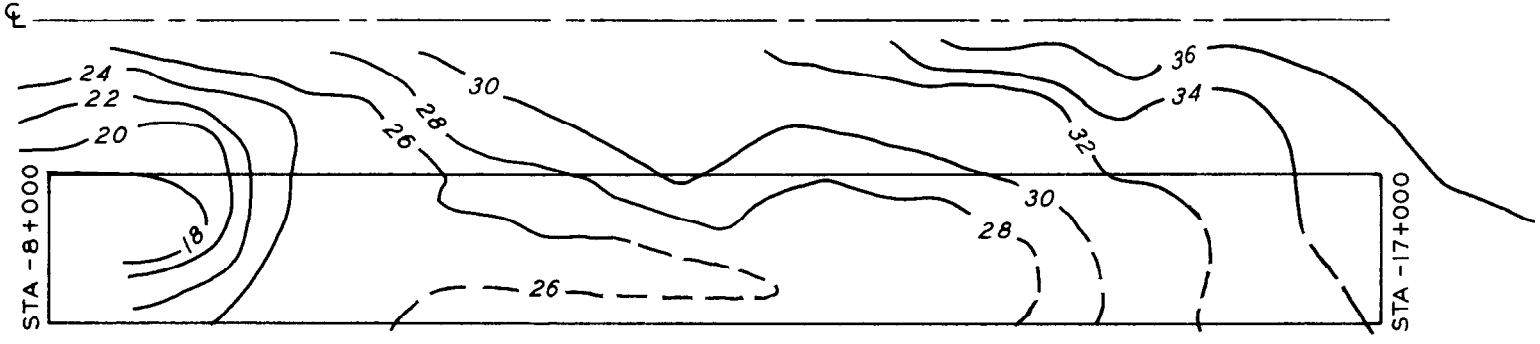
MATAGORDA SHIP CHANNEL

JUN 1967

SCALE

500 0 500 1000 FT

OVERLAY 26



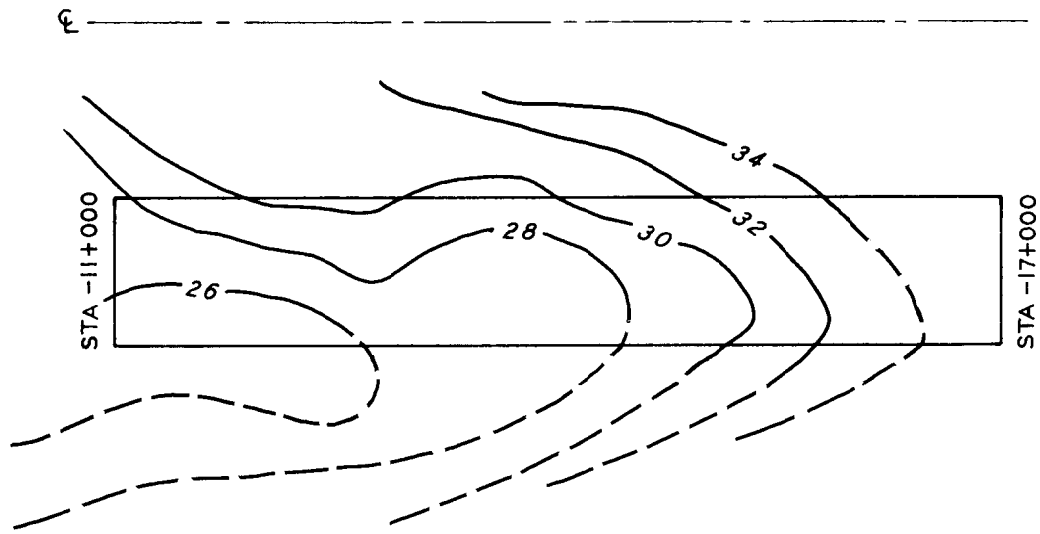
CONTOURED DISPOSAL AREAS

MATAGORDA SHIP CHANNEL

OCT 1967

SCALE

500 0 500 1000 FT



CONTOURED DISPOSAL AREAS

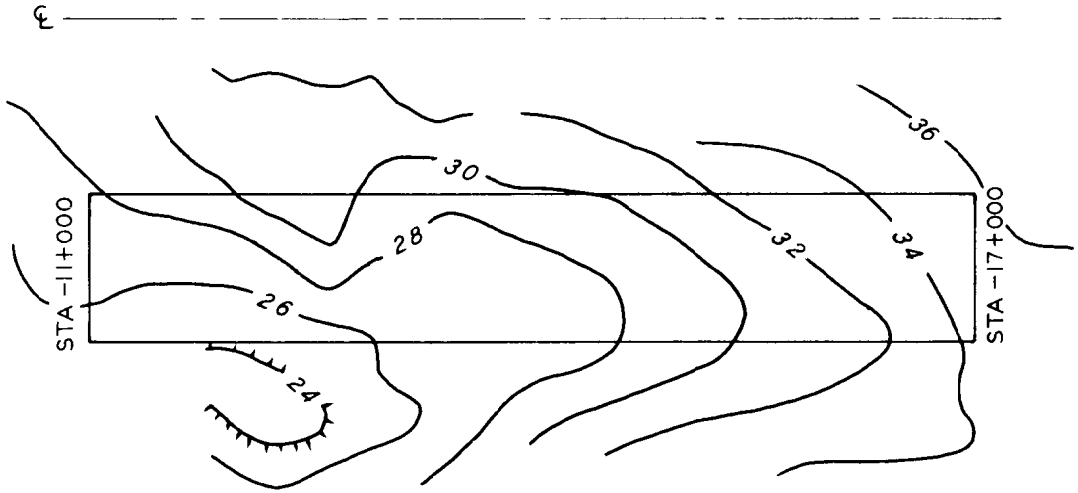
MATAGORDA SHIP CHANNEL

MAR 1968

SCALE

500 0 500 1000 FT

OVERLAY 27



CONTOURED DISPOSAL AREAS

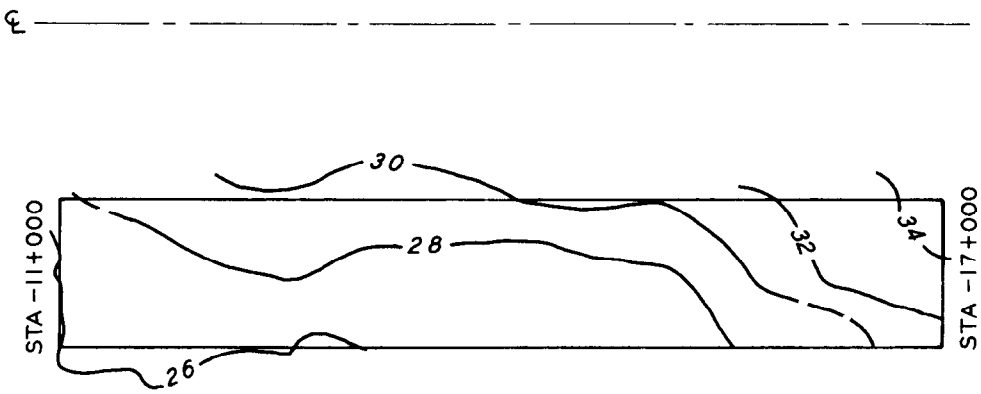
