Coastal Law and the Geology of a Changing Shoreline

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INTRODUCTION

The Gulf of Mexico and bay shorelines of the Texas coast present special land boundary problems that do not exist in most interior locations. Since the shoreline boundary is a littoral boundary, it will change with time as the line of Mean High Tide (MHT) or Mean Higher High Tide (MHHT) moves inland or offshore due to erosion or accretion or relative changes in water level. This means that legal boundary disputes will surely follow the natural changes in the tidal boundary if valuable property is affected. The property in dispute can range from loss of individual homes along the barrier islands due to beach erosion to ownership of large tracts of land of many square miles overlying valuable mineral deposits in the Laguna Madre.

The shorelines of the Gulf of Mexico and the Atlantic Ocean shorelines of the United States, with the exception of parts of New England, are composed of unconsolidated sand and mud. As a result the shorelines and legal land boundaries shift with erosion, accretion, and rising and falling water levels. At times these shorelines are stable for long time periods, when viewed in human time scales. At other times, the shoreline positions change very rapidly due to erosion or deposition caused by a single storm or river flood. Some of the changes are entirely due to natural geologic processes, and others are due to man-made changes in the shorelines or rivers flowing to the coast.

If we observe a totally undeveloped section of the coastline, these changes would be observable only on a succession of maps or aerial photographs. If there was a beach, there will still be a beach, though it may have moved. Without the presence of valuable man made structures, only the mapper would notice the change. However, if the shoreline is developed, then changes relative to man made structures will be very apparent, especially when those structures begin to fall into the sea and the "new" beach wants to be where those structures were previously located. On the other hand, if the beach accretes the shoreline change will generally be welcomed.

"Texas state law defines the boundary between submerged lands belonging to the state and uplands belonging to the private land owner as the projection of the level of either mean higher high tide (MHHT) or mean high tide (MHT) on the sloping shoreface. If the land ownership dates from a Spanish or Mexican land grant, MHHT is used as the boundary. MHT is used as the boundary for land grants under common law after Texas independence" (Watson, Richard. L., et al.,1990). This boundary definition was determined by the Supreme Court of Texas in *Luttes v. State, 324 S.W.2d 167 (Tex. 1958)* and re-affirmed by the Supreme Court of Texas on August 29, 2002 in opinion No. 99-0667 with regard to *The John G. and Marie Stella Kenedy Memorial Foundation and Corpus Christi Diocese of the Roman Catholic Church, Petitioners v. Dewhurst,* 90

S.W.3d at 268 (2002). This opinion clarified the definition of MHHW or MHW, the highest daily water level that occurred in each day, as the average or mean of the highest water level of each day)regardless of whether that level was due to tidal or meteorological factors or both) over a tidal epoch of 18.6 years.

The role of the geologist in these disputes is key to understanding the natural processes and forces that work together to determine the present boundary location and how it came to be at that location. This may include historical changes in the boundary from studies of existing maps, aerial photographs and sedimentological studies to ascertain how the boundary changed prior to the earliest land surveys. In addition, it may be necessary for the geologist to determine, if the shoreline changes are due to man-made changes on near or distant parts of the coast, man-made changes in rivers that affect coastal shorelines and even groundwater pumping that causes land subsidence and rise of relative sea level resulting in shoreline retreat. Finally, the geologist must assist the attorney in understanding these complex physical processes so that he can understand the natural processes and man made changes affecting the boundary location. The geologist must work with the attorney until the he can read and comprehend specialized geologic reports and fully understand and critically evaluate legal testimony by opposing geologists and other scientific experts.

COASTAL PROCESSES

The wind in the nearshore Gulf of Mexico generates waves which move toward the shore in the direction the wind is blowing. As the waves approach shallow water, they become steeper and eventually break, forming surf. Once the waves have broken, they become a moving mass of water approaching the shoreline at a slight angle. This generates a current moving parallel with the shoreline within the surf, (Fig. 1). Whenever a wave breaks, it suspends sand from the bottom into the water. This sand is then carried a short distance along the shoreline until it settles out, only to be re-suspended and carried along by the next breaking wave. This process creates a virtual conveyor belt of sand along the shoreline in the surf zone. It has been called a “river of sand” and frequently amounts to movement of hundreds of thousands of cubic yards per year. Figure 1. shows sand movement in the direction that occurs along the Texas coast south of central Padre Island coast.

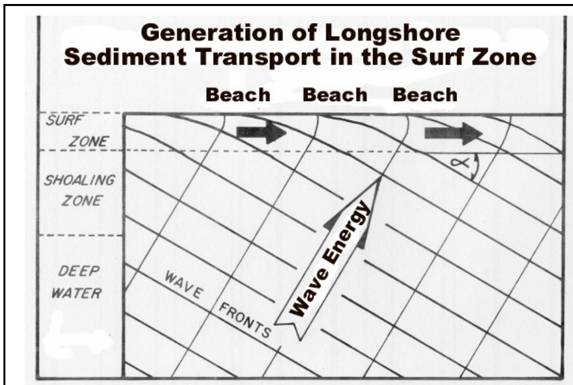

Figure 1.

Sediment transport along the Texas coast moves from the Rio Grande northward to central Padre Island where it converges with sediment moving southward from the east Texas coast. As a result, central Padre Island has an oversupply of sand and it is one of the few places on the Texas coast where the Gulf shoreline is accreting naturally, (Fig.2). The only other places of accretion are occurring in the vicinity of jetties, which have been constructed at inlets and at river deltas, where rivers are flowing directly into the Gulf.

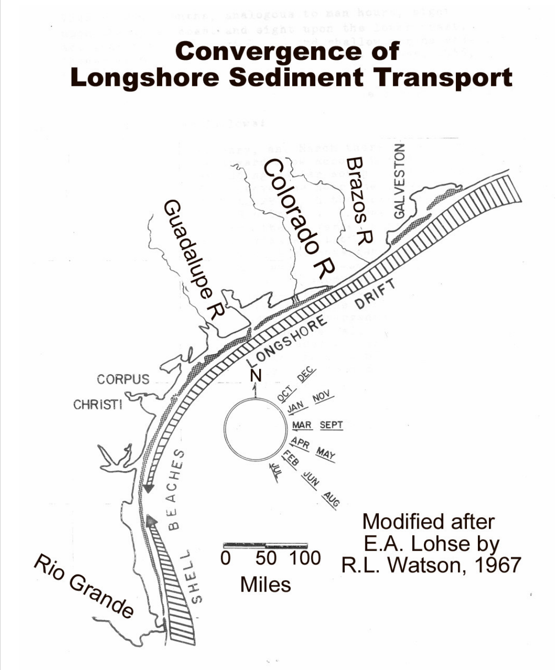

Figure 2. From Watson, 1967

The amount of sediment transported along the shoreline as littoral drift at any location depends on the size of the breaking waves, and the angle they meet the shore. If there is sand present on the beach, it will be transported in a downdrift direction. In order for there to be equilibrium and not have a net loss of sand and beach erosion due to the littoral drift sand transport system, it is critical that each section of beach have the same amount of sand supplied to it from the updrift direction as is removed in the downdrift direction. If less is supplied than is removed, then beach erosion will occur. If more is supplied than removed, then beach growth, or accretion, will occur. This causes a large fillet of sand to build up on the updrift side of a jetty or groin. Sand is being brought in from the updrift side, but none can get past the jetty. At the same time, the downdrift side of the jetty or groin usually has a highly eroded beach. Sand is still leaving on the littoral drift conveyor belt, but no sand is coming from the updrift side. It is trapped by the jetty.


Figure 3.Mansfield Pass looking north

This photo of Mansfield Pass on the lower Texas coast shows the sediment transport is from south to north (bottom to top) in the photo. Note that there has been a huge accumulation of sand on the lower jetty and erosion of the beach on the north or upper jetty (Fig. 3). This has happened since Mansfield Pass was built in 1962.

The Bolivar Roads jetties at Galveston have been trapping sand since jetty construction in 1876. Over 28 million cubic yards have been trapped east of the East Jetty in the area enclosed in the gray line in this photo (Fig 4). That amounts to about 260,000 cubic yards per year. Construction of these jetties at major navigation inlets along the coast has compartmentalized the coast. In the past, sediment was able to travel along the surf zone from the Mississippi Delta all the way to the convergence at central Padre Island without being trapped by long jetties. But now, because jetties built at major inlets trap the sand moving along the shore, most of the Texas Gulf beaches are now starved of sand and are eroding. They were stable or accreting prior to jetty construction and inlet development.

Figure 4. 28 million cubic yards of beach sand trapped by Bolivar Roads jetty

Inlets also produce beach erosion by starving the downdrift beaches of sand. Sand flows in through the inlet and is deposited in the bay. The beaches, downdrift of the inlet, are starved by the amount of sand that flows in through the inlet.

In addition to washing sand into the bays and forming a flood tidal delta in the bay, the ebb jet washes material offshore and forms an ebb tidal delta as well (Fig. 5). The sand in the ebb and flood tidal deltas is no longer available for transport down the beaches (Fig. 5).

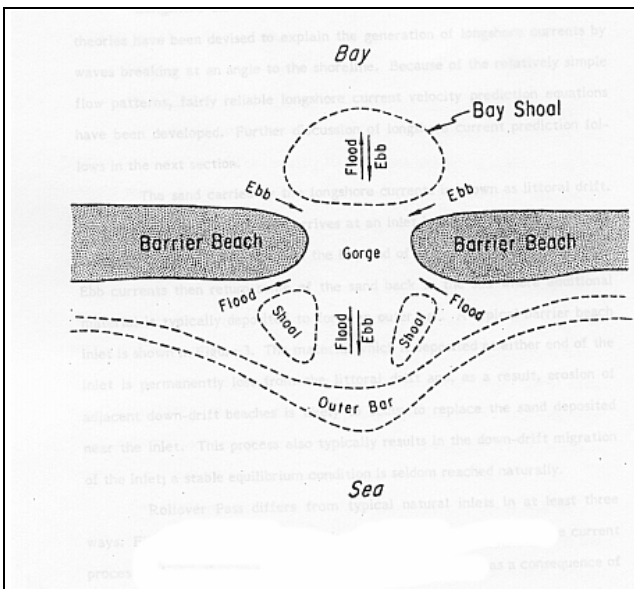

Figure 5. Ebb and Flood deltas (From Bales and Holley, 1984)

Throughout the 1900s, dams were built in nearly every available location on the rivers of Texas. The reservoirs created by those dams catch most of the sand that previously flowed down to the coast to nourish the beaches. In addition, flood control reduced maximum flood flows and further reduced sediment supply to the coast. This has further enhanced beach erosion along the Gulf beaches. Only the Sabine River, the Brazos River, the San Bernard River and the Rio Grande River now flow directly to the Gulf beaches of Texas. The Colorado River used to flow directly to the Gulf but in 1992, it was diverted into Matagorda Bay. As a result, increased beach erosion can be expected to the west of the Colorado River Entrance. So much water is withdrawn from the Rio Grande, that it frequently does not flow at all into the Gulf and has its mouth completely closed by a sand bar at those times. Since the longshore sand transport system carries sand from the Rio Grande northward to central Padre Island, it was very important in nourishing the beaches of South Padre Island. Those beaches are now eroding rapidly and require frequent man-made beach nourishment to prevent loss of beaches and structures. The sediment supply to the East Texas coast between High Island on the Bolivar Peninsula and Sabine Pass has been so reduced that the coast road has been destroyed. The road was moved inland several times, but finally abandoned. Prior to the 1900s, that shoreline was accreting, as shown by a series of beach ridges just south of Sabine Pass. The road between High Island and Gilchrist is in danger of being lost to beach erosion as well (Fig 6). Look at the very top of the photo; the beach is nearly

Figure 6. Road from Gilchrist to High Island.

eroded to the road. If that happens, the only access to the Bolivar Peninsula will be the Galveston Ferry. This will make hurricane evacuation difficult and effectively remove access to the beaches from residents of Port Arthur and Beaumont.

