NORTH PADRE ISLAND STORM DAMAGE REDUCTION AND ENVIRONMENTAL RESTORATION PROJECT

NUECES COUNTY, TEXAS

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

U.S. ARMY CORPS OF ENGINEERS
GALVESTON DISTRICT

JUNE 2002

NORTH PADRE ISLAND STORM DAMAGE REDUCTION AND ENVIRONMENTAL RESTORATION PROJECT NUECES COUNTY, TEXAS

DRAFT ENVIRONMENTAL IMPACT STATEMENT

The responsible agency is the U.S. Army Engineer District, Galveston.

Abstract: The USACE was directed by Congress (Water Resources Development Act of 1999, SEC. 556) to carry out a project for ecosystem restoration and storm damage reduction at North Padre Island (Project). The local sponsor is the City of Corpus Christi. The Project consists of construction of a channel between the Laguna Madre and the Gulf of Mexico across North Padre Island, Nueces County, Texas, and is referred to as Packery Channel. The Project is described in the accompanying Draft Environmental Impact Statement (EIS), as are the benefits and impacts to be expected from the Project. Dredging Packery Channel will provide sand for nourishment of the eroding beach at Packery Channel that will reduce potential future storm damage to North Padre Island. The Project will also create a water exchange pass between the Laguna Madre and the Gulf of Mexico that will periodically reduce hypersaline conditions in the Laguna Madre that will result in ecosystem restoration. A Project Study Plan, prepared by the USACE in 1999, examined three alternative sites. The alternatives considered include: Packery Channel, a channel north of Packery Channel (Fish Pass), and a channel south of Packery Channel (South Alternative). Three different channel widths under three different salinity regimes were examined for all three alternatives to determine the environmental benefits of an opening between the Laguna Madre and the Gulf of Mexico. The environmental benefits of all alternatives were essentially negligible. While information is presented on these alternatives, only the proposed action, construction of Packery Channel, is fully developed and compared with the No-Action alternative in this EIS.

The selected project consists of dredging a 12-foot-deep by 116-foot-wide channel to connect the existing Packery Channel to the Gulf of Mexico and dredging the existing channel to a depth of –7 feet (mean sea level) and a width of 80 feet. The total length of the proposed channel from the Gulf end of the jetties to the Gulf Intracoastal Waterway (GIWW) is approximately 18,500 feet (3.5 miles). Approximately 810,000 cubic yards (cy) of material will be dredged during construction, most of which (544,800 cy) will be placed on the beach south of the proposed jetties. Sandy maintenance material from the channel east of the SH 361 bridge will be used for beach nourishment, and a sand bypass system will be designed to move accumulated sand from longshore drift to the downdrift side of the jetties. Over the 50-year life of the project approximately 11,000,000 cy of sandy maintenance material will be placed on the beach adjacent to the jetties. Approximately 15,000 cy of estimated maintenance dredging every 5 years will be placed in an upland site. Recreational development is proposed by the City of Corpus Christi in conjunction with Packery Channel, but this is not part of the Federal cost-shared project. The proposed recreational development is described in the DEIS as secondary development. Proposed park amenities encompass approximately 14.2 acres and include access to Packery Channel, the beach, and the jetties; passenger and recreational vehicle parking; walkways; restrooms; and vendor facilities. The two potential City of Corpus Christi parks are proposed along the western reach of Packery Channel.

THE OFFICIAL CLOSING DATE FOR THE RECEIPT OF COMMENTS IS 45 DAYS FROM THE DATE ON WHICH THE NOTICE OF AVAILABILITY OF THIS DRAFT EIS APPEARS IN THE *FEDERAL REGISTER*.

If you would like further information on this statement, please contact:

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EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers, Galveston District (USACE), has been directed by the U.S. Congress to carry out a Storm Damage Reduction and Environmental Restoration Project (P.L. 106-53) at North Padre Island, Nueces County, Texas. Pursuant to this directive, an Environmental Impact Statement (EIS) has been prepared to address project impacts. The local sponsor is the City of Corpus Christi. The project consists of construction of a channel between the Laguna Madre and the Gulf of Mexico across North Padre Island referred to as Packery Channel (Project). A Project Study Plan for this Project prepared by the USACE in 1999 examined three alternative sites, including Packery Channel, a channel north of Packery Channel (Fish Pass), and a channel south of Packery Channel (South Alternative). Three different channel widths under three different salinity regimes were examined for all three alternatives to determine the environmental benefits of an opening between the Laguna Madre and the Gulf of Mexico. The environmental benefits of all alternatives were essentially negligible. While information is presented on three alternatives, only the proposed action, construction of Packery Channel, is fully developed and compared with the No-Action Alternative in this DEIS.

The Storm Damage Reduction and Environmental Restoration Project will provide a dredged channel across North Padre Island between the Laguna Madre and the Gulf of Mexico, known as Packery Channel. An existing channel approximately 2.6 miles long that extends from the Gulf Intracoastal Waterway (GIWW) in the Laguna Madre to North Padre Island will be extended an additional 0.9 mile to connect the channel to the Gulf of Mexico under the proposed Project. Packery Channel generally follows the course of a historic pass between the Gulf and the Laguna Madre.

In addition to opening Packery Channel to the Gulf, the Project will add two impermeable rock jetties at the Gulf end of the Channel and deepen and widen the existing channel and Inner Basin. The Project also involves the establishment of four dredged material placement areas (PAs), including the use of some new work material for beach nourishment to counter the effects of wave erosion. The City of Corpus Christi has proposed recreational development in conjunction with the Project; however, recreation is not part of the Federally cost-shared project. The proposed recreational development is addressed in the DEIS as secondary development.

For purposes of the DEIS, the Project study area was established based on the results of modeling of salinity changes expected to be associated with the opening of Packery Channel. The study area extends to the boundary between the Upper Laguna Madre and Corpus Christi Bay to the north and the intersection of the Laguna Madre and Baffin Bay to the south, reflecting the extent of changes in salinity that could result from opening the channel. The study area includes both the area of direct construction impacts and indirect Project impacts. A summary of environmental consequences of the proposed Project, if implemented, is presented below:

Water Exchange. The opening of Packery Channel will result in an insignificant increase of about 0.01 foot in tidal range in Corpus Christi Bay and a decrease of generally less than 0.01 foot in tidal range in the Laguna Madre, except at the mouth of Packery Channel which will see a decrease of up to 0.09 foot in tidal range. These small changes are not expected to have a significant effect on the system.

Salinity. The proposed Project results in an insignificant change in salinity of a few parts per thousand in the vicinity of the inlet and much smaller changes well into Corpus Christi Bay and the Laguna Madre. These changes are expected to have little to no effect on the system.

Water Chemistry. Turbidity from both construction and maintenance material is expected to be temporary, since the finer material from both construction and maintenance dredging will be placed in upland sites. Although potential for oil leaks will increase due to the rise in recreational boat use, the likelihood is very small so the effects are considered to be minor.

Sediment Quality. The chemical analysis of sediment samples indicates no undesirable impacts would occur upon placement of the sediments, since sediment quality in the area has been found to not be a cause for concern.

Coastal Community Types. Approximately 5.2 acres of submerged aquatic vegetation (SAV) will potentially be lost through construction impacts. However, project construction will also result in the creation of 5.4 acres of broad shallow shelves between the sides of the channel and the placement area bulkheads that will be conducive to the natural recruitment of SAV along the channel.

Approximately 11.1 acres of low/high salt marshes will be negatively impacted by channel and Inner Basin construction and dredged material placement.

Approximately 49.1 acres of beach, 1.5 acres of tidal flats, and 23.7 acres of primary and secondary dunes will be impacted by channel dredging and dredged material placement. Approximately 9.2 acres of beach will be displaced by channel dredging, placement of dredged material (PAs 1 and 2) and jetty construction. In addition, an area of approximately 46 acres is proposed for beach nourishment, a beneficial use. Proposed recreational development by the City of Corpus Christi will also displace approximately 0.3 acre of tidal flats, 3.4 acres of primary and secondary dunes, and 3.7 acres of beach.

The placement of dredged material (PA 2, PA 3, and MMPA) will displace approximately 9.9 acres of upland grassland. Proposed recreational development by the City of Corpus Christi, at Packery Point Park, will potentially affect additional grassland communities.

Fish. The new channel will create a small increase in habitat for nekton that are common in deep offshore waters and periodically enter the bay through deep channel corridors. Maintenance dredging will cause temporary negative impacts to nekton. In the unlikely event of oil leaks due to construction and maintenance dredging or recreational watercraft, larval and juvenile finfish and shellfish would be more likely to be impacted than adults, which are more mobile and, thus, more able to avoid affected areas. Changes in circulation and currents produced by Packery Channel would likely cause changes to the existing larval transport process in the Laguna Madre. However, not enough data exist to quantify whether changes would provide net benefits or detriments to the system.

Recreational and Commercial Fisheries. Temporary and minor adverse effects may result from altering or removing productive fishing grounds and interfering with fishing activity. No major reductions of nekton are expected from the proposed channel expansion.

Aquatic Communities. Excavation of the channel will destroy benthic communities, but also creates new habitat since the new channel will be larger than the present one. Dredging would also mobilize potential sediment contaminants, if any, making them more bio-available and increasing suspended sediment in the water column. However, as noted above, sediment quality is good and no contamination is expected.

Wildlife. The channel construction and placement of dredged material will displace dune/beach habitat and some upland grassland habitats. Noise from human activity will disturb avian species, although much of it would be temporary, occurring during construction and maintenance. However, the resulting increased human use of the proposed park facilities and new channel will likely disperse some birds to more suitable areas.

Endangered and Threatened Species. The new channel will remove approximately 6.2 acres of piping plover critical habitat. Another 24.6 acres within the large critical habitat unit, TX-7, will receive placement of dredged sand for beach enhancement, that will essentially move, not destroy, the habitat. This sand will be placed on beach, offsetting shoreline erosion and preserving if not increasing piping plover critical habitat. FWS (1997b) noted that an FWS consultation under the Endangered Species Act relative to opening Packery Channel, in the mid 1990s, found the proposed action was unlikely to jeopardize the continued existence of the piping plover, although the beach had not been declared Critical Habitat at the time. Because of the abundance of preferred algal flats and sand flats in adjacent Critical Habitat areas and heavy vehicle and recreational use of the beach areas in TX-7, impacts from dredging through, and placement on, TX-7 are expected to be insignificant.

Cultural Resources. Only one previously recorded cultural resource site (determined not eligible for the National Register of Historic Places) may be impacted by the Project. Pedestrian surveys and terrestrial and underwater remote sensing have been conducted.

Air Quality. Dredging activities will result in minor short-term impacts from emissions of diesel-powered dredges.

Noise. No extended disruption of normal activities is expected from construction and maintenance dredging. However, increased recreation use in the vicinity could increase seasonal impacts.

Socioeconomics. The completion of Packery Channel would provide an increase in recreation and tourism opportunities. Induced commercial and residential development should result in an increase in the local population, employment, and cost of living.

Relationship to Environmental Requirements. The Recommended Plan is in full compliance with all pertinent environmental laws and regulations, as noted in Section 7 of the DEIS.

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1.0 INTRODUCTION

The "Storm Damage Reduction and Environmental Restoration Project" (P.L. 106-53), or the Packery Channel Project, will provide a dredged channel across Padre Island between the Upper Laguna Madre and the Gulf of Mexico. The channel is located east-southeast of the John F. Kennedy (JFK) Causeway that crosses the Laguna Madre between the City of Corpus Christi and North Padre Island. The proposed Project will extend an existing 2.6-mile channel (Reach 2), between the Gulf Intracoastal Waterway (GIWW) and State Highway 361 (SH 361) to the Gulf, an additional 0.9 mile (Reach 1). The existing channel is largely the result of the modern dredging of a historically shallow cut between what was the historic Packery Channel pass and the Laguna Madre constructed under Department of Army Permit No. 17768. This channel was permitted for a 30- to 50-foot bottom width and 5-foot depth. Placement areas for the permitted Project are on private property that will be developed. An amendment has been recently issued to Permit No. 17768 to remove maintenance dredging. To the south and west of the currently proposed Project is land that has been modified for recreational, commercial, and residential development as well as undeveloped land. North and west of the proposed channel the land is relatively undeveloped and includes the Mollie Beattie Habitat Community, a State-Federal cooperative preserve on State-owned land. The Project area is easily accessible by vehicle or boat from Corpus Christi and is extensively used for recreation.

The Galveston District of the U.S. Army Corps of Engineers (USACE) completed a 905(b) analysis of the potential project in 1998. A 905(b) analysis was authorized by the Water Resource Development Act (WRDA) of 1996 (P.L. 104-303, Sec. 442) and directed the USACE to determine whether there would be a potential Federal interest in a project for environmental restoration, flood damage reduction, navigation, and/or related purposes in the vicinity of Packery Channel. The analysis recommended that the necessary feasibility-level studies be conducted to characterize the potential benefits in more detail and to identify the most cost-effective project features to realize them.

The USACE produced a Project Study Plan (PSP) in 1999 (USACE, 1999) that included a study of three alternative locations and three different channel widths, under three different salinity regimes, to determine the environmental benefits of an opening between the Laguna Madre and the Gulf of Mexico. The study was also to provide information to help the study sponsor assess the likelihood of project authorization for construction upon conclusion of the Feasibility Study (FS). The analysis showed that a new water-exchange pass would significantly ameliorate high salinity episodes in the Upper Laguna Madre. However, these episodes only average about 1 year in 5 and, therefore, the potential environmental benefits to marine resources and area wildlife from the Project would be negligible.

The USACE was subsequently directed by Congress under the WRDA 1999 (PL 106-53, Sec. 556 entitled "North Padre Island Storm Damage Reduction and Environmental Restoration Project") to "carry out a project for ecosystem restoration and storm damage reduction at North Padre Island, Corpus Christi, Texas". Because of the magnitude, potential impacts, new compliance requirements, and the political controversy of this Project, an Environmental Impact Statement (EIS) is being prepared.

The study area for this Project is presented in Figure 1-1, and includes the locations of the proposed Project at Packery Channel, and Project alternatives at Fish Pass and the South Alternative from the PSP (USACE, 1999). The study area is based on the results of modeling of salinity impacts expected to be associated with opening the currently proposed Packery Channel alignment. The study area extends to the boundary between the Upper Laguna Madre and Corpus Christi Bay to the north and the intersection of the Laguna Madre and Baffin Bay to the south, and includes both the area of direct construction impacts and indirect project impacts. The southern limit of the study area goes to Baffin Bay since modeling results exhibited salinity changes extending to this location, whereas modeling results toward Corpus Christi Bay showed little change (not unexpected since the shallow Laguna Madre joins the much deeper bay).

The Project area as denoted in this DEIS includes the existing Packery Channel, the placement areas, proposed recreational development areas, and the proximate area.

1.1 PURPOSE AND NEED

The purpose of the Project is to construct a channel between the Gulf of Mexico and the Upper Laguna Madre that will provide restoration of the eroding Gulf beach resulting in storm damage reduction, and to create a water exchange pass that will periodically reduce hypersaline conditions in the Laguna Madre for ecosystem restoration.

1.2 DESCRIPTION OF PROPOSED ACTION

The length of the proposed channel from the Gulf end of the jetties to the Gulf Intracoastal Waterway (GIWW) is approximately 18,500 feet (3.5 miles). The Packery Channel alignment follows an existing channel southeast of the GIWW for approximately 2.6 miles to a basin southeast of State Highway 361 (SH 361). From this basin the proposed new channel will extend approximately 0.9 mile toward the Gulf following a historic washover channel (Figure 1-2). Packery Channel traffic will allow recreational and small commercial boats access between the GIWW and the Gulf. Traffic will not include large commercial ships, tows, deepwater draft barges, or any floating vessel with a draft greater than 4 feet.

According to the design engineer, URS/Dames & Moore (URS) (URS, 2002), the proposed channel opening involves dredging a new channel from the Gulf into the existing basin area (the Inner Basin) located southeast of the SH 361 bridge (Reach 1). Two impermeable rock jetties will extend from the shoreline approximately 1,400 feet paralleling the channel. The Inner Basin will be reconfigured and deepened to a consistent depth of –12 feet mean sea level (MSL). The existing Packery Channel west of SH 361 (Reach 2) that extends to the GIWW will be deepened from approximately 50 feet in width and 3 to 5 feet in depth to 80 feet in width and 7 feet in depth as described below.

1.2.1 <u>Channel Design</u>

Southeast of the SH 361 bridge in Reach 1, the channel width varies at the Inner Basin from 80 feet expanding to 650 feet at the channel bottom. From bulkhead to bulkhead including side

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Figure 1-1

Location Map

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Job No.: 440561	Scale: 1:250,000
Prepared by: G. Rackley	Date: June 2001
File: N:\440561\arcview\location map.apr (location map)	

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Figure 1-2
Proposed Packery Channel
and Placement Areas

Prepared for: USACE
Job No.: 440561
Scale: 1"=2700' for 8.5"x11" Sheet
Drawn by: G. Rockley
Date: March 2002
File: N:/440561/cad/utm83_14/fig1-2.dgn

slopes, the width is 800 feet at the widest. The proposed new channel extending from the basin toward the Gulf will narrow to a channel bottom width of approximately 116 feet with an approximate 280-foot span (bulkhead to bulkhead including side slopes). The channel depth proposed is –12 feet MSL plus 2 feet advanced maintenance and 2 feet of allowable overdepth.

Within Reach 2, the depth of the channel is proposed at a required depth of –7 feet MSL with 1 foot allowable overdepth. The channel bottom width is designed for 80 feet along Reach 2, and the side slopes may extend the width to approximately 110 feet in certain areas.

The design of the channel width and depth was based on previous study results and boat registration statistics for the area (Shiner, Moseley and Associates, 1987), which determined that a 40-foot Bertram Yacht encompasses the majority of the registered boats in the area. Therefore, a Bertram 390 Yacht was used as the maximum size vessel for the Packery Channel design. This vessel has a hull length of 39 feet, a maximum draft of 4 feet, and a beam width of 13.25 feet. The existing SH 361 bridge over Packery Channel has vertical clearance of 20 feet MSL and a 45-foot span between bridge pilings, thus excluding all sailboats and accommodating most powerboats.

1.2.2 Placement Areas (PAs)

Five Placement Areas are proposed for placement of construction and maintenance material from the Project: PA 1, 2, 3, 4S and N, and MMPA. Approximately 810,000 cubic yards (cy) of new work material will be dredged and placed in PAs 1, 2, 3, and 4S. This number includes approximately 56,200 cy of sand excavated from PA 1 to create the capacity for new work material for this PA. The estimated maintenance dredging volume for the 50-year life of the Project is 11,057,500 cy. Maintenance material will be placed in PA 4S and 4N and MMPA. The majority of the maintenance material will be transported by currents and deposited toward the end of the jetties in Reach 1. Windblown sand deposition is also included in the annual dredging estimate. URS (2002) estimates that 70 percent of the accumulation will be between Stations 168+00 and 198+00, with the remaining 30 percent of accumulation spread evenly throughout the remainder of Reach 1 and the Inner Basin. The average accumulation in the channel in Reach 2 is much less than in Reach 1, as windblown sand is not expected to be a significant source of accumulated sediment since adjacent areas are predominantly vegetated. URS suggests monitoring the accumulation level on a regular basis and after storm events and scheduling dredging before hazardous navigation occurs. A total of 11,867,500 cy of placement area capacity has been identified for the life of the Project including both new work and maintenance material.

Concrete bulkheads are proposed on the north and south sides of the channel from the western end of the jetty to the SH 361 bridge (Reach 1). Behind the bulkheads new work fill material is required in PA 1, PA 2, and PA 3 to bring the ground elevation to grade with the top of the bulkhead. Figure 1-2 identifies the location of these PAs. No bulkheads are proposed for the channel west of the SH 361 bridge. PA 1 and PA 3 will be constructed on the south side of the channel. These two PAs are separated by the floodgate and channel access to Lake Padre. The existing floodwall on the south side will serve as the southern retaining structure for PA 1 and PA 3. PA 2 will be located on the north side of the channel across from PA 1 and PA 3. PAs 1, 2, and 3 will be used for new work dredged material only. The beach nourishment areas (PA 4S and 4N) are located on the Gulf beach north and south of the jetties and will be used for both new construction and maintenance material of high sand content. Suitability for beach placement is determined by fines content (sediment passing through #200 sieve). Beach placement material with a fines content of 5 percent or less if preferred, but to 30 percent is acceptable if the fines fraction does not contain a significant amount of cohesive clay (Brown, 2001). A Maintenance Material PA or MMPA will be used for maintenance material only and is located northwest of SH 361 near Packery Channel County park. Each placement area is described in detail below.

1.2.2.1 Placement Area 1

One-time placement of fine-grained new work material from stations 12+00 through 71+00 (Figure 1-3) and sands between Stations 71+00 through 145+50 will be deposited into PA 1. PA 1 is approximately 20.2 acres in size. Placement capacity for PA 1 is 128,800 cy. The PA must first be excavated (approximately 56,200 cy of sand) to a depth of 0.0 foot mean lower low water (MLLW) to create the capacity required for the new work material for this PA. The sandy material excavated from PA 1 will be placed at PA 4S.

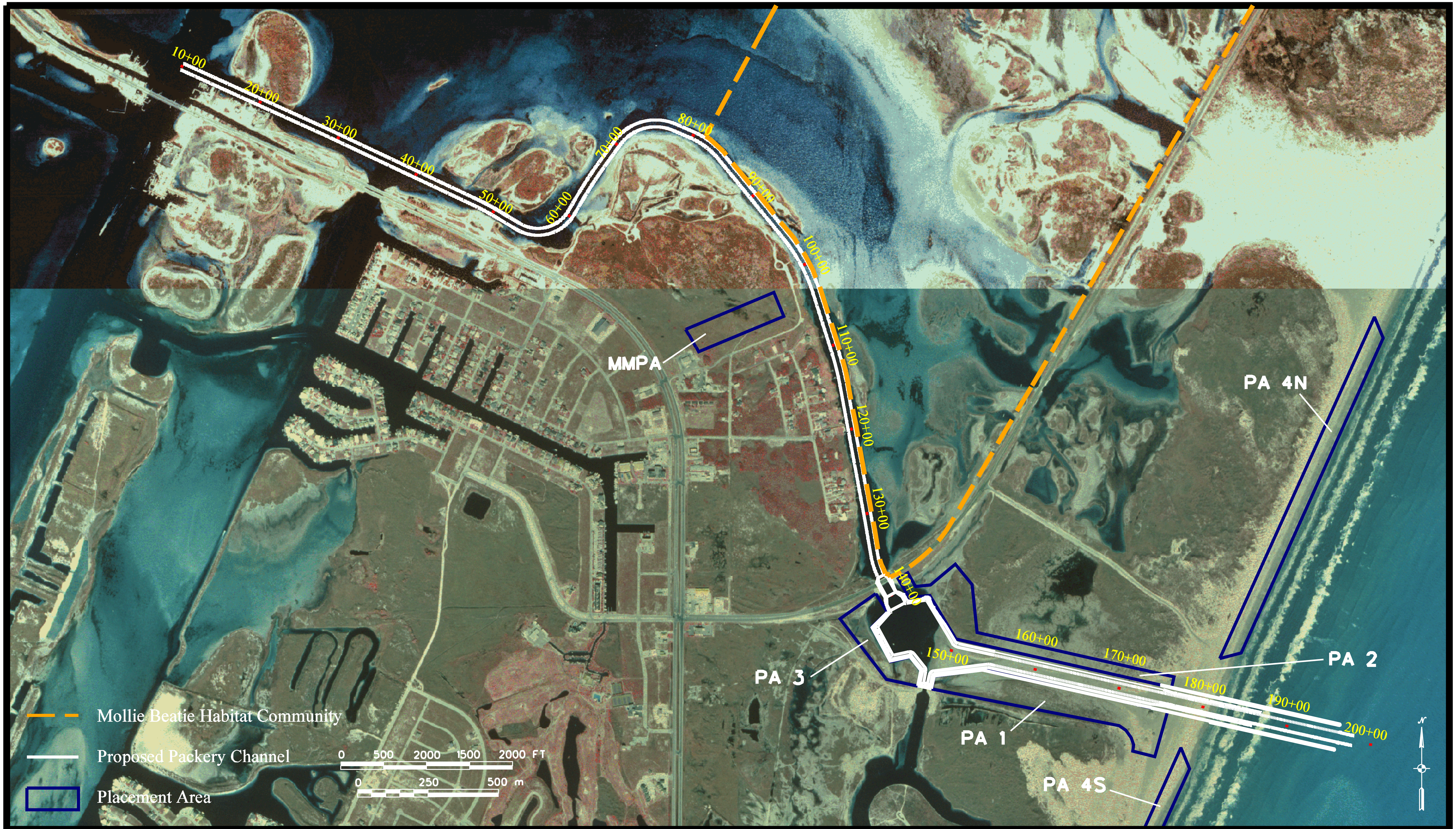
Concrete bulkhead structures will be constructed on the north and western sides of PA 1 and act as retaining structures. The existing floodwall will serve as the southern retaining structure. A levee will be constructed on the eastern end of PA 1 (using material placed in PA 1) with the top elevation of the levee approximately 1 foot higher than the top elevation of the bulkhead cap. Sand will also be piled within the interiors of the bulkhead and the floodwall to an approximate height equal to the top elevation of the bulkhead to prevent seepage and direct drainage toward the weir. A weir will be constructed on the eastern end of the PA to allow for discharges through a drainpipe. A temporary drainage ditch will be constructed to allow water flow from the drainpipe toward the surf.

The initial discharge into PA 1 will include fine-grained material from the western end of Reach 2. The discharge effluent shall be controlled to achieve acceptable levels of total suspended solids (TSS), and samples will be taken daily when effluent is most turbid. To allow settling of the fine-grained material a small impoundment will be constructed in the PA by blocking the weir. Once sufficient settling and clear surface water has formed, the weir blockage can be removed and water allowed to discharge. PA 2 and PA 3 will be filled prior to completing PA 1 to allow the fine-grained material to settle and consolidate. The second stage of filling into PA 1 will use sandy material found further east along the channel. The need for ponding to allow settling and water clarification will not be necessary with sandy material as it is for fine-grained material.

Once a sufficient volume of fill is in place, the site will be graded and any necessary erosion control will be installed. Due to the fine-grained material in this location, there will likely be some subsidence.

1.2.2.2 Placement Area 2

This approximate 15.5-acre placement area with a capacity of 76,000 cy will be taken from within stations 71+00 through 170+50. Concrete bulkheads will be constructed as the southern retaining structure for the PA. Bulkheads will be constructed partially across the northern boundary of



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Drawn by: G. Rockley	Date: Feb 2002
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Figure 1-3
Proposed Packery Channel
Station Numbers

PA 2 with the top elevation of these bulkheads approximately 1 foot higher than the top elevation of the bulkhead cap along the channel. An opening of approximately 575 feet along the northern bulkhead will allow for fill material in PA 2 to grade into existing ground level (secondary dunes) on the north side. A drainage ditch will be located in a west to east direction down the center of PA 2 to allow drainage from the fill material. PA 2 will be open on the east end to drain toward the surf through a temporary drainage ditch. New work material filled in PA 2 will be predominantly sand. Grading will occur once a sufficient amount of fill is in place, and necessary erosion control will be installed.

1.2.2.3 Placement Area 3

The approximately 7.1-acre PA 3 allows for a capacity of 60,400 cy of fill material. Material from between Stations 71+00 through 170+50 will be placed into PA 3. Concrete bulkheads are proposed along the Inner Basin and will serve as the eastern retaining structure for PA 3. The existing floodwall serves as the southern retaining structure and a levee at the SH 361 embankment provides the western containment. Three weirs (each approximately 40 feet in length) will be located along the eastern bulkhead where the bulkhead cap is removed. Below each weir structure on the outside of the bulkhead, riprap will be constructed at the toe of the bulkhead to reduce scouring. It may be necessary to construct a temporary dike within the interior of the bulkhead to direct flow toward the weirs.

Due to the relatively small size of PA 3, placement of dredged material will likely need to be alternated with PA 2 to allow for sufficient time for sedimentation, thus preventing turbid water overflow. The new work material to be placed into PA 3 is predominantly sand. The site will be graded and erosion control installed as necessary, once the volume of fill is in place.

1.2.2.4 Placement Area 4S and 4N

Placement Areas 4S and N are located on the beach south and north of the jetties, respectively, and will provide beach nourishment and storm damage protection for the life of the Project. While only PA 4S will be used for new work material placement, both PA 4S and 4N can be used for maintenance material placement based on need as determined by beach erosion.

PA4S

New work material consisting primarily of sand will be used for beach nourishment at PA 4S to provide protection from major storm events. An approximately 27.1-acre area for beach nourishment will be located south of the jetties. All material in Reach 1 is suitable for beach placement because of its high sand content. Sediment from portions of Reach 2 is also appropriate for beach placement.

The new work material for beach placement at PA 4S will be placed south of the jetties and extend seaward from the seawall, which runs parallel to the beach in front of resort development. This seawall is distinct from, and should not be confused with, the floodwall that runs parallel to the extension of Packery Channel from roughly Station 148+00 to Station 173+00. The volume proposed for placement is 544,800 cy, which includes 56,200 cy excavated from PA 1 and 488,600 cy dredged from Reaches 1 and 2. PA 4S will be located approximately 500 feet south of the south jetty and would extend

500 feet south of the southern end of the seawall, a distance of approximately 5,800 feet. The sand placement will entail constructing an approximately 220-foot-wide berm east from and parallel to the seawall, with a top elevation of 3 feet MLLW (approximately 2 feet above the existing beach elevation). The fill will extend seaward from the berm with a slope of 50 feet horizontally to 1 feet vertically and terminate at the third offshore sand bar, a distance of approximately 700 feet. The transition zones from the berm to the existing beach level on the north and south ends of the placement area will extend approximately 500 feet in each direction.

Placement of the new work material will be discharged onto the beach on the northern end and proceed to the south. If necessary, small retaining dikes will be constructed along the landward edge and along the seaward edge of the Project area to contain the discharge as it is placed on the beach. The retaining dikes will advance along the beach as the fill is placed.

Based on URS (2002) modeling results, it is estimated that material placed on the beach at PA 4S will remain in place providing storm protection for about 3 years. Without replacement the beach placement will erode and the beach slope will flatten to its original condition over 3 years. It is estimated that annual channel maintenance and sand bypass will provide over 200,000 cy of sand each year for beach replenishment, that can be placed in either PA 4S or 4N as needed.

PA 4N

Approximately 19 acres of beach north of the jetties is proposed for placement of channel maintenance material. The placement of the sandy material will be deposited in a similar design as that described above for PA 4S, but with a berm width of approximately 70 feet and an elevation of 3 feet MLLW. Sand from maintenance and sand bypass will be available annually if needed to maintain this beach.

1.2.2.5 MMPA

An additional maintenance material placement area (MMPA) is proposed on City of Corpus Christi property south of the channel and northwest of SH 361 (Figure 1-2). Material not appropriate for beach placement will be placed in this confined upland disposal area. This PA will encompass approximately 7.5 acres of undeveloped property. To accommodate the maintenance material, the perimeter dike will be built with a top elevation of 20 feet from the ground elevation. This site will accommodate anticipated maintenance dredging of 15,000 cy of material every 5 years for the 50-year project life, for a total capacity of 150,000 cy.

1.2.3 Jetties

Two impermeable rock jetties with sidewalks at the crest of each jetty are proposed. The proposed jetties will parallel the channel onshore and offshore, starting approximately at Station 174+00. For both jetties, construction on shore extends approximately 700 feet. The north jetty extends from the shoreline outward approximately 1,430 feet, and the south jetty extends approximately 1,478 feet. The jetties will be oriented at 12 degrees north of shore-normal to provide shelter from southeasterly summer waves. Jetty elevation is proposed at 7.25 feet MSL with a jetty crest width of 16 feet. The footprint at the base of each jetty is approximately 60 feet wide. The approximate distance between the two jetty crests is 280 feet. The channel width of approximately 116 feet extends to approximately 160 feet including benches or side slopes.

1.2.4 Sand Bypassing System

A sand bypassing system is proposed to move the sand that accumulates in the area updrift of the jetty. A sand bypassing pipe case will be constructed at approximately Station 179+00 to allow for transfer of sand from the updrift side of the jetty using fixed or mobile bypassing plants (dredging systems). The average mechanical bypassing volume of sand to maintain current shoreline position is 160,000 cy/year. Sand bypassing may be conducted on a yearly or biennial schedule. Regular monitoring of the beach profile in the vicinity of the jetty should be scheduled to determine where accretion and erosion are occurring on the beach. Using this information it will be determined whether bypassing is needed, as well as the required direction and volume of the bypassing. This material will be placed in PA 4S or 4N as appropriate.

1.2.5 Scour Protection at SH 361 Bridge

To protect the exposure and integrity of the SH 361 bridge piers, rip-rap will be placed around the piers and abutment transition areas around the bridge.

1.2.6 Recreational Development

The City of Corpus Christi has proposed recreational development in association with the construction of the channel. These improvements are considered secondary development impacts and are not part of the Federally cost shared project. The City of Corpus Christi has provided the location and description of the proposed development which will be constructed in two phases. The initial phase of the recreational development will occur in Reach 1 and includes parking lots and access roads, a pavilion, walkways along the channel and on the jetties with access ramps and stairs, vendor kiosks, a bath house/restroom facility, and a boat ramp (see Section 4.11.3). A large portion of the parking areas will be located in PA 2. Additional parking is proposed on the beach north and south of the jetties. The City of Corpus Christi is proposing to construct an underground utility crossing incorporating multiple casings for future use in conjunction with this phase of development.

In a proposed second phase, the City plans to provide additional recreational development at two locations on the south side of the channel along Reach 2 identified as Causeway Area Access Point and Packery Point Park. Specific design information about these areas has not been provided, but these areas will likely include the construction or improvement of public boat ramps, parking facilities, and restrooms.

1.2.7 Aids to Navigation

The channel design will include aids to navigation to assist boaters in maintaining course and speed through the channel. The U.S. Coast Guard (USCG) will install and maintain the aids to navigation. The development of the plan for aids to navigation will involve coordination among the local

USCG Aids to Navigation Team, the USACE, the City of Corpus Christi, and URS. The plan's objective will define the purpose of each navigational aid and designate the design, shape, color, numbering, light characteristics, and location.

1.3 SCOPING AND PUBLIC INVOLVEMENT PROCESS

An initial public scoping meeting for the North Padre Island Storm Damage Reduction and Environmental Restoration Project was held on September 7, 2000, to allow the public to comment on the Project. These comments were considered in the current design of the Project. An additional public meeting is scheduled 45 days from the circulation of the DEIS.

1.4 PERMITS AND APPROVALS REQUIRED

Permits that may be required for the proposed Project include: 1) USACE - Section 404 of the Clean Water Act for the construction in waters of the U.S.; and 2) the TNRCC Clean Water Act Section 401 certification that will show compliance with Texas surface water quality standards; and 3) Dune Protection Permit Application to the Texas General Land Office (GLO).

The proposed action of development in the coastal zone initiates a Texas Coastal Management Program (CMP) consistency determination. The CMP reviews all Federal actions that may affect any natural resource in the coastal zone for consistency with the Federal goals and objectives of the Federal Coastal Zone Management Program (CZM) (created by the Coastal Zone Management Act of 1972). The responsibility for the Texas review belongs to the GLO. Compliance with the goals and policies of the CMP is presented in Appendix A.

2.0 PROJECT ALTERNATIVES

The 1999 PSP, noted in Section 1.0, identified three alternative project locations for analysis of environmental benefits of a water exchange pass between the Gulf of Mexico and the Laguna Madre: (1) an opening north of the proposed Packery Channel at Mustang Island Fish Pass (Fish Pass), (2) a Packery Channel location (Packery Channel Alternative), and (3) an opening south of the proposed Packery Channel but north of the Padre Island National Seashore (South Alternative). Fish Pass is roughly 4 miles north of the proposed Packery Channel Project and was dredged in 1972. It was not stable and was closed by shoaling within 10 years. Historically, it is also a pass that is temporarily opened by hurricanes. The South Alternative was located roughly 5 miles south of the proposed Packery Channel Project, but has never been opened. It was strictly a creation for study purposes. In the PSP, these alternatives were compared with the No-Action Alternative (i.e., no channel opening to the Gulf). Modeling addressed changes of salinity distribution, tidal range, and potential increases to the habitat units of five fish species in the Laguna Madre as a result of constructing a water exchange pass to the Gulf of Mexico. The TxBLEND model developed by the Texas Water Development Board was used for the study. These three project alternatives are presented in the DEIS for comparative purposes; however, only the Congressionally directed Project at Packery Channel is fully developed for identification of resources and impacts analysis in the DEIS.

For ease in modeling, and since only a comparative analysis of three alternative locations was being conducted, the PSP used uniform channel dimensions. The Packery Channel Alternative of the modeling study and the current proposed Packery Channel Project are not exactly the same design. The 1999 modeling study Packery Channel Alternative was designed with uniform channel dimensions while the proposed Packery Channel Project is designed with a major channel dimension reduction west of SH 361.

In addition to variation in location, alternative channel sizes were also evaluated. Inlet size, or hydraulic capacity, was considered an independent variable in the analysis, but some inlet locations required a longer excavated channel than others. Therefore, to equalize the hydraulic capacity of the inlets, the longer excavations were made deeper and wider, which removed the inlet efficiency variable from the modeling of environmental effects within the bay system.

Three channel widths were considered for each location: standard width, one-half width and double width. For the modeling study Packery Channel Alternative, the standard width (165.5 feet) was the hydraulic equivalent of the currently proposed Packery Channel Project, the one-half width channel was 82.8 feet, and the double width channel was 331 feet. The dimensions of the standard, one-half width, and double width channels for the Fish Pass and South Alternatives were selected such that the channels had near hydraulic equality with the Packery Channel Alternative. In this way, channel length differences could be minimized and the focus could be on the effect of Project location.

Three alternative salinity conditions were also modeled for each of the alternatives in the PSP:

A. Mean salinity throughout the year under average annual conditions;

B. Maximum monthly mean salinity under average annual conditions; and

C. Maximum monthly mean salinity under 80th percentile conditions.

These conditions actually represent two time periods. The first time period (A&B) is representative of long-term average salinity, and the other (C) is representative of a high salinity period in the Project area. The long-term average salinity period was determined by using average conditions from the historical database (1958-1997).