MATAGORDA SHIP CHANNEL

JUL 1968

SCALE

500 0 500 1000 FT

OVERLAY 28



CONTOURED DISPOSAL AREAS

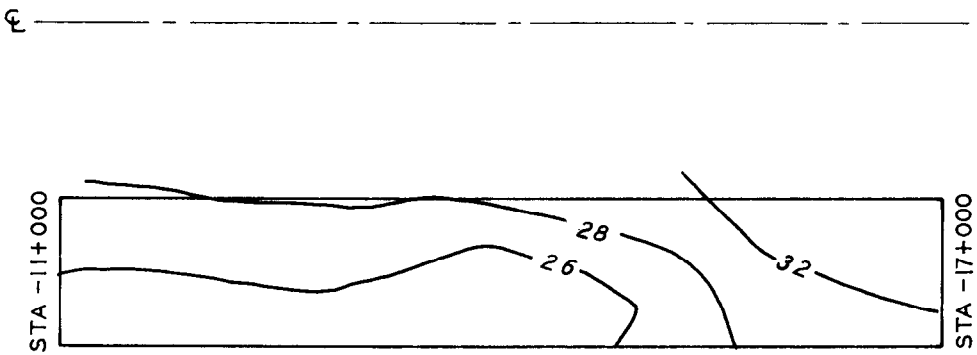
MATAGORDA SHIP CHANNEL

JUL 1969

SCALE

500 0 500 1000 FT

OVERLAY 29



CONTOURED DISPOSAL AREAS

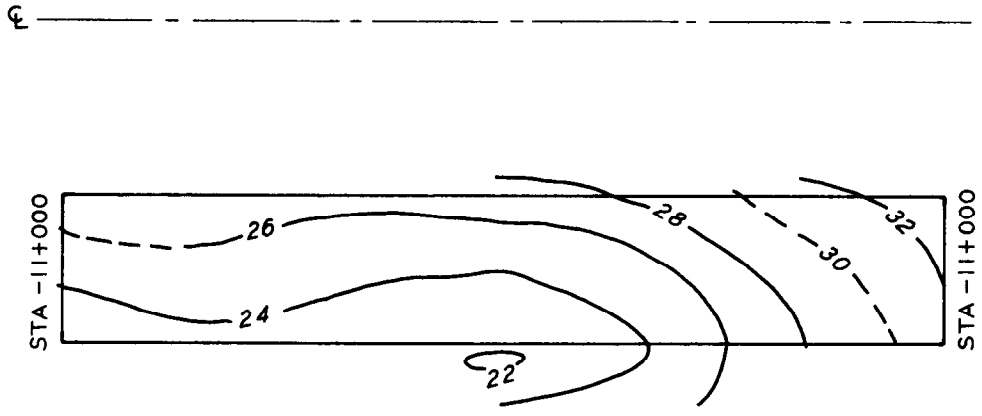
MATAGORDA SHIP CHANNEL

MAR 1970

SCALE

500 0 500 1000 FT

OVERLAY 30



CONTOURED DISPOSAL AREAS

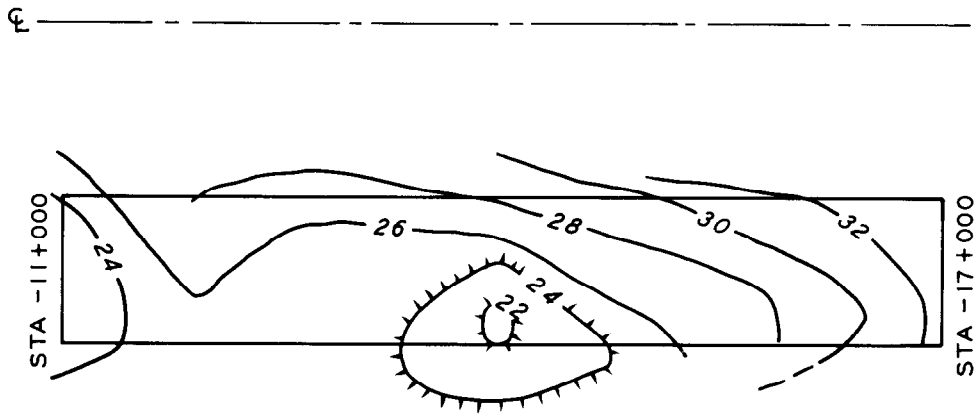