The road between Surfside and Galveston on Follets Island is also about to be lost to beach erosion (Fig 7).

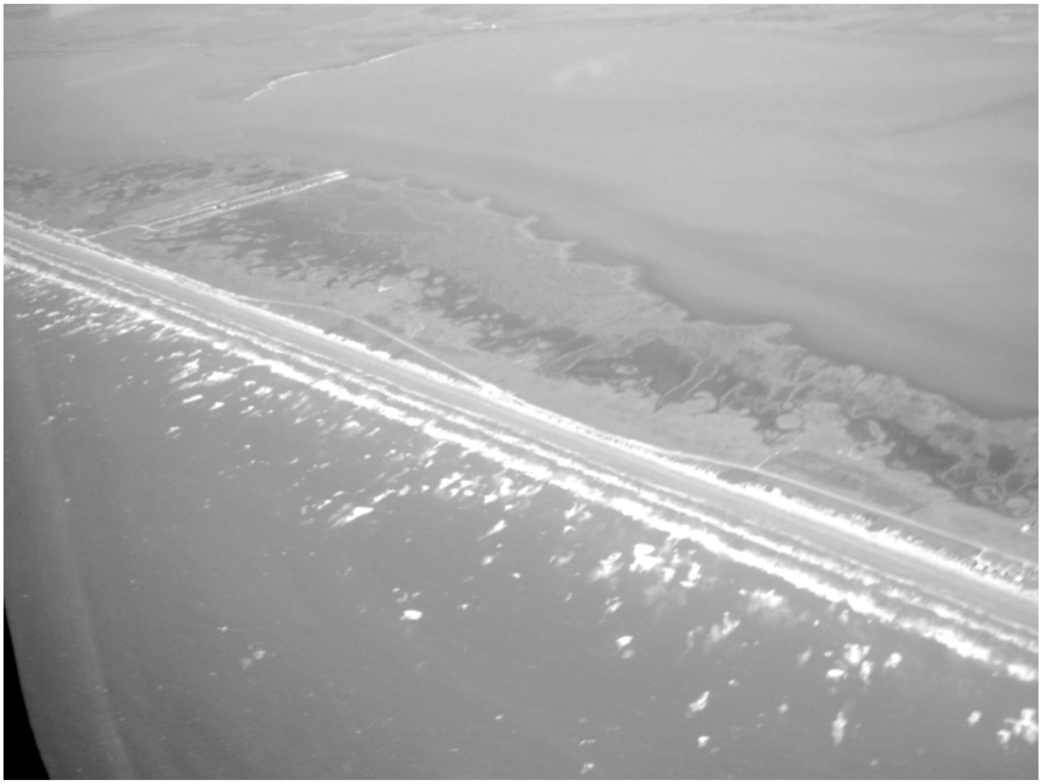

Figure 7. Road on Follets Island is about to be lost to erosion.

Tropical storms and hurricanes cause both permanent and temporary loss of beach sand. During a storm, the upper beach and dunes are eroded and much of that sand is carried offshore into a nearshore bar system. With the return of calm waves after the storm, that material is carried back up onto the beach over a period of many months and sometimes years. Once the sand is deposited on the beach by waves, the wind will blow it inland to the first vegetation and a dune ridge will form. This is important, because the sand in that dune ridge will be carried Gulfward to the bar system in the next large storm. This cycle repeats with every storm. In some cases, if there is no dune ridge and the barrier island or peninsula is very low, a considerable amount of sand is carried inland and deposited as flats on the bay side of the barrier.

If there is no dune ridge storing sand between storms, and sand is either carried inland, or further offshore out of reach of the gentle waves which can carry it back onshore permanent beach erosion results. When storms attack a clay shore, all of the clay is carried permanently away in suspension. It is not deposited just offshore in the bar system to be carried back onshore with the return of gentle waves. This problem exists on the Bolivar Peninsula and in the vicinity of Sargent, Texas.

There are two main ways that the barrier island bay shorelines grow into the bay, filling the bay and expanding the island inland and, of course, moving the shoreline boundary. Washover fans form where there is a prominent break in the foredune ridge near the

Fig. 8. Washover fan on San Jose Island

beach and beach sand is repeatedly transported across the barrier island and deposited in the bay on the back side of the island during hurricanes. Figure 8 shows one of the best developed washover fans on the Texas coast. It is located at the northeast end of San Jose Island. It functions just like a river delta in reverse. Storms flood through the beach opening at the top of the photo and the sediment fans out and spreads into the bay, widening the island.

From central Padre Island southward to Mexican border, the Texas coast is quite arid. As a result, the dune ridges are not well vegetated, and storms can wash sand inland. Since it does not become readily vegetated, the wind then blows the sand inland. This has been going on for tens of thousands of years and has resulted in a region with active sand dunes from the coast inland past highway 77 in the vicinity of Sarita, TX. The entire central Laguna Madre has become filled with wind-blown and hurricane overwash sand moving inland from the beaches of Padre Island (Fig 9). You will remember that this is the area of the convergence of longshore sediment transport and has the greatest sand supply of any beach area of the Texas coast. Hurricane Brett, a small hurricane in the late 1990s, eroded many hurricane channels through the Padre Island beach and deposited sand behind the dune line to continue this process. Laguna Madre will continue to fill with wind-blown and washover sand until it has completely filled. Note that nearly all of the white bare sand areas and slightly darker unvegetated areas in Figure 9 are wind-tidal flats in Laguna Madre.

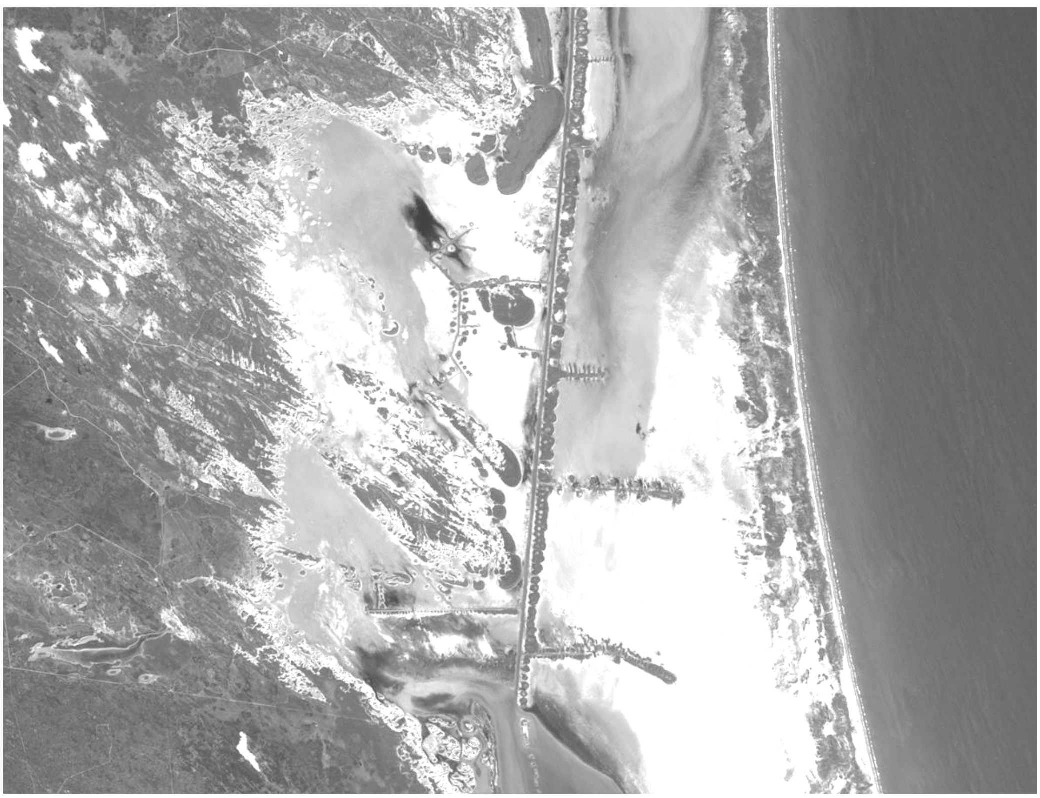

Figure 9. Wind Tidal Flats, Central Laguna Madre

In addition, rising sea level due to natural and manmade changes causes further retreat of the beaches along the Texas coast. Huge amounts of groundwater have been extracted near Baytown, Texas City, and lesser amounts at Freeport. This has caused water bearing clay sediments to de-water and shrink resulting in subsidence (sinking) of the land surface.

Figure 10 shows subsidence of as much as 7.5 feet along the Houston Ship Channel north of Baytown since between 1943 and 1973. It has caused loss of waterfront property. There is similar but lesser subsidence of about 2 feet at Freeport and Surfside also due to groundwater withdrawal.

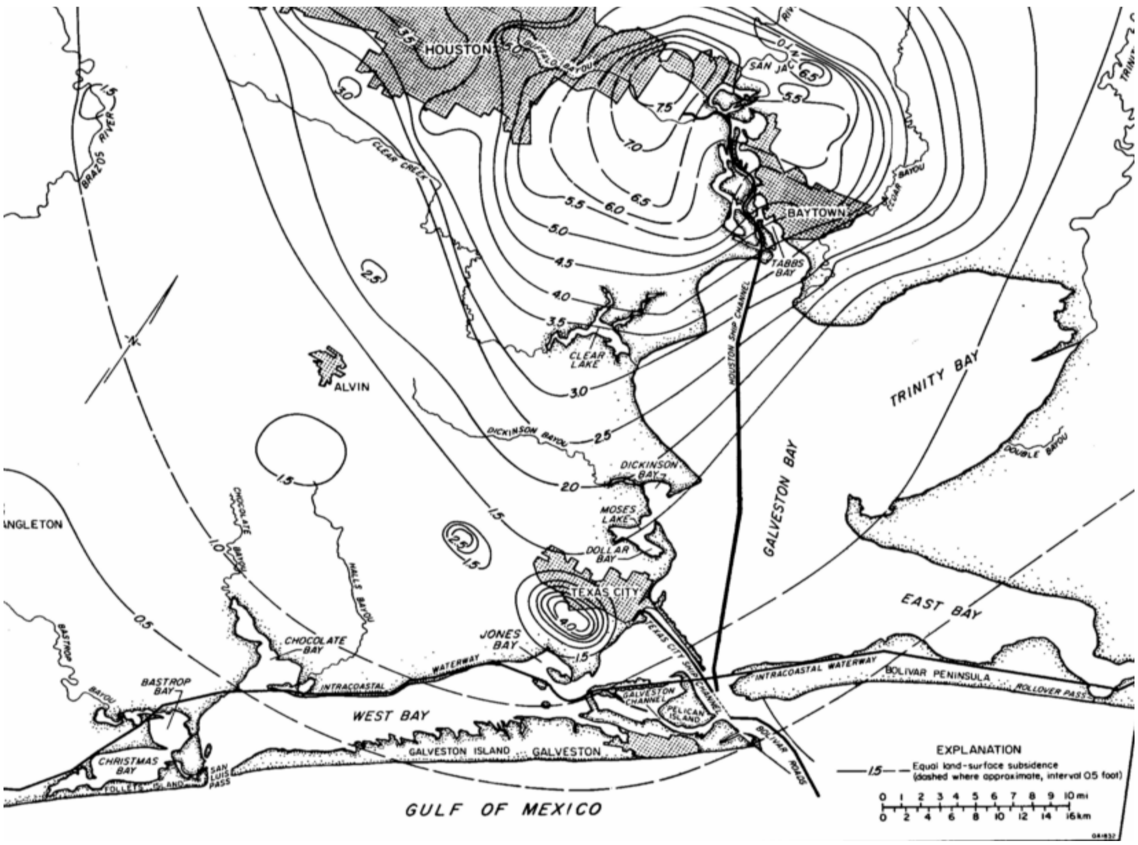

Figure 10. Land subsidence of the Galveston-Houston area, 1943-1973 (modified from Gabrysch, 1982.