The 80th percentile values were chosen to represent high salinity periods for the Project area. The 80th percentile value indicates that 80 percent of the values fall below this concentration. It is also the condition that would theoretically be expected to occur once every 5 years. The same historical period of record was used to calculate the 80th percentile values as for the average annual conditions.

The salinity changes predicted by the TxBLEND model for the various alternatives are presented in Table 2.1-1, for average annual conditions, and Table 2.1-2, for 80th percentile conditions. The negative values in these tables represent salinity decreases while positive values represent salinity increases for each segment. Scenarios, in which the baseline salinity conditions in the vicinity of the inlet were very similar to those in the Gulf, were not evaluated and are referred to as not applicable (NA) in these tables. These instances include the South Alternative for yearly means under average annual conditions and Fish Pass and the Packery Channel Alternative for spring means under 80th percentile conditions. Tables 2.1-1 and 2.1-2 demonstrate that salinity increases are predicted in the study area using the yearly and spring means for average annual conditions. Salinity reductions are predicted for all alternatives using the maximum means for average annual conditions and all 80th percentile conditions.

For both the yearly mean and the spring mean, under average annual conditions (Table 2.1-1), the South Alternative resulted in the largest potential increase in salinity from opening an inlet channel to the Gulf of Mexico, except for the spring mean, double width, which showed the largest gain from the Packery Channel Alternative. The Fish Pass alternative resulted in the least increase for the yearly mean and spring mean under average annual conditions. For the maximum mean salinity under average annual conditions, the South Alternative generally had the largest potential decrease in salinity, with the Fish Pass and the Packery Channel Alternative having less of an effect. For all salinity means under 80th percentile conditions (Table 2.1-2), the South Alternative resulted in the largest potential decrease in salinity from opening an inlet channel to the Gulf of Mexico, while the Fish Pass alternative resulted in the least increase, except for the half-width channel, which showed the least potential decrease in salinity from the Packery Channel Alternative.

After a detailed literature search, data review, and consultation with regulatory agency personnel, brown shrimp, spotted seatrout, Gulf flounder, southern flounder, and red drum were chosen as representative species for the alternatives analysis. Using the Habitat Evaluation Procedure (HEP) methodology and the results of the salinity model, Average Annual Habitat Units (AAHUs) were determined. The study then calculated the net change in AAHUs for all representative species at the three alternative channel sites under the three salinity conditions. This net change in AAHUs served as the final measure of environmental benefit.

TABLE 2.1-1

PREDICTED SALINITY CHANGES, AVERAGE ANNUAL CONDITIONS

Latitude (minute range)	BASELINE SALINITY (ppt)	BASELINE AREA (acres)	ALTERNATIVE: STANDARD Salinity Change (ppt) Location: Fish Pass	STANDARD PCA*	STANDARD South	HALF Salinity Change (ppt) Location: Fish Pass	HALF PCA*	HALF South	DOUBLE Salinity Change (ppt) Location: Fish Pass	DOUBLE PCA*	DOUBLE South
	YEARLY MEAN										
#REF!	#REF!	#REF!	1.00	0.50	NA	1.00	0.00	NA	1.00	0.50	NA
#REF!	#REF!	#REF!	1.00	0.50	NA	1.00	0.00	NA	1.00	0.50	NA
#REF!	#REF!	#REF!	1.25	0.50	NA	1.25	0.00	NA	1.25	1.00	NA
#REF!	#REF!	#REF!	1.50	0.50	NA	1.50	0.50	NA	1.75	1.25	NA
#REF!	#REF!	#REF!	2.25	1.00	NA	2.25	0.75	NA	2.25	1.50	NA
#REF!	#REF!	#REF!	2.50	1.50	NA	2.75	1.00	NA	2.75	2.00	NA
#REF!	#REF!	#REF!	2.50	2.00	NA	2.50	1.50	NA	2.75	2.75	NA
#REF!	#REF!	#REF!	2.50	2.25	NA	2.25	1.50	NA	2.50	3.00	NA
#REF!	#REF!	#REF!	2.25	2.25	NA	2.25	1.25	NA	2.50	2.75	NA
#REF!	#REF!	#REF!	2.00	1.75	NA	2.00	1.25	NA	2.25	2.50	NA
#REF!	#REF!	#REF!	1.75	1.75	NA	1.75	1.00	NA	1.75	2.25	NA
#REF!	#REF!	#REF!	1.50	1.25	NA	1.25	0.75	NA	1.50	2.00	NA
#REF!	#REF!	#REF!	1.00	1.00	NA	1.00	0.75	NA	1.00	1.50	NA
#REF!	#REF!	#REF!	0.75	0.75	NA	0.75	0.00	NA	0.75	1.00	NA
#REF!	#REF!	#REF!	0.00	0.50	NA	0.00	0.00	NA	0.50	0.50	NA
#REF!	#REF!	#REF!	0.00	0.00	NA	0.00	0.00	NA	0.00	0.00	NA
	MAXIMUM MEAN										
#REF!	#REF!	#REF!	-0.50	0.00	0.00	-0.50	0.00	0.00	-0.50	0.00	0.00
#REF!	#REF!	#REF!	-0.50	0.00	0.00	-0.50	0.00	0.00	-0.50	-0.25	0.00
#REF!	#REF!	#REF!	-0.75	-0.25	0.00	-0.75	0.00	0.00	-0.75	-0.50	-0.25
#REF!	#REF!	#REF!	-0.75	-0.50	-0.50	-0.75	0.00	-0.25	-1.00	-0.75	-0.50
#REF!	#REF!	#REF!	-1.50	-0.75	-0.50	-1.50	-0.25	-0.25	-1.50	-0.75	-0.50
#REF!	#REF!	#REF!	-1.75	-1.00	-0.50	-1.75	-0.50	-0.50	-2.00	-1.25	-0.75
#REF!	#REF!	#REF!	-1.50	-1.75	-0.50	-1.50	-1.25	-0.50	-1.75	-2.25	-0.75
#REF!	#REF!	#REF!	-1.50	-1.75	-1.50	-1.50	-1.00	-1.50	-1.50	-2.50	-2.00
#REF!	#REF!	#REF!	-1.50	-1.50	-5.00	-1.50	-1.00	-4.50	-1.50	-2.50	-5.25
#REF!	#REF!	#REF!	-1.50	-1.50	-6.25	-1.50	-1.00	-5.75	-1.50	-2.25	-6.00
#REF!	#REF!	#REF!	-1.25	-1.25	-5.25	-1.25	-0.75	-4.75	-1.25	-1.75	-5.50
#REF!	#REF!	#REF!	-0.75	-0.75	-4.00	-0.75	-0.50	-3.75	-0.75	-1.25	-4.00
#REF!	#REF!	#REF!	-0.25	-0.50	-2.50	-0.25	-0.50	-2.25	-0.25	-0.50	-2.50
#REF!	#REF!	#REF!	-0.25	-0.25	-1.00	-0.25	-0.25	-1.00	-0.25	-0.25	-1.25
#REF!	#REF!	#REF!	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
#REF!	#REF!	#REF!	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SPRING MEAN										
#REF!	#REF!	#REF!	1.00	0.50	0.00	1.00	0.00	0.00	1.00	0.50	0.00
#REF!	#REF!	#REF!	1.00	0.50	0.00	1.00	0.00	0.00	1.00	0.50	0.00
#REF!	#REF!	#REF!	1.25	0.50	0.00	1.25	0.00	0.00	1.25	1.00	0.00
#REF!	#REF!	#REF!	1.50	0.50	0.00	1.50	0.50	0.00	1.75	1.25	0.50
#REF!	#REF!	#REF!	2.25	1.00	0.50	2.25	0.75	0.25	2.25	1.50	0.75
#REF!	#REF!	#REF!	2.50	1.50	0.50	2.75	1.00	0.50	2.75	2.00	0.75
#REF!	#REF!	#REF!	2.50	2.00	0.75	2.50	1.50	0.75	2.75	2.75	1.00
#REF!	#REF!	#REF!	2.50	2.25	1.25	2.25	1.50	1.00	2.50	3.00	1.25
#REF!	#REF!	#REF!	2.25	2.25	1.50	2.25	1.25	1.25	2.50	2.75	1.50
#REF!	#REF!	#REF!	2.00	1.75	1.00	2.00	1.25	1.00	2.25	2.50	1.00
#REF!	#REF!	#REF!	1.75	1.75	1.00	1.75	1.00	0.75	1.75	2.25	1.00
#REF!	#REF!	#REF!	1.50	1.25	0.75	1.25	0.75	0.75	1.50	2.00	0.75
#REF!	#REF!	#REF!	1.00	1.00	0.75	1.00	0.75	0.75	1.00	1.50	0.75
#REF!	#REF!	#REF!	0.75	0.75	0.75	0.75	0.00	0.75	0.75	1.00	0.75
#REF!	#REF!	#REF!	0.00	0.50	0.50	0.00	0.00	0.50	0.50	0.50	0.50
#REF!	#REF!	#REF!	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* PCA - Packery Channel Alternative.

TABLE 2.1-2

PREDICTED SALINITY CHANGES, 80TH PERCENTILE

			ALTERNATIVE								
	BASELINE		STANDARD Salinity Change (ppt)			HALF Salinity Change (ppt)			DOUBLE Salinity Change (ppt)		
Latitude (minute range)	SALINITY (ppt)	AREA (acres)	Location			Location			Location		
			Fish Pass	PCA*	South	Fish Pass	PCA*	South	Fish Pass	PCA*	South
	YEARLY MEAN										
50-52	33.90	10642	-0.50	0.00	0.00	-0.50	0.00	0.00	-0.50	0.00	0.00
48-50	33.90	22633	-0.50	0.00	0.00	-0.50	0.00	0.00	-0.50	-0.25	0.00
46-48	34.10	23818	-0.75	-0.25	0.00	-0.75	0.00	0.00	-0.75	-0.50	-0.25
44-46	34.00	19557	-0.75	-0.50	-0.50	-0.75	0.00	-0.25	-1.00	-0.75	-0.50
42-44	34.76	14235	-1.50	-0.75	-0.50	-1.50	-0.25	-0.25	-1.50	-0.75	-0.50
40-42	35.50	7219	-1.75	-1.00	-0.50	-1.75	-0.50	-0.50	-2.00	-1.25	-0.75
38-40	36.60	7453	-1.50	-1.75	-0.50	-1.50	-1.25	-0.50	-1.75	-2.25	-0.75
36-38	37.80	5074	-1.50	-1.75	-1.50	-1.50	-1.00	-1.50	-1.50	-2.50	-2.00
34-36	40.50	5072	-1.50	-1.50	-5.00	-1.50	-1.00	-4.50	-1.50	-2.50	-5.25
32-34	41.10	5742	-1.50	-1.50	-6.25	-1.50	-1.00	-5.75	-1.50	-2.25	-6.00
30-32	43.00	5075	-1.25	-1.25	-5.25	-1.25	-0.75	-4.75	-1.25	-1.75	-5.50
28-30	42.08	4251	-0.75	-0.75	-4.00	-0.75	-0.50	-3.75	-0.75	-1.25	-4.00
26-28	43.80	3712	-0.25	-0.50	-2.50	-0.25	-0.50	-2.25	-0.25	-0.50	-2.50
24-26	44.08	3387	-0.25	-0.25	-1.00	-0.25	-0.25	-1.00	0.00	-0.25	-1.25
22-24	45.50	2961	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20-22	46.04	2395	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	MAXIMUM MEAN										
50-52	37.40	10642	-0.75	0.00	0.00	-0.75	0.00	0.00	-0.75	-0.50	0.00
48-50	37.40	22633	-0.75	-0.50	0.00	-0.75	0.00	0.00	-0.75	-0.50	0.00
46-48	37.08	23818	-1.00	-0.50	-0.50	-1.00	-0.25	-0.25	-1.00	-0.75	-0.50
44-46	37.86	19557	-1.50	-0.75	-0.50	-1.50	-0.50	-0.50	-1.75	-1.00	-0.50
42-44	39.00	14235	-2.75	-1.00	-0.50	-2.75	-0.75	-0.50	-3.00	-1.50	-0.75
40-42	41.00	7219	-3.50	-1.50	-0.50	-3.50	-1.25	-0.50	-3.50	-2.25	-0.75
38-40	41.44	7453	-3.50	-2.75	-0.50	-3.50	-2.25	-0.50	-3.75	-4.25	-0.75
36-38	42.60	5074	-3.75	-4.00	-3.00	-3.75	-2.25	-3.00	-4.00	-5.50	-3.00
34-36	50.04	5072	-4.00	-4.00	-11.50	-4.00	-2.50	-10.50	-4.00	-6.50	-11.50
32-34	45.70	5742	-3.75	-4.00	-14.00	-3.75	-2.25	-13.50	-4.00	-6.50	-14.00
30-32	50.10	5075	-3.00	-3.25	-13.00	-3.00	-1.75	-12.00	-3.25	-5.25	-13.50
28-30	48.16	4251	-1.50	-2.00	-10.00	-1.50	-1.00	-9.00	-1.75	-3.00	-10.50
26-28	49.70	3712	-0.50	-0.50	-5.00	-0.50	-0.25	-5.00	-0.25	-1.00	-5.50
24-26	49.82	3387	0.00	0.00	-2.00	0.00	0.00	-2.00	0.00	0.00	-2.50
22-24	52.90	2961	0.00	0.00	-0.50	0.00	0.00	-0.50	0.00	0.00	-0.50
20-22	49.40	2395	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SPRING MEAN										
50-52	31.70	10642	NA	NA	0.00	NA	NA	0.00	NA	NA	0.00
48-50	31.70	22633	NA	NA	0.00	NA	NA	0.00	NA	NA	0.00
46-48	32.82	23818	NA	NA	0.00	NA	NA	0.00	NA	NA	-0.25
44-46	32.80	19557	NA	NA	-0.25	NA	NA	0.00	NA	NA	-0.25
42-44	32.20	14235	NA	NA	-0.50	NA	NA	-0.25	NA	NA	-0.50
40-42	33.30	7219	NA	NA	-0.75	NA	NA	-0.50	NA	NA	-0.50
38-40	34.40	7453	NA	NA	-1.00	NA	NA	-0.75	NA	NA	-0.75
36-38	35.00	5074	NA	NA	-1.00	NA	NA	-1.00	NA	NA	-1.25
34-36	38.90	5072	NA	NA	-1.75	NA	NA	-1.00	NA	NA	-2.50
32-34	36.10	5742	NA	NA	-1.50	NA	NA	-1.50	NA	NA	-2.25
30-32	39.16	5075	NA	NA	-1.50	NA	NA	-1.50	NA	NA	-2.00
28-30	39.40	4251	NA	NA	-1.50	NA	NA	-1.50	NA	NA	-2.00
26-28	40.50	3712	NA	NA	-1.25	NA	NA	-0.75	NA	NA	-1.50
24-26	41.96	3387	NA	NA	-0.75	NA	NA	-0.75	NA	NA	-1.00
22-24	44.78	2961	NA	NA	0.00	NA	NA	0.00	NA	NA	-0.75
20-22	45.06	2395	NA	NA	0.00	NA	NA	0.00	NA	NA	0.00

* PCA - Packery Channel Alternative.

The HEP analysis requires two main components: Habitat Suitability Index (HSI) values and area of impact. To calculate the HSI values, species-specific parameters are needed for both baseline (without-project) and with-project alternatives. The baseline conditions for the parameters are important since the HSI models only consider the lowest HSI between the water quality and food/cover components of the model. Therefore, if the food/cover component is not sufficient to support a species and has a low HSI value, changes in salinity are of no consequence. This was the case for red drum, for which the food/cover component drives the model because of the limited amount of emergent vegetation. Therefore, the baseline condition and all project alternatives for red drum would have produced the same number of habitat units. For that reason, red drum calculations were not pursued in the PSP.

The net changes in AAHUs are presented in Table 2.1-3 with respect to species for each alternative. For average annual conditions, Gulf and southern flounder and brown shrimp all showed no habitat benefit or negative net changes in AAHU for all channel sizes. This is because of the increases in salinity that were predicted for yearly and spring mean scenarios under average annual conditions. The increasing salinities lowered the HSI values for these species, ultimately lowering the net AAHU. The spotted seatrout was the only species under average annual conditions that showed habitat gains. The reason for habitat gains is that salinity reductions were predicted using the maximum monthly mean scenario for average annual conditions. These habitat benefits were recorded for all alternatives and channel sizes. The largest habitat gain (3,760 AAHU) for spotted seatrout was achieved with the South Alternative and the double-width channel. The South Alternative exhibited slightly over twice the benefit of either the Packery Channel Alternative or Fish Pass, regardless of channel size.

All species demonstrated habitat gains with respect to the 80th percentile conditions (Table 2.1-3). As previously mentioned, the 80th percentile scenario is reflective of what would theoretically occur once every 5 years. Therefore, these habitat benefits must be weighed in relation to that time frame. The South Alternative demonstrated the largest increases in habitat for all species and all alternatives under the 80th percentile conditions. The habitat benefits reported at the South Alternative included: 1,170 to 1,302 AAHU for Gulf flounder; 1,082 to 1,291 AAHU for southern flounder; 20,878 to 23,572 AAHU for spotted seatrout; and 1,397 to 2,777 AAHU for brown shrimp. The large increases in habitat for the spotted seatrout reflect the linear function present in the HSI model, where reductions in salinity from 45 ppt to 37.5 ppt make large differences in HSI values (0 to 1, respectively).

These data are summarized in Table 2.1-4 as a percentage gain or loss in AAHUs. Table 2.1-4 also presents the number of times each alternative was ranked first, second, or third for HEP benefits, with respect to species and channel size. The South Alternative holds 23 of the possible 24 first place spots, the Packery Channel Alternative had the most benefits once, and Fish Pass none. An examination was conducted to better describe what the number of AAHUs gained or lost meant with respect to the entire study area. Table 2.1-5 presents the net change reported as percentage of AAHU per species for the study area. For example, the net change in AAHU for spotted seatrout from the South Alternative under average annual conditions at standard channel size was 3,574 AAHU (Table 2.1-3). This net change, divided by the available AAHU for the Study Area (61,717 AAHU), results in a 5.8 net percent increase in AAHU for spotted seatrout (Table 2.1-5). Only average annual conditions were examined with respect to percentage change in USACE (1999) because of the problems weighting

TABLE 2.1-3

NET CHANGES IN AVERAGE ANNUAL HABITAT UNITS (AAHU)

	AVERAGE ANNUAL CONDITIONS									**80th PERCENTILE**								
	ALTERNATIVE									ALTERNATIVE								
Latitude (minute range)	STANDARD Net Changes (AAHU)			HALF Net Changes (AAHU)			DOUBLE Net Changes (AAHU)			STANDARD AAHU			HALF AAHU			DOUBLE AAHU		
	Location			Location			Location			Location			Location			Location		
	Fish Pass	PCA*	South	Fish Pass	PCA*	South	Fish Pass	PCA*	South	Fish Pass	PCA*	South	Fish Pass	PCA*	South	Fish Pass	PCA*	South
	YEARLY MEAN - GULF FLOUNDER									YEARLY MEAN - GULF FLOUNDER								
#REF!	0	0	NA	0	NA	NA	0	0	NA	0	NA	NA	0	NA	NA	0	NA	NA
#REF!	0	0	NA	0	NA	NA	0	0	NA	0	NA	NA	0	NA	NA	0	0	NA
#REF!	0	0	NA	0	NA	NA	0	0	NA	0	0	NA	0	NA	NA	0	0	0
#REF!	0	0	NA	0	0	NA	0	0	NA	0	0	0	0	NA	0	0	0	0
#REF!	0	0	NA	0	0	NA	0	0	NA	0	0	0	0	0	0	0	0	0
#REF!	0	0	NA	0	0	NA	0	0	NA	36	36	36	36	36	36	36	36	36
#REF!	0	0	NA	0	0	NA	0	0	NA	97	97	30	97	60	30	97	97	30
#REF!	0	0	NA	0	0	NA	0	0	NA	71	91	71	71	46	71	71	112	91
#REF!	-46	-46	NA	-46	0	NA	-46	-66	NA	76	76	233	76	51	213	76	122	233
#REF!	-75	-52	NA	-75	-29	NA	-75	-103	NA	86	86	322	86	57	293	86	115	322
#REF!	-91	-91	NA	-91	-46	NA	-91	-112	NA	56	56	254	56	25	233	56	81	279
#REF!	-55	-55	NA	-55	-34	NA	-55	-72	NA	21	21	166	21	21	149	21	43	166
#REF!	-33	-33	NA	-33	-15	NA	-33	-48	NA	22	22	104	22	22	104	22	22	104
#REF!	-30	-30	NA	-30	NA	NA	-30	-30	NA	0	0	41	0	0	41	NA	0	41
#REF!	NA	-15	NA	NA	NA	NA	-15	-15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
#REF!	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TOTAL	-331	-323	0	-331	-123	0	-346	-447	0	466	486	1256	466	318	1170	466	627	1302
	YEARLY MEAN - SOUTHERN FLOUNDER									YEARLY MEAN - SOUTHERN FLOUNDER								
#REF!	-64	-32	NA	-64	NA	NA	-64	-32	NA	43	NA	NA	43	NA	NA	43	NA	NA
#REF!	-136	-68	NA	-136	NA	NA	-136	-68	NA	91	NA	NA	91	NA	NA	91	91	NA
#REF!	-143	-71	NA	-143	NA	NA	-143	-143	NA	95	0	NA	95	NA	NA	95	95	0
#REF!	-196	-59	NA	-196	-59	NA	-254	-196	NA	78	78	78	78	NA	0	137	78	78
#REF!	-228	-85	NA	-228	-85	NA	-228	-142	NA	157	100	57	157	57	57	157	100	57
#REF!	-123	-72	NA	-123	-51	NA	-123	-94	NA	79	58	29	79	29	29	108	58	29
#REF!	-127	-97	NA	-127	-75	NA	-149	-149	NA	89	89	30	89	60	30	89	119	30
#REF!	-86	-71	NA	-71	-51	NA	-86	-107	NA	56	76	56	56	41	56	56	96	76
#REF!	-96	-96	NA	-96	-56	NA	-96	-117	NA	66	66	208	66	46	188	66	112	208
#REF!	-92	-69	NA	-92	-46	NA	-92	-109	NA	75	75	281	75	52	258	75	98	281
#REF!	-76	-76	NA	-76	-36	NA	-76	-102	NA	46	46	228	46	20	203	46	71	249
#REF!	-47	-47	NA	-47	-34	NA	-47	-64	NA	21	21	153	21	21	132	21	43	153
#REF!	-30	-30	NA	-30	-15	NA	-30	-48	NA	22	22	93	22	22	93	22	22	93
#REF!	-27	-27	NA	-27	NA	NA	-27	-27	NA	0	0	37	0	0	37	NA	0	37
#REF!	NA	-12	NA	NA	NA	NA	-12	-12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
#REF!	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TOTAL	-1469	-912	0	-1454	-506	0	-1562	-1408	0	918	631	1250	918	347	1082	1005	982	1291
	MAXIMUM MEAN - SPOTTED SEATROUT									MAXIMUM MEAN - SPOTTED SEATROUT								
#REF!	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	0	NA
#REF!	0	NA	NA	0	NA	NA	0	0	NA	0	0	NA	0	NA	NA	0	0	NA
#REF!	0	0	NA	0	NA	NA	0	0	0	0	0	0	0	0	0	0	0	0
#REF!	0	0	0	0	NA	0	0	0	0	0	0	0	0	0	0	0	0	0
#REF!	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#REF!	0	0	0	0	0	0	0	0	0	1949	910	325	1949	621	325	1949	1184	325
#REF!	0	0	0	0	0	0	0	0	0	2109	1848	350	2109	1573	350	2363	2363	686
#REF!	0	0	0	0	0	0	0	0	0	1608	1796	1416	1608	1005	1416	1796	2146	1416
#REF!	172	172	172	172	172	172	172	172	172	0	0	4722	0	0	4342	0	2267	4722
#REF!	195	195	195	195	195	195	195	195	195	3629	3905	5742	3629	2567	5742	3922	5133	5742
#REF!	436	436	1370	436	228	1370	436	639	1370	0	0	5075	0	0	4903	0	0	5075
#REF!	319	319	612	319	162	612	319	468	612	0	0	4107	0	0	3801	0	0	4251
#REF!	174	174	783	174	174	783	174	174	783	0	0	958	0	0	0	0	0	1355
#REF!	234	234	440	234	234	440	234	234	627	NA	NA	0	NA	NA	0	NA	NA	0
#REF!	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0	NA	NA	0	NA	NA	0
#REF!	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TOTAL	1531	1531	3574	1531	1166	3574	1531	1883	3760	9296	8459	22695	9296	5765	20878	10030	13093	23572
	SPRING MEAN - BROWN SHRIMP									SPRING MEAN - BROWN SHRIMP								
#REF!	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
#REF!	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
#REF!	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
#REF!	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
#REF!	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
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#REF!	0	0	0	0	0	0	0	0	0	NA	NA	0	NA	NA	0	NA	NA	0
#REF!	0	0	0	0	0	0	0	0	0	NA	NA	10	NA	NA	10	NA	NA	10
#REF!	-101	-101	0	-101	0	0	-101	-198	0	NA	NA	441	NA	NA	228	NA	NA	543
#REF!	0	0	0	0	0	0	0	0	0	NA	NA	224	NA	NA	224	NA	NA	224
#REF!	-102	-102	0	-102	0	0	-102	-198	0	NA	NA	335	NA	NA	335	NA	NA	442
#REF!	-9	-9	0	-9	0	0	-9	-85	0	NA	NA	293	NA	NA	293	NA	NA	383
#REF!	-74	-74	-74	-74	-74	-74	-74	-145	-74	NA	NA	282	NA	NA	97	NA	NA	282
#REF!	-125	-125	-125	-125	NA	-125	-125	-125	-125	NA	NA	210	NA	NA	210	NA	NA	210
#REF!	NA	-59	-59	NA	NA	-59	-59	-59	-59	NA	NA	NA	NA	NA	NA	NA	NA	684
#REF!	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TOTAL	-411	-470	-259	-411	-74	-259	-470	-810	-259	0	0	1796	0	0	1397	0	0	2777

* PCA - Packery Channel Alternative.

TABLE 2.1-4

ALTERNATIVE RANKINGS BY NET CHANGES IN AVERAGE ANNUAL HABIAT UNITS (AAHU) FOR SPECIES [1]

AVERAGE ANNUAL						80TH PERCENTILE					
STANDARD		HALF		DOUBLE		STANDARD		HALF		DOUBLE	
Rank	AAHU	Rank	AAHU	Rank	AAHU	Rank	AAHU	Rank	AAHU	Rank	AAHU
GULF FLOUNDER											
South	0	South	0	South	0	South	1256	South	1170	South	1302
PCA[2]	-323	PCA	-123	Fish Pass	-346	PCA	486	Fish Pass	466	PCA	627
Fish Pass	-331	Fish Pass	-331	PCA	-447	Fish Pass	466	PCA	318	Fish Pass	466
SOUTHERN FLOUNDER											
South	0	South	0	South	0	South	1250	South	1082	South	1291
PCA[2]	-912	PCA	-506	PCA	-1408	Fish Pass	918	Fish Pass	918	Fish Pass	1005
Fish Pass	-1469	Fish Pass	-1454	Fish Pass	-1562	PCA	631	PCA	347	PCA	982
SPOTTED SEATROUT											
South	3574	South	3574	South	3760	South	22695	South	20878	South	23572
PCA[2]	1531	Fish Pass	1531	PCA	1883	Fish Pass	9296	Fish Pass	9296	PCA	13093
Fish Pass	1531	PCA	1166	Fish Pass	1531	PCA	8459	PCA	5765	Fish Pass	10030
BROWN SHRIMP											
South	-259	PCA	-74	South	-259	South	1796	South	1397	South	2777
Fish Pass	-411	South	-259	Fish Pass	-470	PCA	0	PCA	0	PCA	0
PCA[2]	-470	Fish Pass	-411	PCA	-810	Fish Pass	0	Fish Pass	0	Fish Pass	0

[1] Alternatives ranked in order of environmental benefits.
[2] PCA - Packery Channel Alternative.

OVERALL RANKINGS

	1ST	2ND	3RD
SOUTH	23	1	0
PCA[2]	1	13	10
FISH PASS	0	14	10

TABLE 2.1-5

NET CHANGE REPORTED AS PERCENTAGE OF AVAILABLE ANNUAL HABITAT UNITS (AAHU) FOR SPECIES [1]

AVERAGE ANNUAL					
STANDARD		HALF		DOUBLE	
Rank	%	Rank	%	Rank	%
GULF FLOUNDER					
South	0.0%	South	0.0%	South	0.0%
PCA[2]	-0.3%	Packery	-0.1%	Fish Pass	-0.3%
Fish Pass	-0.3%	Fish Pass	-0.3%	Packery	-0.4%
SOUTHERN FLOUNDER					
South	0.0%	South	0.0%	South	0.0%
PCA[2]	-0.8%	Packery	-0.5%	Packery	-1.3%
Fish Pass	-1.3%	Fish Pass	-1.3%	Fish Pass	-1.4%
SPOTTED SEATROUT					
South	5.8%	South	5.8%	South	6.1%
PCA[2]	2.5%	Fish Pass	2.5%	Packery	3.1%
Fish Pass	2.5%	Packery	1.9%	Fish Pass	2.5%
BROWN SHRIMP					
South	-0.7%	Packery	-0.2%	South	-0.7%
Fish Pass	-1.1%	South	-0.7%	Fish Pass	-1.2%
PCA[2]	-1.2%	Fish Pass	-1.1%	Packery	-2.1%

[1] Alternatives ranked in order of environmental benefits.

[2] PCA - Packery Channel Alternative.

the one-in-five-year relationship for the 80th percentile conditions. Brown shrimp, and southern and Gulf flounder all show no change or very slight negative percentages with respect to overall habitat. The spotted seatrout shows small positive percentages (1.9% to 5.8%) based on the different scenarios.

Using average annual conditions, four of the five representative species showed zero (redfish always showed a zero change, as noted above) or small losses in AAHUs for all of the channel location alternatives. Only the spotted sea trout demonstrated a potential (5–6%) gain as a result of a new water exchange pass, under certain conditions. The PSP noted that the small habitat losses for all other species probably fell into the error range of the analysis and should be interpreted as meaning no environmental benefit instead of a negative environmental benefit.

The total environmental benefits of an opening to the Gulf remained ambiguous after the PSP analysis. While there are other possible benefits, changes in salinity were the only ones that could be quantified. The PSP concluded that even if additional salinity modeling or more sophisticated HEP analyses were conducted, it is unlikely that the results would change. The PSP stated that tidal range changes, fish migration issues, and other non-quantifiable environmental benefits would probably make the South Alternative more desirable. The theoretical 5–6% increase in the spotted sea trout available habitat would probably not translate into an actual increase in recreational catches reported by TPWD surveys (USACE, 1999). While the PSP study showed that a new water exchange pass would reduce high salinity episodes in the Upper Laguna Madre, these average only about once every 5 years. There was no analysis or modeling of storm reduction benefits for these three alternatives in the 1999 PSP study.

As noted above, the USACE was directed by Congress, in Section 556 of WRDA 1999 (PL 106-53, 8/17/99), to carry out a project for ecosystem restoration and storm damage reduction at North Padre Island, Texas. Because of the negligible environmental benefits of the previously studied project alternatives, and because of the language of WRDA 1999, only the proposed Packery Channel Project as designed by the non-Federal sponsor (proposed Project, as described above) is fully developed, examined in the DEIS, and compared with the No-Action Alternative. The No-Action Alternative is the existing channel as constructed under Department of Army Permit No. 17768; a 2.6-mile channel extending from the GIWW to SH 361, varying from a 30- to 50-foot bottom width and 5-foot depth. Under the most recent permit amendment, this existing channel will no longer be maintained. Therefore, the two alternatives examined in detail in this DEIS are the No-Action Alternative and the proposed Project.

3.0 AFFECTED ENVIRONMENT

3.1 ENVIRONMENTAL SETTING

The study area for the Packery Channel Project is located along Mustang and North Padre islands and the adjacent mainland and encompasses the upper end of the Laguna Madre extending south toward Baffin Bay (Figure 1-1). The coastline of this area extends across Nueces and Kleberg counties. The study area comprises bays, flats, marshes, beaches, dunes, and coastal uplands that encompass federal, state, and county properties and commercial and residential properties. Packery Channel is located in the southeastern portion of Corpus Christi Bay, south of Newport Pass and Corpus Christi Pass.

The Laguna Madre, a long, narrow, hypersaline lagoon, is a shallow water body with a natural average depth less than 5 feet (Hedgpeth, 1967). The Laguna Madre is subdivided into two basins referred to as the Upper and Lower Laguna Madre with the two being separated by the Saltillo Flats (Land Bridge) south of Baffin Bay. This study area encompasses an area north of the Land Bridge and north of Baffin Bay. The USACE completed construction of the GIWW in the study area in 1949.

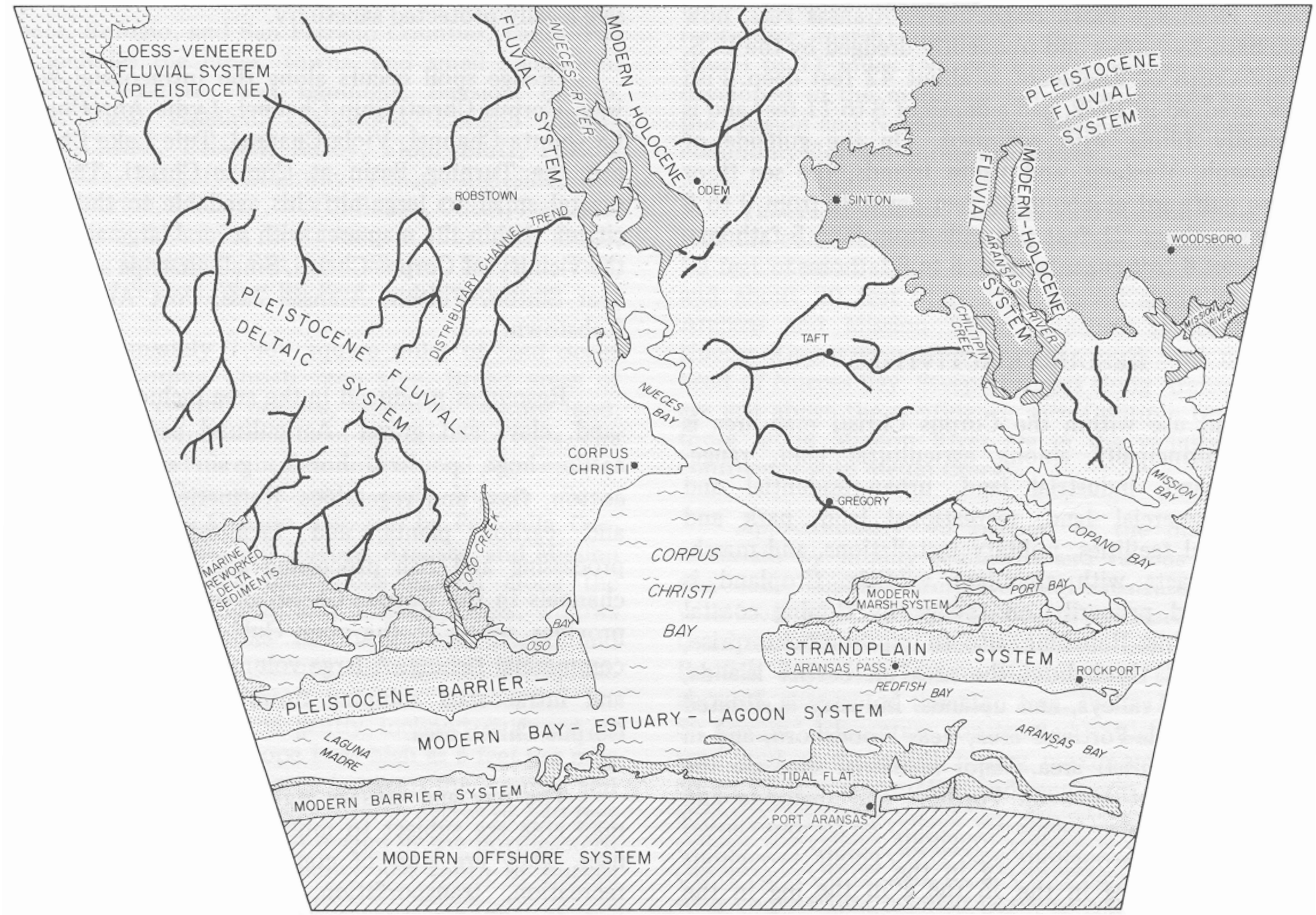
3.1.1 Physiography

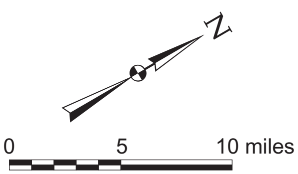
The Laguna Madre is subdivided physiographically into four distinct units: 1) Upper Laguna Madre; 2) the central exposed flats; 3) Baffin Bay and its estuaries; and 4) Lower Laguna Madre. The study area is located within the Upper Laguna Madre which extends northward from the Land Bridge (of the central exposed flats unit) for approximately 40 miles to Corpus Christi Bay. The Upper Laguna Madre gradually widens to a maximum of 3.5 miles at Corpus Christi Bay.

The primary physiographic environments of the study area include fluvial-deltaic, bay-estuary-lagoon, barrier strandplain, and locally distributed marsh systems (Brown et al., 1976) (Figure 3.1-1). The Coastal Zone within the study area is underlain by sedimentary deposits that originated in ancient but similar physiographic environments. These ancient sediments were deposited by the same natural geologic processes that are currently active in shaping the present coastline.

The study area consists of a shallow coastal lagoon bound to the east by a coastal barrier island complex and to the west by a deltaic coastal plain. Topographically, the study area lies a few feet below mean sea level within the submerged areas, to 5 to 30 feet above MSL along the back-island dunes of Padre Island.

The Baffin Bay system is considered a distinct physiographic unit from the rest of the Laguna Madre because it represents drowned stream valleys formed before the buildup of the Padre Island Barrier Chain. The Baffin Bay system consists of Baffin Bay, Alazon Bay, Cayo Del Grullo, and Cayo Del Infiernillo. The main body of Baffin Bay is approximately 14 miles long, a maximum of 4 miles wide and averages about 6 feet deep (Brown et al., 1977).





