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LONG AND SHORT TERM EROSIONAL HISTORY OF MUSTANG AND PADRE ISLANDS WITH PROBABLE IMPACT DUE TO OIL SPILL CLEAN UP PROCEDURES

The following is a report prepared for RPI in order to evaluate the effects of beach cleanup recommendations on long and short term erosion of the beaches affected. This report has been prepared in one day and as a result all pertinent literature could not be read for inclusion. However, based on my fourteen years of experience in Texas coastal geology and familiarity with the literature, I believe that the data presented and the conclusions are substantially correct. A more thorough report can be prepared if required.

INTRODUCTION

With the exception of manmade passes at Mansfield Pass and the Corpus Christi Water Exchange Pass, Mustang and Padre Islands form a continouos barrier island. This barrier island system is unique on the Texas coast in that it is the site of a convergence of longshore drift with the convergence area being centered about ten miles south of Baffin Bay. It should be noted that this convergence is not always located there, but shifts with changes in the seasonal wind and wave regime.

Nearshore currents and littoral drift are to the south during the winter months of northers and to the north during the summer prevailing southeasterly winds. (Watson, 1972, 1970, 1971, 1975) The convergence in the shell beaches area is in reality a net convergence with currents and sediment transport moving throughout the entire area to the north during the summer and to the south during the winter months. The convergence area is the site of the shell beaches on Padre Island. Shell material is transported into the convergence area along with sand by the longshore currents. The high dune ridge prevents hurricanes from washing the shell material inland, while the wind is able to transport much sand inland into the interior of Padre Island leaving a shell lag deposit on the beach. (Watson, 1971).

This shell lag deposit forms a beach sediment with a composition of up to 80% shell material. The highest shell concentrations are on the berm and seaward of the berm and decrease markedly toward the backshore. The shell beaches are characterized by a much steeper profile both above and below MSL than the sand beaches to the north and to the south. This is because beach profile slope is dependent upon the grain size of beach materials (for a constant wave climate), (Bascom 1951). The shell beaches are composed of a southern shell assemblage and a northern shell assemblage which mix in the convergence area. The stability of the beaches in central Padre Island is dependent upon the high concentration of shell material in the beach sediments.

The terrigenous fraction of the sediments on Padre and Mustang Islands also shows a source to the south and a source to the north which mix in the convergence area (Hayes, 1965, Bullard, 1942). The southern province consisting of South Padre Island and up to about ten miles south of Baffin Bay is slightly coarser than that to the north of Baffin Bay.

Quantitative estimates of littoral drift transport - Longshore drift rates can be estimated if good quantitative data exists on wave height, period and direction at the surf zone, and duration. Rates of littoral drift are as follows:

ANNUAL LITTORAL DRIFT (Thousands of Yd^3)

Site	North	South	Net	Gross
Mustang	342	402	60 south	744
Port Mansfield	565	417	148 north	982
Port Isabel	651	479	172 north	1130

(Watson, 1975; unpub., Watson & Behrens, 1976, Kieslich, 1974)
(Monthly data is available.)

Nearshore currents - Nearshore currents tend to be southerly during the winter months October through March and northerly during the summer months June through August and sometimes May. The months April and May and September are transitional between the winter "norther" regime and the summer southeasterly wind regime. However, drift bottle data shows that reversals to this general trend can occur in any season due to the existance of non seasonal winds, ie. an extended period of southeasterly winds during the winter months. (Watson, and Behrens, 1970).

Climate - Mustang and Padre Islands extend across a very significant climate variation from an average annual rainfall of 36 inches at Mustang Island to 26 inches at the Rio Grande. (Mcgowen, Garner and Wilkinson, 1977). This results in the existance of a far stronger and more diverse vegetative cover in the Mustang Island end of the area than in the South Padre Island area. As a result the southern beaches and dunes have greater instability relative to erosion and dune areas do not recover nearly as rapidly from erosion or loss of vegetative cover.

LONG TERM EROSION AND DEPOSITION TRENDS

The Texas Bureau of Economic Geology has published data on long term erosional and accretional trends for the Texas coast. This data is based on the study of shorelines on vintage maps and for later dates study of shorelines on aerial photographs. Some data is based in identifiable structures such as well heads which were drilled on the beach and are now in the surf. The data is in general, probably accurate, however there is some dispute about the very high rates of beach erosion reported on South Padre Island (Personal Communication, Mat Claunch, surveyor, Brownsville). There is no doubt, however, that the area is erosional.