COASTAL BOUNDARY DISPUTES IN TEXAS WHERE GEOLOGICAL INFORMATION WAS CRITICAL

> Shoreline determinations along gently sloping coastal lands present challenges to both the scientific and legal professions. Along the extensive, gently sloping shores of the Laguna Madre of South Texas, there have been several legal controversies regarding land ownership and accurate shoreline boundary determination. At the heart of this problem lies the basic question: are the coastal areas often referred to as the "wind-tidal flats" of the Laguna Madre submerged, and therefore owned by the State, or are they not submerged and owned by the private owner of the adjacent uplands?
>
> The determination of shoreline locations in areas with obvious relief is relatively simple. In contrast, accurate shoreline determination may be difficult in areas where wind-tidal flats are present. A wind-tidal flat is defined as a broad, barren flat that is partially inundated at irregular intervals by lagoonal or bay waters under the influence of wind-generated tides. Scientific complexities in the determination of shoreline locations in wind-tidal flat environments include lack of shoreline vegetation and difficulty in measuring normal astronomical tides, coupled with multi-directional and seasonably variable wind-tides. Surveyors have difficulty because of the geographic remoteness of the flats, the miles of level, featureless terrain, and the lack of tide gauges for determination of mean higher high tide or mean high tide (Watson, et al., 1990, p.755).

We have found that a multi-disciplinary approach works on these difficult wind-tidal flat boundary problems.

> The geologist uses studies of sedimentology, topography, hydrography and climate to provide a qualitative aid in helping locate the present boundary position and to determine and explain the processes which have operated to change the position of the historical boundary to the present boundary, if it has changed in position. He/she also assists the attorney in understanding the complex physical processes affecting the present and historical boundary positions (Watson, R.L. et al., 1990, p.757).

Since the boundary is located at MHHT (Mean Higher High Tide) for civil law (Spanish or Mexican land grants) boundaries and at MHT (Mean High Tide) for common law boundaries (post Texas independence land grants) and since these boundaries are not fixed, but change as the intersection of those tidal levels and the land surface shifts, a team consisting of attorneys, surveyors, geologists and biologists can be necessary. In addition to determining the present location of the tidal boundary, the geologist must determine how that boundary has changed through time at least as far back as the time of the original land grant. The original grant may call for the waters of the Laguna Madre as the boundary, but not map or specify the location of that boundary at the time of the original grant. Further, there would have been little interest in knowing the exact location of the boundary at the time of the original grant. The wind-tidal flats are composed of very soft sand and mud and are very difficult to cross on either foot or horseback. At times, cattle become mired in the soft flats, resulting in their death. At the time of the original grants, the barren salt and algal mats had no economic value whatsoever. However with the passage of time and the development of technology, land that was once useless is now very valuable, especially so when it is underlain by mineral deposits.

The geologist assists in qualitatively determining the present tidal boundary, determining if there has been accretion or erosion and the rates of those processes, and evaluating the recent geological history of the area.

Rates of sedimentation can be estimated by collecting numerous short cores on transects across the study area. The cores are analyzed for environment of deposition based on sediment type and remains of organisms present. Radiocarbon age dates on once-living organisms found in living position within the cores can be used to establish a date at which that level of the core was subaerially exposed. With this information, used in conjunction with the depth of the organism within the core, the long-term sedimentation rate at the site can be determined. Analysis of sedimentation rates throughout the study area, along with the study of surface environments, processes of sediment transport, and sources of sediment supply may aid in determining if there has been accretion or erosion since the date of the original grant.

It may be useful to determine if relative sea level has changed in historical time. Age dating of depth-sensitive organisms within the cores may provide data which can be used to establish relative sea-level at past historical times. Long-term tide gauge records and examination of the scientific literature may also provide information useful in estimating historical changes in sea level.

The recent geologic history of the coastal zone can be partially understood by examination of the scientific literature; however, it is often best to analyze numerous cores within the study area to determine the specific geologic history of the disputed tract. It is then possible to reconstruct the various environments of deposition on a three-dimensional diagram showing the changes in location of each environment through space and time. If there is a detailed modern topographic map of the area, it may be possible to produce a probable topographic map of the area for any historical date by "eroding" the present topography back through time using sedimentation rates by which the surface built up to its present configuration. This enables the estimation of surface conditions at various times in the past.

The environments of deposition along the Laguna Madre shores include: continuously submerged shallow lagoon margin; low wind-tidal flats submerged by wind-tides or by the highest seasonal astronomical tides; high flats where aeolian (wind) processed dominate, submerged only by storm tides; and vegetated mounds of various types, which are primarily aeolian in origin. Blue-green algal mats may provide a useful indicator, as they cannot live where continuously submerged by waters connected with the lagoon because they are destroyed by grazing cerithid gastropods (Watson, R.L. et al., 1990, p.759).

The biologist provides qualitative assistance in supporting the location of the modern boundary position based on the presence or absence of inundation-sensitive plants and animals. He/she assists the geologist in faunal interpretation of surface and subsurface environments of deposition and explains the significance of biological indicators of shoreline position to the attorney (Watson, R.L. et al., 1990, p.757).

The Kenedy Foundation wind-tidal flat boundary dispute

The disputed land in the *The John G. and Marie Stella Kenedy Memorial Foundation and Corpus Christi Diocese of the Roman Catholic Church, Petitioners v. David Dewhurst,* *Commissioner of the General Land Office and the State of Texas, Respondents*, 90 S.W. 3d 268 (Tex. 2002). consisted of over 50 square miles of land overlying rich natural gas deposits (Fig. 11). The photo shows only a portion of the disputed land. The disputed land consists of the algal mat areas, El Toro and the flats throughout the photo west of the Gulf Intracoastal Waterway. It also includes another large area of flats to the south (below) of the photo. The total region of the flats can be seen in Figure 12 between the words PADRE and ISLAND. There had been previous failed attempts to determine that a portion of this tract did indeed belong to the upland owner in: *Sun Oil Co. v. Humble Oil & Refining Co*. 190 F.2d 71 (Tex. 1944).

Figure 11. Disputed land in Kenedy County.

However, back then modern radiocarbon age dating had not yet been developed and the scientists estimates of sediment accumulation in excess of 1 – 1 ½ feet per century were very high. At that time, it was commonly believed that the Laguna Madre passed continuously and naturally through the flats from North to South until the lagoon was closed by hurricane overwash early in the 1900s. The geologists attempted to prove that the flats accreted onto the upland since the original land grant, but they were not successful. Also this decision preceded *Luttes v. State* (1958) which settled the boundary at MHHT for civil law grants, such as this property.

In our study we took about 140 short cores of the surface sediments of the wind-tidal flats. We were able to obtain multiple radiocarbon age dates of algal mats and carbonate sediments within the cores. These, used in conjunction with additional core sample age dates provided ample data to demonstrate that the upward rate of accumulation of the wind-tidal flat sediments was only 0.1 to 0.2 ft/century, much less than the earlier studies suggested. This agreed with the maximum rate that would be possible considering the amount of sand supplied to the region by the longshore sediment transport system along the Gulf beaches of Padre Island, the source area for the wind-tidal flats sediment. Studies by the University of Texas Bureau of Economic Geology, the State geological survey, came to the same conclusion.

This, in fact, proved the present configuration and elevation of the disputed land and its shore boundaries was indeed very similar to the land configuration at the time of the original grants in the early 1800s. The new boundary surveyed by Claunch and Lothrop was purposely placed a bit above the level of MHHT that they determined for the vicinity. Over 50 square miles of "new" upland were now included by the MHHT boundary. We did not have to prove that it became "upland" due to slow and imperceptible accretion to the upland as was required in Sun v. Humble, because we demonstrated that it was already fast land at the time of the original grants.

In the initial trial, the State geologists and surveyors agreed that the disputed land enclosed by the Claunch and Lothrop boundary was above MHHT. The jury agreed. We thought we had won, since we met the requirements determined by the Supreme Court of the State of Texas in *Luttes v. State* in 1958, the decision that had been controlling littoral boundaries in Texas since 1958. However, the State argued that the wind-flats were special, in that inundation occurred several times a year miles and miles beyond our surveyed MHHT line, and that inundation was well above our line. The surveyor for the state presented a line that was near the topographical bluff line many miles inland of any "normal" shoreline. That surveyed line varied several feet in elevation and was made totally without regard to any tidal gauge reference in contradiction to the requirements of Luttes. The jury was allowed to split their decision and to find that the disputed land was all above MHHT, but they could choose the state survey line if they liked it better and they did just that.

We were stunned. The court just threw out long-standing littoral boundary law in Texas. Appeals over many years worked their way up through the courts to the State Supreme court which upheld the trial court's ruling. Finally, in 2001, the Supreme Court of Texas agreed to a rehearing, upheld Luttes and found for our clients, the John G. and Marie Stella Kenedy Memorial Foundation. The final sentence of that decision follows. *"Finally, the dissent studiously ignores one very important fact: that the water reaches the bluff line the State claims as a boundary at most once or twice a year. It is odd to think of a shore as the place where the water almost never is," Kenedy Memorial Foundation,* 90 S.W. 3d at 291. After 8 years of work on this project, I read that sentence with considerable pleasure.

The South Padre Land Company wind-tidal flat boundary dispute

The wind-tidal flats on the back portion of South Padre Island and a small portion of North Padre island just north of Mansfield Pass were in disputed ownership between the South Padre Land Company and the State of Texas in 1978 (*South Padre Land Co., et al. v. State,* Cause Nos. 78-153-C and 78-15-C filed in the 197th District Court of Cameron

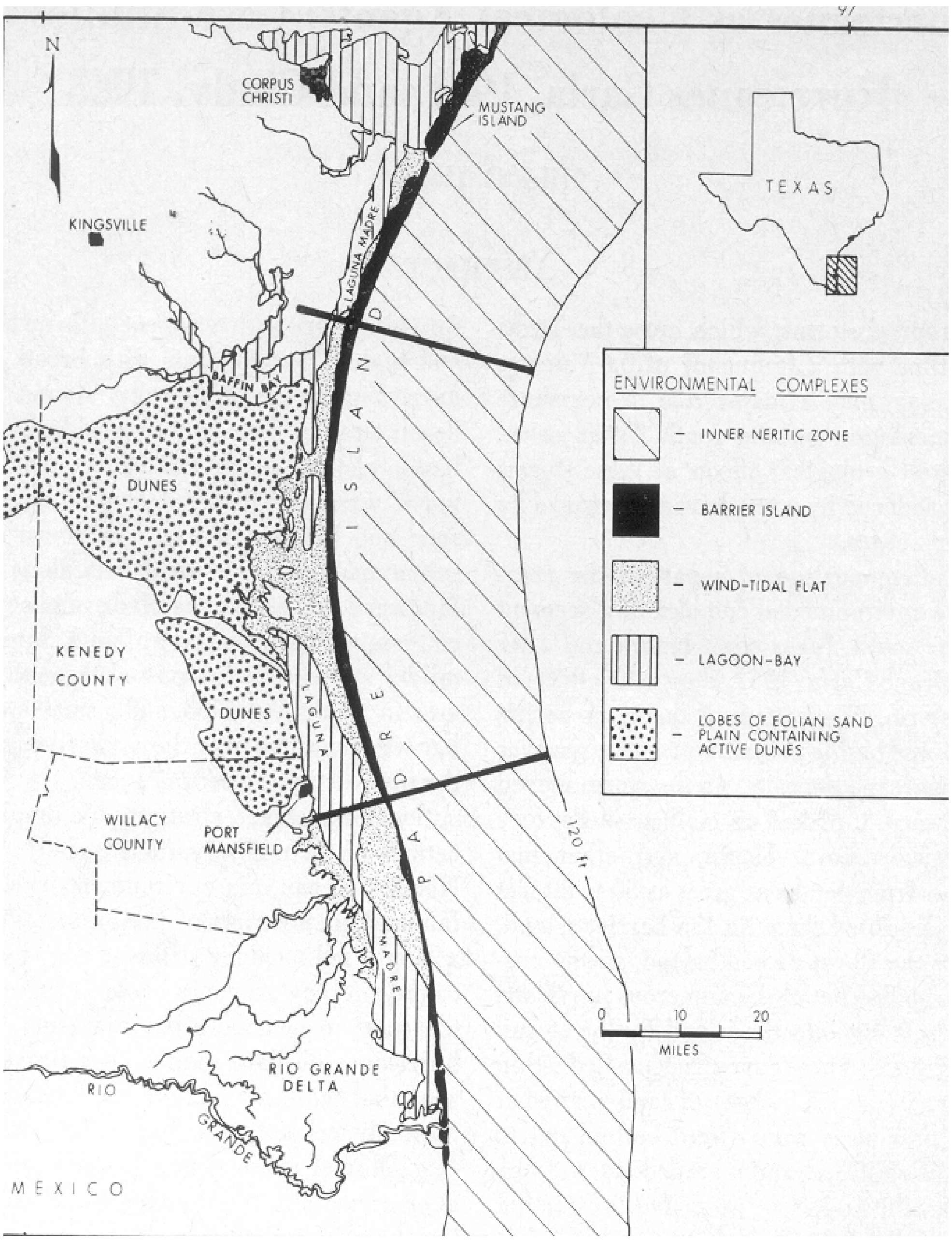

Figure 12. South Padre and Central Padre wind-tidal flats (Hayes, 1967)