MATAGORDA SHIP CHANNEL

AUG 1970

SCALE

500 0 500 1000 FT

OVERLAY 31



CONTOURED DISPOSAL AREAS

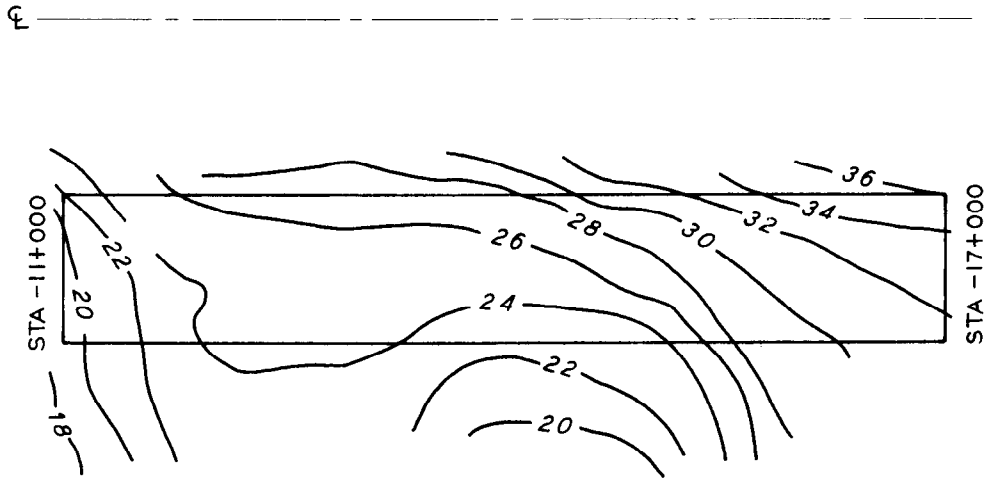
MATAGORDA SHIP CHANNEL

FEB 1972

SCALE

500 0 500 1000 FT

OVERLAY 32



CONTOURED DISPOSAL AREAS

MATAGORDA SHIP CHANNEL

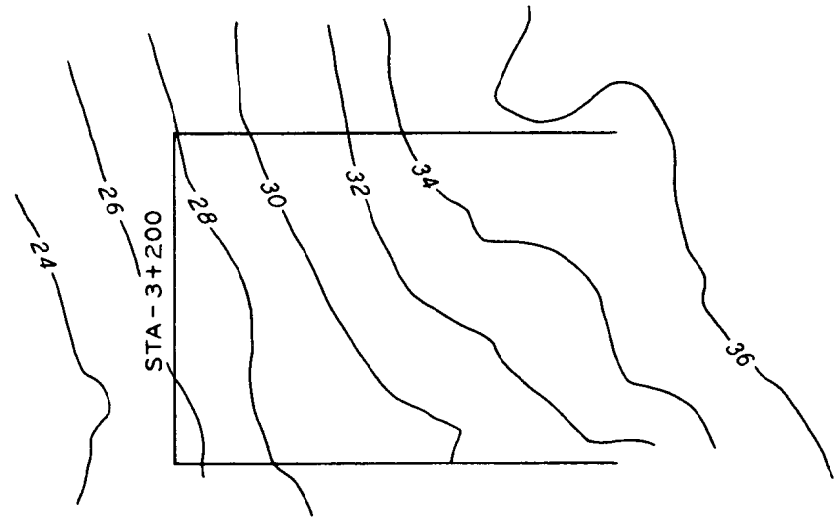
FEB 1973

SCALE

500 0 500 1000 FT

OVERLAY 33

OVERLAY 34



℄

CONTOURED DISPOSAL AREAS

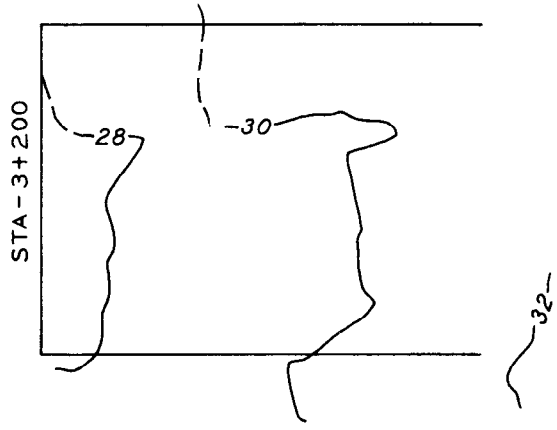