Mustang Island is accretionary to stable to erosional at 0 to 5 ft. per year (Brown, et al., 1974, Morton, 1977, Morton & Pieper, 1977).

Padre Island from the northern end of the National Seashore to the southern end of the land cut area is probably accretionary and is definitely stable (Brown et. al., 1974, Morton, 1977, Morton & Pieper, 1977). This is in the area of the littoral drift convergence and the greatest sediment supply of any part of the Texas coast. No sediment is lost from this area due to longshore transport. This area also has a very high and continuous foredune ridge which is unbreached by storm washover channels for 10 miles (Watson, 1968, 1971, 1972).

South Padre Island from the south end of the land cut to Brazos Santiago Pass - From the south end of the land cut area to about five miles to the north of Mansfield Pass are starved for littoral drift materials and are eroding at a rate of as much as 10 to 15 ft. per year (Morton & Pieper, 1977). South Padre Island from Mansfield Pass to Brazos Santiago Pass is erosional at rates varying from 0 to 5 ft. a year in the northern part to 10 to 15 ft. a year further to the south. This is due to loss to the north by the longshore transport system which is starved due to the longshore drift barrier of Brazos Santiago Pass and its jetties. Extensive amounts of sand are also lost inland by wind deflation and storm washover.

Brazos Island - Brazos Island is undergoing a net erosional trend and has been since 1937 at rates of from 10 to 37 ft. a year. (Morton, & Pieper, 1975). This is probably due to loss of sand supply in impoundments on the Rio Grande.

ACCRETION AND EROSION ACRES

	1958-1975	1860-82 to 1975
Aransas Pass to Yarborough Pass	-519	- 238
Yarborough Pass to Mansfield Pass	-673	+ 17
Mansfield Pass to Rio Grande	-958	-3604

(Morton, 1977)

SHORT TERM EROSION TRENDS (NORTHERS AND HURRICANES)

Hurricanes can produce massive beach erosion in a very short period of time ie., Carla in 1961 (Hayes, 1965). Beach and dune sediments are eroded and transported offshore into deeper water and washed inland across the barrier by storm overwash. Additional sediment can be transported offshore as the storm passes and the bays and lagoons drain back seaward across washover channels. The sediment which is lost inland during these storms is not returned to the beach, but the resumption of low steepness waves can return much of the sediment washed offshore to the beach. The balance is made up by sand supplied by onshore and alongshore transport in the years after the storm. However, on South Padre Island the area is highly erosional and the storm losses tend to be permanent. We have had no significant hurricane erosion since Celia in 1970 and beach erosion by that storm was minor. However, on North Padre and Mustang Islands the beach and part of the foredune ridge were eroded. The beach has rebuilt, and a new well vegetated dune has developed in front of the old foredune ridge and is welding on to it. A hurricane crossing the coast could cause from very little erosion to massive erosion amounting to a loss of 100 feet or more of beach and foredune areas. Damage will be least in the central Padre Island area due to the nearly continuous, very high and very well stabilized foredune ridge with few or no breagks in it. Note that due to the high berm and backshore due to the steep beaches produced by the high shell concentration only the largest storms ever attack dune ridge in this area and thus it is able to grow stronger and provide protection of shell material loss in washovers. This is a positive reinforcement process. Removal of shell material would lower the beach and subject the dunes to more frequent storm wave attack (Watson, 1968).

Gulf mean water levels have an annual cycle of two highs and two lows. Highest water levels occur in October when gulf-wide steric expansion is greatest, and lowest water levels are in January and February when steric contraction is greatest.

(Whitaker, 1971). A second high occurs in April and May and a second low in July. These secondary fluctuations have no correlations with seasonal barometric pressure or steric effects, but do correlate qualitatively with winds. The monthly onshore component of wind is small due to strong winter storms with predominantly offshore winds from September to March, has an annual maximum in April, and remains fairly large from June to September. Thus April high water levels appear to be due to Gulf wind set-up (Watson & Behrens, 1976). These seasonal changes in mean water level will affect the position and elevation of the berm on the beach, due to sediment transport by wave action.