County, Texas. Refer to Figure 12 for a map of those flats. The flats range in width from ¾ mile near the southern limit of the study area to about 4 miles wide south of Mansfield Pass. Surface elevations change on the order of 0.2 ft/mi. or less, and the most significant topography is Rolligon tracks from survey crews. The flats in dispute in the South Padre

Land Company suit were adjacent to the word P A D R E on the map. Land surveys by Matt Claunch showed the entire body of these wind-tidal flats were above MHHT, as required by Luttes v. State. As in the Kenedy case we took core samples and used age dating to show that the vertical accretion rate of these flats was only about 0.1 ft/100yr., and not the much higher rate of over 1 ft/100yr. as commonly believed. In this case, we found an extensive bed of very small pelecypods (clams) in living position, but dead, about 0.1 to 0.4 ft. below the present surface of the flats. They were age dated at 485 to 235 years old, yielding sedimentation rates of 0.02 ft/100yr. to 0.05 ft/10yr. We assumed that the sedimentation rate was twice the fastest indicated by these shells because they were located in a shallow depression behind a vegetated mound where the sedimentation rate was a bit lower than elsewhere on the flats.

This demonstrated that at the time of the 1826 Mexican survey, the general level of the flat was about a maximum of 0.15 ft. lower than at the present time. This would place most of the present flat surface above mean-higher high tide (1929 datum) at the time of the 1826 Mexican survey, and would therefore be fast land to Padre Island at the time of the original grant. Our data indicates these flats began to form and grew to their present size in the last 500 - 1000 years. Figure 13 shows a profile line across the wind-tidal flats along the Willacy-Cameron county line.

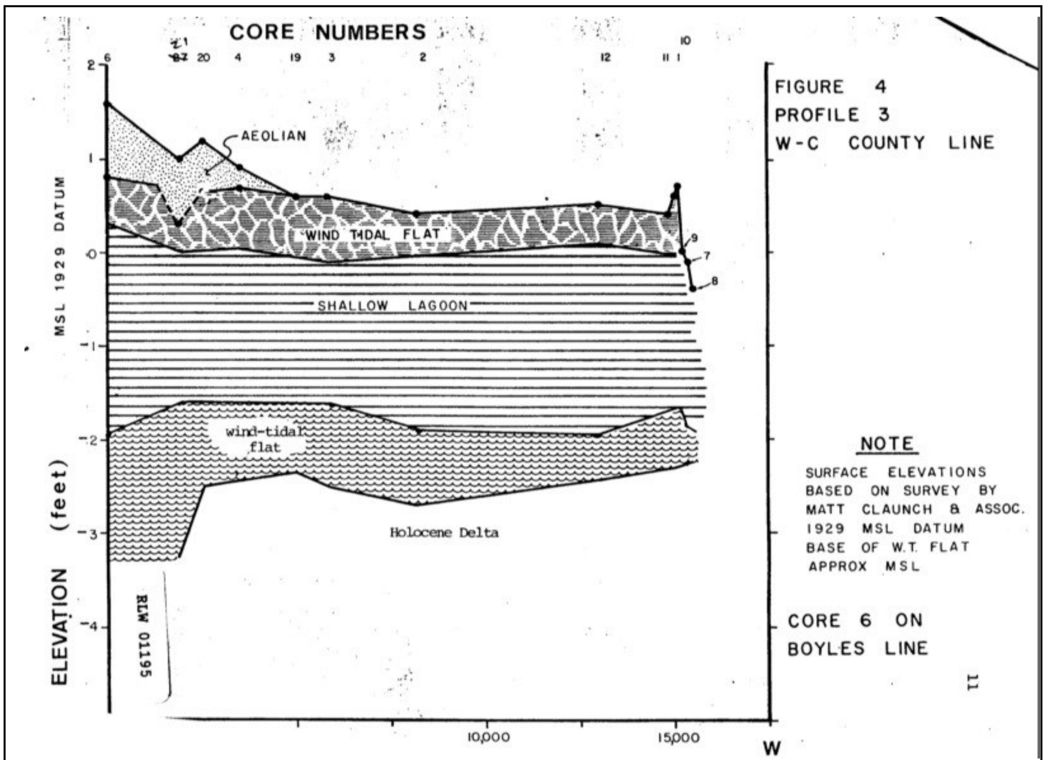

Figure 13. Sediments along the Willacy-Cameron Co. line (Watson, 1979)

Note that the boundary between shallow lagoon sediments and wind-tidal flat sediments is just about at mean sea level (MSL). You can also see in this cross section that wind-tidal flat sediments were deposited on top of old Rio Grande River Delta sediments. Then, apparently the relative rise in sea level accelerated faster than the rate of wind-tidal flat sedimentation and, for a period, the area became a shallow lagoon. Eventually, the rise in relative sea level slowed, and wind-tidal flats sediments were again deposited for the top ¾-1ft. of the surface sediments. The aeolian (wind deposited) sediments in the top left are from wind-blown sand coming from the beaches and sand dune fields along the Padre Island beach. The core samples and cross sections in the Kenedy land dispute showed a similar sequence, with shallow lagoon sediments between two periods of wind-tidal flat deposition. The legally significant findings shown on this cross section are that at the time of the Mexican survey in 1826, the land surface was only about 0.15 feet below the present surface and was in wind-tidal flat sediments which are now and were then above MHHT. We did not have to demonstrate that this land belonged to the upland land owner due to accretion, it was fast land when granted with a boundary calling for the shore of the lagoon. The wind-tidal flats accreted to Padre Island long before 1826 by the addition of aeolian material blown westward from the beaches and dune fields and from sand and shell carried westward across the eastern portion of the flats during hurricane washovers. A small percentage of wind-tidal flat sediment is clay which settled out of suspension from standing water when the flats were flooded by wind-tides and storms.

This case was settled on the first day of court to the benefit of our clients, the South Padre Land Company in concordance with *Luttes v. State* since the disputed land was above MHHT and had been since the time of the original Mexican grant.

Coastal Boundary Disputes Arising from Upland Erosion due to Man Made Changes in the Shoreline

LEGAL IMPLICATIONS

Most of the man made changes in the rivers and coasts of Texas have not directly caused beach erosion and shoreline changes. However, they have set the stage for natural processes of sediment transport in the surf, sand storage at jetties, construction of flood and ebb tidal deltas at inlets, and hurricane washover and hurricane transport of sand offshore, to accomplish long-term and permanent beach erosion and shoreline retreat. The manmade shoreline and river changes that have caused long term shore erosion by natural processes are extremely well documented in research reports by the State Bureau of Economic Geology, the Corps of Engineers, university researchers, engineering companies and independent researchers and consultants.

This is beginning to have legal significance as some land owners and their attorneys are looking at the loss of their land and structures as being in effect the result of a “taking” by the state or federal government. In many cases, it can be proven beyond any doubt that manmade changes in the shoreline, or the rivers, have been the trigger that caused the beach erosion that took their property. In some instances, state and federal funded research has predicted the future beach erosion and loss of private property. Many of those reports went so far as to recommend preventative procedures such as beach nourishment, closing man made inlets and other solutions to prevent the future loss of private upland property. The reports were mostly ignored. When a government entity chooses to build a reservoir or a lake and thus submerge private property, they must purchase that property. Does it not make sense that when that same government makes shoreline or river changes that doom private property to loss by shore erosion that the property should either be protected by beach nourishment or the owner compensated for his entirely predictable loss? Instead, the State often requires the private landowner to tear down and remove his house at his own expense as soon as the vegetation line retreats behind or alongside of his structures, even when the erosion and vegetation line retreat was caused by state changes in the shoreline. This is starting to change and some delay is now allowed, to see if the beach rebuilds and the vegetation moves back seaward. Lawsuits are also being filed for recovery of the value of the lost property when it can be shown that the loss was due to erosion caused by state and federal changes in the shoreline. Some of these suits are being settled in the favor of the plaintiffs.

Rollover Pass, Bolivar Peninsula

Rollover Pass was opened in 1955 as a joint project by the State of Texas and a private hunting and fishing club. When Rollover Pass was designed in 1953 by Lockwood and Andrews, they did not expect runaway erosion. In fact, they expected it to need regular dredging to keep it open like the other man made passes on the Texas coast. What they

Figure 14. Rollover Pass

didn't realize was that the tidal cycle in the adjacent bay was way out of phase with the Gulf tides (Figure 14). This set up a very strong current in the very short pass. Initial erosion was so fast that they had to quickly close the pass with sheet piling to keep from losing a whole section of the peninsula. The pass is now controlled by being completely lined with sheet piling on both sides as well as sheet piling across the pass just below low tide to limit the current flow. In spite of that, huge amounts of sand are lost through the pass into Rollover Bay and the adjacent Gulf Intracoastal Waterway (GIWW).

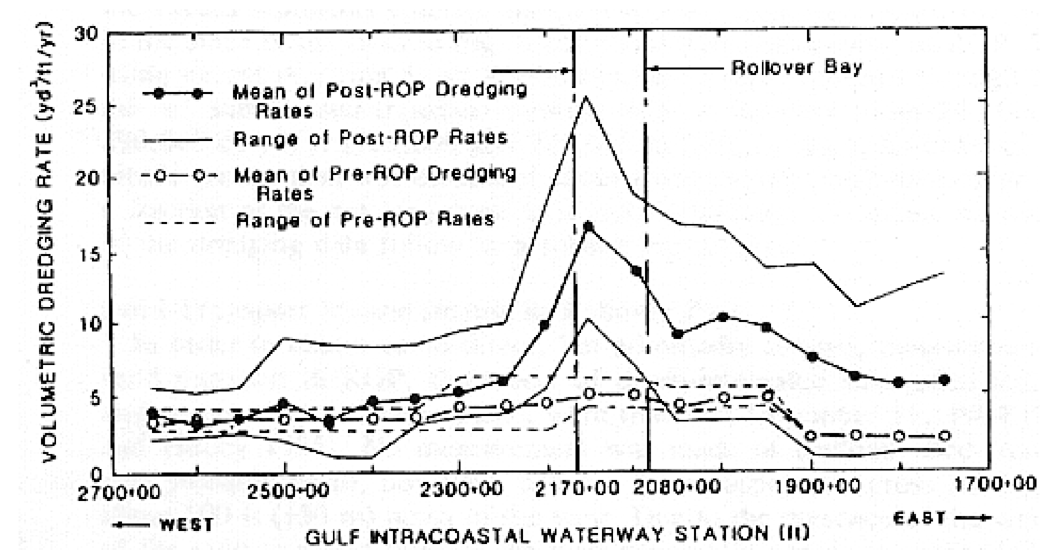

Figure 15. (From Bales and Holley, 1989 and Watson, 1999)

Dredging rates in the Gulf Intracoastal Canal in the vicinity of Rollover Bay and Rollover Pass increased drastically after the pass was opened (Fig. 15). Beach sand was flowing into the Pass and deposited in the Gulf Intracoastal Canal at rates of over 200,000 cuyd/yr. Figure 16 shows the cumulative dredging volume from 1950 to 1980. Note the sudden and sustained increase in the rate of dredging of the Gulf Intracoastal Waterway upon opening of Rollover pass in 1955.