Source: BEG, 1976

PBSJ
· Engineering
· Environmental Consulting
· Surveying

Figure 3.1-1

PHYSIOGRAPHIC MAP

3.1.2 Geology

The regional surface geology of the Gulf Coast region consists of sedimentary beds ranging in age from late Eocene to Recent, which lie as bands nearly parallel with the coast. Recent deposits form the coastline and successive beds crop out toward the interior. Due to the age of exposure of the rocks, the outcrop areas are successively more eroded and dissected toward the interior. The Pleistocene and Recent formation still retain much of their depositional surface (Texas Water Commission (TWC), 1963).

The formations underlying the region occur as a series of gently dipping truncated wedges that thicken toward the coast. The lithology of the wedges reflects three depositional environments: continental (alluvial plain), transitional (delta, lagoon, and beach), and marine (continental shelf) (TWC, 1963). The thick sequence of sedimentary rocks and unconsolidated sediments beneath the present day Gulf Coastal Plain reflect cyclic marine and continental deposition in the region through the Jurassic, Cretaceous, and Tertiary periods, culminating with predominantly fluvial deposits at the end of the Tertiary Period. This pattern continued through the Pleistocene Epoch (i.e., early Quaternary Period, about 2 million years before present), during which sedimentation was largely controlled by sea level fluctuations associated with repeated glacial and interglacial episodes. During each of the Pleistocene glacial stages much of the earth's available water occurred as ice and snow. This resulted in significantly lower sea levels, so that dry land extended out to the edge of the continental shelf (Van Siclen, undated). The river valleys extended seaward to the regressing shoreline. Each time the climate warmed again these effects were reversed, as the glacial melt flowed back into the sea inundating the coastal regions and flooding inland along the entrenched river valleys. The alluvial river valleys and the lower portions of the valleys were inundated, thus forming a series of estuaries. These bodies of water (i.e., Corpus Christi Bay) are transient relics of the lowered sea level during the last glacial stage.

A distinctive topographic feature of Pleistocene deposition is the remnant Ingleside Barrier Island System. According to Van Siclen, this relict barrier island forms most of the mainland shore of the modern lagoons in the Gulf region and occupies the western portion of the study area. The Ingleside Barrier System is discontinuous because it has been breached by the Pleistocene deltas that formed at the mouths of the rivers of the Gulf. The remnants of the Ingleside Barrier System are literally embedded in the resulting fluvio-deltaic plain.

Approximately 5,000 years ago, the sea level reached its present position and has remained constant since that time. The Gulf shoreline, formed by barrier islands and deltaic planes, originated during this stage (Gulf Coast Association of Geological Societies (GCAGS), 1959). The nature and distribution of the barrier island and lagoon (i.e., Padre and Mustang islands and the Laguna Madre) are a result of several active natural processes. The processes include longshore drift, beach swash, wind deflation and deposition, tidal currents, wind generated waves and currents, delta outbuilding, and river point-bar and flood deposition (Brown et al., 1976). The two sources of sand that have formed the long arcuate Texas barrier islands during the Recent epoch are from sand introduced by the Rio Grande, Brazos, and Colorado rivers and the scouring of Recent and late Pleistocene sediments occurring on the Gulf bottom in the Inner Continental Shelf region (GCAGC, 1959). Eolian sediment supply has been important in supplying sediment to the Laguna Madre, on both geologic and historic time scales, and accounts for 43 percent of the average annual sediment supply to the Laguna Madre (Morton et al., 1998).

Geologic materials exposed in the study area are of the Quaternary Period and consist primarily of mixtures of sand, silt, clay, mud and shell deposited within the last 1 million years. Sediment distributions within the lagoon system consist chiefly of terrigenous clastics. Clean quartz sands can be found in some PAs, along parts of the mainland shoreline, and in the wind-tidal flats areas. Muddy sands occur adjacent to dredged material placement mounds, in the shallow bay-margin areas next to the mainland shore and at the edge of the wind-tidal flats. Muddy sand distribution is not depth controlled, rather it is related to hurricane washovers, dredging activities, and reworking of relict sediment (McGowen and Morton, 1979). A hurricane washover channel has historically developed adjacent to Packery Channel. The approximate washover site is the location where the extension of Packery Channel will meet the Gulf shoreline.

3.1.3 Hydrology

Hydrology of the Upper Laguna Madre is influenced primarily by climatological conditions such as rainfall and wind, to a lesser degree from tides and openings, via Corpus Christi Bay, to the Gulf of Mexico and, to a smaller extent on freshwater inflow. The dredging of the GIWW and enhanced water circulation with the Lower Laguna Madre also plays a significant role in the hydrology of the system.

To determine the jetty design, URS (2002) used hydrologic information from the Gulf of Mexico near Packery Channel. Tropical storm data were obtained from an offshore station (WIS 1087, located roughly 15 miles northeast of Packery Channel) and the Automated Coastal Engineering System (ACES) was used to determine significant wave heights for various return periods. Nine tropical storms were recorded from 1977 through 1993, with wave heights that ranged from 7.5 feet for Alicia in 1983 to 23 feet for Allen in 1980. From the available 20-year period of record, the best fit data from ACES gave an extreme significant wave height ranging from 6.43 feet for a 2-year return period to 30.35 feet for a 100-year return period. From these data, it appeared that the 23-foot waves associated with Hurricane Allen represent a 25-year wave event.

The winds in the area are sustained onshore most of the year from the southeast, caused by the land-sea interaction, but are interrupted by northerly frontal passages (Ward, 1977). Offshore wave data, therefore, are predominantly toward the northwest (URS, 2002). The tide in the area has both semi-diurnal and diurnal components, with the diurnal component normally dominating. However, the tidal range is small in the Laguna Madre at Packery Channel (0.36 feet), and is only a fraction of that in the Gulf at Bob Hall Pier (1.34 feet) (Kraus and Heilman, 1997).

3.1.4 Climate

The coastal climate within the study area may be described as subhumid to semiarid. Major climatic influences are temperature, precipitation, evaporation, wind, and tropical storms/hurricanes. This area is subject to extreme precipitation variability with rainfalls averaging about

29 inches in the Corpus Christi vicinity, with the greatest concentration falling in the spring and fall months. The peak rainfall in the fall coincides with the tropical storm/hurricane season. Rainfall totals decrease toward the southern coastline and inland to the west. The temperatures in the area are fairly high with an average in the lower 70s, punctuated with occasional killing freezes.

The persistent wind is from the southeast from March to September and the northeast from October to February. The hurricane season spans June through November with the greatest number occurring in the area in August and September. Wind velocities may be at least 74 miles per hour (mph) with wind gusts exceeding sustained windspeeds by up to 50 percent during tropical storms (Dunn and Miller, 1964). The winds are important agents in eroding and reworking sediments and sands, and affecting water levels and circulation patterns depending on the velocity and duration of the wind. The direction and intensity of persistent winds control the orientation and size of wave sequences approaching the shoreline, ultimately eroding or depositing sediment along the shoreline (Brown et al., 1976).

3.2 WATER QUALITY

The quality of water within the Project area has generally been characterized as good to moderate with some special studies identifying areas of concern. Contributing factors affecting the overall water quality in the Upper Laguna Madre center around a wide range of physical, chemical and biological processes often working in unison with each other to create a highly dynamic environment.

3.2.1 Water Exchange and Inflows

The construction of the GIWW increased circulation within the Laguna Madre and exchange with the Gulf of Mexico. Water exchange between the Upper Laguna Madre and the Gulf of Mexico is primarily attributed to Corpus Christi Bay while within the Lower Laguna Madre, the Brazos-Santiago Pass and Mansfield Channel serve as permanent exchange points with the Gulf of Mexico. The Land Cut allows some continual water exchange between the Upper and Lower Laguna Madre. The western Gulf of Mexico is a microtidal region which characterizes the Laguna Madre tides as extremely small. Water level fluctuation depends more on the meteorological conditions (wind speed and direction, barometric pressure) than the astronomical forcing in much of the lagoon (Gill et al., 1995). The low tide range is attributed to the small number of tidal inlets into the Laguna Madre, the long distances from the inlets to the center of the Laguna Madre, and the large area of the Laguna Madre (Morton et al., 1998). A combination of these factors tends to reduce the impact that oceanic tides have on the Laguna Madre.

The freshwater inflow to the Upper Laguna Madre is essentially limited to intermittent streams draining into Baffin Bay (Coastal Impact Monitoring Program (CIMP), 1995). Although limited compared with other bays and estuaries, the freshwater inflows to the Laguna Madre serve the same important functions. One such function is to blend with the Laguna Madre's saltier water to provide a range of salt concentrations. In general, the majority of organisms that live in estuarine systems need water with different ranges of salinity at varying stages of their life cycles. The CMP (1996) reports that as many as 98 percent of important marine species rely on estuaries during some stage of their life cycle. An additional value that freshwater inflow contributes is the nutrient inputs which are essential to the total productivity of the Laguna Madre. Nutrients (nitrogen, phosphorus, and decomposing organic matter) are typically deposited into the Laguna Madre through surface runoff. The entire food web is dependent on the utilization of these nutrients for primary production by microscopic plankton and utilization by larger plants for growth. The primary productivity sustains the food chain while the larger plants provide food and breeding, hatching, resting, and protective areas for many forms of aquatic and terrestrial animals (Coastal Bend Bays Plan (CBBP), 1998). Another important factor is that freshwater inflows often bring sediments into the Laguna Madre. Sediment inputs help create muddy deltas and sandy barrier islands that act to maintain coastal marshes. Without the replenishment of sediments into estuarine systems, accelerated erosion of coastal uplands and destruction of existing wetlands might occur.

3.2.2 Salinity

The Laguna Madre of Texas is one of only three large hypersaline lagoons in the world (Hedgpeth, 1967). A complex interaction of factors including tidal activity, wind, water depth, evaporation, and freshwater inflow largely regulate the salinity of the Laguna Madre (CIMP, 1995). As previously described, the Laguna Madre is relatively isolated from the Gulf of Mexico by a continuous barrier island with only a few water exchange areas existing, except under extremely high tidal conditions, and only the Land Cut connecting the Upper and Lower Laguna Madre. Due to the shallow water depths throughout the Laguna Madre, Warshaw (1975) notes that broad areas are often left uncovered by water at low tide or during strong winds. During these instances, salt deposits along these tidal flats are left as a result of evaporation and may be redissolved at high tide or during times of heavy runoff (Warshaw, 1975). In addition, the limited amount of freshwater inflow to the Upper Laguna Madre as mentioned above, contributes greatly to the salinity regime. It has also been documented that the construction of the GIWW increased circulation within the Laguna Madre and water exchange with the Gulf of Mexico (Warshaw, 1975).

Prior to the creation of the GIWW, salinities in the Upper Laguna Madre were often greater than 60 parts per thousand (ppt) (Quammen and Onuf, 1993). Warshaw (1975) states that in the 3 years prior to the construction of the GIWW, salinities in the Upper Laguna Madre frequently exceeded 70 ppt. Quammen and Onuf (1993) report that increased exchange with the Gulf of Mexico resulting from channel dredging and increased precipitation have aided in the decrease of hypersaline conditions in the Upper Laguna Madre. Additional factors contributing to salinity changes include sharp declines in association with precipitation during tropical storms and hurricanes. Other more temporal declines in salinity reflect floodwaters entering the Laguna Madre via streams feeding Baffin Bay in the Upper Laguna Madre.

Baseline salinity conditions for the period 1958–1997 are presented in Appendix B, Table B-2, by latitude. The yearly mean for average annual conditions ranges from around 38 ppt in the southern Upper Laguna Madre to around 30 ppt in the northern Upper Laguna Madre and is around 29 ppt in the southern portion of Corpus Christi Bay. The maximum monthly mean salinities for the same areas are 45–35 ppt and 33–34 ppt, and the mean spring salinities (January–May) for the same areas are 36–28 ppt and 28–29 ppt.

3.2.3 Water Chemistry

When considering the size of the defined study area, the actual amount of water quality data, excluding standard parameter information, is small in comparison with other areas along the Texas coast. However, in comparison with other areas along the Texas coast, the potential sources for contamination within the Laguna Madre are limited as well. The Texas Natural Resource Conservation Commission (TNRCC) has designated water uses for the Laguna Madre to include contact recreation, exceptional quality aquatic habitat, and oyster waters (TNRCC, 2000).

High water temperatures have not been reported as a problem in the Laguna Madre (Warshaw, 1975; Bowles, 1983; Webster, 1986). However, low or sudden drops in water temperatures during excessively cold and prolonged northers have done catastrophic damage to marine life in the Laguna Madre (Breuer, 1962). The extreme cold events have caused some extensive fish kills (Lonard and Judd, 1985, 1991). As with water temperature, dissolved oxygen levels reported throughout the majority of the study area have been suitable for the support of aquatic life (Warshaw, 1975; Bowles, 1983; Webster, 1986).

As previously discussed, nutrients are a vital part of any estuarine system. The U.S. Environmental Protection Agency (EPA) has characterized nitrogen and phosphorus in the Laguna Madre based on the Dissolved Concentration Potential (DCP) concept. The DCP is a function of freshwater flushing time (flushing ability) and estuarine volume (dilution ability) (EPA, 1998). The Laguna Madre is estimated to have a medium susceptibility for concentrating dissolved substances. This DCP, combined with the existing nitrogen (total kjeldahl nitrogen) loading, results in a predicted concentration within the medium range for nitrogen while the DCP combined with the existing phosphorus loading, results in a predicted concentration in the high range for phosphorus (EPA, 1998). National Oceanic and Atmospheric Administration (NOAA)/EPA (1989) report that within the Laguna Madre, concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings.

TNRCC (1994) reports that 16 percent of the Laguna Madre is restricted for oyster harvesting due to actual or potential fecal coliform contamination.

Warshaw (1975) reported that the concentrations of heavy metals and other contaminants are low in the water column, and probably constitute baseline levels for the Laguna Madre. More recent studies have demonstrated that only a few areas in the Upper Laguna Madre have reported higher levels of certain compounds within the water column. Ward and Armstrong (1997) reported that elevated metal concentrations were found in the vicinity of the Bird Islands in the Upper Laguna Madre, although no cause was established.

In a recent study conducted for the EPA, chemical analyses were conducted on water, elutriate, and sediment samples from twenty-six stations in the GIWW throughout the Laguna Madre and on samples collected at reference stations (Lee Wilson and Associates (LW&A), 1998; Espey, Huston & Associates, Inc. (EH&A), 1998). Arsenic, barium, cadmium, chromium, copper, lead, zinc, and total petroleum hydrocarbons (TPH) were detected in all water and elutriate samples (EH&A, 1998). There were no pesticides, polychlorinated biphenyls (PCB), or polycyclic aromatic hydrocarbons (PAH) detected in any of the water or elutriate samples. The results of the chemical analyses on the water and elutriate samples indicate that, of the above mentioned detected chemicals, only concentrations of copper in elutriate samples (2.6–25.5 µg/L) exceeded the Texas Acute Marine Water Quality Standard (TWQS) (13.5 µg/L). Since the TWQSs are provided by the TNRCC for the protection of aquatic organisms, this indicates a potential cause for concern (EH&A, 1998). Therefore, an analysis of the dilution required to achieve the TWQS was conducted and indicated that the limiting permissible concentration (LPC) for the water column is not exceeded with regards to the concentration of copper (EH&A, 1998).

Historical water and elutriate data for detected compounds from 1983, 1990, and 1993 from the only GIWW stations near Packery Channel are presented in Table 3.2-1. Arsenic was the only metal found above detection limits in 1983 water and elutriate samples and was always numerically higher in the elutriate samples. However, all concentrations were well below the TWQS for arsenic. No parameters were detected in 1990 in water or elutriate samples. Barium was detected in both water and elutriate samples at all stations in 1993, while zinc was detected in one water and all elutriate samples in 1993. Barium concentrations were numerically higher in elutriate samples than in water samples, indicating a potential release of barium into the water column during dredging and placement. There are no TWQS for barium but the Gold Book criterion (EPA, 1986, as revised) is 1,000 micrograms per liter (µg/L) barium for domestic water supplies. No value exceeded 1,000 µg/L barium, nor was the TWQS for zinc exceeded. Total organic carbon (TOC) was also above detection limits for water and elutriate samples for all stations in 1993. Oil and grease was detected in one 1983 elutriate sample, at 1.5 µg/L, versus a detection limit of 1.0 µg/L. Hexachlorocyclohexane was detected in all 1983 water and elutriate samples, at roughly the same concentrations in both media, and with no exceedances of the TWQS (although one elutriate sample equaled the TWQS). No other organics were detected in 1990 or 1993 for either medium.

Samples were collected for water and elutriate analyses in August 2000 at four stations in the existing Packery Channel between the GIWW and to the east side of the SH 361 bridge (PBS&J, 2001a) and at one station in the beach zone (Figure 3.2-1) for standard and supplemental USACE constituents. The results of these analyses are presented in Table 3.2-2. As an examination of Table 3.2-2 demonstrates, barium, chromium, copper, nickel, zinc, ammonia, and TPH were found in water and elutriate samples at one or more stations and arsenic was found only in the elutriate samples from two stations. There is no apparent trend relative to whether the water or elutriate sample contains the higher concentration for any given parameter and station. For example, copper was numerically higher in water at four stations but higher in the elutriate of one station. Without replication, statistical analyses cannot be conducted to determine whether the differences that do exist are significant, but none of the water or elutriate concentrations exceeded the most recent Water Quality Standards established by the TNRCC for the protection of marine aquatic life.

3.2.4 Brown Tide

Although currently diminishing in the Laguna Madre, a major water quality concern since the early 1990s has been the phytoplankton, brown tide (*Aureoumbra lagunensis*) (DeYoe et al., 1997). The brown tide began in January 1990 in Baffin Bay in an ecosystem that was already disrupted by persistent high salinities that reduced the populations of planktonic and benthic grazers. Two severe

TABLE 3.2-1

DETECTED PARAMETERS IN THE HISTORIC DATA
CORPUS CHRISTI BAY TO MUD FLATS
GULF INTRACOASTAL WATERWAY

			Station:	GIC-CBB-83-01			GIC-CBB-83-02			GIC-CBB-83-03			GIC-CBB-83-DA 171		
			Date:	5/11/1983			#######			5/11/1983			#######		
			Channel Station:	0+000			5+000			10+000			3+000		
Parameter	Liquid Media Unit	Solid Media Unit	Texas Acute Marine Water Quality Standard	Water	Elutriate	Sediment	Water	Elutriate	Sediment	Water	Elutriate	Sediment	Water	Elutriate	Sediment
														(no data)	
Sand									3.14						5.08
Silt									52.4900						19.78
Clay									44.3700						75.1
D50									0.0060						0.002
Oil & Grease	ug/L	mg/kg	NA	<1.0	<1.0	292.0	<1.0	<1.0	250.0	<1.0	1.5	76.0	<1.0		80.0
As	ug/L	mg/kg	149	7.5	14.0	3.5	9.0	14.0	2.29	7.8	20.0	<1.0	14.0		1.0
Ba	ug/L	mg/kg	NA												
Cd	ug/L	mg/kg	45.62	<2.0	<2.0	<0.5	<2.0	<2.0	<0.5	<2.0	<2.0	<0.5	<2.0		<0.5
Cr	ug/L	mg/kg	1,090	<10.0	<10.0	7.14	<10.0	<10.0	5.35	<10.0	<10.0	<5.0	<10.0		<5.0
Cu	ug/L	mg/kg	13.5	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0	<1.0	<5.0	<1.0		<5.0
Pb	ug/L	mg/kg	133	<10.0	<10.0	<5.0	<10.0	<10.0	<5.0	<10.0	<10.0	<5.0	<10.0		<5.0
Hg	ug/L	mg/kg	2.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10		<0.10
Ni	ug/L	mg/kg	118	<20.0	<20.0	5.4	<20.0	<20.0	6.1	<20.0	<20.0	<5.0	<20.0		<5.0
Ag	ug/L	mg/kg	2												
Se	ug/L	mg/kg	564												
Zn	ug/L	mg/kg	92.7	<20.0	<20.0	39.0	<20.0	<20.0	24.0	<20.0	<20.0	<5.0	<20.0		10.0
TOC	mg/L	mg/kg	NA												
Hexachlorocyclohexane	ug/L	mg/kg	0.16	0.09	0.09	<0.50	0.12	0.16	<0.50	0.09	0.10	<0.50			
Ammonia	ug/L	mg/kg	NA	0.09	0.50	36.00	0.10	0.68	40.00	0.07	0.20	10.00			

TABLE 3.2-1

DETECTED PARAMETERS IN THE HISTORIC DATA
CORPUS CHRISTI BAY TO MUD FLATS
GULF INTRACOASTAL WATERWAY

			Station:	GIC-CBB-90-01			GIC-CBB-93-01			GIC-CBB-93-02			GIC-CBB-93-03		
			Date:	11/16/90			12/21/93			12/21/93			12/21/93		
			Channel Station:	10+000			0+000			5+000			10+000		
Parameter	Liquid Media Unit	Solid Media Unit	Texas Acute Marine Water Quality Standard	Water	Elutriate	Sediment	Water	Elutriate	Sediment	Water	Elutriate	Sediment	Water	Elutriate	Sediment
Sand						86.8			61.4			85.5			90.6
Silt						8.0			28.1			11.5			3.6
Clay						5.2			10.5			3			5.8
D50						0.205			0.132			0.191			0.177
Oil & Grease	ug/L	mg/kg	NA												
As	ug/L	mg/kg	149	<2.0	<2.0	<1.0	<1.0	<1.0	<0.50	<1.0	<1.0	<0.50	<1.0	<1.0	<0.50
Ba	ug/L	mg/kg	NA				50.1	74.3	153.00	52.7	71.8	75.19	52.3	64.4	31.79
Cd	ug/L	mg/kg	45.62	<2.0	<2.0	<0.10	<0.10	<0.10	<0.50	<0.10	<0.10	<0.50	<0.10	<0.10	<0.50
Cr	ug/L	mg/kg	1,090	<10.0	<10.0	1.0	<1.0	<1.0	6.70	<1.0	<1.0	3.30	<1.0	<1.0	1.60
Cu	ug/L	mg/kg	13.5	<1.0	<1.0	2.7	<1.0	<1.0	5.50	<1.0	<1.0	2.40	<1.0	<1.0	1.20
Pb	ug/L	mg/kg	133	<5.0	<5.0	<1.0	<1.0	<1.0	5.50	<1.0	<1.0	3.70	<1.0	<1.0	1.90
Hg	ug/L	mg/kg	2.1	<5.0	<0.2	<0.1	<0.2	<0.2	<0.05	<0.2	<0.2	<0.05	<0.2	<0.2	<0.05
Ni	ug/L	mg/kg	118	<5.0	<5.0	2.1	<1.0	<1.0	4.70	<1.0	<1.0	2.30	<1.0	<1.0	0.96
Ag	ug/L	mg/kg	2				<1.0	<1.0	<0.50	<1.0	<1.0	<0.50	<1.0	<1.0	<0.50
Se	ug/L	mg/kg	564	<2.0	<2.0	<0.5	<2.0	<2.0	<1.00	<2.0	<2.0	<1.00	<2.0	<2.0	<1.00
Zn	ug/L	mg/kg	92.7	<5.0	<5.0	5.9	<1.0	4.1	29.5	6.3	3.0	14.4	<1.0	9.2	6.9
TOC	mg/L	mg/kg	NA	1.00	1.00	<100	9.60	13.3	92.0	8.40	9.00	<100.0	9.60	12.7	<100.0

Source: USACE Galveston District Historical Database.
mg/kg - milligrams per kilogram.
ug/L - micrograms per liter.

Proposed Packery Channel

Water & Sediment Sample Location

1000 0 1000 2000 Feet

PBS&J
206 Wild Basin Rd., Ste. 300
Austin, Texas 78746-3343
Phone: (512) 329-8342 Fax: (512) 327-2453

Figure 3.2-1
Water & Sediment Sample Location Map

Prepared for: Steve McVey	
Job No.: 440561	Scale: 1:24000
Prepared by: M Qualls	Date: 9-26-00
File: N:\\440561\arcview\packery_new.apr (crane_sw)	

TABLE 3.2-2
CONCENTRATIONS OF DETECTED PARAMETERS
PACKERY CHANNEL

			Station:	PC-00-1			PC-00-2			PC-00-3			PC-00-4			PC-00-5		
			Date:	8/14/2000			8/14/2000			8/14/2000			#######			8/14/2000		
Parameter	Liquid Media Unit	Solid Media Unit	Texas Acute Marine Water Quality Standard	Water	Elutriate	Sediment	Water	Elutriate	Sediment	Water	Elutriate	Sediment	Water	Elutriate	Sediment	Water	Elutriate	Sediment
Sand						21.4			86.0			88.2			21.9			98.1
Silt						78.6			8.6			11.8			56.8			0.9
Clay						0.0			5.4			0.0			21.3			1.0
As	ug/L	mg/kg	149	<1.0	24.1	11.3	<1.0	<1.0	1.45	<1.0	<1.0	0.87	<1.0	14.8	5.41	<1.0	<1.0	1.14
Ba	ug/L	mg/kg	NA	97.7	276	165	100	94.8	38.8	111	113	35.7	119	173	219	21.7	20.9	1.60
Cd	ug/L	mg/kg	45.62	<0.1	<0.1	0.66	<0.1	<0.1	0.12	<0.1	<0.1	0.11	<0.1	<0.1	0.27	<0.1	<0.1	<0.1
Cr	ug/L	mg/kg	1,090	3.0	4.0	6.42	2.9	3.3	1.15	3.2	3.2	1.21	3.3	2.3	8.58	3.0	<1.0	0.89
Cu	ug/L	mg/kg	13.5	2.8	8.9	10.7	8.2	5.2	0.41	8.2	<1.0	2.35	6.5	2.5	12.9	9.1	<1.0	0.21
Pb	ug/L	mg/kg	133	<1.0	<1.0	12.9	<1.0	<1.0	2.21	<1.0	<1.0	2.35	<1.0	<1.0	9.38	<1.0	<1.0	0.66
Ni	ug/L	mg/kg	118	9.3	<1.0	6.57	<1.0	<1.0	1.17	<1.0	14.8	1.00	<1.0	<1.0	8.04	<1.0	9.7	0.83
Se	ug/L	mg/kg	564	<1.0	<1.0	0.44	<1.0	<1.0	<0.2	<1.0	<1.0	<0.2	<1.0	<1.0	<0.2	<1.0	<1.0	<0.2
Zn	ug/L	mg/kg	92.7	3.4	14.8	45.6	3.8	4.5	6.65	5.6	3.6	7.35	3.5	3.5	47.9	5.5	3.1	4.61
TOC	ug/L	mg/kg	NA	<1,000	<1,000	73,800	<1,000	<1,000	7,480	<1,000	<1,000	6,720	<1,000	<1,000	65,800	<1,000	<1,000	4,580
TPH	ug/L	mg/kg	NA	200	240	575	260	450	122	310	410	132	260	290	447	190	710	143
Total Sulfide	ug/L	mg/kg	NA	<0.1	<0.1	768	<0.1	<0.1	5.0	<0.1	<0.1	0.3	<0.1	<0.1	529	<0.1	<0.1	<0.1
Ammonia	mg/L	mg/kg	NA	9.4	<0.03	153	0.78	<0.03	0.78	0.8	<0.03	0.63	9.5	<0.03	150	0.26	0.15	5.6
% Total Solid		%	NA	N/A	N/A	22.8	N/A	N/A	74.6	N/A	N/A	74.4	N/A	N/A	25.7	N/A	N/A	80.4
% Volatile Solid		%	NA	N/A	N/A	2.33	N/A	N/A	0.8	N/A	N/A	0.68	N/A	N/A	1.98	N/A	N/A	0.2

Source: PBS&J, 2001a.
mg/kg - milligrams per kilogram.
ug/L - micrograms per liter.

freezes in December 1989 caused massive fish kills and the resulting decomposition of these fish released a large nutrient pulse that was sufficient to fuel the initial bloom of brown tide. Whitledge (1993) reports that this brown tide phenomenon has been present at varying times in history and continues to be a recurring problem. Although brown tide continues to be in general decline throughout the Project area, there are sporadic patches of algal blooms, generally in canals and near developments (Villareal and Dunton, 2000).

The brown tide has reduced the clarity of waters of the Laguna Madre, shading seagrass beds and disrupting sport fishing activities. Buskey et al. (1996) estimates that the brown tide has caused a recent loss of 2,471 acres of seagrass coverage in the Upper Laguna Madre and has also contributed to impacts such as decreased abundance, biomass, and diversity of benthic fauna, and reduced larval fish populations. The biomass of roots and rhizomes in the seagrass beds decreased dramatically in the last 2 years of brown tide, indicating the seagrasses were using up their energy reserves (Buskey et al., 1996). Stockwell (1993) suggests that the persistent brown tide has temporarily changed the phytoplankton/seagrass production ratio and altered nutrient cycles within the Laguna Madre. The brown tide has also had a dramatic affect on the benthic organisms of the Laguna Madre as the abundance, biomass and diversity of benthic fauna have all decreased (Buskey et al., 1996). Barrera et al. (1995) reports that under normal conditions, turbidity is minimal and seagrass meadows are extensive in the Laguna Madre, but the persisting brown tide bloom has caused serious problems to the seagrasses of the Laguna Madre. In contrast, the extended brown tide bloom has had no apparent effect on populations of adult fish and shellfish. On the other hand, both laboratory and field studies suggest that brown tide may be toxic to newly hatched larval fish and that larval fish populations are reduced in areas severely impacted by the brown tide (Buskey et al., 1996).

3.2.5 Red Tide

Red tides are caused by blooms of dinoflagellates that at high densities can produce colors from yellow to reddish-brown in the water. The cells are attracted to light and actively swim toward the surface where they may be concentrated in high densities by wind, currents and tides (Tester and Fowler, 1990). Twenty dinoflagellate species are thought to be toxic (Steidinger, 1979). These species are sources of poisonous compounds during blooms causing mass mortalities of marine organisms and leading to human health problems from contaminated seafood or aerosol toxins. So far, there have been two species of dinoflagellates responsible for toxic red tides in Texas: the unarmored *Karenia brevis* (formerly *Gymnodinium breve*) and *Alexandrium* (formerly *Gonyaulax*) *monilata*, an armored, chain-forming species. Typically *Karenia brevis* first blooms in the Gulf of Mexico at least several miles off the coast. Currents may move these blooms to shore and/or into coastal bays, and bloom concentrations can persist from 1 week to several months. Blooms may be confined to a particular bay or estuary (typical of *A. monilata*) or may spread to cover a massive area of coastal waters and embayments (as with *K. brevis*). The toxins in both of these dinoflagellate species can cause extensive mortality in fish and invertebrates, but in Texas, only *Karenia brevis* red tides have been reported to cause human health problems in the forms of temporary respiratory irritation from aerosol toxin and neurotoxic shellfish poisoning (Buskey et al., 1996).

3.3 SEDIMENT QUALITY

Morton, et al. (1998) noted that because of deposition on the east side and erosion on the west side, the Laguna Madre "generally has an asymmetrical cross section that is characterized by smooth flats on the east side that gradually slope toward the lagoon center, and moderately steep and irregular slopes on the west side." Thus the lagoon appears to effectively trap sediment from both the eastern eolian transport and the western erosional transport. The report notes that from a morphological perspective, the Laguna Madre can be divided into four regions: Packery Channel to Baffin Bay, Baffin Bay to "the Hole," "the Hole" to the Arroyo Colorado, and the Arroyo Colorado to Brazos Santiago Pass; the first of which constitutes the majority of the Project area.

Eolian sediment supply (both saltation and suspension) and supply via tidal inlets, storm washover, upland runoff, chemical precipitation, and biogenic sediment formation were all examined as inputs for sediment into the Laguna Madre. Eolian transport has been important in supplying sediment to the Upper Laguna Madre, on both geologic and historic time scales. In fact, eolian transport accounts for 43 percent of the average annual sediment supply to the Laguna Madre. Supply via tidal inlets was the only other category with substantial sediment input into the Laguna, and it was all from Brazos Santiago Pass (21 percent) and Port Mansfield Channel (17 percent). All of the other input mechanisms combined accounted for 19 percent of the average annual sediment supply to the Laguna Madre.

Sediment maps, past cores, grain size distribution studies, and sediment dating studies, as well as several types of cores taken specifically for Morton, et al. (1998), were examined to develop the characteristics of Lagunal sediments to aid in the determination of reworking versus outside sources as the source of maintenance material. Using pre-GIWW engineering plans, as well as more recent data, Morton, et al. (1998) determined that the near-surface sediments in the Upper Laguna Madre are sandy with abundant shell. Warshaw (1975) describes wind-induced water movements, ship traffic, and dredging activities as some of the processes that can cause mixing and transfer of materials from the sediment to the water.

Warshaw (1975) also documented that sediment in the Laguna Madre contains a relatively high proportion of sand and a low proportion of clay, compared with sediments in other Texas bays. Recent sediment investigations (LW&A, 1998; EH&A, 1998) have shown that sediments from the study locations within the GIWW are primarily silts and fine sands with the finer sediments located in the lower half of the Upper Laguna Madre and the upper half of the Lower Laguna Madre, bracketing the land cut. During an intensive benthic macrofaunal analysis of PAs in the Laguna Madre, sediment texture was also analyzed (EH&A, 1998). The sediment classification for the PAs and reference sites identified four major categories: sand; silty sand; silty-clayey sand; and sandy-clayey silt (EH&A, 1998). These sediment types were generally associated with particular PAs with sand and silty-sand sediments most prevalent in the Upper Laguna. Overall, the sediment texture within the PAs was similar in most cases to the texture exhibited at the reference stations (EH&A, 1998). In a few instances, a relatively low percent sand was observed within PAs, indicating that past placement practices may have resulted in changes from predominantly sand habitats to mostly silt-clay habitats (EH&A, 1998). In contrast, occasionally the reference stations exhibited finer sediments than the PAs.

In 1975, Warshaw (1975) reported that the sediment quality within the Laguna Madre was very good, as expected, since no significant industrial discharges were present in the Laguna Madre and barge traffic on the GIWW was light.

Recent sediment investigations report that most sediments throughout the Upper Laguna Madre have low levels of trace metal contamination, except for certain areas (Barrera et al., 1995). These areas in the Upper Laguna Madre involved relatively elevated levels of arsenic, boron, cadmium, copper, lead, mercury and zinc. Ward and Armstrong (1997) have also documented elevated metal concentrations around the Bird Islands in the Upper Laguna Madre. Other recent sediment investigations have demonstrated that, in general, sediment with finer particles tended to have higher trace metal concentrations, sulfides, and ammonia (EH&A, 1998). TPH, phenols, PCBs and pesticides were below detection limits in all sediment samples conducted in a 1997 sediment collection effort spanning the entire range of the Laguna Madre (EH&A, 1998). During that same study, it was reported that detected metals in Upper Laguna Madre sediment samples were not noticeably different from reference samples with the exception of one extremely high (possibly aberrant) value for cadmium (EH&A, 1998).

Sediment concentrations of detected parameters in 1983, 1990, and 1993 are also found in Table 3.2-1. Arsenic, chromium, nickel, and zinc were detected at most stations in 1983; chromium, copper, nickel, and zinc were detected in 1990; and barium, chromium, copper, lead, nickel, and zinc were detected in 1993. Oil and grease were detected in 1983 at all stations, but were discontinued as an analyte after 1983. In 1993, TOC was detected at one station but at a value (92 milligrams per kilogram [mg/kg]) that was below the detection limit. No other organics were detected in any of the historic data.

Samples were collected for sediment analyses in August 2000 at four stations in the existing Packery Channel between the GIWW and to the east side of the SH 361 bridge (PBS&J, 2001a) and at one station in the beach zone (Figure 3.2-1). The results of these analyses are presented in Table 3.2-2. As an examination of Table 3.2-2 demonstrates, the concentrations of all parameters, except perhaps selenium, are strongly tied to the grain size distribution of the sediments since chemicals, including pollutants, adhere to clays and silts, more strongly than to sands.

URS (2002) also analyzed sediments from the proposed Packery Channel. The following table (3.3-1) from URS (2002) gives the location (see Figure 3.2-1 for channel stations), depth, and grain size analysis for the samples. URS (2002) notes that the USACE Galveston District considers material with a sand content of 70 percent or greater as being suitable for beach nourishment. All material from station 51+00 eastward falls into the acceptable category. However, the bridge at SH 361 is approximately at Station 139+00 so material west of this station is not logical for beach nourishment because of the excessive pumping distance. Maintenance material that will accumulate east of the SH 361 bridge is also expected to be primarily sand (URS, 2002) and, therefore, useful for beach nourishment.

TABLE 3.3-1

SUMMARY OF GRAIN SIZE ANALYSIS

Station No.	Surface Elevation in feet (MLLW)	Sample Depth Relative to Surface (ft)		Sample Depth Relative to MLLW (ft)		% Sand	% Fines
3+00	-8	0	-1.5	-8	-9.5	76.2	23.8
22+90	-3	0	-1.5	-3	-4.5	47.0	53.0
30+00	-6	0	-1.5	-6	-6.5	35.0	65.0
37+30	-7	0	-1.5	-7	-8.5	32.0	68.0
51+00	-7.5	0	-1.5	-7.5	-9	95.9	4.1
65+10	-5.93	0	-1.5	-5.93	-7.43	75.3	24.7
79+80	-6.33	0	-1.5	-6.33	-7.83	93.7	6.3
101+10	-5.5	0	-1.5	-5.5	-7	90.7	9.3
113+80	-3	0	-1.5	-3	-4.5	95.8	4.2
120+40	-2.4	-5	-6.5	-7.4	-8.9	71.8	28.2
127+50	-6.1	0	-1.5	-6.1	-7.6	94.1	6.0
136+90	-8.78	0	-1.5	-8.78	-10.3	93.8	6.2
138+70	-2	-5	-6.5	-7	-8.5	95.1	4.9

MLLW - mean lower low water.