Effect of Northers - As a front approaches the area from the northwest, wind is blowing from south to southeast. A decrease in wind speed is accompanied by a swing to the west and northwest. As the front passes, the wind shifts to the north or north-northeast and the speed reaches a maximum (Davis & Fox, 1975). Arrival of a norther causes a reversal in the alongshore component of wind and thus a reversal of wave approach. Swift longshore currents from the northeast rapidly develop. After passage of the frontal system the wind shifts to the southeast and the longshore currents to the northeast resume. High energy conditions during northers cause rapid seaward movement of the first surf bar, strong longshore currents and few rip currents. During low energy conditions the bar builds up and moves landward. Rip currents develop (Davis & Fox). This author has seen the shoreline temporarily retreat to the edge of the foredunes, cause minor foredune erosion and plane the beach to a very gentle slope during strong northers. It is likely that this condition would be most severe during a strong norther when gulf water levels are at their annual high in October. These effects would be minor on the high elevation shell beaches of the convergence area because they are not flooded by northers. It is believed that beach erosion by northers is temporary and non-destructive as the material removed is stored in the foreshore bars and migrates back onshore during the low energy waves between northers and during most of the low energy summer months. This norther erosion and planation of the beach could however erode oil deposits which were incorporated into the summer beach building phase.

EXPECTED RESULTS OF MODERATE AND HIGH LEVELS OF BEACH SEDIMENT REMOVAL BY BEACH CLEANUP OPERATIONS

Mustang and North Padre Island - Mustang Island and Padre Island north of the shell beaches are stable and may be accretionary. Further they are composed of only one grain size population and removal of sediment will not affect the character of the beach sediment or its response to wave action and beach processes. I believe that moderate cleanup efforts will pose no hazards to the beach. If heavy or continuous cleanup efforts are used and a significant quantity of sediment is removed relative perhaps to rates of longshore transport, then the sediment should probably be replaced with sand of similar grain size distribution. There are abundant local sources for this purpose and many such are located on federal and state land. If the beaches in this area are not kept clean, the oil may become buried in the beach sediments to be exposed upon normal cyclical erosion due to northers. If this is deemed to be an excessive hazard to the fauna and flora and to human usage, regular cleaning may be advisable. Unless a large amount of sediment is removed, this will probably cause no long term damage, however it would be best to replace the sand removed with clean sand. Sources for this sand and methods of dispersal can be investigated if that course of action is chosen.

Convergence area and shell beaches - Any removal of coarse shell material (coarser than the terrigenous sand fraction) in these beaches could result in a slope inequilibrium in a high concentration of course shell material. Most of this coarse shell material is concentrated in the berm and seaward of the berm (where the oil fouling is probably concentrated). Loss of the shell material might result in flattening of the entire beach with drastic seaward transport as wave action adjusts the beach profile to be in equilibrium with a finer sediment. This could result in eventual wave attack on the strongest part of the dune ridge along the Texas coast. There are no suitable sources for replacement material for beach nourishment if the coarse shell material is removed. Further, many of the shells making up the beach are several thousand years old (watson, 1968) and the shell beach accumulation may represent a very old and slow forming deposit. I believe that any removal of this shell material should be approached with great caution.

South Padre Island - South Padre Island is very unstable with regard to erosion. It seems to be eroding regularly due to loss northward by the littoral drift system and losses inland due to wind action and storm overwash. Even a small hurricane will badly overwash South Padre Island. Further, South Padre Island is very thin, only about 10 feet at Mansfield Pass (Kieslich) and only about 3 to 5 feet adjacent to the Arroyo Colorado Rio Grande Holocene delta lobe, with deltaic sediment outcropping on the beach and in the surf zone (personal observations). As a result, I believe that any sand removed by beach cleanup operations should be replaced with sediment of similar grain size composition. Much of the source areas for such sediment are on private land, but some is probably on state or federal land. If the sediment is replaced, I doubt if the cleanup operations will be harmful. Massive sand removal without replenishment is to be avoided. I do not believe that sediment removal here will cause slope changes as it might in the shell beaches unless it was to result in a grain size distribution change in the beach sediments.

CONCLUDING REMARKS

It appears that light and frequent removel of oiled sand should not be harmful to Mustang or North Padre Islands.

Light removal on South Padre Island should probably be replenished due to the erosional nature of those beaches, although the only erosion will probably be due to that carried off in the trucks. Heavy removal there must be replaced.

Without evidence to the contrary, I believe that removal of the coarse fraction (shells) on the shell rich beaches could cause an erosional change to low slope beaches which might not be reversible. Only the minimum amount of shell material should be removed as there is no source to replace it and removal will change the composition of the sediment.

Very heavy removal from any beach should probably be replaced with other sediments of similar grain size composition.

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