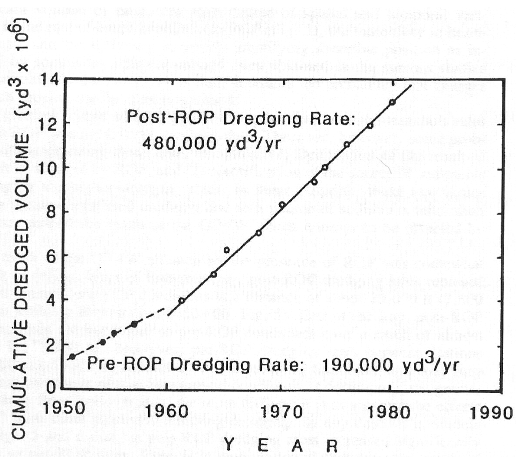

Figure 16. Cumulative Dredging Rates (From Bales and Holley, 1989)

The wealth of nearly 50 years of scientific and engineering studies of Rollover Pass and erosion of beaches in the vicinity of the pass demonstrate that loss of beach sand through Rollover Pass into the GIWW and Rollover Bay is causing accelerated beach erosion of the beaches west of Rollover Pass. There are indications the sand loss is also causing erosion of the beaches east of Rollover Pass, but to a lesser extent.

Dredging data from the U.S. Army Corps of Engineers (Bales and Holley, 1985, 1989) indicates that 240,000-290,000 cubic yard of beach materials are transported through Rollover Pass and deposited in the Gulf Intracoastal Waterway annually. This means that almost 10 million cubic yards of sand has been lost from the beaches through Rollover Pass since it was built in 1956.

All of Bolivar Peninsula has been eroding for many years, with the exception of the 7 miles of beaches east of the Galveston north jetty. The long-term erosion rate has been about 5 feet per year. Since Rollover Pass opened in 1956, beaches west of Rollover Pass have been eroding much faster than the general long-term rate for the area. Since 1995, and the occurrence of tropical storms Dean, Josephine, and Frances, the beach erosion within about 5 miles west of Rollover Pass and a short distance to the east of Rollover Pass has accelerated with losses as great as 60 feet in a single storm. Losses this great have never occurred near Rollover Pass in the past.

This massive new erosion is not just due to these three tropical storms (Fig. 17). Bolivar Peninsula has been subjected to attack by tropical storms and hurricanes throughout its history. Rather, this extreme erosion is because there were 40 years of sand loss greater than 200,000 cu yd/yr from the beaches through Rollover Pass. The present shoreline would be at the location of the line or further to the east (left in the photograph) in the absence of beach erosion caused by sand loss through Rollover Pass. This has resulted in the total removal of the normal sand reservoir in the offshore bars, on the beach and back beach and in the dunes for over three miles west of the pass. This is clearly shown by the clay beach exposed by tropical storm Dean in 1995 (Fig. 19). There is no sand left. It all went into the GIWW and Rollover Bay. The beaches continue to erode as longshore sediment transport carries the remaining sand westward where it accumulates north of the Galveston jetty.

Figure 17. Rapid erosion west of Rollover Pass.

The 40 years of sand lost through Rollover Pass have removed the natural sand storage in the offshore bars, beach and dunes. As a result, the beach cannot rebuild between storms by moving sand onshore from the bars back onto the beach, as would normally be the case. This is going to result in ever increasing acceleration of erosion with each succeeding storm because the profile inland from the present vegetation line contains even more clay and less sand.

The Parks and Wildlife Department has known of the sand loss through Rollover Pass and the need for beach nourishment of 20,000 to 200,000 cu yd/yr since at least 1959. This estimate was raised to 240,000 to 290,000 cu yd/yr in 1985. The sand flowing into the Gulf Intracoastal Waterway requires that that the channel be dredged about every two years at a cost of over $720,000 to the Corps of Engineers (Watson, 1999).

The result of this long term and accelerating beach erosion west of Rollover Pass has been the loss of numerous beach homes while others have been moved inland when the owners had additional property. The photos below show the Gordon house named 'The Breakers". It has been on Bolivar Peninsula since the very early 1900s (Figures 18 to 20). Note the rapid erosion (in only 4 years) of the wide grassy front yard. The beach was eroded down to the underlying clay marsh sediments. Note where the palm trees are in the various photos. This house has since been moved several hundred feet inland.

Figure 18. The Breakers in 1994.

Figure 19. The Breakers, 1995. Note that the beach sand is gone, it has been eroded down to the underlying clay!

Figure 20. The Breakers, 1998

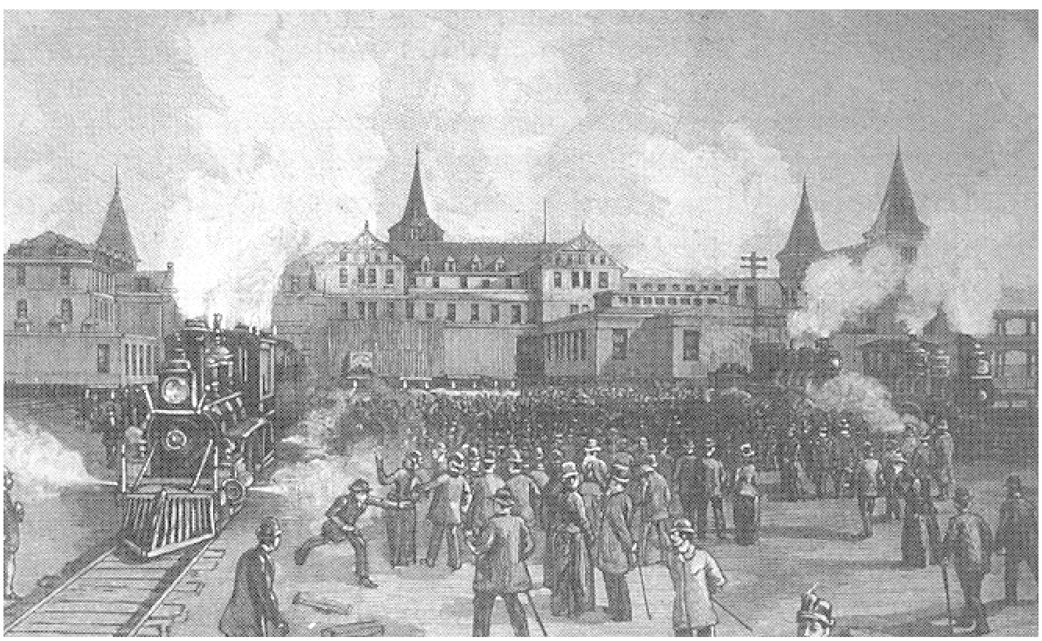

Figure 21. Trains moving hotel inland in the late 1800s in New York or New Jersey.

Moving buildings to save them from erosion is not a new idea (Figure 21).

As a result of the long term and accelerating beach erosion west of Rollover pass at Gilchrist, TX, I helped several of the property owners sue the state for their loss of property in a suit filed *as Roy Steinhagen, et al., Plaintiffs v. Gulf Coast Rod, Reel and*

Gun Club, et al. Defendants in the 58th Judicial District Court, Jefferson County Texas, No. A156012. The Texas Parks and Wildlife Department was a co-defendant since the pass was constructed by its predecessor agency, the Game and Fish Commission.

From shortly after the pass was opened until the present, there have been numerous reports and studies with new reports every few years describing the beach erosion caused by the pass and recommending that the pass either be closed, or the sand that passes through it pumped back on the Gilchrist beaches, or both. Some of these studies were done for the Parks and Wildlife department, some by the U.S. Army Corps of Engineers, some by engineering firms and some by university researchers.

> In 1979, the Texas Parks and Wildlife Department considered closing Rollover Pass. "During its February 1978 and February 1979 Executive Sessions, the Commission reviewed reports on the background and condition of the Rollover Fish Pass. During its June 1979 Public Hearing Session, the Commission authorized the Executive Director to take the necessary action to discontinue the operation of Rollover Pass" (Proposed Agenda Item, Texas Parks and Wildlife Department, September, 1979). In the June, 1979 meeting they stated: "The existing Rollover Fish Pass is causing accelerated erosion of that portion of the Gulf Beach southwest of the pass and is causing deposition of silt in Rollover Bay which is a degradation of the biological quality of the bay." "It is in the best interests of the people of Texas that said beach erosion and biological degradation of Rollover Bay be halted." The staff recommendation was: "*Due to economic necessity, the Commission authorizes the Executive Director to take necessary action to discontinue operation of Rollover Pass* (emphasis mine)"(Watson, 1999, p40).
>
> In a 1996 letter from Garry Mauro, then Commissioner, Texas General Land Office to Governor George W. Bush, Mauro, among other emergency measures to alleviate beach erosion in the wake of tropical storm Josephine, requested: "*Direct the Texas Parks and Wildlife Department to undertake the emergency closure of Rollover Pass using concrete removed from Caplen Beach and Gilchrist (*emphasis mine)." It is apparent Commissioner Mauro recognized the role of Rollover Pass in accelerating beach erosion in its vicinity. The Texas Coastwide Erosion Response Plan (Mauro, 1996b) recommended beach nourishment of the beaches west of Rollover Pass and either the installation of a sand bypassing system *or closure of Rollover Pass* (Watson, 1999*) (emphasis mine in italics).*

When faced with the overwhelming evidence in numerous documents, including those cited above, as well as agreement by their own expert geologist from the Bureau of Economic Geology, the State and the Gulf Coast Rod, Reel and Gun Club settled with the Plaintiffs before trial. There was no doubt whatsoever that the loss of private property through beach erosion was caused my man made changes in the coast, in particular the construction of Rollover Pass.

It was our recommendation that all of the sand that flowed into Rollover Bay and the sand which is stored in dredge material disposal sites along the Gulf Intracoastal Waterway be dredged back onto the beaches. It is not likely to be accomplished due to the high cost relative to the value of the local real estate. There has been some remedial beach nourishment by pumping sand from Rollover Bay onto the beaches of Gilchrist, but not nearly enough for a long term solution to the beach erosion caused by Rollover Pass. This problem would not have happened, it early advice was taken to close the pass and stop the erosion. The amount of sand that has been lost through Rollover Pass every year is about the same amount that accumulates east of the east jetty at Bolivar Roads (Fig. 4). That huge accumulation amounts to 28 million cuyd.. Rollover Pass has caused the loss of over 10 million cuyd. of beach sand into the bay and Intracoastal Canal where it costs $720,000 every two years for the Corps of Engineers to remove it. The fish caught at Rollover Pass are very expensive fish indeed.

BEACH EROSION AT SURFSIDE, TEXAS

The beach at Surfside Texas has been suffering accelerating beach erosion in recent years (Fig.22). The loss of many houses to beach erosion at Surfside, with many more threatened, has prompted beach front property owners to sue the State of Texas in order to either be compensated for the loss of their property or to have the beach restored and protected. The suit has been filed in the 239th Judicial District court, Brazoria County, Texas as *Bob Albert Brannan, et al., Plaintiffs vs. The State of Texas, et al., Defendants,*

Figure 22. Beach erosion at Surfside Texas.