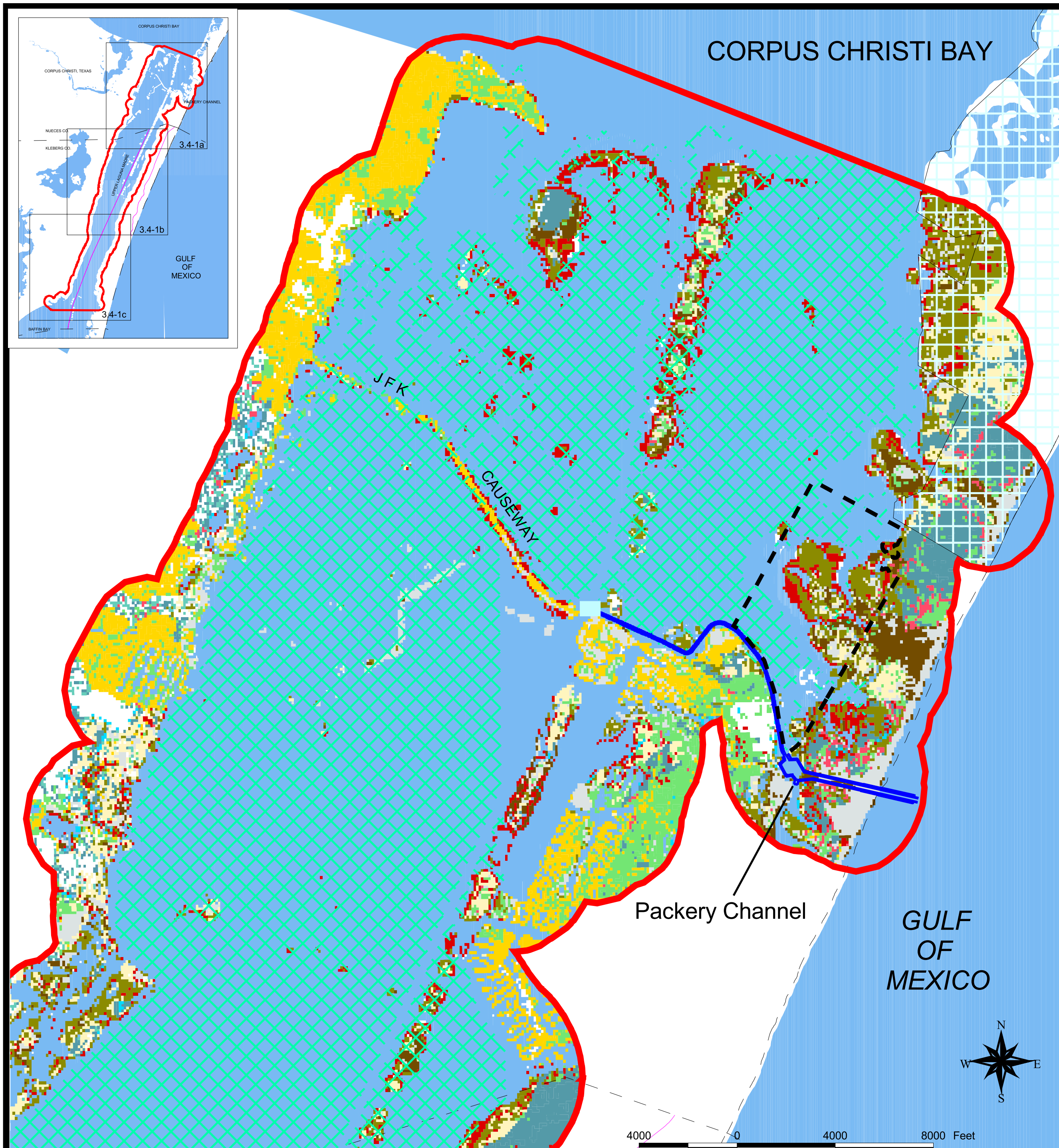
3.3.1 Toxicity Testing

There is very little information with regards to toxicity testing within the Laguna Madre or southern Corpus Christi Bay. Solid phase bioassays and bioaccumulation studies were conducted on sediment from six test stations on Reference Control Sediment, on a True Control, and archive samples (LW&A, 1998; EH&A, 1998). The survival of organisms exposed to test sediments from the Upper Laguna Madre in the solid phase bioassays was not significantly different from survival of organisms exposed to the solid phase of the reference control. With regards to bioaccumulation, based on the examination of numerous factors as required by the Tiered Approach in EPA/USACE (1991), significant ecological impacts would not be indicated by the results of this bioaccumulation study (EH&A, 1998).

In 1986, a series of solid phase bioassays and a bioaccumulation study was conducted on sediment collected from the section of the GIWW from Corpus Christi Bay to the Land Bridge (EH&A, 1987). The purpose of the study was to determine the potential environmental impact of the proposed bay placement of maintenance material to be dredged in order to maintain the GIWW along the reach. The report summarized that there was no significant difference among mean survival of organisms exposed to the solid phase of sediments from the test stations and the reference control and that there was no indication of bioaccumulation of any parameter in tissue for any station (EH&A, 1987). It can be concluded with reasonable assurance that no significant undesirable impacts would occur upon placement of the sediments tested.

3.4 COASTAL COMMUNITY TYPES

Texas is divided into ten vegetational areas (Ecoregions or Natural Regions) according to Gould (1975). Geology, soils, and climate are the physical factors that create the conditions that support the various vegetational landscapes. The study area lies within the southeastern portion of the Gulf Prairies (approximately 9 million acres) and Marshes (approximately 0.5 million acres) vegetational region, as described by Gould (1975). This vegetational area extends from Mexico to Louisiana. It is a nearly level plain less than 250 feet in elevation that includes the barrier islands and mainland lowlands adjacent to the coastline (Hatch et al., 1990). The region is subdivided into two vegetation units: 1) the low marshes with tide water influence (where the study area is located); and 2) the prairies or grasslands extending 30 to 80 miles inland (Hatch et al., 1990). The descriptions and acreage values for the vegetation communities of the Project area, which includes much of the Upper Laguna Madre, were derived from the Land Use/Land Cover classification produced by the Texas Parks and Wildlife Department (TPWD) from satellite imagery (1995) that incorporated U.S. Fish and Wildlife Service (FWS) National Wetland Inventory (NWI) data and the Texas Natural Heritage Program (TNHP, 1993). The areas in the immediate vicinity of the proposed Project (i.e., adjacent to the existing Packery Channel and the historical outlet to the Gulf of Mexico) were determined by field observations in combination with 1995 U.S. Geological Survey (USGS) Digital Ortho Quarter Quadrangle (DOQQ). Sections 3.4.2 through 3.4.5 provide brief descriptions of the various coastal habitats found within the study area. Generalized maps of the habitats (derived from land use/land cover data) for the entire Project area are shown in figures 3.4-1a through 3.4-1c. The distribution of habitats in the immediate vicinity of the proposed Project are shown in figures 3.4-2a through 3.4-2e.



Land Use Land Coverage

- Bottomland/Riparian forest
- Developed land
- Estuarine marsh
- Estuarine shrubland
- Levees/Spoils
- Marine/Estuarine shore sand
- Nonsaline marsh
- Nonsaline mud/organic flats
- Open water
- Saline mud/organic flats
- Salt prairie
- Unvegetated nonsaline land
- Upland grassland
- Vegetated salt flats

National Parks

- Padre Island

State Parks

- Mustang Island
- Study Area
- Submerged Aquatic Vegetation
- County Line
- Roads
- Mollie Beattie Habitat Community

Sources: Land Use Land Cover-Rice University, Energy and Environmental Systems Institute, no date;
Texas Parks and Wildlife, 1997.
Natinal Parks-Department of the Interior, National Park Service, 1993.
State Parks-Texas Parks and Wildlife Department, 1997.
Submerged Aquatic Vegetation-Texas Parks and Wildlife Department, 1994.

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Figure 3.4-1a
Special Aquatic Habitats

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Job No.: 440561 | Scale: 1:75000

Prepared by: M Qualls | Date: 02-05-01

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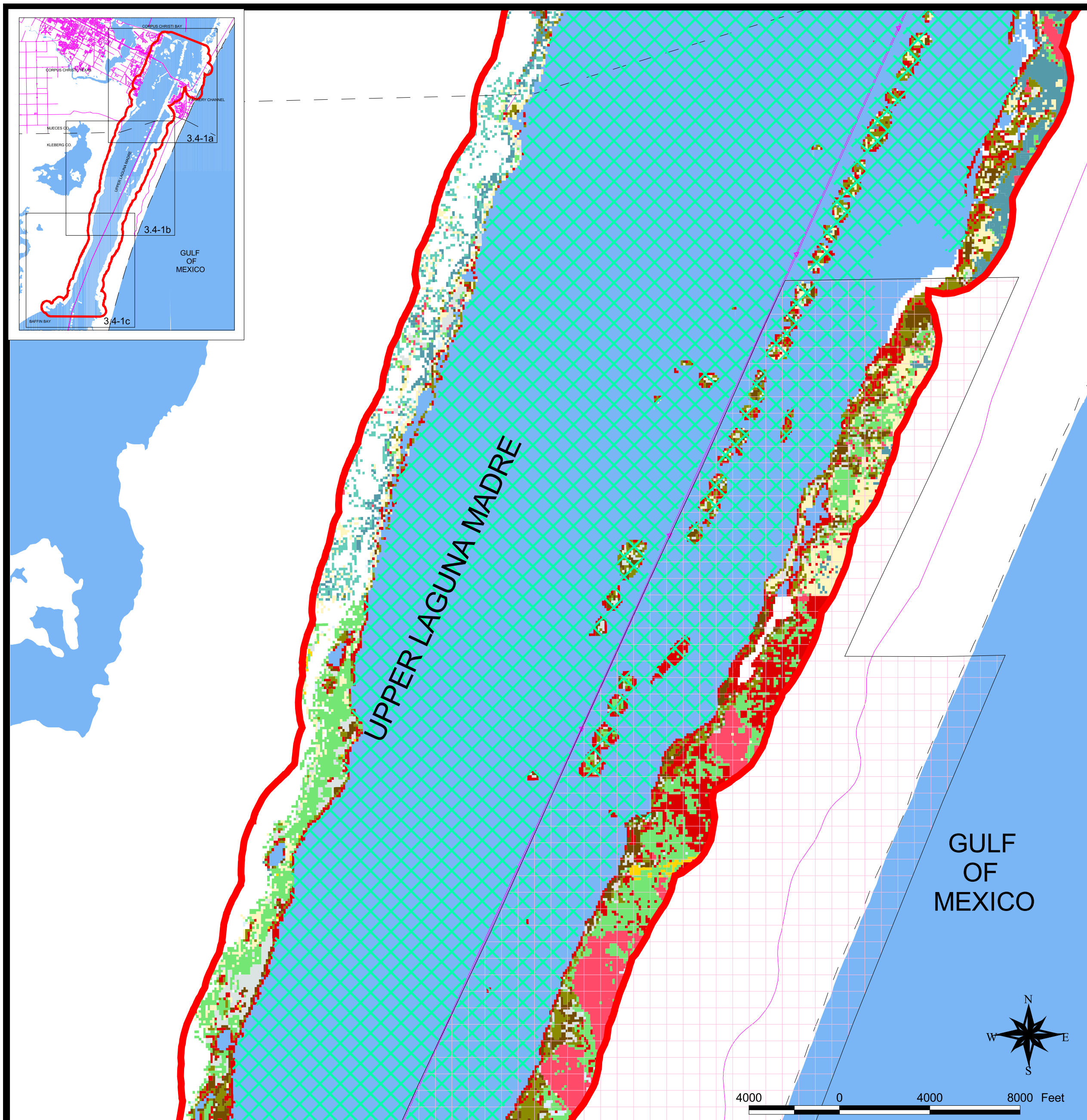

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Figure 3.4-1b
Special Aquatic Habitats

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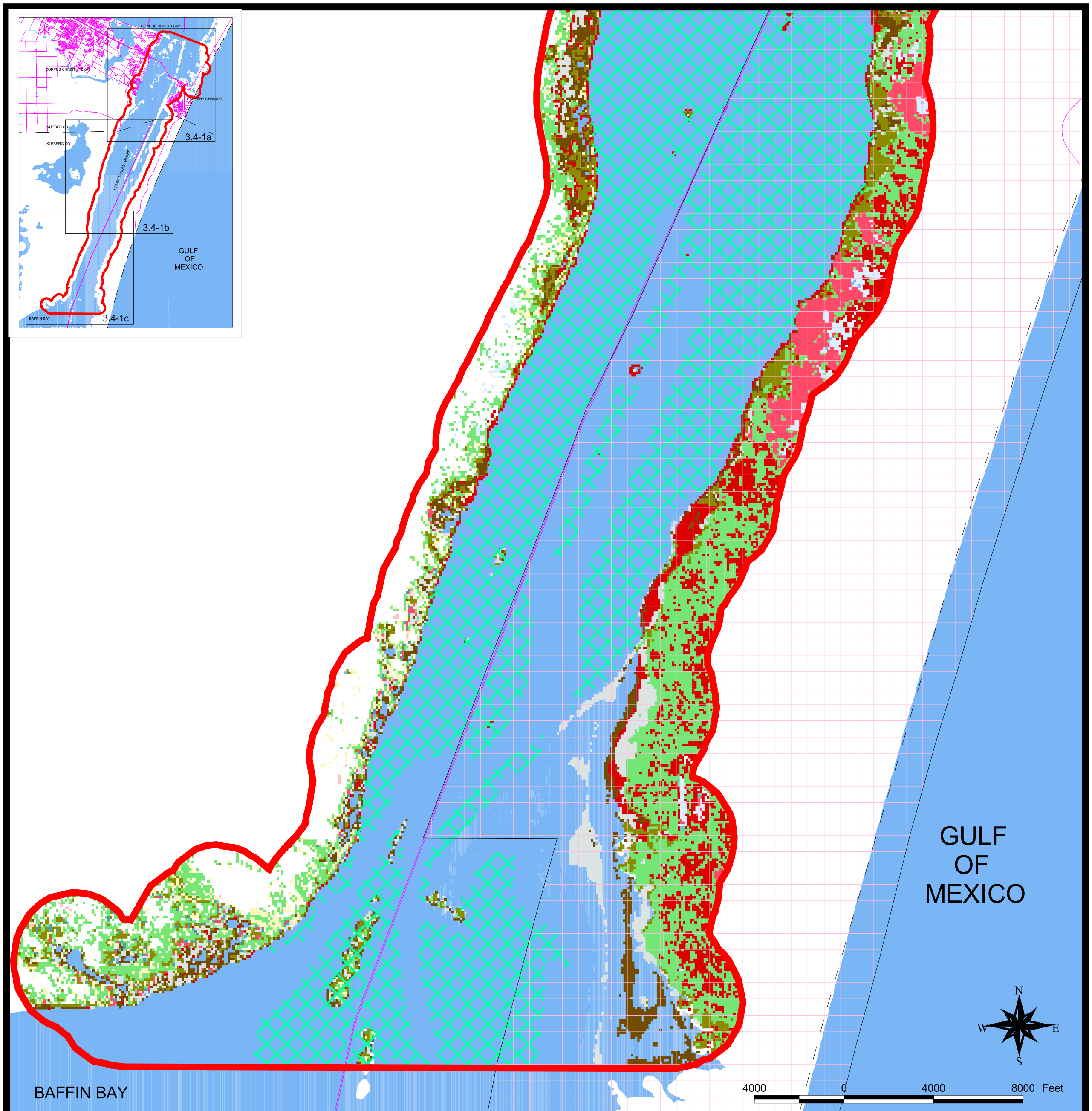

Land Use Land Coverage
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National Parks
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State Parks
- Mustang Island
- Study Area
- Submerged Aquatic Vegetation
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- Roads
- Mollie Beattie Habitat Community

Sources: Land Use Land Cover-Rice University, Energy and Environmental Systems Institute, no date; Texas Parks and Wildlife, 1997.
Natinal Parks-Department of the Interior, National Park Service, 1993.
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Submerged Aquatic Vegetation-Texas Parks and Wildlife Department, 1994.

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Figure 3.4-1c
Special Aquatic Habitats

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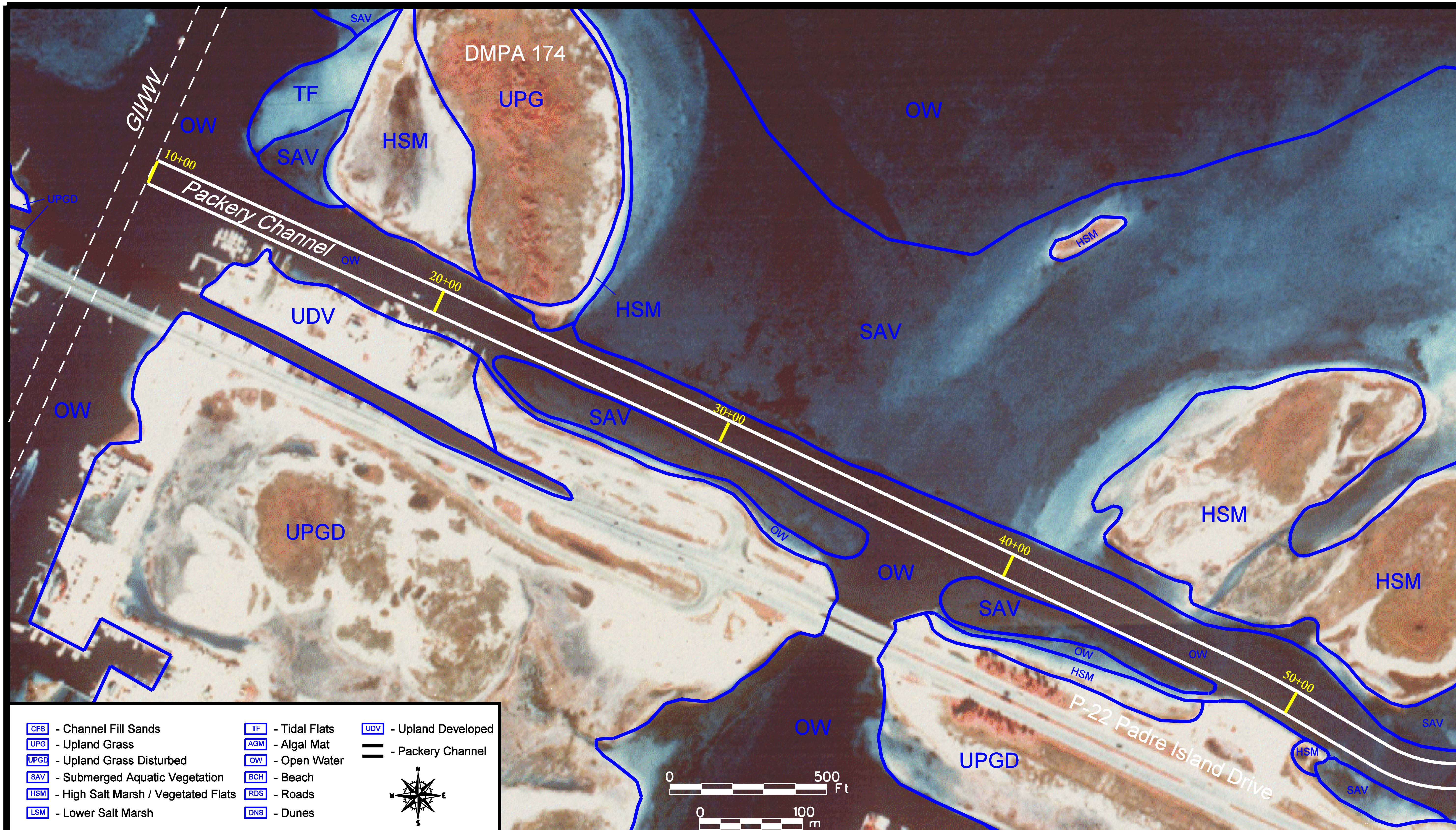

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Figure 3.4-2a
Proposed Packery Channel
Coastal Communites

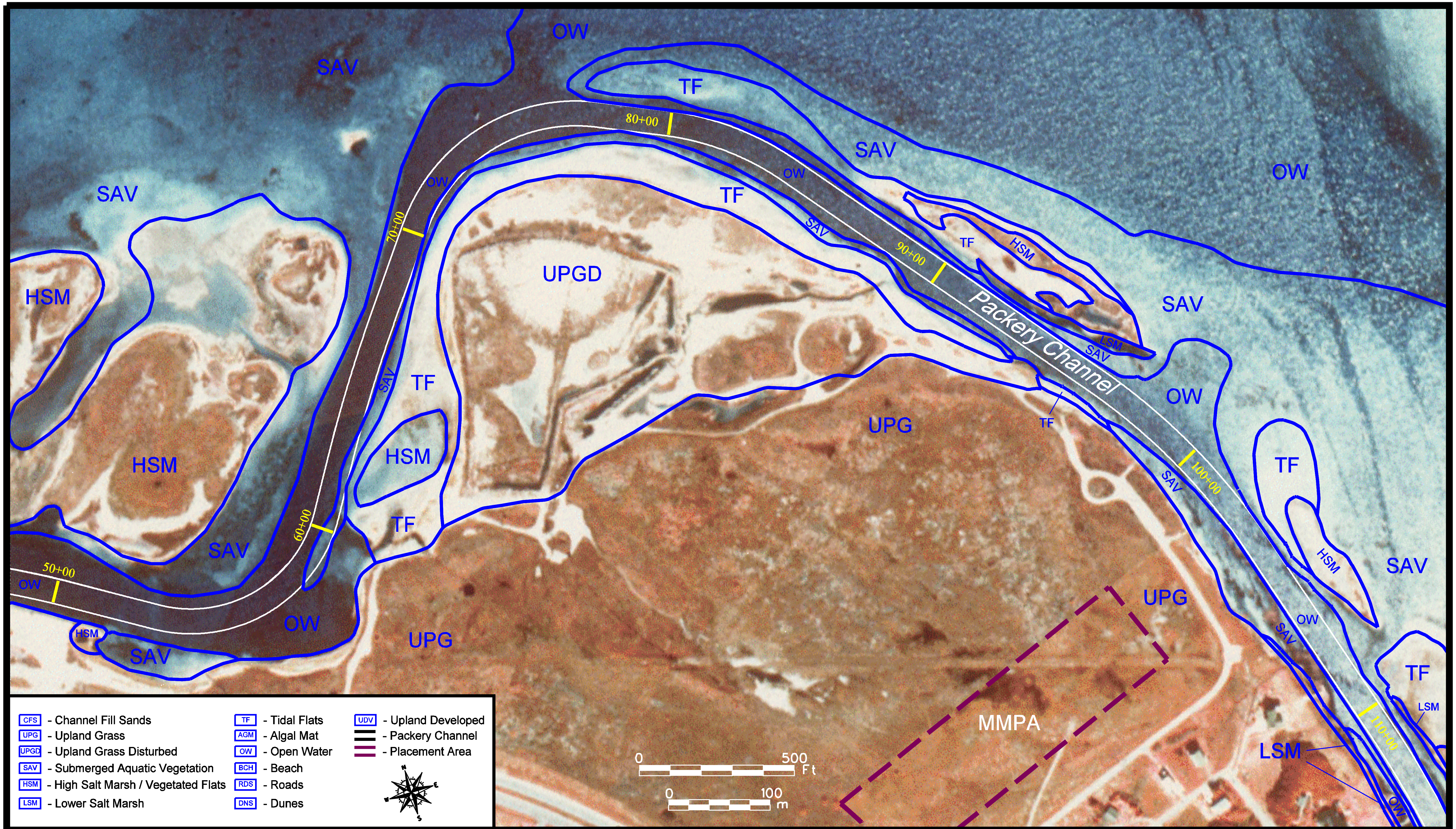

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Figure 3.4-2b
Proposed Packery Channel
Coastal Communities

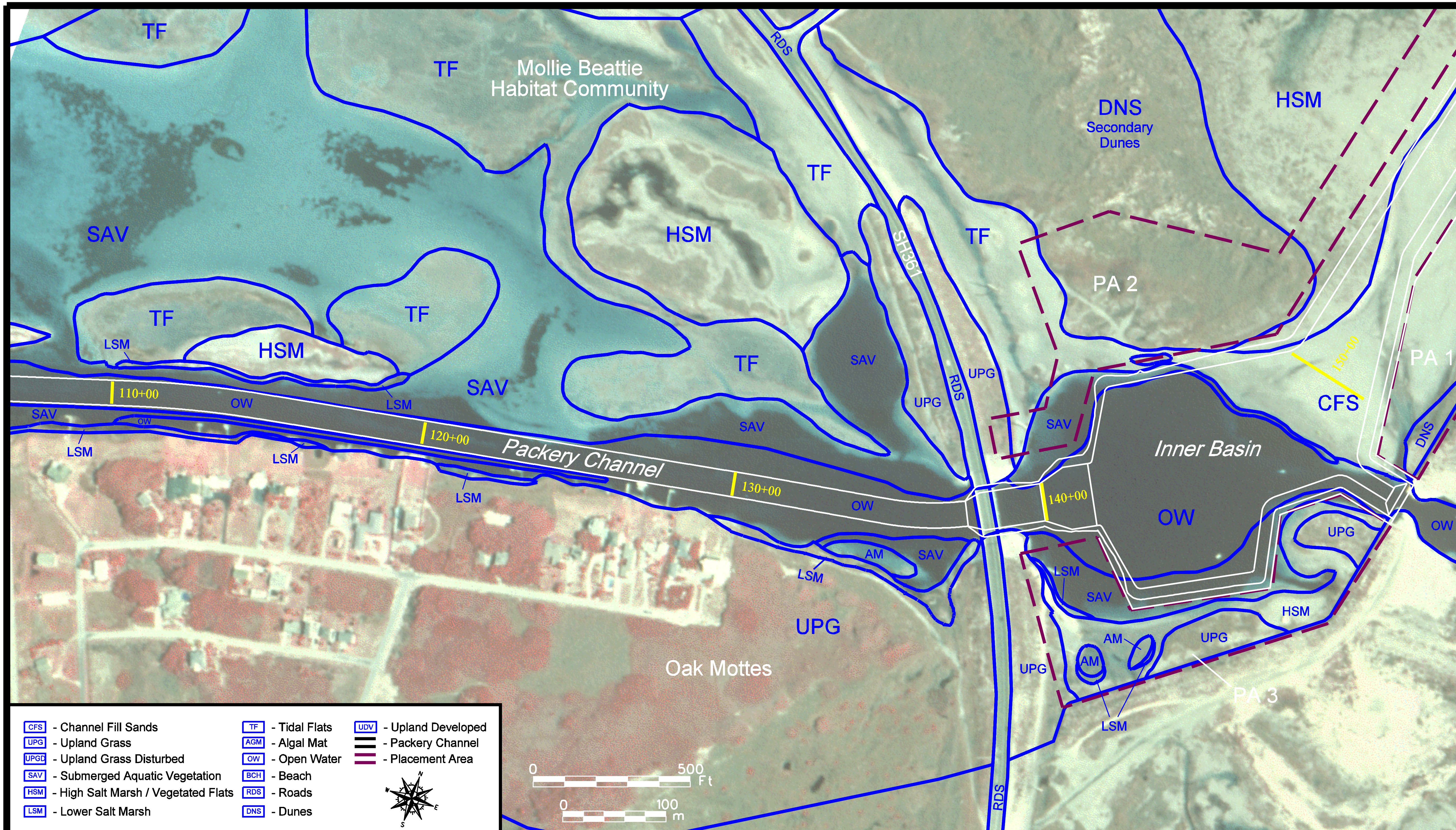

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Figure 3.4-2c
Proposed Packery Channel
Coastal Communities

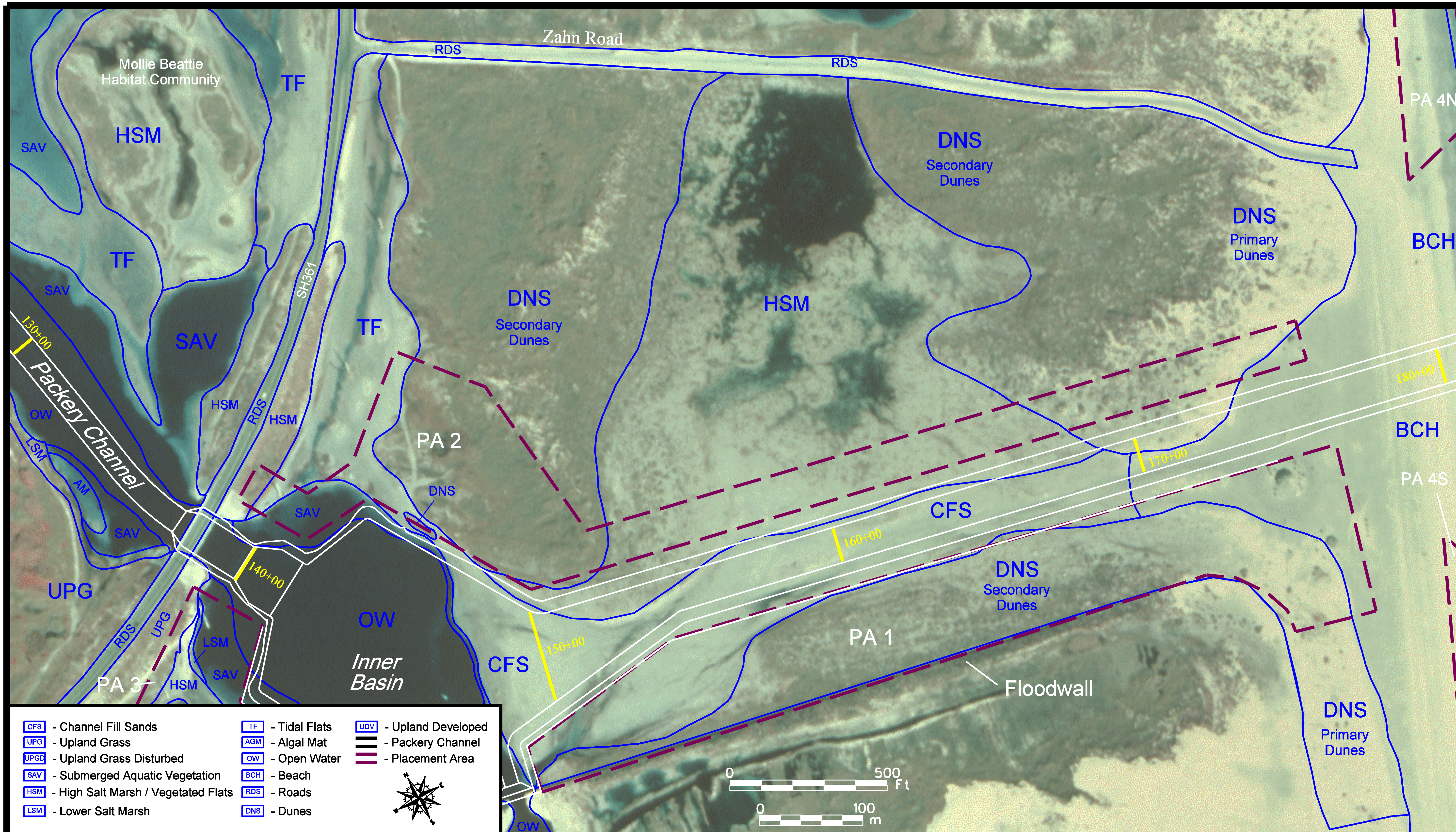

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Figure 3.4-2d
Proposed Packery Channel
Coastal Communities

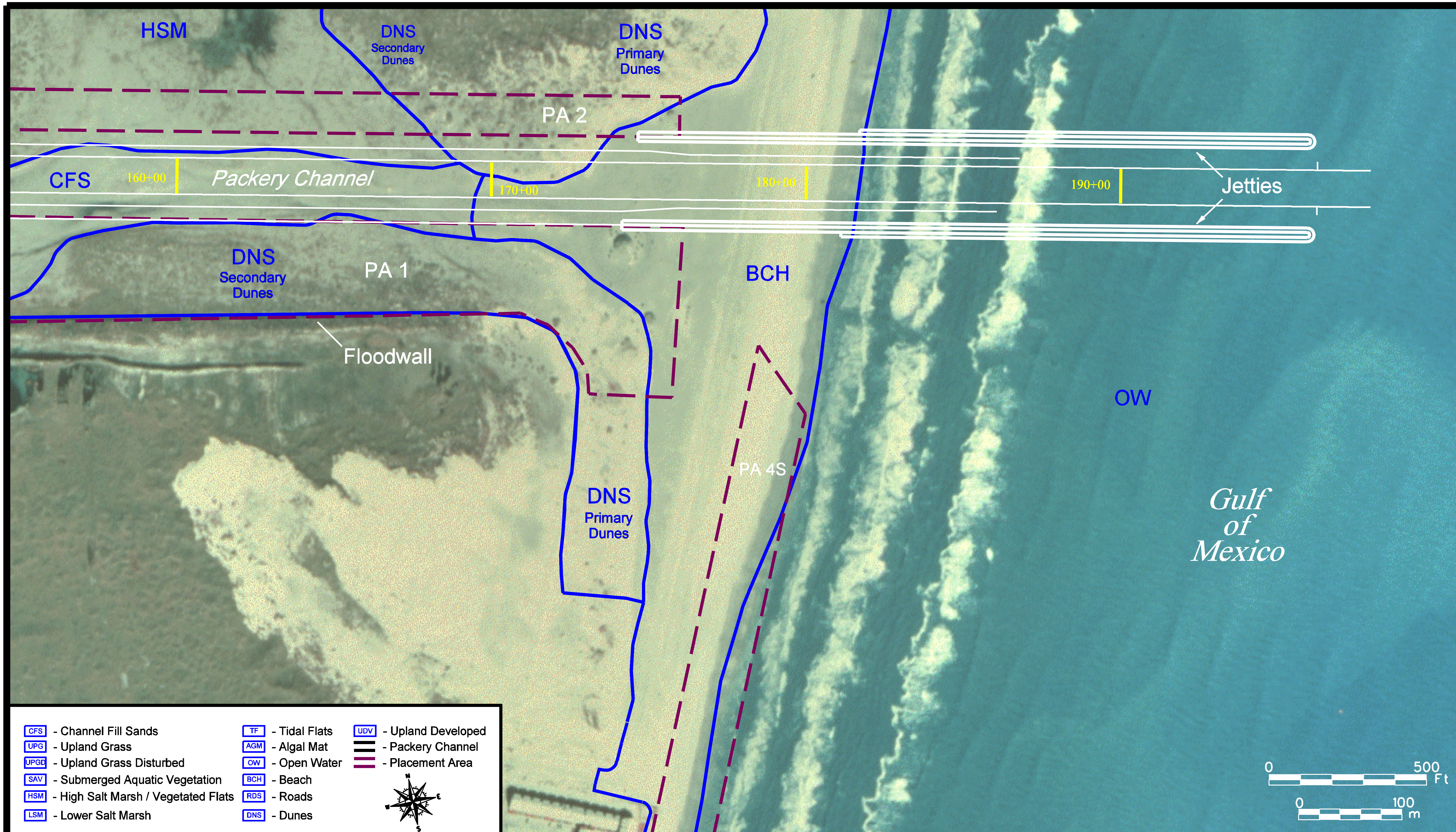

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Figure 3.4-2e
Proposed Packery Channel
Coastal Communities

3.4.1 Mollie Beattie Habitat Community

The Mollie Beattie Habitat Community (MBHC), a State-Federal cooperative preserve on State-owned land, is located in the immediate area of the proposed Project, north of the existing Packery Channel and west of SH 361. MBHC covers approximately 1,000 acres of high and low salt marshes, seagrass beds, coastal prairies, and tidal flats which serve as valuable habitat for a variety of shorebirds, including the threatened piping plover (*Charadrius melodius*), wadingbirds, and other species (GLO and FWS, 1998). Tidal flats and seagrass beds predominate the landscape.

Approximately 200 acres of seagrass beds (primarily the shoalgrass *Halodule wrightii*) are located within the MBHC, along with approximately 515 acres of tidal flats, including algal flats, and approximately 300 acres of salt marsh and islands of coastal prairies (GLO and FWS, 1998). This preserve provides recreational resources for bird watching, as MBHC is best known for the shorebirds and wading birds that inhabit it. Other human use activities at the MBHC include fishing and crabbing, waterfowl hunting in the vicinity, and scientific studies (GLO and FWS, 1998).

The goals of the MBHC Management Plan include the protection of listed species and their habitats from both direct and indirect impacts and educational outreach to ensure a greater public awareness of the importance of this habitat community. The GLO is responsible for coordinating the management plan goals and objectives while involving the management plan team (FWS, TPWD, Texas Audubon Society, Mustang Island State Park) and others in implementation of these goals.

3.4.2 Submerged Aquatic Vegetation (Seagrass)

Submerged Aquatic Vegetation (SAV) includes all rooted, vascular plant species that grow in water but are not emergent. In the study area, SAV includes the true seagrasses such as shoalgrass, turtlegrass (*Thalassia testudinum*), manateegrass (*Syringodium filiforme*), and clovergrass (*Halophila engelmannia*); it also includes widgeongrass (*Ruppia maritima*) which is not considered a true seagrass because it grows in freshwater environments as well. SAV meadows occur in shallow marine and estuarine waters (<4.6 feet). In the study area, they occur both as narrow bands along bay and channel margins and as extensive beds in broad shallow, relatively low energy areas in bays and lagoons (Tunnell et al., 1996). Seagrass communities generate high primary productivity and provide refuge for numerous species including shrimp, fish, crabs and their prey. Animal abundances in seagrass beds can be 2 to 25 times greater than in adjacent unvegetated areas (Pulich, 1998). All five species listed above are found within the Upper Laguna Madre and Corpus Christi Bay, with shoalgrass most abundant (Pulich, 1998).

The shallow depth of the Laguna Madre coupled with the nutrient and suspended particle concentrations of the system provide for extensive coverage of seagrasses (Pulich, 1980). Figures 3.4-1a through 3.4-1c depict seagrass coverages for the defined study area as reported by the GLO (2001). The figures are a compilation of several sources. Approximately 80 percent of seagrass habitat in Texas is located in the Laguna Madre System (165,000 acres); 36,000 acres of which are found in the study area (TPWD, 1995).

Along both sides of Reach 2, narrow bands of shoalgrass (up to 30 feet wide) occur along the channel shallows (PBS&J, 1999a and 2000). Immediately southeast of the SH 361 bridge in the broad shallow water of the Inner Basin, the shoalgrass beds are broader. Figures 3.4-2a through 3.4-2e show the SAV coverage within and adjacent to the proposed Project. These include narrow bands that parallel the existing channel and somewhat broader areas in the Inner Basin.

An analysis of SAV trends conducted by the FWS (Quammen and Onuf, 1993) documents major seagrass changes in the Laguna Madre. This analysis was based on surveys in 1988 and a review of historical data collected by TPWD (McMahan, 1965-1967; Merkord, 1978). The study showed a 66 percent increase in SAV, primarily shoalgrass but also clovergrass and widgeongrass, from 1967 to 1976 and a 29 percent total increase from 1976 to 1988 (Quammen and Onuf, 1993). However, from 1988 to 1994, a 3.8 percent decrease in shoalgrass occurred, most likely due to a persistent brown tide, possibly related to excess nutrient levels caused by anthropogenic sources (Pulich, 1998). Pulich (1998) also reports that some patches of manateegrass have recently become established in the Upper Laguna Madre, and are continuing to spread. Unlike the SAV trends in the Laguna Madre, the acreage of seagrass in Corpus Christi Bay has remained relatively stable since 1958 (Pulich et al., 1997).