PORT MANSFIELD

AUG 1966

SCALE

500 0 500 1000 FT

OVERLAY 35



℄

CONTOURED DISPOSAL AREAS

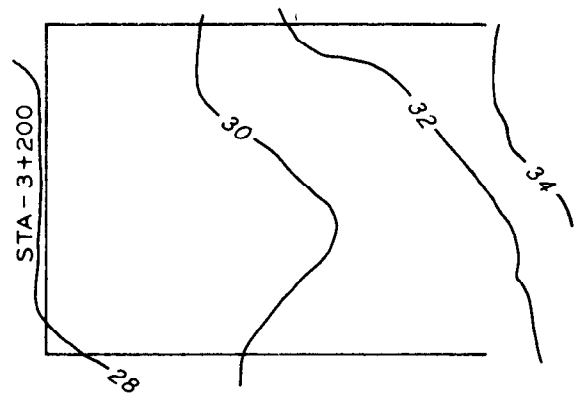
PORT MANSFIELD

APR 1969

SCALE

500 0 500 1000 FT

OVERLAY 36



℄

CONTOURED DISPOSAL AREAS

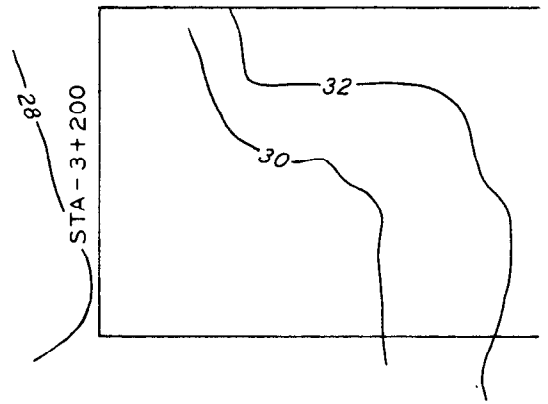
PORT MANSFIELD

NO DATE

SCALE

500 0 500 1000 FT

OVERLAY 37



℄

CONTOURED DISPOSAL AREAS

PORT MANSFIELD

MAY 1970

SCALE

500 0 500 1000 FT