*C*ause no. 15802*JG01.

The Surfside area may be unique in that it is subject to ALL of the manmade and natural causes of beach retreat operating on the Texas coast. These include: diverting the Brazos River to a location 6.5 miles south of its original outlet, lengthening, widening and deepening the Freeport Ship Channel in 1992, and groundwater withdrawal by Freeport industry which has caused several feet of subsidence, and thus relative sea level rise at Surfside, resulting in considerable shoreline retreat. Prior to the diversion of the Brazos

River mouth from the location of the Freeport Harbor Entrance to a location 6.5 miles to the south in 1929, Surfside was located on a stable river delta. Now, the delta is building at the new location, and the old delta has eroded away, leaving no sand supply for Surfside or the beaches at Quintana or Bryan Beach. The Freeport Harbor Entrance was widened, and lengthened in 1992, which resulted in doubling the dredge maintenance volume and rapidly increasing erosion of the beach at Surfside.

> Construction of long jetties and a deep channel precludes sand transport in either direction across the harbor entrance. In addition, sand moving southwest along the beach at Surfside is carried out along the east jetty and deposited in the channel, where it is forever lost to the Surfside beach, unless it is placed back on the beach by a dredge during beach nourishment accompanying channel maintenance.
>
> The Corps of Engineers and the Bureau of Economic Geology maintain that the lack of an updrift fillet of sand and the recently accelerated erosion at Surfside Beach may be due to wave amplification by the recently extended east jetty or sand inventory reduction by dredging of the channel. Since the jetty was extended in 1992 and the channel was deepened to 45 feet, the amount of sediment dredged annually from the outer bar channel has nearly doubled.
>
> It has been nearly 75 years since the Brazos river was diverted to the south, and the old Brazos delta has completely eroded away and no longer serves as a nearshore source for sand that waves can bring onshore to nourish the beach. There is, now, little sand offshore, with only a thin veneer of sand over deltaic mud. Likewise, dunes in the Surfside area are very small and store only a small volume of sand which can be transported offshore during storms to flatten the beach profile and reduce wave attack. If any of that sand is washed offshore onto the clay zone, it will not be transported back to the beach.
>
> Finally, extraction of large amounts of ground water for the Freeport industries has caused subsidence of the land surface at Surfside, resulting in at least one foot of relative sea level rise. Extrapolation of the rate of subsidence suggests the total is now two or 2.5 ft. at Surfside, resulting in additional shoreline retreat.
>
> Distant man-made changes in the shoreline have drastically reduced the amount of sand which is available to be transported to the southwest along the coast. About 11 million cu.yd. of sand has been lost inward through Rollover Pass since it was built in 1956 and more than 30 million cu.yd. of sand have been caught and permanently stored east of the jetties at Bolivar Roads. A smaller amount of sand is stored in the fillet at East Beach, Galveston in the wave shadow of the jetties (Watson, R.L.,2003).

The aerial photos of Figure 23 clearly show the change in the deltas of the Brazos River. The top photo was taken in 1935 and clearly shows the extent of the original delta at the mouth of the Brazos on the right. Note the arcuate bar in deep water extending nearly to the end of the west jetty. Note also the underwater growth of the new Brazos delta on the left as shown by the seaward offset of depth contours offshore of the new mouth of the Brazos.

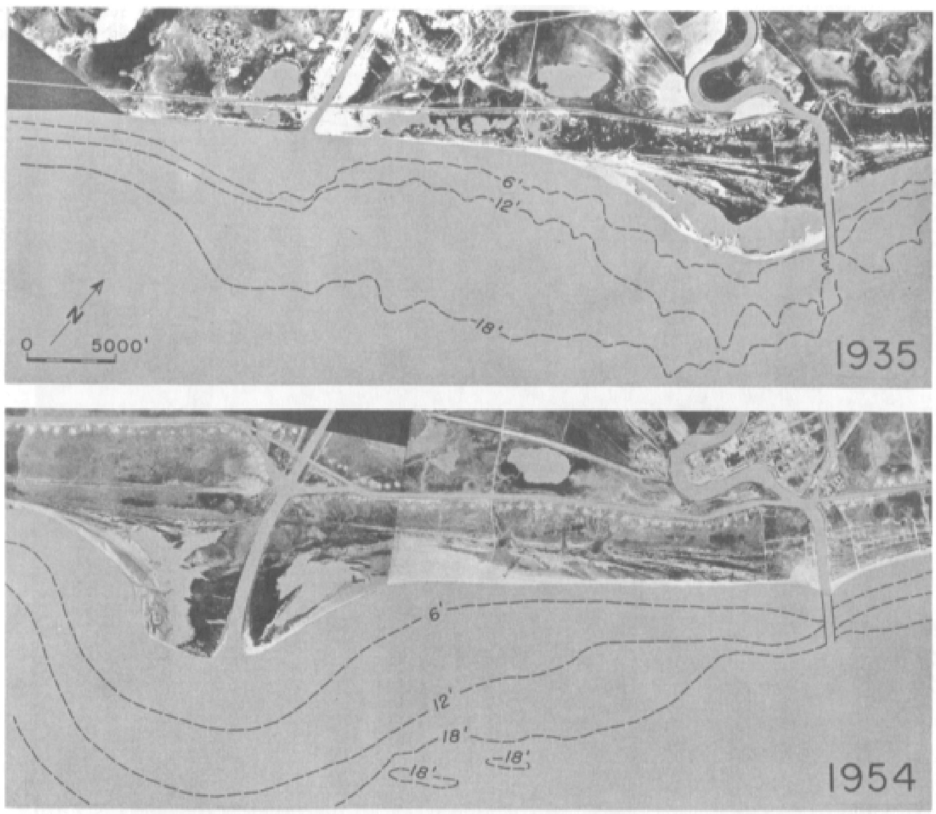

Figure 23. Old and new Brazos deltas in 1935 and 1954.
(From Bureau of Economic Geology, The University of Texas at Austin.)

By 1954, most of the old delta at the jetties had eroded away, but there was still a fillet of sand at the base of both jetties and a wide beach at Surfside. The extent of the erosion of the old delta can be seen by comparing beach ridges on the two photos. The subaerial new delta had grown quite large and the submarine delta even larger, as indicated by the contour lines sweeping out to sea. It is very likely that neither Surfside or Quintana would be having an erosion problem today if the Brazos river was still discharging at its original, natural mouth. An intermediate photo from 1939 shows that erosion was rapidly destroying the old delta at the jetty entrance while the new delta was forming at the new mouth to the west. Note that the beach at Surfside was still quite wide, but that sand was moving into the jetty channel from both sides (Fig. 24).

Figure 24. Brazos River Deltas in 1939.

In 1999, the new Brazos Delta still projected far beyond the normal shoreline into the Gulf showing the huge volume of sediment accumulated at the new delta since the river was diverted in 1929 (Fig. 25). If the river had not been diverted, that delta would have been nourishing the beaches at the town of Surfside and there would have been no beach erosion.

Figure 25. New Brazos River Delta, 1999. The river in the foreground is the San Bernard River. Freeport Harbor Entrance is at the top left.

Present rates of erosion at Surfside are on the order of 9 - 14 ft/yr. with even higher rates at Quintana on the west side of the Freeport Harbor Entrance.

> In general the erosion of Surfside Beach is the result of the sand-starved environment similar to the entire Gulf of Mexico infrastructure. However, the targeted project area of the Pedestrian Beach , a one mile strip north of the Freeport jetties, represents a recognized anomaly experiencing accelerated erosion, in an area that should be experiencing accretion due to littoral drift toward the jetty. The Corps of Engineers and the University of Texas Bureau of Economic Geology have both commented on this anomaly and possible causative factors have included: increased scouring due to wave amplification by the jetty structure … sand inventory reduction from dredging and the displacement of the Brazos River mouth, subsidence (>2 feet documented) from historical industrial ground water pumping and sand loss due to the porosity of the jetty and/or inability to migrate across the cut (25 ft. depth at jetty mouth). {Note, RLW, this should be 45 ft. depth}The result is erosion at approximately two to three times the average coastal rate for this area that also has the highest population density for the community of Surfside and is one of the most popular tourist venues (Project Goal Summary Surfside Beach, 9/29/99, General Land Office website.
> http://www.glo.state.tx.us/coastal/erosion/projects/pdf/cycle01/SurfsidePGS.pdf

Two photographs from the Surfriders Club show the massive erosion at Surfside Beach (Fig. 26).

Figure 26. Two photos from Surfside show the dome building and the wide beach in 1969 and the dome in 2000 with no beach shortly before it was demolished. This location is a short distance east of the jetties. (Photos from Surfriders website)

The best solution to provide a beach at Surfside (and to stop further erosion) is to nourish the beaches with beach quality sand from nearby sources. The severe beach erosion at both Surfside and Quintana is almost entirely due to man-made changes in the Brazos River and the coastline. Only man-made changes in the form of beach nourishment and/or armoring the shoreline with a sea wall or revetment will stop the erosion.

It appears that about $3 million of state and federal funding have been appropriated to build a 4,800 foot long ProTecTube geotextile tube system to prevent storm damage along the mile of Surfside beach east of the jetty. In addition, this project will rebuild the beach along that mile with Colorado River sand brought from inland borrow sites. It is anticipated that the completed beach will be about 100 feet wide and that the relatively coarse river sand will be more resistant to erosion. There are no good adequate local sand sources for beach re-nourishment since Surfside is a thin sand veneer on top of clay rich Brazos River delta sediments.

Sources of beach quality sand to nourish the beaches at Surfside are limited, and even if exploited, will not be sufficient to serve long into the future. Even though there is reluctance to armoring the shoreline with seawalls or revetments, such structures may be the only long term solution to erosion and shoreline retreat at Surfside and at Quintana. Such structures will mean there will be no usable pedestrian beach in front of them in the future, but they can stabilize the shoreline and prevent further erosion for a long time. This was done in the Sargent area to protect the Gulf Intracoastal Waterway and the remaining houses seaward of the waterway.

One of the greatest drawbacks of using seawalls and revetments such as at Galveston and at Sargent is they accelerate beach erosion in the downdrift direction. This should not be a concern if these structures are used at Surfside and Quintana because the beaches downdrift of the Freeport jetties are receiving no sand from the updrift beaches at present and the beaches downdrift of the new Brazos delta are being nourished by sand from the delta and the Brazos River. There are few locations where armoring the shoreline would cause less downdrift damage than such structures at Surfside and Quintana.

There is no other location on the coast which is subject to such a complete collection of man-made causes of beach erosion. Of the possible man-induced causes of beach erosion: river diversion, reduced sand output by a nearby river, jetty construction, maintenance of a deep channel, land subsidence due to water or oil extraction, and blockage of updrift sand sources, all are present at Surfside.

Beach Maintenance Procedures Threaten Natural Dune Seawall at Port Aransas

We have just witnessed the incredible natural destructive power of two major hurricanes, Katrina and Rita on the Texas, Louisiana, Mississippi and Alabama coasts. Now we are seeing the intentional destruction of our own dunes in Port Aransas. Our natural dune seawall is our only defense against the tragic loss of life and property that we saw elsewhere just a few months ago when Katrina and Rita came ashore. Whole towns have been wiped from the face of the earth at Holly Beach, Cameron, Waveland, Gulfport, and other locations. These and other storms have caused severe erosion along Bolivar Peninsula, Galveston Island and Follets Island (Surfside Village) in Texas, and people are losing their homes to the sea.