Quammen and Onuf (1993) suggested that the shifts in seagrass cover in the Laguna Madre are likely attributable to changes in the salinity regime caused primarily by changes in bay/Gulf interchange via channels (including ship channels and the GIWW), increased turbidity caused by maintenance dredging operations of the GIWW, and eutrophication resulting from nutrient inputs. Other researchers have suggested that the brown tide has played a major role in the alteration of seagrass communities (Buskey et al., 1996; Stockwell, 1993; Barrera et al., 1995; Pulich, 1998). Recently, the USACE funded independent studies of the potential impacts of unconfined open-bay disposal of dredged material from the GIWW on seagrass beds in the Laguna Madre (Teeter, 2000; Burd and Dunton, 2001). Although not directly relevant to the proposed Project that has no placement of dredged material in bay waters, the studies did indicate that short-term elevations in total suspended solids (TSS; i.e, measure of turbidity and relative water clarity/light availability) should not impact SAV survival or productivity.

3.4.3 Coastal Wetlands

The coastal wetlands of the Upper Laguna Madre and Corpus Christi Bay play an important part in sustaining the health and abundance of life within these ecosystems. Coastal wetlands are distinct areas between terrestrial and aquatic systems where the water table is at or near the surface, or the land is covered by shallow water with emergent vegetation. They are important natural resources that provide important habitat for fish, shellfish, and other wildlife (Tunnell, 2002). Coastal estuarine wetlands also serve to filter and process agricultural and urban runoff and buffer coastal areas against storm and wave damage (White and Paine, 1992). The broad, level, coastal lowlands often support landscape mosaics of several community types that intergrade. These communities include low and high salt and brackish marshes, salt prairies, vegetated and nonvegetated flats. There are approximately 4,600 acres (approximately 6 percent) of estuarine wetlands in the Project area (TPWD, 1995). The wetlands and upland habitats in the area immediate to the proposed Packery Channel alignment are shown on figures 3.4-2a through 3.4-2e.

3.4.3.1 Estuarine Marshes

The terms “low” and “high” in reference to marshes indicates wetter (low) and drier (high) soil conditions in these plant communities. This generally correlates to slope position or relative elevation, i.e., the high salt marsh is upslope from the adjacent low salt marsh. The low salt marsh corresponds to the Smooth Cordgrass Series, Saltgrass-Cordgrass Series, and the high salt marsh corresponds to the Glasswort-Saltwort Series as described by the Texas Natural Heritage Program (TNHP, 1993). The Smooth Cordgrass Series (*Spartina alterniflora*) is restricted to areas along the coast that are subject to daily tidal inundation. Associated species may include black rush (*Juncus romerianus*), saltgrass (*Distichlis spicata*), big cordgrass (*Spartina cynosuroides*) and marshhay cordgrass (*Spartina patens*). In contrast to the upper Texas coast, there is only a small percentage of smooth cordgrass (*Spartina alterniflora*) associated with the low salt marshes of the Laguna Madre and the Coastal Bend. The more common plant species include saltwort (*Batis maritima*), seashore saltgrass (*Distichlis spicata*), and seashore dropseed (*Sporobolus virginicus*). The Saltgrass-Cordgrass Series (*Distichlis spicata-Spartina* spp.) is a salt or brackish marsh community that forms along the Gulf Coast. It can form nearly pure stands, but smooth cordgrass, marshhay, *Paspalum* spp., *Sporobolus* spp., and lovegrass (*Eragrostis* sp.) may be present. High salt marsh corresponds to the TNHP Glasswort-Saltwort Series (*Salicornia* spp.- *Batis maritima*). This plant community forms on alternately wet and dry saline soils, commonly on wind tidal flats. Associated species include shoregrass (*Monanthochloe littoralis*), camphor daisy (*Machaeranthera phyllocephala*), bushy sea ox-eye (*Borrichia frutescens*), seepweed (*Suaeda* spp.), sea purslane (*Sesuvium portulacastrum*), and seashore dropseed.

Salt prairie is a common term for the Gulf Cordgrass Series (*Spartina spartinae*), a transitional area including wetlands and nonwetlands (TNHP, 1993). Salinity also varies and species composition may include sedges (*Carex* spp.), flatsedges (*Cyperus* spp.), switchgrass (*Panicum virgatum*), and bushy bluestem (*Andropogon glomeratus*). It generally occurs between the upland grasslands and the coastal marshes (Diamond and Smeins, 1984).

Estuarine marshes, specifically low and high salt marshes, occur along the shorelines adjacent to Packery Channel from the GIWW to the Inner Basin, just east of SH 361. Some of these areas include the USACE Dredged Material Placement Area (DMPA) 174 (adjacent to the GIWW, north of Packery Channel, approximately from Stations 10+00 to 25+00), Packery Point Park (southern shoreline of the channel, approximately from Stations 60+00 to 110+00), and MBHC (northern shoreline of channel, approximately from Stations 80+00 to 139+00).

3.4.3.2 Tidal Flats (Including Algal Flats)

Tidal flats include unvegetated to sparsely vegetated (less than 30 percent areal coverage) coastal wetlands that are periodically flooded by tidal waters. This category includes sandbars, mud flats, and other nonvegetated or sparsely vegetated habitats called salt flats. Sparse vegetation of salt flats may include glassworts (*Salicornia* spp.), saltwort, and shoregrass. Tidal flats serve as valuable feeding grounds for coastal shorebirds, including the threatened piping plover; fish; and invertebrates. Many of the tidal flats in the study area are wind tidal flats meaning that they are exposed primarily by wind and storm tides as opposed to daily tides. These areas are generally hypersaline, which prevents or restricts macrophytic vegetation, although blue-green algal mats may form in these areas. Hedgpeth (1967) reported that algal flats in the Laguna Madre are covered with algal mat communities consisting mostly of the blue-green algae *Lyngbya confervoides*. There are approximately 4,000 acres (approximately 5 percent) of tidal flats in the study area (TPWD, 1995).

3.4.3.3 Estuarine Scrub-Shrub Wetlands

The estuarine intertidal scrub-shrub category describes coastal wetlands dominated by woody vegetation and periodically flooded by tidal waters. Examples of estuarine intertidal scrub-shrub species in the study area include the black mangrove (*Avicennia germinans*) and big leaf sumpweed (*Iva frutescens*). Bushy sea ox-eye is a woody species and commonly considered scrub-shrub species; however, it is frequently a co-dominant species in high salt marsh and for the purposes of this report is described above with the marshes. There are no scrub-shrub wetlands in the immediate area of the proposed Project although there are a very few scattered black mangroves along the shoreline between Stations 115+00 and 125+00.

3.4.3.4 Freshwater Marshes

Freshwater marshes generally occur at inland sites or in isolated depressions on the barrier islands, but may occur within estuaries if rainfall or river flow is sufficient to prevent regular salt water intrusion. Common plants in this habitat type include rushes (*Juncus* spp.), sedges, cattails (*Typha* spp.), and common reed (*Phragmites australis*). Freshwater marshes at lower elevations are generally dominated by obligate wetlands species while marshes at higher elevations, also known as wetland prairies, may be dominated by facultative wetland species, i.e., those species that are as likely to occur in wetlands as nonwetlands. No freshwater marshes occur in the immediate area of the proposed Project.

3.4.4 Open Water/Reef Habitat

Open-water areas in the study area that support communities of benthic organisms and corresponding fisheries populations include the Upper Laguna Madre, Corpus Christi Bay, and Gulf of Mexico. Approximately 52,000 acres (approximately 70 percent) of open-water habitat exists in the study area (TPWD, 1995).

According to the Corpus Christi Bay National Estuary Program Center for Coastal Studies (CCBNEP) (1996), no living reefs of the eastern oyster (*Crassostrea virginica*) have been reported in the Upper Laguna Madre, although FWS (1997b) notes that "oysters historically thrived in the washover pass areas at the southern end of the Mustang Island when Packery Pass and nearby passes were open, but became scarce in the high Laguna Madre salinities that prevailed when the passes closed." A second type of reef environment present in the Laguna Madre is the serpulid reef. Serpulid worms are polychaetes (segmented marine worms) that build calcareous tubes that are attached to hard substrates or other tubes. Serpulid reefs provide habitat for numerous species of crustaceans, mollusks, and polychaetes. The nearest serpulid reefs are located across the mouth of Baffin Bay (LW&A, 1998), approximately 24 miles south from Packery Channel. Although a few living individuals of reef-building serpulid worms (*Hydroides dianthus*) occur in Baffin Bay and the Upper Laguna Madre near Baffin Bay, the reefs are no longer actively being built, but are remnants of a previous less saline environment (Tunnell, 2002; White et al., 1989).

3.4.5 Coastal Shore Areas/Beaches/Sand Dunes (including Channel Fill Sands)

The coastal shore areas function primarily as buffers protecting upland habitats from erosion and storm damage, and adjacent marshes and waterways from water-quality problems. The coastal barrier, critical erosion lines, dune protection lines, and washover areas are depicted on figures 3.4-1a through 3.4-1c. A variety of birds occur on coastal shores of the Laguna Madre; cranes, rails, coots, gallinules, and other groups can be found on the shorelines and in fringing marshes of the study area.

Beaches along the south Texas and Coastal Bend coastline are dynamic habitats subject to a variety of environmental influences, such as wind and wave action, salt spray, high temperature, and moisture stress. The harsh conditions associated with the beach/dune system support a relatively small number of adapted animals and plants. Sand dunes help absorb the impacts of storm surges and high waves and also serve to slow the intrusion of water inland. In addition, dunes store sand that helps deter shoreline erosion and replenish eroded beaches after storms. The dune complexes are of two types, primary and secondary, which support two plant communities. The primary dunes, located immediately landward of the beach, are taller and offer more protection from wind and hurricane storm surge than the secondary dunes, which are landward of the primary dunes, and are shorter and more densely vegetated. On the barrier islands of the Texas Coastal Bend, typical plant species of the primary dunes include sea oats (*Uniola paniculata*), bitter panicum (*Panicum amarum*), Gulf croton (*Croton punctatus*), beach morning glory (*Ipomea pes-caprae* var. *emarginata*) and fiddleleaf morning glory (*Ipomea stolonifera*). Secondary dune species include marshhay cordgrass (*Spartina patens*), seashore dropseed, seashore saltgrass, pennywort (*Hydrocotyle bonariensis*) and partridge pea (*Chamaecrista fasciculata*).

Prior to the dredging of the Corpus Christi Ship Channel (CCSC) in the 1920s, Packery Channel was a natural pass between the Gulf of Mexico and Corpus Christi Bay, although not with the proposed configuration. After the ship channel was completed, the pass shoaled in and is currently an upland remnant of the tidal channel. Periodically, the channel is temporarily reopened by storm events. This area is referred to as Channel Fill Sands in this study. Vehicles use this area to access the Inner Basin from the beach.

The littoral drift along Mustang Island is from north to south. The beach within the study area, like other Texas beaches, experiences erosion due to littoral drift and lack of replacement sand supplied by rivers. South of the proposed channel cut to the Gulf there is a narrow beach (approximately 100 feet) directly in front of the seawall. In the undeveloped area north of the proposed pass, the beach and dune complex is better developed.

3.4.6 Upland Grasslands

Virtually all of the original coastal prairie community in Texas has been converted to agricultural and development uses. Undeveloped upland grasslands usually have a mix of the original prairie species and introduced pasture species as well as various forbs and occasional shrubs such as honey mesquite (*Prosopis glandulosa*), eastern baccharis (*Baccharis halimifolia*) and southern wax-myrtle (*Myrica cerifera*). Hatch et al. (1990) list common species as follows: little bluestem (*Schizachyrium scoparium*), coastal bluestem (*S. scoparium* var. *littoralis*), yellow Indiangrass (*Sorgastrum nutans*), eastern gammagrass (*Tripsacum dactyloides*), hairy awn muhly (*Muhlenbergia capillaris*), Texas wintergrass (*Stipa leucotricha*), panicgrasses (*Panicum* spp.), several *Paspalum* species, broomsedge bluestem (*Andropogon virginicus*), smutgrass (*Sporobolus indicus*), threeawn grasses (*Aristida* spp.), yankeeweed (*Eupatorium compositifolium*), western ragweed (*Ambrosia cumanensis*), prickly pear (*Opuntia* spp.), several *Aster* species, Texas paintbrush (*Castilleja indivisa*), poppy mallows (*Callirhoe* spp.), phlox (*Phlox* spp.), bluebonnets (*Lupinus* spp.) and evening primrose (*Oenothera* spp.).

West of SH 361, upland grasslands are generally only on the south side of the channel. East of SH 361, both sides of the channel support dune complexes that are technically upland grassland, but have a unique community, described in Section 3.4.4 as part of Coastal Shore Areas.

3.5 FISH AND WILDLIFE RESOURCES

3.5.1 Finfish and Shellfish Resources

The study area includes the Upper Laguna Madre along with a portion of Gulf of Mexico shore waters on the eastern side of Padre Island. Within the Laguna Madre environmental fluctuations are reflected by the inhabitant biota that reflect this lack of stability in the environment (Warshaw, 1975). Large changes in habitat occur on a daily basis with respect to wind, tidal action, salinity regimes, and occasionally freshwater inflow. These ongoing natural processes, coupled with natural events such as freezes, droughts, hurricanes, and anthropogenic pressures (i.e., management practices and coastal projects), all contribute pressure on the Laguna Madre ecosystem. Nevertheless, the biological community present in the Laguna Madre remains diverse and abundant. Breuer (1962) compiled an annotated list of fauna of the Lower Laguna Madre which included 104 invertebrate species and 80 fish species. More recently, Tunnell et al. (1996) reports 234 fish species within the CCBNEP study area which includes the Corpus Christi Bay and the Upper Laguna Madre. As reported by Tunnell and Alvarado (1996) for the CCBNEP, a total of 89 fish species representing 42 families are found within the Baffin Bay/Upper Laguna Madre ecosystem. In addition, Sheridan (1998) reported a diverse community of fish and decapods present along six PAs (three each in the Upper and Lower Laguna Madre). In that evaluation, 79 taxa comprising 20,636 individuals were collected. The Gulf beach fish community includes many species found in both estuarine and offshore oceanic habitats (Tunnell et al., 1996). Most of the species in the Gulf nearshore waters are temperate in biogeographic distribution with a few tropical species (Tunnell et al., 1996). The most common finfish species found within the Project area include Gulf menhaden (*Brevoortia patronus*), bay anchovy (*Anchoa mitchilli*), hardhead catfish (*Arius felis*), sheepshead (*Archosargus probatocephalus*), pinfish (*Lagodon rhomboides*), silver perch (*Bairdiella chrysoura*), sand seatrout (*Cynoscion arenarius*), spotted sea trout (*Cynoscion nebulosus*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), stripped mullet (*Mugil cephalus*), Gulf flounder (*Paralichthys albigutta*) and southern flounder (*Paralichthys lethostigma*). Of the shellfish species, the most common found are brown shrimp (*Farfantepenaeus aztecus*), pink shrimp (*Farfantepenaeus duorarum*), white shrimp (*Litopenaeus setiferus*), and blue crab (*Callinectes sapidus*).

The above-mentioned environmental factors add pressure to the ecosystem, yet these same natural processes and events increase the diversity and abundance of organisms in the Laguna Madre ecosystem. The high energy flow in the Laguna Madre, attributed in part to the shallow water depth with respect to a large surface area, results in high phytoplankton primary production (Tunnell et al., 1996). Higher salinities and reduced levels of nutrients also play major roles in increasing the ecological efficiency. This high ecological efficiency found in the Laguna Madre results in high abundances of the higher level consumers, such as benthic mollusks and fishes (Tunnell et al., 1996).

A second factor regarding the diversity and abundance of organisms is past and present management strategies. As reported in CCBNEP-06C (CCS, 1996), "Management strategies are affected by estimated population densities, biology of target organisms, habitat quality, fishing technology, consumer demand, economic value, and special interest group demands." The competing forces of recreational and commercial fishing have led to increased management activities along the Texas coast, including the elimination of gillnets in Texas bays and designation of red drum (*Sciaenops ocellatus*) and spotted seatrout as "game species" (CCS, 1996). The opening of inlets to the Laguna Madre (i.e., the GIWW) has also played a role in the biological productivity in lowering salinity concentrations and providing means for ingress/egress of aquatic organisms, including anadromous species such as red drum and spotted seatrout (Tunnell et al., 1996).

An Environmental Benefits Determination was presented in the PSP for Packery Channel, FS Phase, Version 3 (USACE, 1999) in order to expand upon and update existing information for the Upper Laguna Madre and Corpus Christi Bay. The study included a literature search and data review, information gathering sessions with various agencies (TPWD, FWS, TNRCC, Texas Water Development Board (TWDB), GLO, National Marine Fisheries Service (NMFS), USGS, USACE, Coastal Bend Bays Foundation (CBBF), and county representatives), and interviews. The methodology, results, and discussions are provided in the PSP.

3.5.1.1 Recreational and Commercial Species

The principal finfish harvested by sport-boat anglers in Texas bays and passes from 1982 to 1992 were spotted seatrout, sand seatrout, Atlantic croaker, red drum, southern flounder, black drum (*Pogonias cromis*), and sheepshead (Warren et al., 1994). The Upper Laguna Madre was responsible for 11 percent of coastwide fishing pressure and 7 percent of landings from 1983 to 1992 (Warren et al., 1994). Private anglers fishing offshore near Port Corpus Christi accounted for 25 percent of the landings and 54 percent of the fishing pressure (1982-1992) with sand seatrout, king mackerel (*Scomberomorus cavalla*), and red snapper (*Lutjanus campechanus*) the most commonly landed finfish (Warren et al., 1994). Recreational boat landings since 1974 for all finfish have shown a decline which may be due to shifts in effort (i.e., fewer recreational boats available for fishing) and regulations being put into effect that dictate size, bag and possession limits on certain fish species in order to prevent depletion (Warren et al., 1994).

The most important commercial finfish species currently reported from the Laguna Madre are black drum, flounder (*Paralichthyes* spp.), sheepshead, and striped mullet (Robinson et al., 1998). Leading Gulf catches for commercial finfish include snapper, black drum, and flounder (Robinson et al., 1998). In 1995, commercial black drum landings increased to record highs in the Upper Laguna Madre (Fuls and McEachron, 1997). Overall, from 1972 to 1997, black drum, flounder and sheepshead landings have declined in the Laguna Madre. Striped mullet, in the Lower Laguna Madre, is the only species of the main four that has shown increased landings (Robinson et al., 1998). However, during the last 5 years of the study (1993-1997), 58 percent of the finfish in Texas bays were landed in the Laguna Madre (Upper=37%, Lower=21%) (Robinson et al., 1998).

The main shellfish species occurring in the Laguna Madre and Gulf shore include brown shrimp, pink shrimp, white shrimp, blue crab, and eastern oyster. Within the Laguna Madre, as with the Texas coast in general, brown shrimp are far more common than the other two shrimp species. In general, the Laguna Madre does not support a significant commercial shellfish industry. TPWD reports that from 1993 to 1997, only 1 percent or less of the total Texas coastal landings for brown, white, and pink shrimp or blue crab occurred in the Laguna Madre (Robinson et al., 1998). Since 1972, the landings for shellfish in the Laguna Madre have been varied but are typically quite limited. No live eastern oyster reefs occur in this area, but did historically (FWS, 1997b).

3.5.1.2 Aquatic Communities

In addition to the finfish discussed above as having high recreational and commercial value to humans, there are many additional aquatic communities present in the Laguna Madre that serve to support the ecological diversity and abundance. The sheepshead minnow (*Cyprinodon variegatus*), which feeds on blue-green algae is one of relatively few species occurring on the previously described mud/algal flats (Warshaw, 1975). Warshaw (1975) adds that other species found mainly in shallow areas, though not confined to the tidal flats, include the longnose killifish (*Fundulus similis*), Gulf killifish (*Fundulus grandis*), and tidewater silverside (*Menidia peninsulae*). Inhabitants of seagrass meadows include the pinfish, silver perch (*Bairdiella chrysura*), sheepshead, and pigfish (*Orthopristis chrysoptera*) (Warshaw, 1975). Species often found in deeper waters, including the GIWW, are the Atlantic croaker, Gulf menhaden, and hardhead catfish, while a number of fish occurring in abundance in both seagrass meadows and deeper areas are such species as the bay anchovy, spot, and striped mullet (Warshaw, 1975). A study by Shaver (1984) of surf-zone fish revealed that almost 90 percent of species sampled were larvae and small juveniles of a few species, including sardine (*Harengula jaguana*), Atlantic croaker, anchovy, Atlantic thread herring (*Opisthonema oglinum*), Florida pompano (*Trachinotus carolinus*), mullet, and Gulf menhaden.

The entire food chain is dependent on the microscopic plankton which utilizes nutrients and provides an abundant food source. The plankton community consists of small plants (phytoplankton) and animals (zooplankton) that are suspended in the water column. Diverse and abundant plankton communities exist throughout the Laguna Madre and offshore to nearshore. Abundance has been correlated with salinity and temperature as well as seasonal patterns for both phyto- and zooplankton (Tunnell et al., 1996).

The benthic macroinvertebrates of the Laguna Madre form a highly diverse group of organisms with a wide variety of functions in the aquatic community. In addition to serving as a major food source for vertebrate predators, such as fish, macroinvertebrates have important roles as herbivores, detritivores, and carnivores. Calnan et al. (1986) reported that benthic macroinvertebrates found in the sediments of the Lower Laguna Madre were primarily polychaetes, bivalves, gastropods, and crustaceans. The distributions of the macroinvertebrates were found to be related to bathymetry and sediment type (Calnan et al., 1986).

Benthic fauna found in natural sand-mud bottom areas offshore from Corpus Christi, near the CCSC ocean dredged material disposal site, include polychaetes, gastropods, decapods, bivalves, echinoderms, ribbon worms (*Rhynchocoela*) and peanut worms (*Sipuncula*) (EPA, 1988). Science Applications (1984) reported on 1983 EPA findings at the CCSC site and indicated that the sampling locations in natural mixed bottom habitat recorded higher numbers of individuals, taxa, and species diversity in comparison with those found in the primarily sand-bottomed disposal sites.

More recent studies (EH&A, 1998; Sheridan, 1998) have been conducted to evaluate changes in benthic communities in response to open-water placement of dredged material. EH&A (1998) evaluated the benthic macroinfaunal community composition within the Laguna Madre in conjunction with evaluation of environmental impacts of the historic practice of open-water placement of dredged material. The purpose of the study was to characterize the benthic community at two different times of the year in and near PAs in the Upper and Lower Laguna Madre and at reference sites across the GIWW from the selected PAs (EH&A, 1998). A total of 92,649 individuals representing 396 taxa were identified from 178 discrete samples in the spring sampling, and 26,015 individuals representing 308 taxa were identified from 177 discrete samples during the fall sampling event (EH&A, 1998). During both times of the year, polychaetes comprised the majority of individuals and the greatest number of taxa (EH&A, 1998). In the Upper Laguna Madre, a total of 46 taxa of polychaetes were found in the spring sampling and 52 polychaete taxa were found during the fall sampling (EH&A, 1998).

Sheridan (1998) examined the temporal and spatial effects of open-water placement of dredged material on habitat utilization. The objective of the study was to document how long alterations in habitat from maintenance material placement were detectable and to determine the spatial extent of such alterations. Three PAs each in the Upper and Lower Laguna Madre were examined. A diverse community of benthic organisms was revealed with over 220 taxa and 78,145 individuals collected (Sheridan, 1998). Of these, 59 percent were annelids, 34 percent were non-decapod crustaceans, 6 percent were mollusks, and 1 percent comprised miscellaneous taxa (Sheridan, 1998).

3.5.1.3 Essential Fish Habitat

Essential Fish Habitat (EFH) is defined by the Gulf of Mexico Fishery Management Council (GMFMC) as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The proposed Project is located in an area that has been identified by the GMFMC as EFH for adult and juvenile white shrimp, brown shrimp, red drum, Spanish mackerel (*Scomberomorus maculatus*), Gulf stone crab (*Menippe adina*), juvenile pink shrimp and gray snapper (*Lutjanus griseus*). EFH for these species known to occur in the Project area includes estuarine wetlands, estuarine mud and sand substrates, and SAV. Detailed information on red drum, shrimp, and other Federally managed fisheries and their EFH is provided in the 1998 amendment of the Fishery Management Plans for the Gulf of Mexico prepared by the GMFMC. The 1998 EFH amendment was prepared as required by the

Magnuson-Stevens Fishery Conservation and Management Act as amended (MSFCMA) (P.L. 104 – 297).

The following describes the preferred habitat of each species and relative abundance of each species based on information provided by GMFMC (1998).

Juvenile brown shrimp are considered abundant within the Project area from February to April with a minor peak in the fall. The density of postlarvae and juveniles is highest in marsh edge habitat and SAV, followed by tidal creeks, inner marsh, shallow open water and oyster reefs. Juveniles and sub-adults of brown shrimp occur from secondary estuarine channels out to the continental shelf but prefer shallow estuarine areas, particularly the soft, muddy areas associated with the plant-water interface. Adult brown shrimp occur in neritic Gulf waters (i.e., marine waters extending from mean low tide to the edge of the continental shelf) and are associated with silt, muddy sand, and sandy substrates (GMFMC, 1998).

Juvenile white shrimp are considered abundant within the Project area from May through November with peaks in June and September. Postlarval white shrimp become benthic upon reaching the nursery areas of estuaries, where they seek shallow water with muddy-sand bottoms high in organic detritus. As juveniles, white shrimp are typically associated with estuarine mud habitats with large quantities of decaying organic matter or vegetative cover. Densities are usually highest in marsh edges and SAV, followed by marsh ponds and channels, inner marshes, and oyster reefs. As adults, white shrimp move from estuaries to coastal areas, where they are demersal and generally inhabit bottoms of soft mud or silt (GMFMC, 1998).

Postlarvae and juveniles of pink shrimp occur in estuarine waters of wide-ranging salinity (0 to >30 ppt). Juveniles are commonly found in estuarine areas with seagrass where they burrow into the substrate by day and emerge at night. Postlarvae, juveniles, and subadults may prefer coarse sand/shell/mud mixtures. Densities are highest in or near seagrasses, low in mangroves, and near zero or absent in marshes. Adults inhabit offshore marine waters with the highest concentrations in depths of 30 to 150 feet. Preferred substrate of adults is coarse sand and shell with a mixture of less than 1 percent organic material (GMFMC, 1998).

Red drum occur in a variety of habitats, ranging from depths of approximately 130 feet offshore to very shallow estuarine waters. In the juvenile life stages they are considered common within the Project area year-round. They are commonly known to occur in all Gulf estuaries where they are found over a variety of substrates including sand, mud and oyster reefs. An abundance of juvenile red drum has been reported around the perimeter of marshes in estuaries (Perret et al., 1980). Young fish are found in quiet, shallow, protected waters with grassy or slightly muddy bottoms (Simmons and Breuer, 1962). Shallow bay bottoms or oyster reef substrates are especially preferred by subadult and adult red drum (Miles, 1950). Spawning occurs in deeper water near the mouths of bays and inlets and on the Gulf side of the barrier islands (Simmons and Breuer, 1962; Perret, et al, 1980). Larvae are transported into the emergent estuarine wetlands where they mature before moving back to the Gulf.

As juveniles, Spanish mackerel are considered common in relative abundance only during the high salinity season between August and October. Although nursery areas are in emergent estuarine communities, juveniles are found offshore and in beach surf and are generally not considered estuarine dependent. Adult Spanish mackerel are usually found along coastal areas, extending out to the edge of the continental shelf (GMFMC, 1998).

Adult stone crabs burrow under rock ledges, coral heads, dead shell, or grass clumps. In seagrass flats (primarily turtlegrass) and along the sides of tidal channels, they inhabit burrows which may extend 50 inches into the substrate. They occasionally inhabit oyster bars and rock jetties, as well. Juveniles (less than 1.2 inches carapace width) do not dig burrows; they use readily available hiding places that offer close proximity to food items. Juveniles have been reported to be abundant on shell bottom, sponges, and *Sargassum* mats as well as in channels and deep grass flats. After reaching a width of about one-half inch, the crabs live among oyster shells and rocks in shallow parts of estuaries. There are numerous reports of abundant large juveniles-small adults (up to 2.4-inch carapace width) on oyster reefs (GMFMC, 1998).

Larval gray snapper are planktonic, occurring in peak abundance from June through August in offshore shelf waters and near coral reefs. Postlarvae move into estuarine habitat and are found particularly over dense beds of shoalgrass and manateegrass. Juveniles also are marine, estuarine, and riverine, often found in estuaries, channels, bayous, ponds, grassbeds, marshes, mangrove swamps, and freshwater creeks. They appear to prefer turtlegrass flats, marl bottoms, seagrass meadows, and mangrove roots. Adult gray snapper are bottom and mid-water dwellers, occurring in marine, estuarine, and riverine habitats. They occur up to about 20 miles offshore and inshore as far as coastal plain freshwater creeks and rivers. They are found among mangroves, sandy grass beds, and coral reefs and over sandy, muddy and rocky bottoms (GMFMC, 1998).

3.5.2 <u>Wildlife Resources</u>

The study area lies within Blair's (1950) Tamaulipan biotic province. The area is semi-arid and hot, with marked deficiency of moisture for plant growth. The vertebrate fauna of this province includes considerable elements of neotropical as well as grassland species. Wildlife habitats found within the Project area include upland prairies, salt marshes, and tidally influenced lowlands. The coastal wetlands of the Laguna Madre are represented by salt marshes (previously defined in Section 3.4.2) on the bay side of the barrier islands, a large, open hypersaline lagoon, and a narrow belt of mainland salt marshes backed by relatively unspoiled coastal prairie. The Upper Laguna Madre supports two Audubon sanctuaries, documented migratory/waterbird nesting sites, Padre Island National Seashore, MBHC and Mustang Island State Park. The Audubon sanctuaries are associated with North and South Bird islands in the Upper Laguna Madre. Padre Island National Seashore extends from Mansfield Pass to near the northern boundary of Kleberg County. Mustang Island State Park is located approximately 2 miles north of Packery Channel.

Common shorebird species found within the adjacent MHBC and surrounding coastal communities include the black-bellied plover (*Pluvialis squatarola*), American avocet (*Recurvirostra americana*), greater yellowlegs (*Tringa melanoleuca*), willet (*Catoptrophorus semipalmatus*), ruddy turnstone (*Arenaria interpres*), least sandpiper (*Calidris minutilla*), and dunlin (*Calidris alpina*). Wading species common to the area include the great blue heron (*Ardea herodias*), snowy egret (*Egretta thula*), tricolored heron (*Egretta tricolor*), black-crowned night-heron (*Nycticorax nycticorax*), white-faced ibis (*Plegadis chihi*), and roseate spoonbill (*Ajaia ajaja*). Other common avian species include the American white pelican (*Pelecanus erythrorhynchos*), double-crested cormorant (*Phalacrocorax auritus*), clapper rail (*Rallus longirostris*), osprey (*Pandion haliaetus*), and sedge wren (*Cistothorus platensis*).

The Tamaulipan biotic province supports a diverse fauna composed of a mixture of species that are common in neighboring biotic provinces. The fauna includes a substantial number of neotropical species from the south, a large number of grassland species from the north and northwest, a few Austroriparian species from the northeast, and some Chihuahuan species from the west and southwest (Blair, 1950).

At least 19 species of lizards and 36 species of snakes occur in the Tamaulipan biotic province (Blair, 1950). Reptile species of potential occurrence in the study area include such amphibians as Blanchard's cricket frog (*Acris crepitans blanchardi*), Texas toad (*Bufo speciosus*), Great Plains narrowmouth toad (*Gastrophryne olivacea*), and bull frog (*Rana catesbiana*). Terrestrial reptiles of potential occurrence in the study area include the western glass lizard (*Ophisaurus attenuatus attenuatus*), six-lined racerunner (*Cnemidophorus sexlineatus sexlineatus*), keeled earless lizard (*Holbrookia propinqua propinqua*), Texas spotted whiptail (*Cnemidophorus gularis*), western coachwhip (*Masticophis flagellum tesaceus*), ground snake (*Sonora semiannulata*), and western diamondback rattlesnake (*Crotalus atrox*). Five species of sea turtles are also known to occur within the Gulf of Mexico and associated bays. These sea turtles include the loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), Atlantic hawksbill sea turtle (*Eretmochelys imbricata*), and Kemp's Ridley sea turtle (*Lepidochelys kempii*).

The study area and vicinity support an abundant and diverse avifauna. Tidal flats and beaches create excellent habitat for numerous species of gulls, terns, herons, shorebirds, and wading birds. Some common species which occur within the Project area include the laughing gull (*Larus atricilla*), ring-billed gull (*Larus delawarensis*), royal tern (*Sterna maxima*), sandwich tern (*Sterna sandvicensis*), great blue heron, little blue heron (*Egretta caerulea*), sanderlings (*Calidris alba*), least sandpiper (*Calidris minutilla*), roseate spoonbill, and white ibis (*Eudocimus albus*). Thousands of sandhill cranes (*Grus canadensis*) utilize tall grass coastal prairies and fallow agricultural fields throughout the south Texas coast.

Other avian species that are associated with prairies and marshes include many species of raptors, passerines (songbirds), and migratory waterfowl. Raptor species common to prairies and marshes include the northern harrier (*Circus cyaneus*), white-tailed hawk (*Buteo albicaudatus*), red-tailed hawk (*Buteo jamaicencis*), crested caracara (*Caracara cheriway*), and American kestrel (*Falco sparverius*). Common songbird species include the horned lark (*Eremophila alpestris*), marsh wren (*Cistothorus palustris*), American pipit (*Anthus rubescens*), common yellowthroat (*Geothlypis trichas*), savannah sparrow (*Passerculus sandwichensis*), Lincoln's sparrow (*Melospiza lincolnii*), and red-winged blackbird (*Agelaius phoeniceus*). The specialized Laguna Madre habitats are also used extensively by migrant neotropical birds. Waterfowl species common to the area include the blue-winged teal (*Anas *discors*), northern pintail (*Anas acuta*), northern shoveler (*Anas clypeata*), American wigeon (*Anas americana*), redhead (*Aythya americana*), and lesser scaup (*Aythya affinis*). Texas is one of the most significant waterfowl wintering regions in North America with 3 to 5 million waterfowl annually (recent years) wintering in Texas (TCMP, 1996).

At least 61 mammalian species occur or have occurred within recent times in the Tamaulipan biotic province (Blair, 1950). Terrestrial mammals likely to occur in the study area include the black-tailed jack rabbit (*Lepus californicus*), Gulf coast kangaroo rat (*Dipodomys compactus*), marsh rice rat (*Oryzomys palustris*), fulvous harvest mouse (*Reithrodontomys fulvescens*), common raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and coyote (*Canis latrans*). Marine mammals are also likely to occur within the Laguna Madre and associated waters. The bottle-nosed dolphin (*Tursiops truncatus*) is likely to be the most frequently encountered marine mammal.

3.6 THREATENED AND ENDANGERED SPECIES

The Endangered Species Act [16 U.S.C. 1531 et. Seq.] of 1973 (ESA), as amended, was enacted to provide a program for the preservation of endangered and threatened species and to provide protection for the ecosystems upon which these species depend for their survival. All federal agencies are required to implement protection programs for these designated species and to use their authorities to further the purposes of the act. The FWS and the NMFS are the primary agencies responsible for implementing the ESA. The FWS is responsible for birds and terrestrial and freshwater species, while the NMFS is responsible for non-bird marine species.

An endangered species is one that is in danger of extinction throughout all or a significant portion of its range in the U.S. A threatened species is one likely to become endangered within the foreseeable future throughout all or a significant portion of its range. State-listed threatened and endangered species, while addressed in this assessment, are not protected under the ESA, nor are Species of Concern (SOC), which are species for which there is some information showing evidence of vulnerability, but not enough data to support a Federal listing. Only those species listed as endangered or threatened by the FWS or NMFS are afforded complete Federal protection. It should be noted that inclusion on the following lists does not imply that a species is known to occur in the study area, but only acknowledges the potential for occurrence. County lists of special species provided by TPWD's Biological Conservation Data System (TXBCD, 2002), in addition to the most recent list of threatened and endangered species of Texas by county promulgated by FWS (2001), were reviewed.

3.6.1 Plants

Table 3.6-1 presents Federally and State-endangered plant species and SOCs that may occur in the Project area. TPWD uses the same listing designations as the FWS for the plants. The plants having a geographic range including Nueces and Kleberg counties are briefly discussed.

Three plant species are listed by both the FWS and TPWD as endangered which may potentially occur within the study area. These plants include south Texas ambrosia (*Ambrosia*

TABLE 3.6-1

POTENTIAL ENDANGERED, THREATENED,
AND SPECIES OF CONCERN IN THE STUDY AREA
NUECES AND KLEBERG COUNTIES, TEXAS[1]

Common Name[2]	Scientific Name[2]	Status[3]		
		NMFS	FWS	TPWD
Plants				
Black-laced cactus	*Echinocereus reichenbachii var, albertii*		E	E
South Texas ambrosia	*Ambrosia cheiranthifolia*		E	E
Slender rush-pea	*Hoffmanseggia tenella*		E	E
Bailey's ball moss	*Tillandsia baileyi*		SOC	--
Lila de los llanos	*Echeandia chandleri*		SOC	--
Texas windmill grass	*Chloris texana*		SOC	--
Theiret's skullcap	*Scutellaria thieretii*		SOC	--
Roughseed sea-purslane	*Sesuvium trianthemoides*		SOC	--
Welder machaeranthera	*Psilactis heterocarpa*		SOC	--
Amphibians				
Sheep frog	*Hypopachus variolosus*		--	T
Black-spotted newt	*Notophthalmus meridionalis*		SOC	T
South Texas siren	*Siren* sp.		--	T
Rio Grande lesser siren	*Siren intermedia texana*		SOC	--
Birds				
Brown pelican	*Pelecanus occidentalis*		E	E
Reddish egret	*Egretta rufescens*		SOC	T
White-faced ibis	*Plegadis chihi*		SOC	T
Bald eagle	*Haliaeetus leucocephalus*		T/PDL	T
Northern gray hawk	*Buteo mitidus maximus*		SOC	--
White-tailed hawk	*Buteo albicaudatus*		--	T
Ferruginous hawk	*Buteo regalis*		SOC	--
Zone-tailed hawk	*Buteo albonotatus*		--	T
Northern aplomado falcon	*Falco femoralis septentrionalis*		E	E
American peregrine falcon	*Falco peregrinus anatum*		--	E
Arctic peregrine falcon	*Falco peregrinus tundrius*		--	T
Black rail	*Lateralus jamaicensis*		SOC	--
Whooping crane	*Grus americana*		E	E
Piping plover	*Charadrius melodus*		T	T
Mountain plover	*Charadrius montanus*		PT	--
Eskimo curlew	*Numenius borealis*		E	E
Interior least tern	*Sterna antillarum athalassos*		E	E

Table 3.6-1 (Concluded)

Common Name[2]	Scientific Name[2]	Status[3] NMFS	FWS	TPWD
Birds (cont'd)				
Sooty tern	*Sterna fuscata*		SOC	T
Black tern	*Chilidonias niger*		SOC	--
Loggerhead shrike	*Lanius ludovicianus*		SOC	--
Cerulean warbler	*Dendroica cerulea*		SOC	--
Texas olive sparrow	*Arremonops rufivirgatus rufivirgatus*		SOC	--
Texas Botteri's sparrow	*Aimophila botteri texana*		SOC	T
Sennett's hooded oriole	*Icterus cucullatus sennetti*		SOC	--
Audubon's oriole	*Icterus graduacauda audubonii*		SOC	--
Wood stork	*Mycteria americana*		--	T
Fish				
Dusky shark	*Carcharhinus obscurus*	C		
Sand tiger shark	*Odontaspis taurus*	C		
Night shark	*Carcharhinus signatus*	C		
Saltmarsh topminnow	*Fundulus jenkinsi*	C		
Speckled hind	*Epinephelus drummondhayi*	C		
Goliath grouper	*Epinephelus itajara*	C		
Warsaw grouper	*Epinephelus nitrigus*	C		
Oppossum pipefish	*Microphis Brachyurus*		--	T
Mammals				
Southern yellow bat	*Lasiurus ega*		--	T
Maritime Texas pocket gopher	*Geomys personatus maritimus*		SOC	--
Ocelot	*Leopardus pardalis*		E	E
Jaguar	*Panthera onca*		E	E
Jaguarundi	*Herpailurus yagouaroundi*		E	E
West Indian manatee	*Trichechus manatus*		E	E
Reptiles				
Loggerhead sea turtle	*Caretta caretta*		T	T
Green sea turtle	*Chelonia mydas*		T	T
Leatherback sea turtle	*Dermochelys coriacea*		E	E
Atlantic hawksbill sea turtle	*Eretmochelys imbricata*		E	E
Texas tortoise	*Gopherus berlandieri*		--	T
Kemp's Ridley sea turtle	*Lepidochelys kempii*		E	E
Texas diamondback terrapin	*Malaclemys terrapin littoralis*		SOC	--
American alligator	*Alligator mississipiensis*		T/SA	--
Texas horned lizard	*Phrynosoma cornutum*		SOC	T
Scarlet snake	*Cemophora coccinea*		--	T

Table 3.6-1 (Concluded)

Common Name[2]	Scientific Name[2]	Status[3] NMFS	FWS	TPWD
Reptiles (cont'd)				
Indigo snake	*Drymarchon corais*		--	T
Northern cat-eyed snake	*Leptodeira septentrionalis septentrionalis*		--	T
Gulf salt marsh snake	*Nerodia clarkii*		SOC	--
Insects				
Maculated manfreda skipper	*Stallingsia maculosus*		SOC	--

1 According to FWS (1995, 2001) and TXBCD (2002), 64 FR 33466-33467.

2 Nomenclature follows AOU (1998), Collins (1990), Hatch et al. (1990), and Jones et al. (1997).

3 FWS - U.S. Fish and Wildlife Service; TPWD - Texas Parks and Wildlife Department; NMFS - National Marine Fisheries Service.

E Endangered; in danger of extinction E/SA, T/SA - No longer biologically threatened or endangered but because of the similarity of appearance to other protected species, it is necessary to restrict commercial activities of specimens taken in the USA to ensure the conservation of similar species that are biologically threatened or endangered.

T Threatened; severely depleted or impacted by man.

-- Not listed.

PDL Proposed delisting.

PT Federally proposed threatened.

SOC Species of concern - species for which there is some information showing evidence of vulnerability but not enough data to support listing at this time.

C Candidate - species that may warrant listing in the future.

cheiranthifolia), slender rush-pea (Hoffmanseggia tenella), and black lace cactus (Echinocereus reichenbachii var. albertii).

South Texas ambrosia is an inhabitant of open prairies in grassland/mesquite-dominated savannah in clay loam to sandy loam soils (59 FR 43648-43652). Much of its original habitat has been converted to cropland or introduced forage species. It is known from Nueces, Kleberg, and Jim Wells counties in the U.S. and Tamaulipas in Mexico. Known stands of this species occur in rights-of-way along highways and railways, where the species is subject to weed-control measures including mowing and herbicide applications (Turner, 1983). Its occurrence in the study area is unlikely due to unsuitable soils.

The slender rush-pea is known from only four populations in Kleberg and Nueces counties. It is found in barren openings within native grassland and brush in calcareous clay soils (FWS, 1997a). Introduction of non-native grasses and conversion of prairies to agriculture are thought to be responsible for its decline. It is unlikely to occur in the sandy soils of the Project area.

One endangered cactus is known to have a geographic range which includes the study area. The black lace cactus has a range in the south Texas plains which includes Jim Wells, Kleberg, and Refugio counties (Poole and Riskind, 1987). This cactus occurs in shrubby, grassy areas along brushy streams where the coastal plain meets the inland mesquite/huisache/blackbrush savannah (Poole and Riskind, 1987). The occurrence of this species within the Project area is unlikely due to lack of suitable soils and habitat.

Six plant species identified as SOC by the FWS have records in Nueces or Kleberg counties. These species include: Bailey's ballmoss (*Tillandsia baileyi*); lila de los llanos (*Echeandia chandleri*); Texas windmill grass (*Chloris texensis*); Thieret's skullcap (*Scutellaria thieretii*); Roughseed sea-purslane (*Sesuvium trianthemoides*); and Welder machaeranthera (*Psilactis heterocarpa*). Although the potential for all of these exists, the best potential for occurrence is Thieret's skull cap and roughseed sea purslane, based on habitat occurrence in the study area.

Bailey's ballmoss is an epiphyte found growing on various trees and shrubs in the South Texas brush country and in the lower Rio Grande Valley subtropical woodlands. Honey mesquite and live oak (*Quercus virginiana*) are common host trees to Bailey's ballmoss. Lila de los llanos occurs on level to gently undulating sites along and somewhat inland from the Gulf coast of Texas. It prefers full sunlight and grows among prairies and chaparral thickets on heavy clay and loamy clay soils (Poole, 1985). Texas windmill grass occurs along the Gulf coast and throughout the northeastern Rio Grande Plain of Texas. It prefers silty and sandy loam soils and is known from Nueces County (Poole et al., 2000). Thieret's skullcap occurs on shell, sand, shell ridges, or sandy meadows usually not far from brackish marshes. It is also found growing in close association within woodlands dominated by honey locust (*Gleditsia triacanthos*) and sugar hackberry (*Celtis laeviagata*) in non-disturbed soils (Kral, 1983). Roughseed sea-purslane occurs on dunes of south Texas (Correll and Johnston, 1970) and in brackish swales, marshes and depressions along the coast (Jones, 1977). Poole et al. (2000) show its range occurring only in Kenedy County. Welder machaeranthera occurs in shrub-invaded grasslands and open mesquite-huisache woodlands on mostly gray clays to silty soils overlying the Lissie and Beaumont formations (Texas Organization for Endangered Species [TOES], 1993). It has been documented in both Kleberg and Nueces counties (Poole et al., 2000).

3.6.2 Wildlife

Table 3.6-1 lists wildlife taxa that may occur in the Project area that are considered by FWS and TPWD to be endangered or threatened or species of concern. Table 3.6-1 lists endangered and threatened species that have a geographic range which may include Nueces or Kleberg counties. As with the flora noted above, inclusion on the list does not imply that a species is known to occur in the study area, but only acknowledges the potential for occurrence. The following paragraphs present distributional data concerning each Federally or State-listed species, along with a brief evaluation of the potential for the species to occur within the study area.

3.6.2.1 Amphibians

Four rare amphibians are listed by TPWD and FWS as potentially occurring within the study area counties. The three species that are State-listed as threatened include the sheep frog (*Hypopachus variolosus*), black-spotted newt (*Notophalmus meridionalis*), and South Texas siren (*Siren* sp.). The black-spotted newt and Rio Grande lesser siren (*Siren intermedia texana*) are identified as SOC by the FWS. The sheep frog is known to occur in moist burrows of subterranean mammals, under vegetative debris, and around pond edges and irrigation ditches (Garrett and Barker, 1987). The black-spotted newt inhabits heavily vegetated, shallow water lagoons, streams, ditches and swamps (Garrett and Barker, 1987). The black-spotted newt may occur in wetland sites within the study area. The South Texas siren is known to occur in the study area in habitat similar to that occupied by the black-spotted newt; however, the newt requires year-round open water since it cannot aestivate in dry ground like the south Texas siren. The Rio Grande lesser siren prefers warm, shallow waters with vegetative cover such as those in ponds, irrigation canals and swamps in permanently to semipermanently inundated areas found along the lower coast of Texas and along the Rio Grande (Bartlett and Bartlett, 1999). All of these species (except the South Texas siren for which little information is known) have been recorded from the study area counties (Dixon, 2000).

3.6.2.2 Birds

Twenty-six endangered, threatened, and rare (SOC) bird species are listed by the FWS and/or TPWD as occurring or potentially occurring in the study area. Several of these are predominantly inland species that are not ordinarily expected on the coast or are migrants that pass through the region seasonally. Others may occur as breeding birds, permanent residents, or post-nesting visitors. Federally listed species are described below, followed by descriptions of State-listed species and then Federal SOC.

The Federally and State-endangered brown pelican (*Pelecanus occidentalis*) is primarily a coastal species that rarely ventures very far out to sea or inland. In Texas, it occurs from Chambers County on the upper coast to Cameron County on the lower coast (Campbell, 1995). Brown pelicans are colonial nesters, usually nesting on undisturbed offshore islands in small bushes and trees, including mangroves (National Fish & Wildlife Laboratory [NFWL], 1980; Guzman and Schreiber, 1987). This species is a common resident of the study area and is likely to occur near open-water habitat and tidal flats.

The bald eagle (*Haliaeetus leucocephalus*) has recovered sufficiently to be downlisted to threatened throughout its range, and the FWS has proposed to delist the species in the near future (64 FR 36453-36363; July 6, 1999). Two subspecies are currently recognized based on size and weight: the northern bald eagle and the southern bald eagle. The northern population nests from central Alaska and the Aleutian Islands through Canada into the northern U.S. The southern population primarily nests in estuarine areas and inland lakes of the Atlantic and Gulf coasts, northern California to Baja California, Arizona and New Mexico (Snow, 1981). Wintering ranges of the two populations overlap. The bald eagle inhabits coastal areas, rivers and large bodies of water as fish and waterfowl comprise the bulk of their diet. Nests are seldom far from a river, lake, bay, or other waterbody. Nests are generally built in the dominant or co-dominant tree of woodlands, woodland edges, or open areas (Green, 1985). The 2001 bald eagle nesting survey in Texas identified 98 occupied nesting territories statewide, the southernmost found in Refugio and Goliad counties (Ortego, 2001). Concentrations of wintering northern eagles are often found around the shores of reservoirs in Texas, with most wintering concentrations occurring in the eastern part of the state. Wintering bald eagles in Texas have been observed as far south as Cameron County (Oberholser, 1974; Mabie, 1990). No nests are known to occur in the study area, nor have any been reported from Nueces or Kleberg counties (Ortego, 2001). The bald eagle should occur in the study area only as a rare migrant or post-nesting visitor.

The northern aplomado falcon (*Falco femoralis septentrionalis*) is listed as endangered by both the FWS and TPWD. This falcon is considered a rare summer resident of the lower Rio Grande Valley and into the Trans-Pecos (Texas Ornithological Society [TOS], 1995). Its preferred habitat in south Texas includes coastal prairie with widely scattered mesquites and yuccas (Hector, 1983). In Texas, the northern aplomado falcon formerly ranged from Cameron County northward to San Patricio County and west from Ector and Midland counties to El Paso County (Oberholser, 1974). Successful efforts have been made for the reintroduction of the aplomado falcon at the Laguna Atascosa National Wildlife Refuge in Cameron County. It is possible, but unlikely, for this species to be found within the study area.

Each year, the entire wild breeding population of the Federal and State-endangered whooping cranes (*Grus americana*) migrates 2,600 miles from Canada's Northwest Territories and winters along a narrow section of the Texas coast centered around the Aransas National Wildlife Refuge. Rest areas along the migration route include the central and eastern panhandle of Texas (FWS, 1995). In Texas, the principle winter habitat is brackish bays, marshes, and salt flats, as whooping cranes feed in nearby upland sites characterized by oak mottes, grassland swales, and ponds (Campbell, 1995). They eat a wide variety of plant and animal foods in their wintering habitat: blue crabs, clams, berries of Carolina wolfberry (*Lycium carolinianum*), acorns, snails, crayfish, and insects (Campbell, 1995). The whooping crane has been recorded from counties within the study area but is generally restricted to the Aransas National Wildlife Refuge in Aransas, Refugio, and Calhoun counties. Though the leeward side and interior of Padre Island provide suitable winter habitat for whooping cranes, they are unlikely to occur in the Project area.

The Federally and State-threatened piping plover is a winter resident and spring and fall migrant of the study area. This small shorebird breeds in the northern Great Plains of the U.S. and Canada, along beaches of the Great Lakes, and along the Atlantic coastline from North Carolina to Newfoundland (Haig and Oring, 1987). Post-breeding and wintering sites include the southern U.S. Atlantic coastline; the Gulf of Mexico from Florida to Veracruz, Mexico; and on scattered Caribbean islands (Haig and Oring, 1985). The piping plover can be found along Texas beaches, tidal flats, dunes, and offshore disposal islands (American Ornithologists' Union [AOU], 1998; FWS, 1995) arriving in mid- to late-July (Haig and Oring, 1985). The piping plover is a regular migrant and winter resident along the lower Texas coast (Oberholser, 1974; Haig and Oring, 1985). The checklist of birds of Mustang Island State Park lists the piping plover as a fairly common winter resident and a common migrant (Pulich et al., 1985). This species is also known to occur at Packery Channel and within the MBHC (Shiner, Moseley and Associates, 1994; Zonick and Ryan, 1996; PBS&J, in-house data; GLO and FWS, 1998) and has been documented there as recently as April 2001 by PBS&J (2001b).

PBS&J conducted a piping plover survey in the Corpus Christi Bay area between September 2000 and April 2001 (PBS&J, 2001b). Two of the four study sites, the GIWW and Fish Pass, fall within the northern portion of the Packery Channel study area. The study sites were visited monthly. Altogether, 652 piping plovers were recorded at the GIWW study site in 185.6 hours of observation at a rate of 3.5 birds per hour. Many of these birds were undoubtedly seen on more than one occasion. The number of individuals at the GIWW site ranged from 27 in October 2000 to 182 in March 2001, while the number of birds encountered per hour ranged from 1.5 for October 2000 to 7.8 for March 2001. Thus, a minimum of 182 piping plovers utilized the GIWW study site during the 2000-2001 survey. At the Fish Pass study site, 148 piping plovers were recorded during 122.8 hours of observation at a rate of 1.2 birds per hour. Apart from December 2000 when no piping plovers were recorded, the number of individuals ranged from 8 in November 2000 to 45 in March 2001, while the number of birds encountered per hour ranged from 0.6 for February 2001 to 3.4 for March 2001. Thus, at least 45 piping plovers utilized the Fish Pass study site. No surveys were conducted at the MBHC by PBS&J.

Several areas along the Texas coast have been identified by the FWS as essential wintering habitat for the piping plover. Essential wintering habitat for the piping plover provides the space and requisite resources necessary for the continued existence and growth of piping plover populations and consists of coastal beach, and tidal flat habitat.

Critical habitat has recently been designated in Texas, some of which lies within the study area as follows: the northern tip of TX-3; TX-5; TX-6; and part of TX-7. The MBHC forms part of TX-6. Figure 3.6-1 presents the location of Packery Channel and proposed PAs in relation to two critical habitat units that will be affected.

The current status of the Eskimo curlew (*Numenius borealis*) is considered uncertain and possibly extinct (TOS, 1995), but it is Federally and State-listed as endangered. This species was extremely abundant in the nineteenth century, but was subject to extreme hunting pressures. The breeding habitat of the Eskimo curlew was treeless arctic and subarctic tundra (Gill et al., 1998). Non-breeding birds use a variety of habitats, such as grasslands, pastures, plowed fields, and less frequently, marshes and mud flats (AOU, 1983). Spring migration would bring them through Texas and the

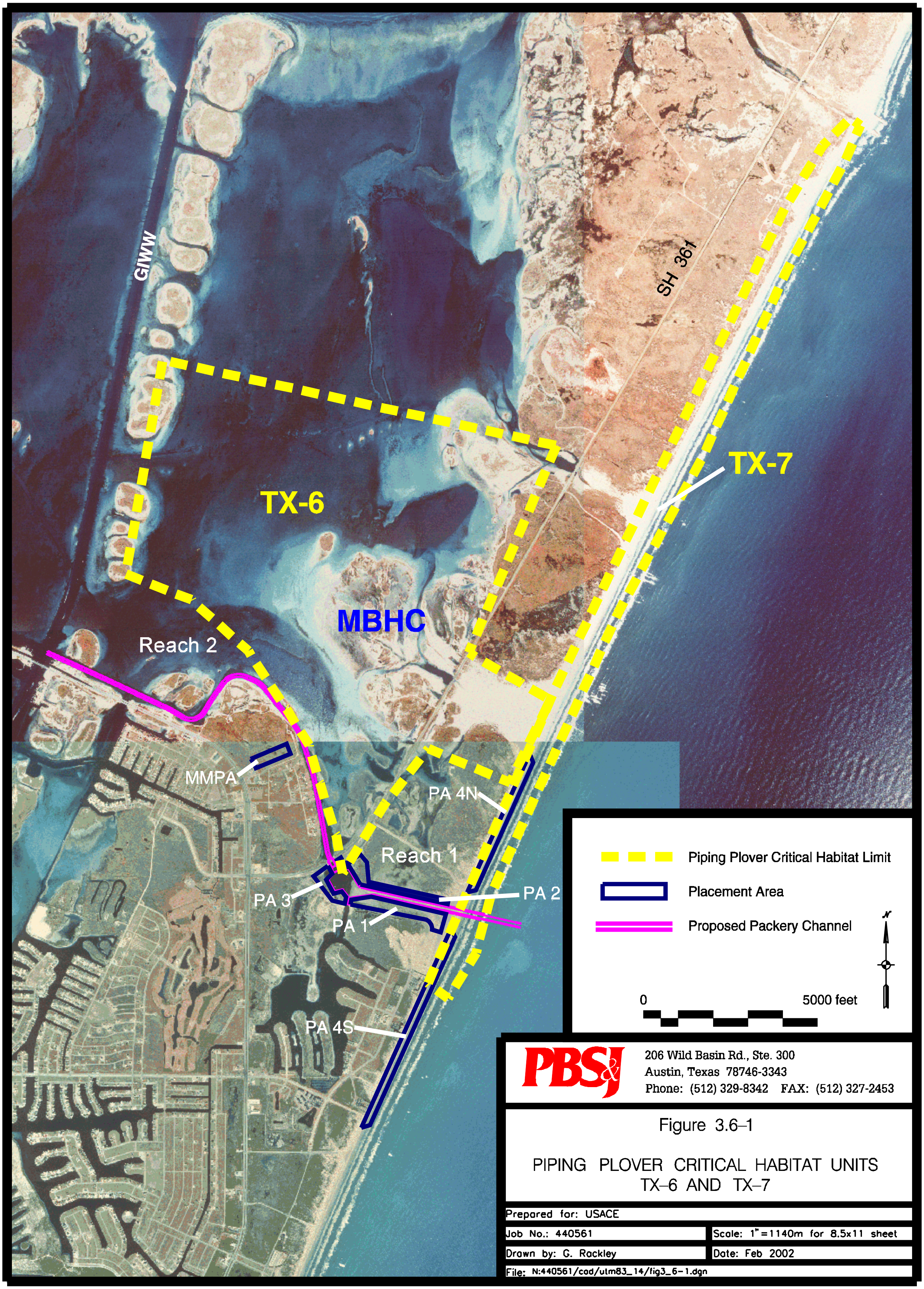


Figure 3.6–1

PIPING PLOVER CRITICAL HABITAT UNITS TX–6 AND TX–7

Midwestern U.S. (Gill et al., 1998) from mid-March to late April in Texas (Oberholser, 1974). One record does exist from Galveston, Texas, in 1962 and others since have been reported, but the validity of these recent records is uncertain (TOS, 1995). The Eskimo curlew is unlikely to occur in the study area due to its extreme rarity and the lack of recent records of occurrence.

The interior least tern (*Sterna antillarum athalassos*) is listed as endangered by the FWS and TPWD. It is a rare local summer resident in the eastern panhandle of Texas and along the Red River. Nesting usually occurs in small colonies on sand bars or sandy flats along rivers (Oberholser, 1974). The Project area is considered to be within potential breeding range of the interior least tern (FWS, 1995). Least terns are known to occur in the study area; however, the unprotected coastal subspecies (*Sterna antillarum antillarum*) is likely the one most frequently occurring.

The mountain plover (*Charadrius montanus*) was proposed for listing as a federally threatened species on February 16, 1999 (64 FR 7587). Non-breeding birds prefer short-grass plains, fields, plowed fields, sandy deserts, and sod farms (NatureServe, 2000a). The mountain plover is a rare to uncommon local winter resident on the coastal plains, and inland from south Texas through the Edwards Plateau into the South Plains (TOS, 1995). The mountain plover has been recorded from Nueces County (Oberholser, 1974). It is most likely to occur in the agricultural areas away from the seashore. This species appears as an uncommon migrant on the checklist for birds of the Corpus Christi area (Audubon Outdoor Club of Corpus Christi [AOCCC], 1994), but is absent from checklists for Mustang Island State Park (Pulich et al., 1985) and the Padre Island National Seashore (Southwest Parks & Monuments Association [SPMA], 1990). This species is unlikely to occur within the study area.

The reddish egret (*Egretta rufescens*), a State threatened species and Federal SOC, typically inhabitants saltwater bays and marshes. Its breeding range is restricted to the Gulf coast where it commonly nests in yucca-prickly pear thickets (Oberholser, 1974). The white-faced ibis (*Plegadis chihi*) is a common resident along the coast. This species is also State-listed as threatened and a Federal SOC. Preferred habitats of the white-faced ibis have been described as ranging from freshwater marshes and sloughs and irrigated rice fields to salt marshes (Oberholser, 1974). Both of these species occur within the study area.

The white-tailed hawk (*Buteo albicaudatus*) is considered an uncommon local resident along the Texas coastal plain (TOS, 1995). The white-tailed hawk could be present in savannah-like, grassland habitats within the study area. The zone-tailed hawk (*Buteo albonotatus*) is a rare to uncommon breeding bird in the Trans-Pecos and Edwards Plateau regions of Texas (Oberholser, 1974). Observations of zone-tailed hawks have been reported in Kleberg County, but there are no verified breeding records (Oberholser, 1974). The zone-tailed hawk, a mesa- and canyon-inhabiting species, is unlikely to occur in the study area. These two hawks are State-listed as threatened in Texas.

All North American peregrine falcons were delisted from the endangered species list (63 FR 45446-45463, Aug. 26, 1998). The Arctic peregrine falcon (*Falco peregrinus tundrius*), which was listed as endangered due to similarity of appearance (E/SA), was delisted Federally but remains on the TPWD threatened list. The Arctic peregrine falcon winters along the entire Gulf coast and occurs statewide during migration (FWS, 1995), thus there is potential that it could occur in the study area. The American peregrine falcon (*Falco peregrinus anatum*) remains on the State endangered list.

The sooty tern (*Sterna fuscata*), a State-listed threatened species and Federal SOC, is considered a rare local summer resident along the central and lower coast (TOS, 1995). This pelagic bird spends almost its entire life at sea. Many records have been reported on the Texas coast following large tropical storms. Oberholser (1974) shows a breeding and a summer record of the sooty tern in Nueces County. This species is a rare, but potential, vagrant to the study area.

The Texas Botteri's sparrow (*Aimophila botterii texana*) is an uncommon to locally common summer resident on the lower coastal plain, with isolated breeding records from Duval, Jim Wells, and San Patricio counties (TOS, 1995). This species may occasionally occur in the study area. This sparrow is an inhabitant of tall bunch grass prairies with widely scattered shrubs and small trees mostly within 20 miles of the Gulf coast (Oberholser, 1974). The reason for a decline in numbers of this species is attributed mostly to depletion of habitat due to agriculture practices (Oberholser, 1974). TPWD considers this sparrow to be State-threatened.

The wood stork (*Mycteria americana*) is listed as threatened by TPWD. This species is Federally listed as endangered only in Alabama, Florida, Georgia, and North and South Carolina. This bird is an uncommon to common post-breeding visitor to the central and upper coastal prairies and a regular visitor of lakes and reservoirs in central and east Texas. This species has been recorded within the study area counties (Oberholser, 1974; TOS, 1995).

Two additional *Buteo* species, northern gray hawk (*Buteo nitidus maximus*) and ferruginous hawk (*Buteo regalis*), are considered SOC by the FWS. The northern gray hawk is a rare to uncommon local resident in the Lower Rio Grande Valley (TOS, 1995). In Texas, this hawk inhabits mature woodlands of the river valleys and nearby semi-arid mesquite and scrub grasslands (Oberholser, 1974). Oberholser (1974) shows a fall record of the northern gray hawk from Nueces County. This species is unlikely to occur in the study area. The ferruginous hawk ranges the wide open spaces of the dry Great Plains and Great Basin in western North America (Oberholser, 1974). It may occur in the study area as a migrant or winter resident. It is considered locally uncommon on Texas' barrier islands and the central and south coastal plains (TOS, 1995). Two ferruginous hawks are known to overwinter in the study area (Beasley, 1998).

Three additional avian Federal SOC of potential occurrence in the study area include the black rail (*Laterallus jamaicensis*), black tern (*Chlidonias niger*), and loggerhead shrike (*Lanius ludovicianus*). The black rail is a rare migrant and winter resident to the state (Oberholser, 1974) and a potential migrant to the study area. It is primarily a bird of coastal marshes, typically dominated by smooth cordgrass (*Spartina alterniflora*). The black tern is a common migrant in all parts of Texas including offshore waters (TOS, 1995). It breeds in marshy areas of the northern U.S. and Canada, and may migrate through Texas during all months except January, February, and March (Oberholser, 1974). This species occurs within the study area. The loggerhead shrike is an inhabitant of open country with scattered trees and shrubs. It is a rare to common resident throughout the state, except for portions of the South Texas Plains. It is a possible resident/migrant within the study area.

Four songbirds of potential occurrence within the study area are considered SOC by the FWS. These four species are the cerulean warbler (*Dendroica cerulea*), Texas olive sparrow (*Arremonops rufivirgatus*), Sennett's hooded oriole (*Icterus cucullatus sennettii*), and Audubon's oriole (*Icterus gradaucada audubonii*). The cerulean warbler is a rare-to-uncommon spring migrant in the eastern half of the state, mostly on the coast, and south to the Rio Grande Valley (TOS, 1995). It prefers deciduous or mixed woodlands near stream bottoms. This species is likely to occur within the study area only during migration. The olive sparrow is a common resident in southern Texas, extending north to Goliad, Karnes, Uvalde, and Val Verde counties (TOS, 1995). This sparrow inhabits dense brushy areas where it spends much of its life on or near the ground. This species is unlikely to inhabit the study area, due to a lack of appropriate habitat. Sennett's oriole is a summer resident and rare winter resident in south Texas, where it inhabits areas closely associated with towns where it nests in palm (*Washingtonia* sp. and *Sabal* sp.) and pecan (*Carya illinoinensis*) trees (Oberholser, 1974). Audubon's oriole is a rare to uncommon resident in south Texas and is typically found in wooded or brushy areas. During the warmer months, it tends to prefer mesquite woodlands. In winter it can be found in evergreen trees such as live oak along with huisache (*Acacia smallii*) and Texas ebony (*Pithecellobium flexicaule*) (Oberholser, 1974). The presence of either of these orioles in the study area is unlikely.

3.6.2.3 Fish

A candidate species is, as its name implies, a candidate for listing under the ESA. More specifically, it is a species or vertebrate population for which sufficient reliable information is available that a listing under the ESA may be warranted. There are no mandatory Federal protections required under the ESA for a candidate species (NMFS, 2001).

The dusky shark (*Carcharhinus obscurus*), also known as the bronze whaler or black whaler, was added to the NMFS candidate species list in 1997. It has a wide-ranging (but patchy) distribution in warm-temperate and tropical continental waters (NMFS, 2001). It is coastal and pelagic in its distribution where it occurs from the surf zone to well offshore and from surface depths to one-quarter mile (Compagno, 1984). It is not commonly found in estuaries (Compagno, 1984; Musick et al., 1993), and is unlikely to occur in the study area.

The Atlantic and Gulf of Mexico populations of the sand tiger shark (*Odontaspis taurus*) were added to the candidate species list in 1997. Sand tiger (grey nurse) sharks have a broad inshore distribution. In the western Atlantic, this shark occurs from the Gulf of Maine to Florida, in the northern Gulf of Mexico, in the Bahamas and in Bermuda. This species was first reported in Texas in the 1960s and is thought to be common (Hoese and Moore, 1998). A cool temperate species, sand tiger sharks are more common north of Cape Hatteras (Hoese and Moore, 1998). They are generally coastal, usually found from the surf zone down to depths around 75 feet. However, they may also be found in shallow bays, around coral reefs and to depths of 600 feet on the continental shelf. They usually live near the bottom, but may also be found throughout the water column (NMFS, 2001). The sand tiger shark is unlikely to inhabit the study area.

NMFS designated the night shark (*Carcharhinus signatus*) a candidate species in 1997. Data on this species are minimal because it is a deepwater shark. The night shark has been reported in waters from Delaware south to Brazil, including the Gulf of Mexico. It is a tropical species occurring in depths greater than 600 feet (NMFS, 2001), and therefore it is improbable that the night shark will occur in the study area.

The speckled hind (*Epinephelus drummondhayi*) inhabits warm, moderately deep waters from North Carolina to Cuba, including Bermuda, the Bahamas and the Gulf of Mexico. Its preferred habitat is hard bottom reefs in depths ranging from 150 to 300 feet, where the temperatures are from 60 to 85 degrees Fahrenheit (°F) (NMFS, 2001). It is highly unlikely that this species will occur in the study area.

NMFS designated the saltmarsh topminnow (*Fundulus jenkinsi*) as a candidate species in 1997. This rare species is restricted to coastal streams and adjacent bay shores on the western side of Galveston Bay and from Vermilion Bay to the Florida Panhandle. Usually found in low salinities, it has been taken from the Chandeleur Islands (Hoese and Moore, 1998). This species tends to live in salt marshes and brackish water, although it has been known to survive in freshwater. This species can also be found in shallow tidal meanders of cordgrass marshes (NMFS, 2001). The presence of this species in the study area is highly unlikely.

The goliath grouper (*Epinephelus itajara*), formerly named the jewfish, was added to the candidate species list in 1991 for the region of North Carolina southward to the Gulf of Mexico, which encompasses the entire range of this species in U.S. waters. Historically, goliath grouper were found in tropical and subtropical waters of the Atlantic Ocean, both coasts of Florida, and from the Gulf of Mexico down to the coasts of Brazil and the Caribbean. They were abundant in very shallow water, often associated with piers and jetties along the Florida Keys and the southwest coast of Florida; however, they are no longer found in these areas (NMFS, 2001). It is unlikely the goliath grouper will occur in the study area.

The Warsaw grouper (*Epinephelus nitrigus*) was added to the candidate species list in 1997. It is a very large fish found on the deepwater reefs of the southeastern United States. Warsaw grouper range from North Carolina to the Florida Keys and throughout much of the Caribbean and Gulf of Mexico to the northern coast of South America. The species inhabits deepwater reefs on the continental shelf break in waters 350 to 650 feet deep (NMFS, 2001). Small Warsaw groupers have been found around oil platforms and jetties, and juveniles have been observed in seagrasses inshore (Hoese and Moore, 1998). This species may potentially be found in the study area.

TPWD recognizes one State-threatened fish which may potentially occur in the Project area. The opossum pipefish (*Microphis brachyurus*) has been reported from the Rio Grande River, and in low salt marshes and *Sargassum* mats in the Gulf of Mexico (Hoese and Moore, 1998). Brooding adults are found in fresh or low salinity waters and the young move into more saline waters (TXBCD, 1999).

3.6.2.4 Mammals

The ocelot (*Leopardus pardalis*) and the jaguarundi (*Herpailurus yagouaroundi*) are listed by the FWS and TPWD as endangered. Both of these cat species are included on TXBCD's Special

Species List as potentially occurring in the study area counties. The ocelot is a medium-sized cat whose range stretches from southern Texas and Arizona to northern Argentina (Campbell, 1995). According to Campbell (1995), the ocelot prefers habitat described as dense thorn scrub with a dense canopy cover. Ocelots have been known to prey on small mammals, birds, reptiles, amphibians and some fish (Davis and Schmidly, 1994). The ocelot currently occurs only in the extreme south of the state (Davis and Schmidly, 1994) and is unlikely to occur in the study area, due to the lack of suitable brushy habitat.

The Federally and State-listed endangered jaguarundi occurs in south Texas, east and western portions of Mexico, and south into South America (Hall, 1981). In Texas, this cat inhabits very similar habitat as described for the ocelot: very dense thornscrub (Davis and Schmidly, 1994) with a preference for riparian habitats (Goodwyn, 1970; Davis and Schmidly, 1994). Current records show that jaguarundi distribution in Texas is likely restricted to the Rio Grande Valley (Tewes and Everett, 1987). Due to the lack of suitable brushy habitat and any known populations in the area, this species is unlikely to occur in the study area.

The jaguar (*Panthera onca*) was once fairly common over southern Texas into Louisiana and north to the Red River (Davis and Schmidly, 1994). Presently, the jaguar has been considered extirpated from the state with the last record of this large cat occurring in the mid-twentieth century (TXBCD, 2001). It is listed as endangered by the FWS and threatened by TPWD.

The West Indian manatee (*Trichechus manatus*) is a Federally and State-listed endangered aquatic mammal which inhabits brackish water bays, large rivers, and salt water bodies (Davis and Schmidly, 1994). They feed upon submergent, emergent, and floating vegetation with the diet varying according to plant availability (O'Shea and Ludlow, 1992). The manatee is more common in the warmer waters off of coastal Mexico, the West Indies, and the Caribbean to northern South America (NatureServe, 2000b). In the U.S., populations are primarily found in Florida, but occasional vagrants migrate along the coast into Texas. Although extremely rare in Texas, recent Texas records include specimens from Cameron, Galveston, Matagorda, and Willacy counties (FWS, 1995). Davis and Schmidly (1994) describe a record of a manatee which was found dead in the surf near the Bolivar Peninsula near Galveston, Texas, in 1986. More recently, Albert Oswald of the Texas State Aquarium spotted a manatee in the inlet between the aquarium and the Lexington Museum on 23 September 2001 (Beaver, 2001). Manatees are unlikely to occur in the study area, although possible, due to their unpredictable wanderings.

The southern yellow bat (*Lasiurus ega*) is a neotropical bat that is listed by the State as threatened. In the U.S., this bat has been recorded from southern California, southern Arizona, extreme southwestern New Mexico and south Texas (Schmidly, 1991). In Texas, the southern yellow bat occurs in the extreme south where it utilizes trees as roosting sites. In some areas of south Texas, palm trees appear to be preferred roosting sites (Davis and Schmidly, 1994). This mammal is unlikely to be found in the study area.

The maritime Texas pocket gopher (*Geomys personatus maritimus*), a Federal SOC, is known from Kleberg and Nueces counties (TOES, 1995; TXBCD, 1999). It inhabits areas with deep, sandy soils where it constructs its burrows and tunnels. It is a possible resident of the study area.

3.6.2.5 Reptiles

Five sea turtles are Federally and State endangered within Nueces and Kleberg counties. These sea turtles include the loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), Atlantic hawksbill sea turtle (*Eretmochelys imbricata*), and Kemp's Ridley sea turtle (*Lepidochelys kempii*). These sea turtles are known to occur in the Gulf of Mexico, including associated bay and estuarine waters, and sometimes nest along the Gulf beaches (Garrett and Barker, 1987).

The loggerhead sea turtle is widely distributed within its range. It can be found in waters hundreds of miles offshore as well as inshore areas such as bays, lagoons, salt marshes, ship channels, and mouths of large rivers (FWS, 1995). This species feeds on various marine invertebrates – primarily crustaceans, mollusks, sponges, echinoderms, and gastropods as well as some plants, fish, and jellyfish. They nest on high energy beaches on barrier islands, steeply sloped beaches with gradually sloped offshore approaches. The nesting range in the U.S. is mainly the Atlantic coast, although nesting on barrier islands along the Texas coast has been recorded (NMFS and FWS, 1991a; Shaver, 2000).

The green sea turtle's favored habitat appears to be lagoons and shoals with an abundance of marine grasses and algae (FWS, 1995). The adults are primarily herbivorous while the juveniles consume more invertebrates. Foods consumed include seagrasses, macroalgae and other marine plants, mollusks, sponges, crustaceans, and jellyfish (Mortimer, 1982). Terrestrial habitat is typically limited to nesting activities on deep, coarse to fine sands with little organic content, along high energy beaches. Major nesting activity occurs on Ascension Island and Aves Island in Costa Rica and Surinam with small numbers nesting in Florida and rarely in Texas, Georgia and North Carolina (NMFS and FWS, 1991b). This species has been recorded in Nueces County (Dixon, 2000).