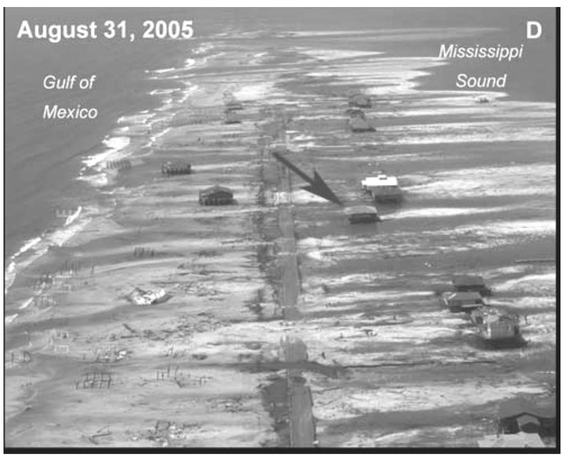

Figure 27. Dauphin Island, AL after hurricane Katrina, 2006 (USGS)

Figure 27 shows the massive overwash on Dauphin Island, Alabama by Hurricane Katrina. Dauphin Island had little dune development to protect it. Figure 22. shows Surfside Village, Texas where several rows of houses have already been lost to beach erosion. Look at the houses now on the beach. Surfside has little or no natural dune seawall to protect it. The natural dune protection that it had has been removed by previous storms.

Figure 28 shows Surfside Village after hurricane Rita. Even with the storm passing far to the northeast, damage was severe. There was no natural dune seawall to provide protection. As a result Surfside Village was severely damaged.


Figure 28. Surfside Village Beach after hurricane Rita, 2006.

Figure 29. Holly Beach, LA before hurricane Rita, 2006.

Holly Beach, LA had no natural dune seawall (photo from National Geographic News) (Figure 29. The photo below shows what little is left of Holly Beach, LA after Rita (Figure 30.).

Figure 30. Holly Beach after Hurricane Rita, 2006.

Port Aransas and Mustang Island are fortunate to be protected by a wide band of strong, high vegetated dunes. This is our natural dune seawall and it provides the very best protection from destructive hurricane overwash, far better than an expensive and unsightly man made seawall. Short-sighted beach management is putting our entire town at risk at the same time that it is costing large amounts of money to move sand. I am sure that we can find better uses for that money in our rapidly developing town and at the same time manage our beaches to enhance the growth, strength and stability of our natural dune seawall.

Erosion of Port Aransas and Mustang Island Beaches

Most of Mustang Island is undergoing beach erosion and shoreline retreat of 2-3 ft./yr. From the Aransas Pass jetties to about 4 miles south of the jetties the beach and shoreline are stable and may even be growing slightly. This is because that section of the shoreline is in the wave shadow of the jetties and is protected from waves coming from the northeast and east which carry sand south along the beach. But, the southeast and south winds create waves that still carry sand to the north along the beach causing net growth or stability in that four mile stretch of beach just south of the jetties. We are lucky that the older part of the City of Port Aransas is located at one of the very few places in the Texas coast where there is little or no beach erosion and shoreline retreat. This is wonderful. It is good insurance for us to make sure our natural dune seawall is the strongest that it can be.

If we look at a typical profile across a barrier island like ours, we can see the relationship between the beach and the dunes and how they change in storms and the recovery period after storms. This diagram from the Texas General Land Office (GLO) is very similar to the actual situation here in Port Aransas (Figure 31).

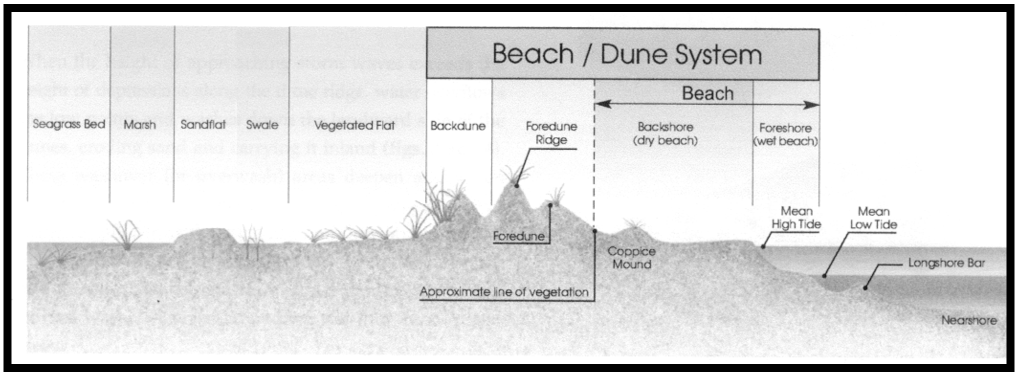

Figure 31. Cross Section of a Texas Barrier Island (Dune Protection and Improvement Manual, fourth edition, Texas General Land Office).
http://www.glo.state.tx.us/coastal/pdf/DuneManual.pdf

Note the location of the coppice dunes with vegetation is in the transition zone between the beach and the dunes at the upper backshore (dry beach). They are miniature dunes and their correct name is coppice dunes. These coppice dunes form when dry sand blows up from the foreshore and the seaward part of the backshore and begins to accumulate around patches of vegetation or in small dunes with no vegetation. With time, the vegetation causes more sand to accumulate and the coppice dunes grow larger and eventually weld onto the foredune ridge or begin to form a new dune ridge seaward of the existing one. In this way, the line of vegetation and the vegetated dunes slowly grow seaward in the interim between hurricanes. The GLO paper defines "*critical dunes* as all dunes (coppice dunes, foredunes, foredune ridge, and some backdunes) that store sand to replenish eroding public beaches." Clearly the dunes that form on the backshore of Port Aransas beaches are *critical dunes* and need to be protected.

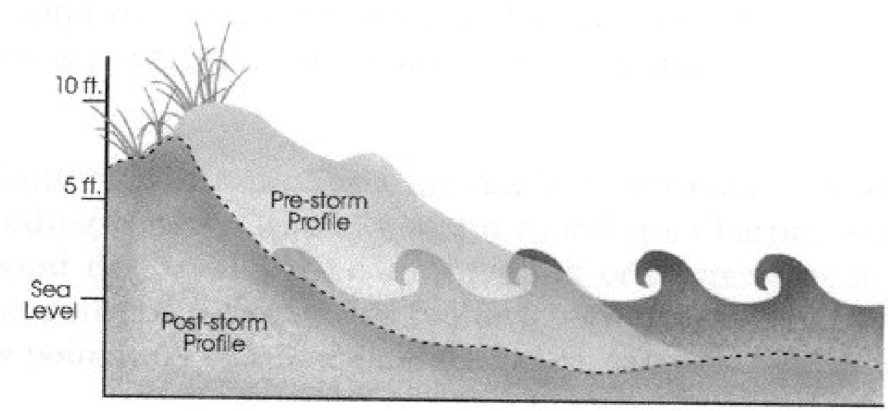

Figure 32. Beach and dune erosion during storms. (Dune Protection and Improvement Manual, fourth edition, Texas General Land Office.)

This GLO illustration (Figure 32), shows how the beach-dune system changes during a storm. The higher the storm surge water level, the more important the protection by a strong natural dune seawall. Sand from the beach, the coppice dune area and the foredunes is eroded and is transported offshore into the nearshore bar zone, flattening the beach profile. This has the very useful benefit of causing waves to expend more energy offshore and reduce the rate of attack on the main dune line, buying precious time so that the storm has time to pass before destroying the entire natural dune seawall and the structures behind it. If the coppice dunes and the foredunes are well vegetated, the root system slows the rate of erosion of these *critical dunes* during wave attack by storms. Well vegetated coppice dunes on the upper beach in front of the main foredune line protect the foredunes from rapid undercutting and collapse during wave attack. In extreme storms, the dunes erode back as much as 100 yards. Hurricane Carla which struck the coast at Port O'Conner in 1961, eroded the dunes back about 200 feet at Port Aransas, far to the south of where Carla went ashore. Parts of the coast with a poorly developed foredune ridge, well protected at the toe by vegetated coppice dunes can lose their entire dune system and then be subject to massive hurricane overwash which destroys virtually all man-made structures further inland. We just saw that happen in Katrina and Rita.

What is the Problem with Port Aransas Beach Management?

Figure 33. Note the unnaturally wide beach at Port Aransas due to beach maintenance.

Port Aransas from Horace Caldwell Pier to the Aransas Princess Condominium has an unnaturally wide beach created by our beach management practices since Hurricane Allen eroded the dunes in 1980. Note how wide the beach is from the pier to the Aransas Princess (between the white arrows) (Figure 33).

Since 1980, traffic has been forced by traffic barrier posts to drive very close to the toe of the dunes, where vast amounts of dry sand is naturally blown in from the lower beach and deposited by the wind. This is the nursery where *critical coppice dunes* naturally form. Between the traffic and regular removal of the loose sand by road graders and front end loaders, the *critical coppice dunes* have not been allowed to form and grow the vegetated dune line seaward to make up the loss in vegetated dunes eroded by Hurricane Allen back in 1980. In fact heavy machinery is destroying the nursery where infant dunes are born.

Shortly after Hurricane Allen, a new line of mile markers on high posts was installed along the beach. They are now buried in the high dune ridge facing the beach. If you look south of the Aransas Princess, the same line of mile markers is well inland, showing how much the *critical coppice dunes* have built the vegetated dunes seaward in the intervening period since Hurricane Allen. Also south of the beach where the traffic has been forced to drive up next to the dunes, you can see how much narrower the beach is. Our beach is not wide because it is newly deposited beach, it is wide because the *critical coppice dunes* have been either destroyed or not permitted to form. This weakens our natural dune seawall and has some very serious implications for our future ability to withstand a pounding attack of hurricane surge and waves. Remember, we will most definitely be subject to direct attack by a major storm again in the future. The only question is when.

As you can see, the normal cycle is for storms to erode the dunes and then for the dunes to rebuild seaward to their previous location or farther in the time between storms. This provides a larger reservoir of sand in the *critical coppice dune area and the foredunes* that must be eroded before more inland dunes and the town itself can be attacked by the storm surge and storm waves. We have not allowed the dunes to properly repair themselves in the 25 years since Hurricane Allen eroded them back. If we continue with this beach management method, we will have a net loss of *critical dunes* and our natural dune seawall with each succeeding storm. Instead of losing dune protection which then naturally repairs itself, the main dune line will retreat further with each storm until, finally, there is no natural dune seawall to protect us at all.

In other communities like Surfside Village near Freeport and Gilchrist on the Bolivar Peninsula, West Galveston, South Padre Island, and even North Padre Island, the residents are begging to have sand placed on the upper beach to stop the loss of their homes into the sea. There is no better hurricane protection than multiple wide rows of high and continuous vegetated dunes. Most residents along the coast would be thrilled to have what Port Aransas is so willing to discard.

It has been argued that we need the wide beach to attract tourists. Cars never park more than one deep along our beaches, so at the minimum there is one car's width of beach space for all beach goers. Visitors might be happier if they didn't have to worry about getting stuck because they are driving in the loose sand *critical coppice dune* area. If we move the cars further down the beach where the sand is hard, cars won't get stuck as they do now and *critical coppice dunes* will be able to form in their natural nursery area.

Figure 34. Front end loader removing huge quantities of sand from the dune nursery area just in front of the foredune ridge at Port Aransas, October 27, 2006.

The city is currently moving hundreds of truck loads of sand from the road area on the upper beach and dropping it into the water. This apparently is with the blessing of the GLO (Figures 34 & 35). They don't seem to grasp the seriousness of the situation and the fact that *critical coppice dunes* which are protected by state law are being destroyed. If a private party was to remove that sand or disturb that vegetation they would get a very heavy fine. A few years ago a tourist in a rented beach buggy was fined over $1000 for driving over a very small amount of vegetation in the very same area that the city is removing it with heavy equipment.

Figure 35. Hundreds of dump trucks of sand have been removed from the dune nursery area and returned to the sea.