Leatherback sea turtles are considered to be the most pelagic of the sea turtles, seldom approaching land except for nesting. They are mainly found in coastal water only when nesting and when following concentrations of jellyfish, which is the principal food source (TPWD, 2000; FWS, 1995; Garrett and Barker, 1987). The leatherback nests on sandy, sloping beaches, often near deepwater and rough seas (NMFS and FWS, 1992). The largest nesting beaches are found in the U.S. Virgin Islands, Puerto Rico, and Florida (NMFS, 2000).

The Atlantic hawksbill sea turtle is found in rocky, shallow, coastal waters; lagoons; estuaries; and mangrove-bordered bays in water generally less than 60 feet deep (FWS, 1995). This species prefers foraging habitat of coral reefs, rocky outcrops, and high energy shoals, which are optimum sites for sponge growth; sponge being one of their principal food sources. Other forage foods include crabs, sea urchins, shellfish, jellyfish, plant material, and fishes. Nesting activities may include deep sand beaches of low energy to high energy beaches. Nesting in the Continental U.S. is limited to the southeast coast of Florida, Florida Keys, Puerto Rico, and U.S. Virgin Islands. Most of the Texas sightings involve posthatchlings and juveniles which are primarily associated with stone jetties and originated from nesting beaches in Mexico (NMFS, 2000).

The Kemp's Ridley sea turtle is known to inhabit shallow coastal and estuarine waters usually over sand or mud bottoms where a food source of crabs can be found (FWS, 1995). Other food items include shrimp, snails, bivalves, sea urchins, jellyfish, sea stars, fish, and occasional marine plants (Campbell, 1995). Nesting activities are essentially restricted to the Gulf of Mexico at Rancho Nuevo, Tamulipas, Mexico. Sporadic nesting has been reported from Mustang Island, Texas, southward to Isla Aquada, Campeche, Mexico (NMFS, 2000; Hildebrand, 1983, 1986, 1987).

Although it is a possibility for all the aforementioned sea turtles to occur along the Gulf beach and associated waters, the green, Kemp's Ridley, and loggerhead sea turtles are the most likely to occur within the Laguna Madre.

The American alligator (*Alligator mississippiensis*) was first Federally-listed as endangered in 1967 because hunting and poaching had substantially reduced its numbers. It was reclassified as threatened in certain parts of Texas in 1977 because of partial recovery. In 1983, it was further reclassified in Texas as threatened due to similarity of appearance (T/SA) reflecting complete recovery of the species in the State. Thus, the alligator in Texas is no longer biologically threatened or endangered, but because of the similarity of appearance of its hides and parts to protected crocodilians elsewhere, it is necessary to restrict commercial activities involving alligators taken in Texas to safeguard against excessive harvesting, and to ensure the conservation of other crocodilians that are still biologically threatened or endangered. The potential for this species to occur within the study area is low.

The Texas tortoise (*Gopherus berlandieri*) and Texas horned lizard (*Phrynosoma cornutum*) are listed as threatened species by TPWD. Texas horned lizard is also a Federal SOC. The Texas tortoise is confined to arid south Texas and northeastern Mexico. The Texas tortoise prefers sandy soils in areas of low, sparse vegetation (Garrett and Barker, 1987). If appropriate habitat is present then there is some potential for their occurrence within the study area. The Texas horned lizard was historically found throughout the state in areas with flat, open terrain, scattered vegetation, and sandy or loamy soils. Over the past 20 years, it has almost vanished from the eastern half of the state, but still maintains relatively stable numbers in west Texas. This species has been recorded from the counties within the study area (Dixon, 2000).

Three snakes that are listed as threatened by the TPWD, but not by the FWS, and may potentially occur in the study area are the scarlet snake (*Cemophora coccinea*), northern cat-eyed snake (*Leptodeira septentrionalis septentrionalis*), and indigo snake (*Drymarchon corais*) (Dixon, 2000; TXBCD, 1999). In addition, the Gulf salt marsh snake (*Nerodia clarkii*) is considered a SOC by the FWS within Nueces County (FWS, 2001). The scarlet snake inhabits loose, sandy soil potentially associated with baygall thickets, live oak scattered across sand dunes, watermelon patches, and dry, sandy land dominated by honey mesquite, huisache (*Acacia smallii*) and prickly pear (Werler and Dixon, 2000; Tennant, 1984). The northern cat-eyed snake inhabits brushland bordering ponds and streams, and the indigo snake is most common in thorn brush woodland in riparian corridors and in mesquite savannah (Tennant, 1984). The Gulf salt marsh snake inhabits crayfish and fiddler crab burrows in the saltgrass-lined margins of tidal mud flats (Garrett and Barker, 1987). This species is shown to be outside of its range in Nueces County by Dixon (2000), yet the FWS (2001) indicates Nueces County to be within its range. Although there is potential for the scarlet snake to occur within the study area, this rare snake is unlikely to be found. Potential occurrence of the northern cat-eyed snake and indigo snake is low due to the lack of suitable habitat, except inland or on Padre Island. Habitat for the Gulf salt marsh snake is present in the study area, thus there is potential for occurrence.

The Texas diamondback terrapin (*Malaclemys terrapin littoralis*) is identified as a SOC by the FWS (2001) in Nueces County. This species occurs from the Texas-Louisiana border south to Nueces County (Dixon, 2000). This turtle inhabits brackish or saltwater in coastal marshes, lagoons, and tidal flats (Garrett and Barker, 1987). This species has been observed in the Upper Laguna Madre (EH&A, 1993a) and may occur in the study area.

3.6.2.6 Insects

One insect species, the maculated manfreda skipper (*Stallingsia maculosus*), is a rare butterfly known from several south Texas counties and northern Mexico. The FWS (2001) identifies this species as a SOC in Nueces and Kleberg counties. The larvae of this species are closely associated with Texas tuberose (*Manfreda maculosus*) which grows on prairies and chaparral covered hills of the Rio Grande Valley and Plains (Tilden and Smith, 1986; Correll and Johnston, 1970). Its presence in the study area is unlikely.

3.7 HAZARDOUS, TOXIC AND RADIOACTIVE WASTES

The objective of this assessment is to identify indicators of potential hazardous materials or waste issues relating to the study area. A regulatory agency database review, an aerial photographic review, contact with regulatory officials, and a site reconnaissance were conducted to determine the location and status of sites regulated by the State of Texas and the EPA and any unreported hazardous material sites.

A hazardous, toxic, and radioactive waste (HTRW) survey and assessment of Packery Channel and Laguna Madre from Packery Channel (MS 552) to Baffin Bay (MS 576), including adjacent areas to one-half mile on either side of these water bodies was conducted by PBS&J and presented to the USACE under separate cover (PBS&J, 2001a). This report provides support data and comprehensive information which was utilized for this assessment. This survey also included the collection of five representative water and sediment samples that were collected along the length of the proposed Packery Channel and were chemically analyzed. Results of the sampling and analysis activities are summarized in Section 3.2.3 of this DEIS. This HTRW assessment was conducted in general accordance with procedures described in the Department of the Army, USACE (1992a) document ER 1165-2-132, “Water Resource Policies and Authorities – Hazardous, Toxic and Radioactive Waste Guidance for Civil Works Projects.”

3.7.1 Aerial Photograph Review

PBS&J obtained aerial photography for the study area covering two separate time periods. The USGS aerial photographs depict the Project site as it appeared in 1969 and 1995. The 1969 photographs were photocopied from the original negatives at a scale of either 1″ = 3,166′ or

1″ = 6,000′. The photocopies were electronically scanned and a mosaic was created for presentation. The 1995 aerial photographs are DOQQs of 1-meter resolution. The scale of the original photographs is 1″ = 2,000′. Review of the aerial photographs enabled PBS&J to examine the historical usage of Packery Channel and the Laguna Madre.

The 1969 aerial photography indicates Packery Channel is identifiable as it roughly parallels South Padre Island Drive, crosses SH 361, and reaches the Gulf of Mexico. Five commercial buildings are visible on the southern shore on this segment of the channel. With the exception of a few residences on the southern shore of the waterway, the land along this segment is vacant, undeveloped property. Southeast of SH 361, the channel is no longer apparent; however, the waterway is defined on both sides by undeveloped beach front and is connected to the Gulf through a hurricane washover channel.

The 1969 aerial photographs indicate the majority of the study area along the Laguna Madre is undeveloped land typical of the Texas Coastal Zone. The channel of the GIWW is the most prominent feature within the submerged portion of the study area. Numerous small PAs are evident along the GIWW. The PAs located in the northern portion of the study area form a nearly contiguous linear feature of emergent land. The cities of Corpus Christi and Flour Bluff are evident along the western shore of the Laguna Madre. The urban area is developed with numerous improved roads that provide access to residential, commercial and industrial properties. Several oil and/or gas well sites are visible within the Laguna Madre and along the western shoreline. Land use along the western shoreline south of the city of Corpus Christi to Baffin Bay appears to be undeveloped property that is limited to oil and gas production and agriculture. Padre Island appears to be predominantly undeveloped land.

Review of the 1995 aerial photography indicates Packery Channel remains basically unchanged from the previous time period. However, the eastern portion of the waterway, which was previously connected to the Gulf, has apparently silted in. The waterway now consists of a small harbor that provides water access to boat docks in a residential development. New residential and commercial development along the western bank of the Laguna Madre is evident.

3.7.2 Regulatory Agency Records Review

The scope of the regulatory information search included a review and evaluation of available public information relating to the site including: the National Priority List (NPL); the State Equivalent Priority List (State Sites); Comprehensive Environmental Response Compensation and Liability Information System Database (CERCLIS); Resource Conservation and Recovery Act (RCRA) Generators and Violators List; RCRA Corrective Actions List (COR); RCRA Treatment, Storage, or Disposal (TSD) List; TNRCC Underground and Aboveground Storage Tank Database (UST and AST); Leaking Underground Storage Tank (LUST) Listings; City/County Solid Waste Landfill (SWL) listings; Emergency Response Notification System (ERNS) Database; TNRCC Spills Incident Information System (SPILL) Database; Facility Index System (FINDS) Database; National Pollution Discharge Elimination System (NPDES) Database; and the Toxic Release Inventory System (TRIS) Database, and the Railroad Commission of Texas (RCT).

The regulatory agency review located one CERCLIS site, one RCRA Generator site, one NPDES site, two FINDS sites, thirteen registered storage tank sites, six LUST sites, and eighteen ERNS sites within a one-half-mile radius of the shoreline along the Laguna Madre and within a one-half-mile radius along the centerline of Packery Channel. No registered NPL, RCRA TSD, RCRA COR, TRIS, State Sites, Spills, or SWL were identified within the study area. None of the sites reported appear to provide a threat or environmental concern to the Project.

Marker 37, a marina located on a PA adjacent to the GIWW, is identified as a LUST site. This facility is located approximately 1,300 feet south of Packery Channel, adjacent to the JFK Causeway. According to TNRCC records, the facility currently operates two 1,000-gallon USTs to store gasoline. According to a TNRCC representative, the operator reported a release from the UST system in 1999, but as of March 2002, the operator has yet to file a release report. The nature of the release is unknown and initial directives have yet to be issued by the TNRCC. The TNRCC has ranked the site as a low priority and has determined that no receptors are threatened. Due to this determination and the distance from the Project area, the potential for the LUST site to impact the Project is minimal.

3.7.3 Site Inspection

A visual inspection of the study area was conducted by PBS&J personnel in August 2000 by boat and automobile. The site inspection was intended to identify indicators of potential hazardous waste and confirm the mapped locations of sites identified through the various regulatory agency reviews. All sites reported in the regulatory agency review were identified and appeared to be located accurately. Development along Packery Channel is isolated and limited to commercial fishing and residential development. Development along the reaches of the Upper Laguna Madre within the study area is also isolated to the urban areas of Corpus Christi. Numerous oil and gas wells and pipelines are identified in the records research; however, very little physical evidence of the majority of these features was observed during the visual inspection. No environmental conditions were noted at any of the accessible well sites or identified pipeline easements.

3.7.4 Oil/Gas Well and Pipeline Review

Though specific sites such as underground and aboveground fuel storage tanks, active gas/oil wells and pipelines are identified in this survey, by definition, HTRW sites do not include petroleum or natural gas sites, unless already included under CERCLA Section 42 of the U.S. Code, Chapter 9601(14). However, the search of the RCT files indicated a total of 263 permitted wells located within the study area. Fifty-two of the wells are listed as producing; 106 are listed as plugged; 78 are listed as dry; three are currently used as injection wells; one is used as a disposal/injection well; 12 wells have been permitted, and 11 are listed as abandoned. Forty-nine of the producing wells are listed as oil wells; 76 are listed as gas wells, and 37 are listed as producing oil and gas.

A total of 278 pipelines were identified within the study area. Twenty of the pipelines are listed as active pipelines; 56 are listed as abandoned; and 202 are listed as inactive. The RCT data identified the inactive and abandoned pipelines with a miscellaneous easement code. According to Terry

Pardo, Gas Services Division of Pipeline Safety with the RCT (Pardo, 2000), it is reasonable to assume that these miscellaneous easements contain a pipeline.

One inactive pipeline owned by the City of Corpus Christi is reported by the RCT to cross the existing Packery Channel south of the SH 361 bridge. The nearest well is located adjacent to the existing channel near channel station 65+00.

3.8 HISTORIC RESOURCES

The Packery Channel Project area is located in the Southern Coastal Corridor (SCC) Archeological Region of the Central and Southern Planning Region of Texas as delineated by the Texas Historical Commission (THC) (Mercado-Allinger and Ricklis, 1996). This archeological region encompasses the Coastal Bend from the Colorado River in Matagorda County south to the Rio Grande (Bailey, 1987; Ricklis, 1990). Pursuant to THC guidelines, maps depicting the location of specific cultural resources sites are not included in this public document.

The SCC Archeological Region contains five subareas, each possessing unique geographic and cultural features. Packery Channel marks the north-south division of the Aransas/Guadalupe and Baffin/Oso subareas. In these subareas the primary resource zones are the coastal estuaries and terrestrial flood plains with adjacent prairies.

3.8.1 <u>Cultural History Overview</u>

Indigenous groups were present in the SCC Archeological Region from at least 10,000 B.C. through the time of European contact and colonization (Mercado-Allinger and Ricklis, 1996). The generally accepted cultural history of the area is divided into four periods, the Paleoindian, Archaic, Late Prehistoric, and Historic. Each of these periods is briefly summarized below.

The Paleoindian is the earliest recognized cultural period, dating from at least 10,000 B.C. to circa 6000 B.C. Little is known about this initial adaptation to the region, but researchers have suggested that this period was marked by a very low population density, small band sizes, and extremely large territorial range (Black, 1989). In Nueces County, the presence of early materials along Oso and Petronila creeks demonstrates that assemblages dating to Paleoindian times occur in this region (Shafer and Bond, 1983).

The Archaic period (approximately 6000 B.C. to A.D. 1000) is identified during the early and middle Holocene by intensive human utilization of a wide variety of ecological niches including the coastal zone. The tripartite division of the Archaic is the Early (6000 B.C. – 2500 B.C.), Middle (2500 B.C. – 1000 B.C.), and Late (1000 B.C. – A.D. 1000) subperiods. Sites with identified Early Archaic deposits in Nueces County include 41NU124, the Means Site (Fox and Hester, 1976) and sites at White's Point on Nueces Bay (Ricklis, 1993).

During the Middle Archaic subperiod exploitation of marine resources appears to have accelerated. This may be evidenced by thicker shell strata in shell middens as well as more abundant fish remains. The presence of central Texas related groups in the region during the Middle Archaic and later periods is more conclusively indicated. Clear Fork Phase *Nolan* and *Travis* type dart points, dated to the beginning of the Middle Archaic period (Prewitt, 1981), occur at three sites, 41KL5, 41KL8, and 41KL9 (Campbell, 1964). Single specimens of later Middle Archaic *Lange* points (Prewitt, 1981) were collected from Site 41KL3 (Campbell, 1964).

During the Late Archaic the sea level stabilized at its modern position and remains from this period are abundant and varied. Sites dating to the Late Archaic are shell middens with thick deposits that yield a greater range and quantity of artifacts than do the shell middens dating to the Early Archaic. All of this suggests more frequent and/or intensive occupations, and perhaps a higher regional population density (Ricklis, 1995). Settlement during this time is also characterized by summer occupations in the interior Gulf coast area resulting in open lithic scatters. Numerous cemeteries have been identified in the SCC Archeological Region dating to the Late Archaic and Late Archaic/Late Prehistoric associations.

The Late Prehistoric Period is represented by the advent of the bow and arrow and ceramic vessels. The Rockport phase (Ricklis, 1995) directly precedes the Historic Period and is characterized by the exploitation of larger game and an intensified exploitation of fish (Campbell, 1964). Settlement and subsistence patterns during the Rockport phase involved, to some significant degree, shifting seasonal emphases, with occupation of shoreline fishing camps during the fall through winter-early spring, and late spring through summer residences at hunting camps commonly located along the upland margins of stream valleys (Ricklis, 1995).

In terms of resource exploitation and cultural assemblages, the pattern for this phase tentatively established a link between the Rockport phase sites and the Karankawas, a historically known coastal group of Coahuiltecan speaking indigenous people (Thomas and Weed, 1980a). The Rockport phase dates from about A.D. 100 until the extinction of the Karankawas in the mid-nineteenth century (Newcomb, 1993). Most of the prehistoric sites thus far investigated in depth in the region are interpreted as reflecting a littoral adaptation with a secondary dependence on inland prairie resources (Prewitt, 1984). Historically, the Karankawa are reported to have camped on shell middens located near sources of fresh water whenever possible. Artifacts associated with Rockport sites include shell containers, jewelry, shell working-tools, asphaltum, burned clay nodules, sandstone shaft straighteners, and decorated ceramics including polychrome (Calhoun, 1964), asphaltum-painted black on gray (Fitzpatrick, et al., 1964) and scallop-shell scored (Calhoun, 1964).

Late Prehistoric cemeteries and burials are relatively common along the Texas coast and are often found in clay dunes (Headrick, 1993). One coastal cemetery is documented for the Oso Creek/Oso Bay area in Nueces County. According to Hester (1980) the Texas coast encompasses the largest number of prehistoric cemeteries in the region.

The post contact historic period for the Texas coast and south Texas effectively begins with the explorations of the Gulf of Mexico by Spanish explorers seeking to locate new land and economic resources for the Spanish royal crown in Madrid. Following Alonzo Pineda's initial mapping of the Gulf of Mexico and Corpus Christi Bay in 1519, Cabeza de Vaca traversed the area in the 1520s (Webb, 1952).

3.8.2 Historic Coastal Groups

Two historic Indian groups were indigenous to the Texas coastal area: the Coahuiltecan and the Karankawas. These nomadic hunters and gatherers were decimated by European diseases and by encroachment of the Spaniards from the south and the Apaches and Comanches from the north, as well as the Anglo-Americans from the east. By 1850 neither the Coahuiltecans nor the Karankawas occupied the coastal area (Campbell, 1956).

By the 1700s, the indigenous populations were being affected by Spanish missions and presidios such as the Goliad missions of Espiritu Santo and Rosario, as well as by raiding Lipan Apaches and other central and southwestern groups (Mounger, 1959; Headrick, 1993). By the early 1840s, most remaining members of the Karankawa tribe had migrated to Mexico.

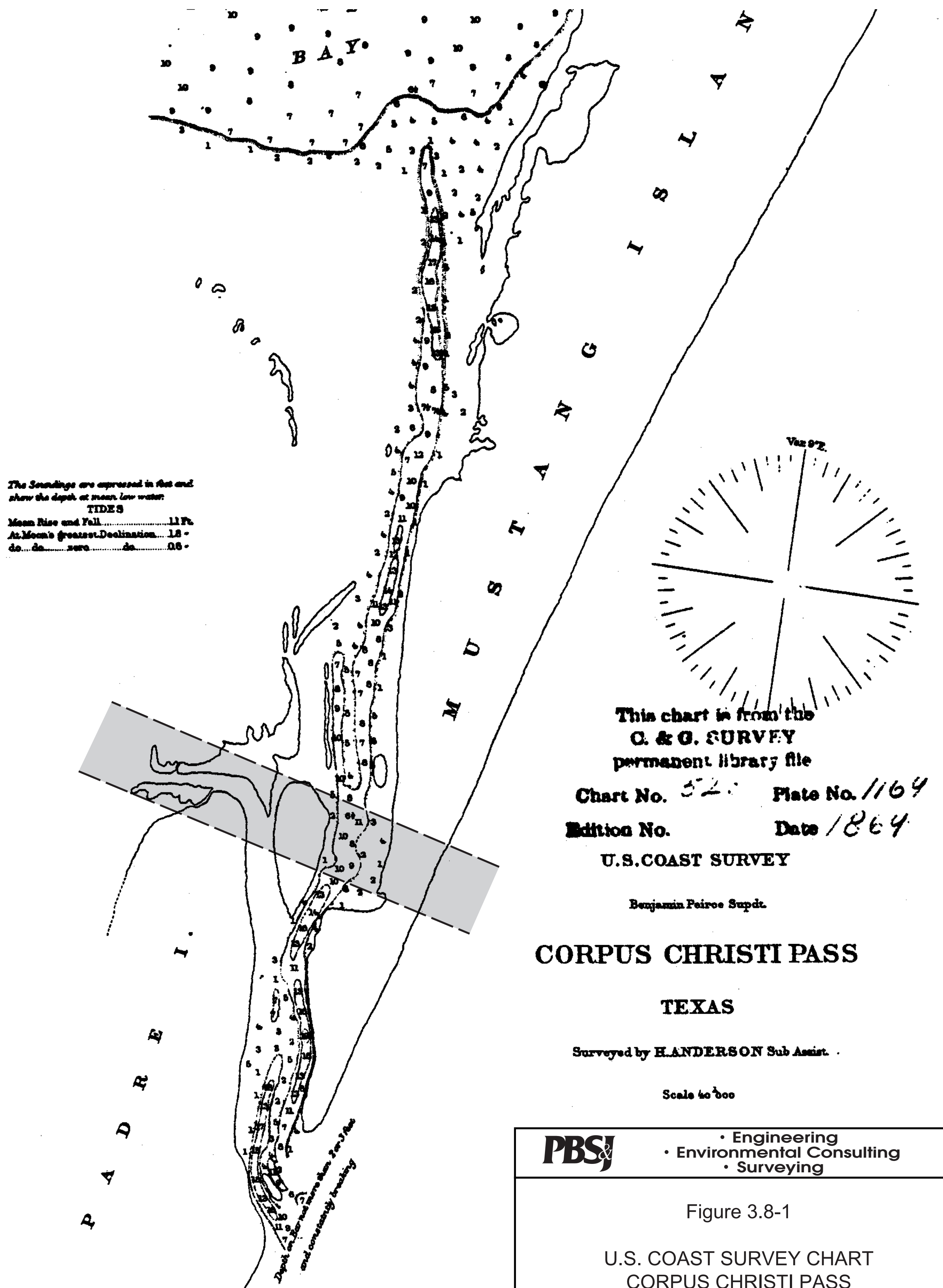
3.8.3 Early Settlement

Much of the region's early economic development was related to the settlement and growth of the community of Corpus Christi. This settlement was largely the result of the efforts of entrepreneur and promoter Henry Lawrence Kinney, who arrived at Corpus Christi in 1832, and who had established a trading post there by 1840 (Webb 1952). In 1845 Corpus Christi was made the county seat of San Patricio County. One year later, when Nueces County was formed and organized from portions of San Patricio County, Corpus Christi became the county seat of the new county and San Patricio reverted to being the county seat of San Patricio County (Tyler, 1996). Kleberg County was organized in 1916 with Kingsville as the county seat. Although a trading commerce with Mexico and the Rio Grande valley was increasingly important during the early settlement years, ranching and agriculture were the primary economic industries throughout most of the nineteenth century.

3.8.4 Historic Packery Channel

Historic documentation of Packery Channel is difficult because it is not identified by that name on early maps. On early historic maps the project area is referenced as Corpus Christi Pass (Board of Engineers, 1846: U.S. Coast Survey, 1869 (Figure 3.8-1). Nineteenth- and early twentieth-century maps do not label any area waterway as Packery Channel. Modern maps identify another pass, located approximately 2.5 miles north of the project area, as Corpus Christi Pass. This latter pass is totally separate from the historic development of Packery Channel; it is not part of the area's historic navigation and all discussion of Corpus Christi Pass in the following text in Section 3.8 references the historic nineteenth century channel that is now silted in. The nineteenth century Gulf outlet for the Corpus Christi Pass was located approximately 1.5 miles south of the proposed channel to be dredged across Padre Island. Figure 3.8-1 presents the historic location of Packery Channel (U.S. Coast Survey, 1869) with an overlay of the Packery Channel Project Area (PCPA).

Historically the Corpus Christi Pass has always been shallow. Originally it extended northward from its Gulf outlet along the west edge of Mustang Island, passing to the east of the Crane Islands before entering the bay. During the nineteenth century there was no channel outlet into the Laguna Madre, and much of the area between north Mustang Island and Flour Bluff is depicted on 1887



Approximate Location Packery Channel Project Area

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Figure 3.8-1

U.S. COAST SURVEY CHART
CORPUS CHRISTI PASS
1869

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Coast Chart No. 210 as "…flats with less than 6 inches of water." The existing channel that extends west from the SH 361 bridge around Packery Point to connect with the Crash Boat and Causeway channels is largely the result of the modern dredging of a historically shallow cut between what was the historic Corpus Christi Pass and the Laguna Madre.

Early maps and navigation charts list a maximum depth at both the Gulf and Corpus Christi Bay outlets as no more than 2 to 3 feet. C.W. Howell, in an 1879 USACE annual report on a survey of the Corpus Christi Pass, noted that "A man of ordinary stature can wade it now at several points" (1879:930). A notation on one of the USACE maps by Assistant Engineer H.C. Collins (Collins et al., 1878) states that depth at the Gulf entrance did not exceed 2 feet and was breaking across the bar at the entrance. Collins' description of the survey, included in Howell's (1879) report, notes that their schooner could not enter the Corpus Christi Pass, and with a "yawl-boat" drawing only 1.5 feet, it was necessary to sail as close to the shore as possible to take soundings.

At the time of Howell's survey and report, the Corpus Christi Pass was apparently little used, and he proposed constructing a dam across the Corpus Christi Pass to further restrict its flow (1879:930). The proposed dam (1879: figures 1 and 3) was to be of stone construction and would be approximately 1,900 feet in length, with the crest of the dam being no higher than the plane of mean low tide. Howell proposed that the dam would enable the Corpus Christi Pass to continue to act as a safety valve for major storm surges while at the same time increasing the tidal flows at the more important Aransas Pass. Howell also thought that the dam would improve the channel connecting Corpus Christi Bay and the Laguna Madre to the south, noting that the latter bay was important because its salt production was required by the beef packers along that portion of the coast.

Although the USACE had concluded that the maintenance of the Corpus Christi Pass was not a viable option in the late 1800s, promoter and land developer Colonel E.H. Ropes was not dissuaded. In 1890 Ropes commissioned the steam powered "dipper dredge" *Josephine* to establish a cut through Padre Island at Packery Channel. While Ropes succeeded in cutting through the island, the cut quickly filled. His dredge was unable to extricate itself and had to be abandoned (Alexander et al., 1950). As the precise location on Rope's channel has not been ascertained, the dredge *Josephine* has not yet been relocated although two "boilers" are identified on NOS chart 11308 in the Laguna Madre to the north of Packery Channel. It is possible these boilers may be related to the *Josephine*. A later attempt at maintaining a dredged channel between 1938 and 1940 was only slightly more successful in that the dredge was not lost.

When the moniker Packery Channel came into common use is not certain, although a notation on an 1878 USACE map makes reference of a distance between Packery and "Baffins" Bay. The term "packery" refers to a beef processing plant constructed by J.T. Lend on Corpus Christi Pass in the late 1860s (Webb, 1952; Alexander et al., 1950). The packery, which is identified on an 1869 U.S. Coast Survey chart, was located near the Gulf entrance to the pass. A comparison of historic and modern maps indicates that the packery was located near the mouth of the pass and was probably more than 1 mile south of the current Project area. Seven other historic structures are indicated on this map; three are well to the south of the Packery Channel Project area, and four others were possibly located on Packery Point immediately adjacent to the existing Packery Channel. A quarantine station was reported at the pass (*Corpus Christi Caller Times*, 1972); however, none of the reviewed maps has disclosed its location.

The development of the Padre Island side of Corpus Christi Pass largely came to a halt in 1879 when Patrick Dunn and his brother purchased most of the island for a cattle ranch and severely restricted access to the property. While Dunn spent most of his life in Corpus Christi he did construct a two-story house on the pass in 1907. The structure, destroyed in 1916, was reported to have been located one-quarter mile north of Park Road 22 and is probably south of the area to be affected by the proposed Project.

The role of the Corpus Christi Pass in navigation to Corpus Christi Bay was seriously reduced by its tendency to shoal and the economic interests in the last half of the nineteenth century, which favored the development of Aransas Pass for a shipping outlet. There are several reports of beef products being shipped outbound from Corpus Christi Pass to overseas destinations (Alexander et al., 1950:168). Although some references suggest that the shallow pass required the use of lighter vessels to make the seaward connection, shallow-draft vessels, in at least one instance, were reported to be carrying packery products north through Corpus Christi Bay rather than seaward through the pass (Alexander et al., 1950).

Specific references to known shipwrecks in the immediate Corpus Christi Pass area, other than the *Josephine*, are few. One vessel of French registry may have foundered in the area in 1880 (Alexander et al., 1950). A Norwegian Barque was reportedly lost when Corpus Christi Pass was mistook for Aransas Pass. Although there are only limited references to losses at Corpus Christi Pass, it was known for dangerous shoaling. It is probable that it claimed many small vessels, especially those unregistered boats used to lighter materials to the ships waiting beyond the breakers.

3.8.5 Previous Investigations

3.8.5.1 Regional Studies

Some of the earliest archeological investigations in this region were conducted in the 1920s. Syntheses of this work have been prepared by Suhm et al. (1954), Campbell (1958) and Briggs (1971). Since the acquisition of the land by the National Park Service, several major archeological investigations have been conducted within Padre Island National Seashore, as well as a number of more limited surveys related to proposed oil-exploration and extraction activities. T.N. Campbell conducted the first professional investigations on Padre Island in 1963 (Campbell, 1964). His survey areas were located between Corpus Christi Bay and a point about 15 miles north of Mansfield Pass. A total of 15 prehistoric and proto-historic sites were recorded, 12 of which were within the then-proposed National Seashore boundaries. Three distinct clusters of sites were documented but were confined to the northern end of the island. The significance of this distribution however, is uncertain because of erratic ground surface visibility and other problems in site identification.

Cultural resource management surveys and testing programs have proliferated in the Baffin/Oso Subarea since the 1970s (Mercado-Allinger and Ricklis, 1996). This work has provided models of Late Prehistoric settlement and subsistence patterns, as well as native responses to Spanish colonization (Patterson and Ford, 1974; Carlson, 1983; Warren, 1987). Additionally, these investigations have also contributed to the enhancement of the Archaic chronology of the region (Ricklis and Cox, 1991; Ricklis, 1993, 1995).

3.8.6 Records and Literature Review

A literature and records review was conducted to identify known cultural resource sites and to determine the location and type of sites previously identified adjacent to the project area and within 500 feet of the project area shoreline. Records on file at TARL and at the THC were reviewed for locations and information on previously recorded sites in the project area. The files at the THC were reviewed for previous archeological investigations. The listings on the NRHP were reviewed for sites listed on, or determined eligible for inclusion on the NRHP. The list of State Archeological Landmarks (SAL) prepared by the Department of Antiquities Protection at the THC was consulted for sites determined significant by the State. The Historical Marker Program of the THC was also consulted.

Based on the site location maps at TARL, the literature and records review revealed two previously recorded sites, 41NU6 and 41NU219, within the project area. Another 17 previously recorded sites, including one SAL (41NU7), were recorded within the larger study area. All 19 previously recorded sites are listed in Table 3.8-1. One Historical Marker was found. Located adjacent to Park Road 22 on the east side, just north of the intersection with SH 361, the marker chronicles Mr. Dunn's ranching activities across Padre Island in the late nineteenth century. Only one shipwreck is recorded for the Laguna Madre. The wreck is identified on the NOAA Automated Wrecks and Obstruction Information System as a 127-gross-ton freighter sunk in 1945. As the Laguna Madre has historically been very shallow and was not navigable until the GIWW was opened in 1949, it must be concluded that the wreck data is in error.

3.8.6.1 Studies in the Packery Channel Project Area

The existing Packery Channel and land that will be directly affected by the proposed Project have been subjected to at least seven separate cultural resource studies. Because of the nature and requirements of many of these studies, and the recording procedures of the various investigators, archeological survey coverage can only be verified for the Warren (1984) and PBS&J (Bond and Rogers, 2001) surveys. Survey coverage is identified on Figure 3.8-2.

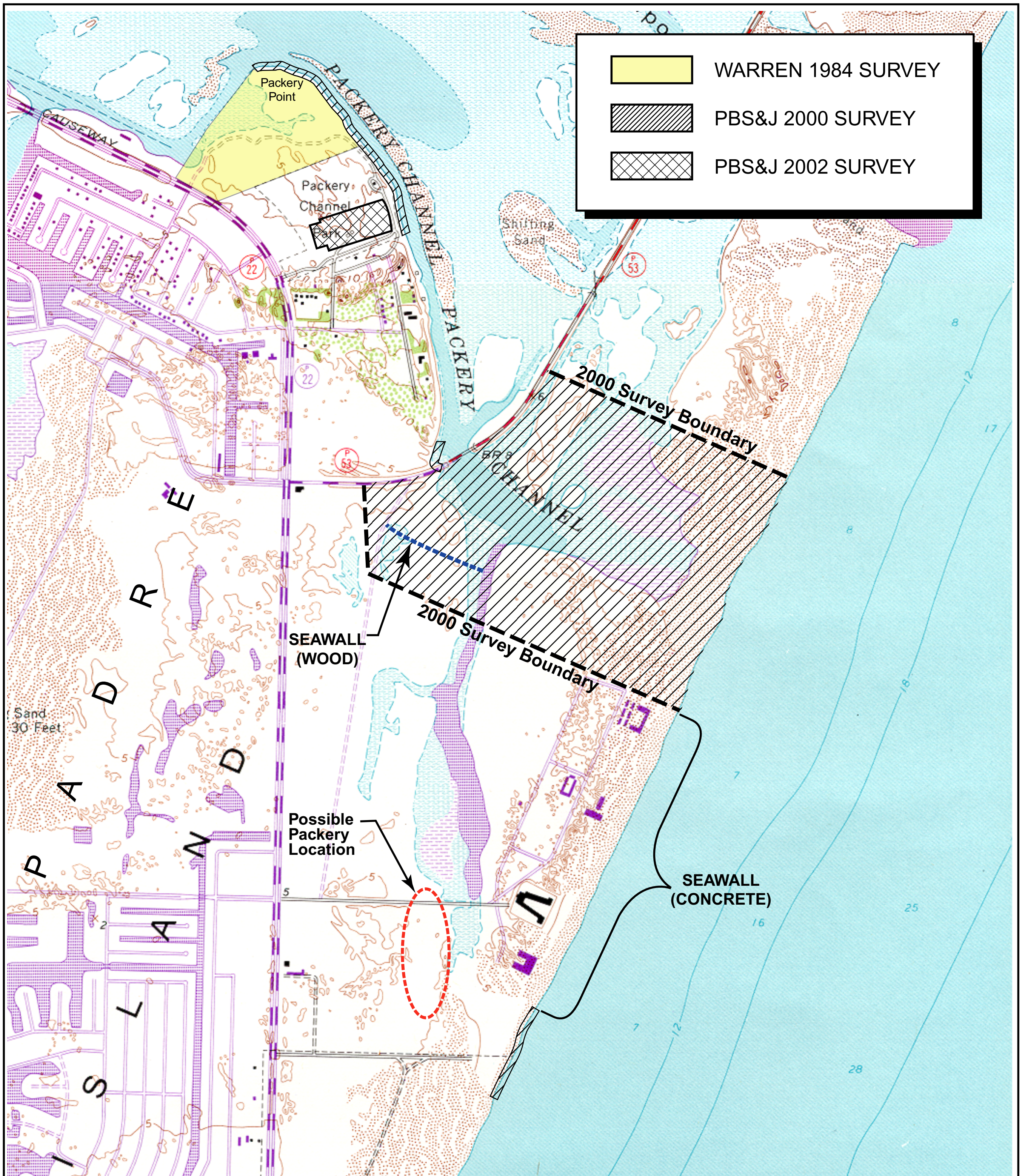
The first study to cover a portion of the Project area was a reconnaissance level archeological survey conducted by T.H. Campbell (1964). The study was a review of potential Padre Island resources for the National Park Service preparatory to the establishment of the National Seashore. Campbell and a volunteer crew of amateur archeologists revisited one cultural resources site, 41NU6, which had been previously recorded in the Project area.

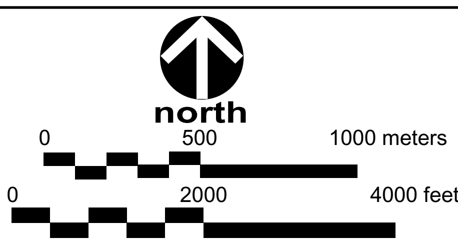
In 1984, an archeological survey was conducted on a 60-acre tract adjacent to the existing Packery Channel for a proposed marina project, which resulted in the location of Site 41NU219 (Warren, 1984). Another brief study by Carolyn Good (1984), a USACE archeologist with the Galveston

TABLE 3.8-1

PREVIOUSLY RECORDED CULTURAL RESOURCES PROPERTIES
ADJACENT TO PCPA AND WITHIN 500 FEET OF STUDY AREA SHORELINE

Site No.	Status/Designation	Site Name	Type of Site	Owner	Quad Map
41NU1		Webb Island/ Arrowhead Island	Extensive campsite kitchen midden	Mr. Webb	Oso Creek NE
41NU4			No Information	Nueces County	Oso Creek NE
41NU6			Prehistoric Campsite	Padre Island Investment Corporation	Crane Island SW
41NU7	State Archeological Landmark	Mustang Island State Park Sites	lithic/ceramic scatter Rockport Phase	Texas Parks and Wildlife Department	Crane Island NW
41NU45			No Information	Nueces Co. - Corpus Christi, TX	Oso Creek NE
41NU68			No Information	Nueces Co. - Corpus Christi, TX	Oso Creek NE
41NU69			No Information		Oso Creek NE
41NU70			No Information		Oso Creek NE
41NU219	Determined Eligible to the National Register	Gopher Mount Site	Prehistoric Campsite	Packery Point Ltd. Inc.	Crane Island NW
41NU224			Prehistoric Campsite	Texas Parks and Wildlife Department	Crane Island NW
41NU233			Mortuary (?)	John Hogan- Corpus Christi, TX	Oso Creek NE
41NU284		MZ-2	Prehistoric shell scatter/ Historic Road	Texas Parks and Wildlife Department	Crane Island NW
41NU285		MI-1	Prehistoric shell clusters	Texas Parks and Wildlife Department	Crane Island NW
41KL57			No Information		Port of Rocks
41KL58			No Information		Port of Rocks
41KL60			No Information	Nueces County Park	Crane Island SW
41KL62		Rawalt's RK 1	No Information	National Park Service	South Bird Island
41KN12		Rawalts RK 7	No Information	National Park Service	S. Bird Island SE
41KN23		Temp Site 3	Historic Scatter	Cypress Engineering	S. Bird Island SE





Base Map: USGS 7.5' Quadrangles; Crane Islands NW and Crane Islands SW, Texas

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Figure 3.8-2

PROJECT AREA SURVEYS

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District, examined a portion of the Project area and reevaluated Site 41NU6 as part of the permitting for a dredged material disposal site for the Padre Island Investment Corporation.