Other municipalities along the Texas coast, including Gilchrist, Galveston, Surfside, North Padre Island, and South Padre Island are spending millions of dollars to put sand on their upper beaches. Every bit of sand that is removed from the *critical coppice dune* area and the upper beach is sand that a hurricane would have to remove before it could attack the main dune ridge and our homes. That sand prevents small storms from damaging the main dune line and delays major storm attack on the main dune line. Over decades the sand that is being thrown away in the water can build a strong and complete dune ridge adding to our natural dune seawall. Why would we want to throw away storm protection that the natural system provides at no cost? Look at Figure 35 see how much sand has been removed from the front of our dune system. Where there is now a "cliff" of sand at the posts about 4 feet high, there was a gentle slope off to the left beyond the limits of the photo. That natural slope forces storm waves to slowly expend their wave energy, rather than undercut the main dune line.


Figure 35. Cliff in the dune face from recent sand removal, February, 2006.

Our Beach Management Program is EXPENSIVE!

It costs a lot of money to continually scrape our upper beach so that cars can drive where dunes want to form. We are spending a fortune to unsuccessfully maintain a driving lane in the nursery where *critical dunes* form and weakening the future of our natural dune seawall at the same time. There is a better way! Port Aransas can surely find a better use for the money that is being spent moving vast amounts of sand.

Natural barrier island beaches and dunes undergo a cycle of erosion during major storms and rebuilding in the calm between storms. We have broken that cycle in Port Aransas by not allowing the *critical coppice dunes* to rebuild seaward and extend the foredunes since Hurricane Allen struck 25 years ago. The problem is being made worse now that upper beach sand, deposited naturally is being transported to the lower beach for it to wash away and be lost to our natural dune seawall forever. This is extremely short sighted when most other Texas coastal communities are spending millions to place sand on their upper beaches, the very place where we are removing it. The first four miles of Port Aransas south of the jetties the beach is stable or growing while most of the rest of the coast is eroding, including the rest of Mustang Island. But, the natural dune seawall is our only protection from total destruction in a major hurricane. The last major storm was Celia in 1970 and Carla before that in 1961. As Hurricane Katrina and Hurricane Rita have shown, coastal towns with no man-made seawall or natural dune seawall get totally destroyed in such storms.

Beach management that reduces the ability of our natural dune seawall to build out and up to the maximum possible is a great mistake when we realize that one day we will have our Katrina, or Rita, or Celia, or Carla, or 1919 storm. It is coming, the only question is when. Let's allow natural beach processes to build our *critical coppice dunes* so that they join onto the foredune ridge and extend it and improve our natural dune seawall protection.

State and Local Beach and Dune Regulations

Excerpt from Title 31, Part 1, Chapter 15, Subchapter A, Rule 15.7 section (l) Maintaining the Public Beach

(l) Maintaining the public beach. Local governments shall prohibit beach maintenance activities unless maintenance activities will not materially weaken dunes or dune vegetation or reduce the protective functions of dunes. Local governments shall prohibit beach maintenance activities which will result in the significant redistribution of sand or which will significantly alter the beach profile or the line of vegetation. All sand moved or redistributed due to beach maintenance activities shall be returned to the area between the line of vegetation and mean high tide. The General Land Office encourages the removal of litter and other debris by handpicking or raking and strongly discourages the use of machines (except during peak visitation periods which disturb the natural balance of gains and losses in the sand budget and the natural cycle of nutrients.

Note that the regulation states that "All sand moved or redistributed due to beach maintenance activities shall be returned to the area between the line of vegetation and mean high tide." This does NOT mean putting the sand back in the edge of the water! Even putting sand near Mean High Tide is a very bad practice. Mean High Tide is the average high tide for 18.6 years. Half of those days, the daily high tide is higher than MHT and the sand will be washed away just as effectively as if it was placed on the beach at low tide.

The purpose of this regulation is to ensure the maximum growth or re-growth of the dunes and the sand storage in the upper beach an dunes for protection from the next hurricane, whenever it may come. When sand is placed back in the water or low enough on the beach that some of the high tides can reach it, surf currents will carry it away to the north or to the south. It is likely lost to the section of beach from which it was removed.

The following is quoted from the Port Aransas Coastal Management Plan. Page 39: Part VIII, B. General Standards, Section 12. Maintaining the Public Beach

"The City of Port Aransas shall prohibit beach maintenance activities unless maintenance activities will not materially weaken dunes or dune vegetation or reduce the protective functions of the dunes. The City of Port Aransas shall prohibit beach maintenance activities which will result in the significant redistribution of sand or which will significantly alter the beach profile."

It is obvious that our beach maintenance activities are significantly altering the beach profile and moving significant quantities of sand. These practices stunt the present and future growth of our protective dune system and are clearly in opposition to the intent, if not the exact wording, of the State and local dune protection regulations.

The dune protection in regulations in Texas are designed to prevent damage to critical dunes, including coppice dunes, foredunes just inshore of the beach and dunes within about the first thousand feet inland of the vegetation line. Allowing these destructive beach maintenance activities to continue definitely defies the intent of the dune protection regulations. Further, removing sand which is being naturally transported landward from the beach to the dunes by wind and water prevents present and future growth of those protective dunes. Though this may not be damaging existing dunes, it certainly is preventing their full re-growth in the dune building periods between major storms which erode the dunes back, sometimes as much as 300 feet in a single storm. The effect of these practices has the same long term effect as bulldozing the existing dunes. There will be a smaller, narrower, and lower dune ridge available when the next major storm strikes.

There are two important legal land boundaries on Texas beaches. The Mean High Water line (MHW) defines the seaward limit of ownership for the upland owner. The vegetation line limits the seaward limit that the upland owner can have structures on his property. Both of these important legal boundaries shift landward and seaward with erosion and accretion as well as rising or falling long term water levels. If these important legal boundaries are not fixed in position, but change with natural changes in the shoreline, it makes no sense at all that the position of a sand road on the beach should be fixed in position and not allowed to move landward with shoreline erosion and seaward with natural accretion of the foredune ridge and the coppice dunes in the nursery area seaward of the foredune ridge. In preventing the natural seaward growth of the foredune ridge AND the vegetation line, the natural enhancement of the size and the value of the upland property owner's land is being limited and the likelihood of the upland owner losing even more land during the next major storm is seriously increased. In fact there should be a protected, vehicle and heavy equipment free zone seaward of the foredune ridge to allow the dunes to grow in the calm years and decades between major storms. As this zone fills naturally with new dunes and they become vegetated, this zone should be extended further seaward, so that the dunes can continue their natural growth. The dunes are our very best protection from devastating frontal overwash as depicted on the photos of Holly Beach, Surfside, and Dauphin Island. In other words, the beach road should be moved seaward now, and continue to be moved seaward as the dunes grow. The natural systems will build us the best possible hurricane protection, a natural dune seawall, if we will allow it to happen. This happens at no cost to us at all and may cost us heavily in the next major storm if we prevent the growth of these dunes during the natural building period between storms.

How Can We Manage the Beach Better?

We can preserve a pedestrian beach and still have driving and parking on the beach at Port Aransas and allow the dunes to grow for our protection if we take the following simple steps.

Put a row of bollards about in the middle of the present beach road to protect the dune nursery area in front of the present foredunes from vehicles and heavy equipment.

Narrow the driving lane or move the seaward traffic control bollards seaward to maintain the same width driving land and parking area.

This will maintain a traffic protected pedestrian beach, still provide parking and driving, allow the dunes to grow and probably have lower road maintenance because more of the road will be on harder sand. In short this is a win-win situation. We lose nothing of importance on our vitally important tourist beach and we allow our protective natural dune seawall to grow. It might even save money now being spent on removing hundreds of trucks of sand from just in front of the foredune ridge, our natural dune seawall.

Soon enough another major hurricane will strike and erode all of the new dunes which we have allowed to grow and the road will again move landward, but those dunes that we allow to grow will buy time in that storm and protect the main foredune ridge and the city behind it.

In the Past Dune Buggies Were the Problem

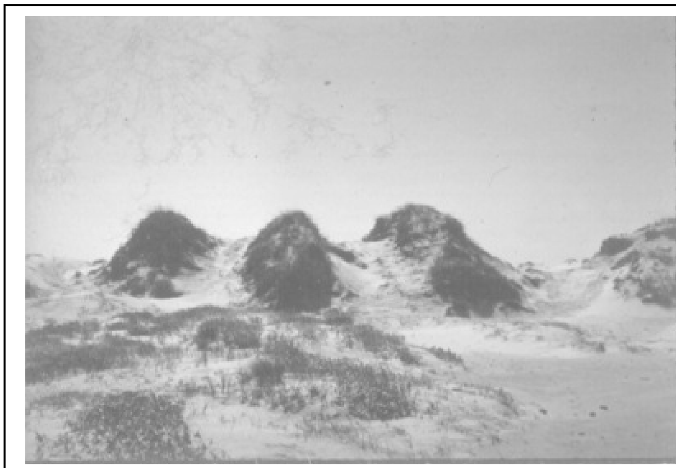
Figure 36. Foredune ridge heavily damaged by dune buggies in 1970.

I spearheaded the effort to get highly destructive dune buggies and 4 wheel drive vehicles out of the dunes of Mustang and Padre island in the 1970 with an educational campaign. Figure 36 shows the severe damage done to the dunes by these vehicles.

I organized graduate students and we gave slide shows, had kids do poster contests and talked on TV. At our request, the Marine Science Institute placed huge signs along the beach access road asking people ***"Don't Drive in the Dunes, Protect the Natural Dune Seawall."*** It worked and the roads and the gulleys through the dunes healed with time. That lead to Nueces County writing the first dune protection laws which was followed by the state dune protection laws now administered by the GLO. Now the damage is being done by city government, apparently with the approval of the very state agency which is entrusted with protecting the dunes and our natural dune seawall.

Preventing the natural dune seawall from being to rebuilt after storms, removing sand from the *critical coppice dune* area and the upper beach reduces the sand reservoir available to protect us when we get hit by the big one. We were able to stop damage to the dunes done by dune buggies 35 years ago. Can we prevent damage being done by government now? http://texascoastgeology.com/pabeach/naturalduneseawall.html

CONCLUSIONS

The conditions defining coastal boundaries along gently sloping shorelines and those composed of easily eroded materials are complex. Sometimes a multi-disciplinary team composed of attorneys, surveyors, geologists, and other experts is required to define the location of littoral boundaries and to determine the history of that boundary since the time of the original land grants. This is especially true when the location of the boundary is the cause of a major property ownership dispute.

Man made changes in the shorelines and rivers which feed sediment to the shoreline have greatly accelerated beach erosion along most of the Texas coast. Until recently, beach erosion merely destroyed a few beach front homes, or they were required by the State to be destroyed when they became seaward of the vegetation line. Accelerating beach erosion along with rapidly increasing construction and development along our Gulf beaches has lead to the number of structures that have been destroyed or are being threatened to increase dramatically.

Private property owners along the most threatened parts of the coast from the Bolivar Peninsula to South Padre Island are beginning to work together to try to find solutions to these problems. In some cases, they have hired attorneys and geologists to sue the State to try to force the State to either repair their beaches or compensate them for loss of their property under the theory that the erosion was caused by actions taken under the auspices of the State. In many cases that theory is hard to dispute and the state settles to the benefit of our clients or begins remedial beach nourishment to protect the upland property.

Many of the Atlantic Coast states have been dealing with severe beach erosion problems for over 75 years. A lot has been learned from their mistakes about the beneficial and damaging use of shore protection structures. Texas citizens are now demanding that their property be protected and are just beginning to learn the high costs of halting shore erosion. The best solution is beach nourishment with suitable sand, but the result is only temporary. Seawalls, breakwaters, groins and other hard structures can stabilize the shoreline, but usually with the result of elimination of the beach in front of the seawall and increased beach erosion elsewhere on the coast.

Our best hurricane overwash and beach erosion protection is the presence of a strong and growing natural dune seawall. We must insist that our state and local governments protect our present dunes and prevent beach maintenance activities that stunt present and future growth of these vital protective dune systems.

As the Texas coast continues to develop we must find equitable ways to protect the rights of the private landowner while protecting beaches and beach access for all Texans.

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