Working for the Reopen Packery Channel Association, James Warren (1987) conducted a reconnaissance level survey over most of the Project area east of SH 361 to the Gulf shore. Warren failed to identify any resources in the area and subcontracted with EH&A (1988) to conduct a magnetometer survey over part of the area. Twenty-eight magnetic anomalies were located, 11 of which were recommended by EH&A for further investigation.

In 1989 Warren again revisited the area he had studied in 1984 for the marina. This time the area was proposed as the potential location for dredged material disposal. Warren's effort was to confirm the location and dimensions of archeological Site 41NU219, which was adjacent to the disposal site.

One year prior to Warren's 1989 visit, archeologist Herman Smith (1988) with the Corpus Christi Museum conducted an archeological test investigation at 41NU219 and offered somewhat different conclusions about the site's dimensions as originally reported by Warren (1984). Warren (1989) was critical of Smith's interpretations and suggested that Smith's work was insufficient to determine the site's boundaries. It was Warren's opinion that the proposed placement of dredged material did not threaten the site.

In 1992 area developers revived efforts to permit the marina which was first proposed in 1984. As Site 41NU219 had been determined eligible for the National Register of Historic Places (NRHP), the USACE Galveston District (1992b) stipulated that a data recovery plan be formulated and implemented prior to construction in the area. The consulting parties had difficulty in developing that plan because of the conflicting opinions of Warren (1984, 1989) and Smith (1988), and employed EH&A to conduct additional studies. Archeologist Steve Kotter (1993) conducted additional shovel testing, surface survey, and mapping at 41NU219. Kotter confirmed the site's research potential and, like Warren, found considerable variability in different parts of the site.

A pedestrian cultural resources survey of the currently proposed Project area, augmented with controlled shovel tests, was performed by PBS&J staff archeologists on October 26-27, 2000 (Bond and Rogers, 2001). A second survey was completed in February 2002 by PBS&J which investigated the area proposed for the MMPA and also included a remote-sensing survey of terrestrial and marine portions of the Project area (Bond et al., 2002). Details of those survey investigations follow.

3.8.6.2 October 2000 Survey

PBS&J's 2000 survey included: (1) an examination of the Packery Channel shoreline north and east of previously recorded prehistoric Site 41NU219; (2) an assessment of the current conditions at previously recorded prehistoric Site 41NU6; (3) a survey of the proposed channel from SH 361 to the Gulf beach; and (4) a survey of portions of the Gulf beach south of the proposed channel. In addition to these survey areas, a brief visit was made and photographs were taken of the probable location of the historic packery depicted on late nineteenth century maps (Figure 3.8-2). A total of twenty-one controlled shovel tests were excavated during the study.

Geomorphologic features within these surveyed areas included beaches, fore-island dunes and fore-island blowout dunes, sand flats, wash-over channels and wash-over fans, and barrier flats. Areas of dredged material also were present.

Approximately 2,500 feet of shoreline along Packery Channel north and east of previously recorded 41NU219 were surveyed. Most of this area is within the confines of Packery Channel Park, and includes fore-island blowout dunes and barrier flats. The northern end of the surveyed area included some dredged material. No prehistoric artifacts were observed along the surveyed portion of the shoreline. Four shovel tests, dug inland from the channel shoreline on the barrier flat to the north of Site 41NU219, also encountered only culturally sterile sand.

Previously recorded Site 41NU6 is located on the south side of SH 361, west of Packery Channel. When recorded by Campbell in 1964, the site was described as a shallow area overlooking Packery Channel. The site's surface was thinly littered with marine shells including oyster. Campbell did not locate any prehistoric artifacts during his brief 1964 visit to 41NU6. A later collection made from the site by a local avocational archeologist included *Perdiz* and *Fresno* arrowpoints and *Rockport* ceramics (Texas Archeology Research Laboratory [TARL] Site Files).

A reconnaissance was made of the site during the current investigation. Previous impact to the site south of SH 361 included erosion from vehicular traffic and from the construction of a retaining wall. No artifacts or other evidence of the site was located at its mapped location. An examination of the area immediately north of SH 361 found no evidence that the site extended in that direction.

The pedestrian survey of the proposed channel to the Gulf beach commenced on the portion of the tract east of the existing Packery Channel. The southern portion of this area, which included the Gulf beach, partially inundated wash-over channel, sand flats, fore-island blow out dunes and wash-over fan, was surveyed in a zigzag manner. Ten shovel tests were excavated in this effort, with particular attention focused on the area of the blowout dunes and wash-over fan in the northern part of the tract. No cultural materials other than modern trash were observed.

The remaining portions of the proposed channel from the Gulf inland includes beach, fore-island dunes, wash-over fan, dredged material and barrier flat. With the exception of the dredged material, all of the geomorphologic features were examined with shovel tests. No cultural materials were observed in any of these areas.

Approximately 1.1 miles of Gulf shoreline beach south of the proposed channel were included in the October 2000 investigation. However, most of the beach swash zone along this section was encompassed within a concrete seawall, and the foredunes along this stretch have been developed into resorts. The pedestrian survey was thus limited to an area of about 650 feet paralleling the beach. No cultural materials other than modern trash were observed in this area.

A brief visit was made to the area of the historic packery depicted on a late nineteenth century map. While photographs of the area were taken, no effort was made to survey this land as it is now a subdivision well outside the Project area and no impacts are anticipated.

3.8.6.3 PBS&J 2001-2002 Investigations

PBS&J conducted additional cultural resource investigations in the PCRA in 2001 and 2002. These investigations included the following:

a. Terrestrial remote-sensing survey along the alignment of the proposed Packery Channel on North Padre Island;

b. Underwater remote sensing along the existing Packery Channel from Station 0+000 to approximately Station 14+000;

c. Underwater remote-sensing in an off-shore area adjacent to Padre Island, measuring 2,640 feet on either site of the proposed jetties and extending from the island southward to 1,000 feet beyond the end of the proposed jetties; and

d. Terrestrial archeological survey and limited shovel testing of the proposed MMPA 20-acre parcel located in Nueces County Park No. 2, with special attention to identifying Site 41NU219 in relation to the proposed Project area.

No potentially significant magnetic anomalies, side-scan sonar targets, or cultural resources sites were located as a result of the remote-sensing survey, and no further archeological investigations are recommended for the areas covered by that survey. One prehistoric site (41NU255) and one isolated find were discovered by the terrestrial shovel-testing survey. The NRHP-eligibility status of Site 41NU255 remains unknown; however, it is outside the proposed MMPA and will not be impacted. The single isolated find is not considered an archeological site, nor potentially eligible for inclusion in the NRHP.

3.9 AIR QUALITY

The Clean Air Act, which was last amended in 1990, requires the EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards:

- Primary standards set limits to protect public health, including the health of “sensitive” populations such as asthmatics, children, and the elderly.
- Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

The EPA Office of Air Quality Planning and Standards has set NAAQSs for six principal pollutants which are called “criteria” pollutants. They are carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), lead (Pb), particulate matter with particle diameters of 10 micrometers or less (PM_{10}), particulate matter with particle diameters of 2.5 micrometers or less ($PM_{2.5}$), and sulfur dioxide (SO_2). In its General Air Quality Rules, the State of Texas provides for enforcement of the Federal NAAQSs. In addition, the TNRCC has set standards for net ground-level concentrations for particulate matter and sulfur compounds. Resulting air concentrations from sources on a property that emit these air contaminants should not exceed the applicable property-line standards. Air quality is generally considered acceptable if pollutant levels are less than or equal to established standards on a continuous basis. These pollutants are summarized in Table 3.9-1.

The Clean Air Act also requires EPA to assign a designation of each area of the U.S. regarding compliance with the NAAQS. EPA categorizes the level of compliance or noncompliance as follows:

1. Attainment – area currently meets the NAAQS
2. Maintenance – area currently meets the NAAQS, but has previously been out of compliance
3. Nonattainment – area currently does not meet the NAAQS

Nueces County is considered to be "near nonattainment" for ozone under Federal air quality standards and, therefore, is monitored closely by State and Federal environmental agencies. Once a metropolitan area has violated ozone levels over a 3-year period, the EPA can require stringent measures to bring that area back into compliance with the NAAQS.

TNRCC is responsible for monitoring air and water quality within the State and for reporting that information to the public. The staff examines and interprets the causes, nature, and behavior of air pollution in Texas. The TNRCC operates several monitors located in the Corpus Christi area. There are no TNRCC continuous air monitoring stations within the defined Project area. The locations of the monitors in the Corpus Christi area, in general, are listed in Table 3.9-2.

TNRCC'S Corpus Christi Regional Office maintains these monitors. Four of the eight active monitoring stations measure the concentrations of the criteria pollutants in the air. All are used to measure meteorological parameters such as air temperature, wind velocity, and other meteorological parameters. The ozone monitors operate continuously 24 hours a day, 7 days a week, and are checked by technicians who perform equipment maintenance and conduct quality assurance checks.

Monitored values for the criteria pollutants in Nueces County are shown in Table 3.9-3. No data are available for CO, NO_2 or Pb. The monitoring data show that in 1995, the area exceeded the ozone and sulfur dioxide NAAQS standards (0.12 parts per million (ppm) and 0.14 ppm, respectively) for the 1-hour value. Since then, monitored values have been below the NAAQS.

When measured by the EPA's newer 8-hour standard instituted in 1997, Corpus Christi has had exceedances. Although challenged in federal court, the U.S. Supreme Court recently upheld the standard. This 8-hour standard will apply to the Corpus Christi area in lieu of the 1-hour standard.

In 1996, Nueces and San Patricio counties, acting through the Corpus Christi Air Quality Committee, finalized a 5-year plan for identifying actions that have been implemented by residents and businesses on a voluntary basis to control and reduce air pollution including ambient ozone. The plan was formalized in a Flexible Attainment Region memorandum of agreement approved by the EPA and TNRCC. Since then, residents and businesses of Nueces and San Patricio counties have carried out the

TABLE 3.9-1

NATIONAL AMBIENT AIR QUALITY STANDARDS & TNRCC PROPERTY LINE NET GROUND LEVEL CONCENTRATION STANDARDS

Air Constituent	Averaging Time	NAAQS Primary	NAAQS Secondary	TNRCC Regulation Standard
Sulfur Dioxide (SO_2)	30-min.	---	---	0.4 ppm (1021 μg/m^3) 0.28 ppm (for Galveston or Harris County) 0.32 ppm (for Jefferson or Orange County)
	3-hr.	---	0.50 ppm	
	24-hr.	0.14 ppm		
	Annual Arithmetic Mean	0.03 ppm		
Particulate Matter (PM)	1-hr.	---	---	400 μg/m^3
	3-hr.	---	---	200 μg/m^3
Inhalable Particulate Matter (PM_{10})	24-hr.	150 μg/m^3	150 μg/m^3	---
	Annual Arithmetic Mean	50 μg/m^3	50 μg/m^3	---
Fine Particulate Matter ($PM_{2.5}$)	24-hr.	65 μg/m^3	65 μg/m^3	---
	Annual Arithmetic Mean	15 μg/m^3	15 μg/m^3	---
Nitrogen Dioxide (NO_2)	Annual Arithmetic Mean	0.053 ppm	0.053 ppm	---
Carbon Monoxide (CO)	1-hr.	35 ppm	---	
			---	---
	8-hr.	9 ppm		
Lead (Elemental) (Pb)	3-mo. (Calendar Quarter)	1.5 μg/m^3	1.5 μg/m^3	---
Ozone (O_3)	1-hr. 8-hr.	0.12 ppm 0.08 ppm	0.12 ppm 0.08 ppm	---

μg/m^3 - micrograms per cubic meter.
ppm - parts per million.

TABLE 3.9-2

CORPUS CHRISTI AREA MONITORING STATION SITES

Site Name/No.	Street Address	Pollution Parameters Currently Monitored	Meteorological Parameters Monitored?	Current Status
Corpus Christi West C4	902 Airport Blvd.	SO_2, O_3, $PM_{2.5}$	Yes	Active
Corpus Christi Tuloso C21	9860 La Branch	SO_2, O_3	Yes	Active
Corpus Christi Huisache C98/C155	3810 Huisache Street	SO_2 Hydrogen Sulfide	Yes	Active
Corpus Christi Huisache C149	3810 Huisache Street	SO_2 Hydrogen Sulfide	Yes	Deactivated December 7, 1999
Corpus Navigation C121	1111 Navigation Blvd.	--	Yes	Active
Corpus Christi Poth C164	Poth Lane Near Oak Park Area	--	Yes	Active
Corpus Christi Hillcrest C170/168	1802 Nueces Bay Blvd.	--	Yes	Active
Corpus Christi Hillcrest C195	CITGO Refinery Co.	--	Yes	Deactivated October 5, 1998

Source: TNRCC, 2002a.

TABLE 3.9-3

MONITORED VALUES COMPARED WITH PRIMARY NAAQS
CORPUS CHRISTI, NUECES COUNTY, TEXAS

Year	2nd 24-hr Value for PM_{10} ($\mu g/m^3$)	Annual Mean Value for PM_{10} ($\mu g/m^3$)	2nd Max 1-hr Value for O_3 (ppm)	4th Highest 8-hr Value for O_3 (ppm)	2nd Max 24-hr Value for SO_2 (ppm)	Annual Mean Value for SO_2 (ppm)	2nd Max 1-hr Value for CO (ppm)	2nd Max 8-hr Value for CO (ppm)	Annual Mean Value for NO_2 (ppm)	Quarterly Mean Value for Pb ($\mu g/m^3$)
1995	56	31.1	0.128	no data	0.144	0.002	no data	no data	no data	no data
1996	45	25.1	0.103	no data	0.015	0.002	no data	no data	no data	no data
1997	74	30.5	0.094	0.077	0.020	0.003	no data	no data	no data	no data
1998	67	34.9	0.102	0.082	0.029	0.003	no data	no data	no data	no data
1999	88	35.2	0.103	0.085	0.019	0.002	no data	no data	no data	no data
2000	71	35.7	0.099	0.083	0.017	0.003	no data	no data	no data	no data
2001	48	27.6	0.090	0.077	0.017	0.002	no data	no data	no data	no data
NAAQS	150	50	0.12	0.08	0.14	0.03	35	9	0.053	1.5

Source: EPA, 2002.

$\mu g/m^3$ - micrograms per cubic meter.
ppm - parts per million.

provisions of the plan embodied in that agreement, successfully reducing and controlling ambient ozone. According to the TNRCC (2001b), key controls include:

- Controls of dockside emissions by industry
- Use of cleaner gasoline
- Training aimed at small and large businesses

As part of the TNRCC State Implementation Plan, regional strategies aimed at the eastern portion of the State, including Corpus Christi, will require the use of cleaner diesel fuel in vehicles such as tractors and bulldozers, and cleaner low-sulfur gasoline.

As a result, Nueces and San Patricio counties, which comprise the Corpus Christi urban air shed, are currently in attainment of the NAAQS for ozone adopted by the EPA pursuant to the Clean Air Act.

The air quality issues present in the immediate Project area appear limited to non-road mobile sources such as vessel emissions from waterborne traffic including barges, dredges, and the various types of recreational and commercial boats. Additional sources may include marinas and vessel painting/cleaning facilities. Although the surrounding area is typically rural, air quality is hampered with dust from agricultural plowing, automobile emissions, open trash burning, vehicle paint shops, manufacturing, and industrialization (TNRCC, 1998).

3.10 NOISE

As directed by Congress in The Noise Control Act of 1972 as amended by the Quiet Communities Act of 1978, the EPA has developed appropriate noise-level guidelines. The EPA generally recognizes rural areas to have an average day-night noise level (Ldn) of less than 50 decibels A-weighting (dBA) (EPA, 1978). Average outdoor noise levels in excess of 70 dBA or more for 24 hours per day over a 40-year period can result in hearing loss (EPA, 1974). Several factors affect response to noise levels including background level, noise character, level fluctuation, time of year, time of day, history of exposure, community attitudes and individual emotional factors. Typically, people are more tolerant of a given noise level if the background level is closer to the level of the noise source. People are more tolerant of noises during daytime than at night. Residents are more tolerant of a facility or activity if it is considered to benefit the economic or social well being of the community or them individually. Noise levels also affect outdoor activities greater than indoor activities. The immediate activities within the Project area affecting noise levels could include waterborne transportation (i.e., barges, commercial fishing vessels, sport and recreational boats, etc.) and dredging. The noise levels within the Project area would increase in proximity to urban communities due to vehicular traffic and major construction activities.

3.11 SOCIOECONOMIC RESOURCES

This section presents demographic, economic, and land use characteristics of the area surrounding the proposed Packery Channel. The study area, for the purposes of this section, is defined differently than other sections of this document. The study area described in this section is the same as in Figure 1-1, except that it excludes Kleberg County, because Kleberg County has a very low degree of urbanization and its population is very small. Thus, socioeconomic information that incorporated Kleberg County would poorly represent the population living near Packery Channel. The study area for this section includes Nueces County census tracts 29, 30, 31, 51.01, and 54.06. These census tracts are shown in Figure 3.11-1. This section discusses a variety of socioeconomic characteristics of the study area, and compares these characteristics with those of the City of Corpus Christi, Nueces County, the State of Texas, and the U.S. Study area land use, tourism, and recreation are also discussed.

3.11.1 Population, Employment, and Economics

3.11.1.1 Population Characteristics

The proposed Project is located on North Padre Island, approximately 20 miles southeast of downtown Corpus Christi in southeastern Nueces County. The channel would run northwest to southeast from Corpus Christi Bay through North Padre Island to the Gulf of Mexico. The study area is completely within the city limits of the City of Corpus Christi, and hence the City of Corpus Christi provides police, fire, emergency medical services, water, sewer and garbage collection to the area.

Population data for the study area (see Figure 3.11-1) are compared with city, county, state and national data in Table 3.11-1. The 2000 population of the study area was 26,312. The population within the study area grew at a very rapid rate from 1980 to 1990, at 31.3 percent, which is much greater than the rates of the City of Corpus Christi, Nueces County, Texas, or the U.S. From 1990 to 2000 the study area population growth rate was more moderate, at 10.3 percent. This was slightly higher than the growth rates of the City of Corpus Christi and Nueces County, much lower than the Texas growth rate, and slightly lower than the growth rate of the U.S. The average annual population growth rate for the study area from 1980 to 2000 was 1.9 percent, which was substantially higher than that of the City of Corpus Christi, Nueces County, and the U.S.; and was the same as that of the State.

As shown in Table 3.11-2, population projections provided by the Texas Water Development Board (TWDB) indicate that population growth in both the City of Corpus Christi and in Nueces County is expected to be slower than for the State from 2000 through 2050. The TWDB predicts that the City of Corpus Christi and Nueces County population will be 523,099 and 565,502, respectively, in 2050, which is close to double the population for both areas over 2000 population figures. The average annual increase in population for the City of Corpus Christi and for Nueces County, from 2000 to 2050 is projected to be 2.9 percent and 2.7 percent, respectively, which is slightly lower than that of the State (at 3.3 percent).

The 2000 race characteristics of the study area are provided in Table 3.11-3, and compared with city, county, state, and national figures. Within the study area, the proportion of White persons (69.9 percent) was substantially higher than the City of Corpus Christi (38.5 percent), Nueces County (37.7 percent), and the State (52.4 percent) and slightly higher than the U.S. (69.1 percent). The proportion of African-American persons living in the study area (3 percent) was slightly lower than the City of Corpus Christi (4.5 percent), and Nueces County (4.1 percent) and substantially lower than the State (11.3 percent) and the U.S. (12.1 percent). The proportion of Hispanics (21.5 percent) living in the study area is substantially lower than the City of Corpus Christi (54.3 percent), Nueces County (55.8 percent),

Study Area

1999/2000 Census Tracts

Kleberg County

Nueces County

4000 0 4000 8000 Meters

PBSJ
206 Wild Basin Rd., Ste. 300
Austin, Texas 78746-3343
Phone: (512) 329-8342 Fax: (512) 327-2453

Figure 3.11-1
Packery Channel
1999/2000 Census Tracts

Prepared for: USACE

Job No.: 440561	Scale: 1:250000
Prepared by: G. Rackley	Date: March 2002

File: N:\440561\arcview\census.apr (2000 census tracts layout)

TABLE 3.11-1

POPULATION TRENDS, 1980 – 2000

	Population			Percent Change		
Place	1980	1990	2000	1980-90	1990-2000	Average Annual 1980-2000
Study Area*	18,156	23,847	26,312	31.3%	10.3%	1.9%
City of Corpus Christi	231,999	257,453	277,454	11.0%	7.8%	0.9%
Nueces County	268,215	291,145	313,645	8.5%	8.7%	0.8%
State of Texas (in 1,000s)	14,229	16,987	20,852	19.4%	22.8%	1.9%
United States (in 1,000s)	226,542	248,710	281,422	9.8%	13.2%	1.1%

Source: USBOC, 1980, 1990; 2000.

*Population data for the study area includes Nueces County Census Tracts 29, 30, 31, 51.01, and 54.06 (1990 and 2000). The Census tract boundaries in 1980 were different than the 1990 and 2000 census tract boundaries. Therefore, the population total for the study area for 1980 is an estimate, and is probably slightly lower than the actual population for that year.

TABLE 3.11-2

POPULATION PROJECTIONS, 2000 – 2030

Place	Projected Population						Percent Change					
	2000	2010	2020	2030	2040	2050	2000-2010	2010-2020	2020-2030	2030-2040	2040-2050	Average Annual 2000-2050
Nueces County	332,581	374,552	422,288	470,779	520,861	565,502	12.6%	12.7%	11.5%	10.6%	8.6%	2.7%
City of Corpus Christi	296,339	335,580	379,799	424,861	471,428	523,099	13.2%	13.2%	11.9%	11.0%	11.0%	2.9%
State of Texas (in 1,000s)	20,865	24,537	28,792	32,775	36,414	39,617	17.6%	17.3%	13.8%	11.1%	8.8%	3.3%

Source: Texas Water Development Board, 2001.

Table 3.11-3
Ethnic Distribution, 2000

Place	White		African-American		Hispanic Origin		Other Races		TOTAL
	#	%	#	%	#	%	#	%	
Study Area Census Tracts (Nueces County)									
29	1,107	53.1%	365	17.5%	435	20.9%	178	8.5%	2,085
30	5,456	61.6%	396	4.5%	2,386	27.0%	612	6.9%	8,850
31	6,542	69.5%	318	3.4%	1,898	20.2%	653	6.9%	9,411
51.01	5,352	86.7%	55	0.9%	572	9.3%	192	3.1%	6,171
54.06	1,046	55.6%	26	1.4%	797	42.4%	37	2.0%	1,880
Study Area Total/Avg.	**18,396**	69.9%	**795**	3.0%	**5,653**	21.5%	**1,494**	5.7%	**26,312**
City of Corpus Christi	106,901	38.5%	12,404	4.5%	150,737	54.3%	7,412	2.7%	277,454
Nueces County	118,178	37.7%	12,718	4.1%	174,951	55.8%	7,798	2.5%	313,645
Texas (in 1,000's)	10,933	52.4%	2,364	11.3%	6,670	32.0%	885	4.2%	20,852
United States (in 1,000's)	194,553	69.1%	33,948	12.1%	35,306	12.5%	17,615	6.3%	281,422

Source: USBOC, 2000.

and the State (32 percent) but substantially higher than the U.S. The proportion of “Other Races” living in the study area (5.7 percent) was slightly higher than the City of Corpus Christi (2.7 percent), Nueces County (2.5 percent), and the State (4.2 percent), and slightly lower than the U.S. (6.3 percent).

There is some variation in the racial characteristics of specific study area census tracts which is noteworthy when compared with the City of Corpus Christi, Nueces County, the State, and the U.S. Nueces County census tract 51.01 had a substantially higher proportion (86.7 percent) of White persons than the City of Corpus Christi (38.5 percent), Nueces County (37.7 percent), the State (52.4 percent) and the U.S. (69.1 percent). Nueces County census tract 29 had a substantially higher proportion of African-Americans (17.5 percent) than the City of Corpus Christi (4.5 percent), Nueces County (4.1 percent), the State (11.3 percent), and the U.S. (12.1 percent). Nueces County census tracts 29, 30, and 31 had a somewhat higher proportion of “other race” persons (with 8.5 percent, 6.9 percent, and 6.9 percent respectively) than the City of Corpus Christi (2.7 percent), Nueces County (2.5 percent), the State (4.2 percent), and the U.S. (6.3 percent). Nueces County census tract 54.06 had a substantial proportion of Hispanics (42.4 percent) when compared with other study area census tracts (average of 21.5 percent), the State (32 percent), and the U.S. (12.5 percent). However, this census tract exhibits a lower proportion of Hispanics than the City of Corpus Christi (54.3 percent), and Nueces County (55.8 percent).

As shown in Table 3.11-4, the population living in the study area had a slightly lower proportion of poverty status persons (16.3 percent) than the City of Corpus Christi (19.6 percent), Nueces County (25 percent), and the State (18.1 percent), and a slightly higher proportion than that of the U.S. (12.8 percent). Also, it is noteworthy that 40.8 percent of the persons living in Nueces County census tract 54.06 were living below the poverty line, which was substantially higher than the averages for the study area, the City of Corpus Christi, Nueces County, the State, and the U.S.

Median household income for the study area is provided in Table 3.11-4. The population living in the study area had a slightly higher median household income ($28,604) than the City of Corpus Christi ($25,773), Nueces County ($25,337), and the State ($27,016), and a slightly lower median household income than the U.S. ($30,056). It is noteworthy that Nueces County census tract 51.01 had a median household income of $47,348, which is substantially higher than the average for the study area, the City of Corpus Christi, Nueces County, the State, and the U.S.

Table 3.11-5 shows the age characteristics for the study area, and provides a comparison with the City of Corpus Christi, Nueces County, the State, and the U.S. On average, the median age within the study area (34.6) was slightly higher than the City of Corpus Christi (33.2), Nueces County (33.3), and the State (32.3), and slightly lower than the U.S. (35.3). The study area population had a greater proportion of “baby boomer”[1] age persons (32.1 percent), than the City of Corpus Christi (28.8 percent), Nueces County (28.6 percent), Texas (28.4 percent), and the U.S. (29.4 percent). Relative to the city, county, State, and national averages, the study area population had somewhat higher proportions of its population within the following age cohorts: 10 to 14 (8 percent), 55 to 59 (5.1 percent),

[1] Baby boomers were born between 1946 and 1964, and therefore fit into the 35 to 44 and 45 to 54 age cohorts for the 2000 Census.

Table 3.11-4
Poverty Status and Median Household Income - 1989

Place	Total Population	# Persons of Pov. Status in 1989	% Pov. Status in 1989	Median Household Income in 1989
Study Area Census Tracts (Nueces County)				
29	1,865	88	4.7%	$26,010
30	8,121	1,561	19.2%	$22,125
31	8,688	1,110	12.8%	$32,351
51.01	2,750	149	5.4%	$47,348
54.06	2,390	976	40.8%	$17,766
Study Area Total/Avg.	*23,814*	*3,884*	16.3%	$28,604
City of Corpus Christi	257,453	50,525	19.6%	$25,773
Nueces County	58,749	14,686	25.0%	$25,337
Texas (in 1,000s)	16,987	3,075	18.1%	$27,016
United States (in 1,000s)	248,710	31,742	12.8%	$30,056

Source: USBOC, 1990.

Note: 1990 Census Data were used for this table because 2000 Census figures for these data fields (for the State of Texas) had not been released as of the date of this document. These data will be published in the Summary File 3 data set, which is due for release around September 2002.

Table 3.11-5
Age Characteristics, 2000

Place	Years of Age													
	under 5		5 to 9		10 to 14		15 to 19		20 to 24		25 to 34		35 to 44	
Study Area Census Tracts (Nueces County)	#	%	#	%	#	%	#	%	#	%	#	%	#	%
29	308	14.8%	268	12.9%	182	8.7%	115	5.5%	289	13.9%	580	27.8%	284	13.6%
30	669	7.6%	688	7.8%	744	8.4%	791	8.9%	694	7.8%	1,195	13.5%	1,542	17.4%
31	558	5.9%	722	7.7%	886	9.4%	840	8.9%	466	5.0%	1,005	10.7%	1,664	17.7%
51.01	306	5.0%	231	3.7%	263	4.3%	263	4.3%	365	5.9%	803	13.0%	1,031	16.7%
54.06	118	6.3%	134	7.1%	191	10.2%	207	11.0%	119	6.3%	177	9.4%	326	17.3%
Study Area Total/Avg.	1,959	6.9%	2,043	7.2%	2,266	8.0%	2,216	7.8%	1,933	6.8%	3,760	13.2%	4,847	17.1%
City of Corpus Christi	21,544	7.8%	21,592	7.8%	21,487	7.7%	22,480	8.1%	20,346	7.3%	37,792	13.6%	43,275	15.6%
Nueces County	24,247	7.7%	24,560	7.8%	24,728	7.9%	25,828	8.2%	22,551	7.2%	41,967	13.4%	48,621	15.5%
Texas (in 1,000s)	1,625	7.8%	1,654	7.9%	1,632	7.8%	1,637	7.9%	1,539	7.4%	3,163	15.2%	3,322	15.9%
United States (in 1,000s)	19,176	6.8%	20,549	7.3%	20,527	7.3%	20,219	7.2%	18,964	6.7%	39,893	14.2%	45,149	16.0%

Place	Years of Age												Total	Median
	45 to 54		55 to 59		60 to 64		65 to 74		75 to 84		85 and over			
Study Area Census Tracts (Nueces County)	#	%	#	%	#	%	#	%	#	%	#	%	Persons	Age
29	51	2.4%	4	0.2%	1	0.0%	1	0.0%	2	0.1%	0	0.0%	2,085	23.1
30	1,191	13.5%	386	4.4%	291	3.3%	423	4.8%	198	2.2%	38	0.4%	8,850	32.1
31	1,573	16.7%	494	5.2%	378	4.0%	546	5.8%	232	2.5%	47	0.5%	9,411	36.5
51.01	1,172	19.0%	479	7.8%	442	7.2%	604	9.8%	198	3.2%	14	0.2%	6,171	43.3
54.06	269	14.3%	78	4.1%	67	3.6%	89	4.7%	83	4.4%	22	1.2%	1,880	34.7
Study Area Total/Avg.	4,256	15.0%	1,441	5.1%	1,179	4.2%	1,663	5.9%	713	2.5%	121	0.4%	28,397	34.6
City of Corpus Christi	36,585	13.2%	12,024	4.3%	9,527	3.4%	16,944	6.1%	10,533	3.8%	3,325	1.2%	277,454	33.2
Nueces County	41,223	13.1%	13,874	4.4%	11,041	3.5%	19,438	6.2%	11,840	3.8%	3,727	1.2%	313,645	33.3
Texas (in 1,000s)	2,611	12.5%	897	4.3%	702	3.4%	1,142	5.5%	692	3.3%	238	1.1%	20,852	32.3
United States (in 1,000s)	37,679	13.4%	13,470	4.8%	10,805	3.8%	18,392	6.5%	12,360	4.4%	4,240	1.5%	281,422	35.3

Source: USBOC, 2000.

and 60 to 64 (4.2 percent). Finally, within the study area, the population had somewhat lower proportions within the following age cohorts: 25 to 34 (13.2 percent), 75 to 84 (2.5 percent), and 85 and over (0.4 percent).

Table 3.11-6 provides length of residence data for the study area population, and compares them with municipal, county, State, and national data. Generally speaking, the population living within the study area moved into their household units relatively recently when compared with city, county, State, and national figures. Within the study area, the proportion of the population that moved into their household units between 1985 and 1990 was substantially higher (68.9 percent) compared with the City of Corpus Christi (55.3 percent), Nueces County (53.9 percent), the State (54.8 percent), and the U.S. (49.1 percent). Also, within the study area, the proportion of the population that moved into their household units in 1969 or earlier (5.9 percent) is substantially lower than for the City of Corpus Christi (17.7 percent), Nueces County (18.5 percent), the State (14.5 percent), and the U.S. (18.3 percent). Within the study area, census tract 29 is noteworthy because 100 percent of the population living in that area moved into their household units between 1985 and 1990, which is much higher than the study area average (68.9 percent). Census tract 51.01 had an exceptionally high proportion of the population that moved into their household units between 1989 and 1990 (58.9 percent), as compared with the study area average (35.6 percent). Census tract 54.06 had an exceptionally low proportion of its population that moved into their household units between 1989 and 1990 (18.1 percent) and a relatively high proportion of population that moved into their household units between 1960 and 1969 (12.3 percent), as compared with the study area averages, at 35.6 percent and 3.9 percent, respectively.

Table 3.11-7 provides the housing characteristics for the study area population and makes a comparison with municipal, county, State, and national data. Within the study area, the proportion of occupied housing units (85.7 percent) is slightly lower than for the City of Corpus Christi (91.6 percent), Nueces County (89.7 percent), the State (90.6 percent), and the U.S. (91 percent). Within the study area, the proportion of owner-occupied housing units (63.1 percent) is slightly higher than that of the City of Corpus Christi (59.6 percent) and Nueces County (61.3 percent), and slightly lower than that of the State (63.8 percent) and the U.S. (66.2 percent). Conversely, the study area is characterized by a slightly lower than average proportion of renter occupied housing units (36.9 percent), when compared with that of the City of Corpus Christi (40.4 percent) and Nueces County (38.7 percent) and slightly higher when compared with the State (36.2 percent) and the U.S. (33.8 percent).

3.11.1.2 Employment and Economic Characteristics

Historically, the basis of the area's economy has been agriculture and oil and gas related industries. Today, the area's economy has become more diversified, relying heavily on petrochemicals, manufacturing, retail trade, government (including military), tourism, and services.

The petrochemical industry inputs over $1 billion per year into the area economy, providing an estimated 50,000 jobs in the Coastal Bend region, which are highly concentrated in the vicinity of Corpus Christi. Top employers in the petroleum refining industry include Koch Refining Company (1,253 employees), Valero Refining Company (485 employees), CITGO (700 employees), Coastal Refining and Marketing (360 employees), and Coastal Javelina (60 employees), which together

Table 3.11-6
Length of Residence, 1990

Place	Year Moved Into Housing Unit												
	1989 - 1990		1985 - 1988		1980 - 1984		1970 - 1979		1960 - 1969		1959 and earlier		Total
	#	%	#	%	#	%	#	%	#	%	#	%	
Study Area Census Tracts (Nueces County)													
29	218	56.6%	167	43.4%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	385
30	1,196	39.6%	1,025	34.0%	444	14.7%	220	7.3%	92	3.0%	41	1.4%	3,018
31	667	23.0%	1,000	34.5%	531	18.3%	497	17.2%	132	4.6%	68	2.3%	2,895
51.01	733	58.9%	349	28.0%	100	8.0%	52	4.2%	11	0.9%	0	0.0%	1,245
54.06	133	18.1%	218	29.7%	94	12.8%	146	19.9%	90	12.3%	53	7.2%	734
Study Area Total/Avg	2,947	35.6%	2,759	33.3%	1,169	14.1%	915	11.1%	325	3.9%	162	2.0%	8,277
City of Corpus Christi	25,664	28.7%	23,817	26.6%	10,639	11.9%	13,554	15.1%	8,368	9.4%	7,426	8.3%	89,468
Nueces County	27,347	27.4%	26,402	26.5%	11,955	12.0%	15,637	15.7%	9,457	9.5%	8,942	9.0%	99,740
Texas (in 1,000s)	1,622	26.7%	1,704	28.1%	864	14.2%	1,002	16.5%	461	7.6%	419	6.9%	6,072
United States (in 1,000s)	19,208	20.9%	25,964	28.2%	12,845	14.0%	17,102	18.6%	8,428	9.2%	8,400	9.1%	91,947

Source: USBOC, 1990.

Note: 1990 Census Data were used for this table because 2000 Census figures for these data fields (for the State of Texas) had not been released as of the date of this document. These data will be published in the Summary File 3 data set, which is due for release around September 2002.

Table 3.11-7
Housing Characteristics, 2000

Place	Number of Units	Units Occupied	% Units Occupied	Units Vacant	% Units Vacant	Owner Occupied	% Owner Occupied	Renter Occupied	% Renter Occupied
Study Area Census Tracts (Nueces County)									
29	516	487	94.4%	29	5.6%	30	6.2%	457	93.8%
30	3946	3,369	85.4%	577	14.6%	1,714	50.9%	1,655	49.1%
31	3610	3,363	93.2%	247	6.8%	2,472	73.5%	891	26.5%
51.01	3648	2,812	77.1%	836	22.9%	2,034	72.3%	778	27.7%
54.06	580	516	89.0%	64	11.0%	402	77.9%	114	22.1%
Study Area Totals/Avg. %	12,300	10,547	85.7%	1,753	14.3%	6,652	63.1%	3,895	36.9%
City of Corpus Christi	107,831	98,791	91.6%	9,040	8.4%	58,912	59.6%	39,879	40.4%
Nueces County	123,041	110,365	89.7%	12,676	10.3%	67,679	61.3%	42,686	38.7%
Texas (in 1,000's)	8,158	7,393	90.6%	764	9.4%	4,717	63.8%	2,676	36.2%
United States (in 1,000's)	115,905	105,480	91.0%	10,425	9.0%	69,816	66.2%	35,664	33.8%

Source: USBOC, 2000.

employ a total of 2,858 people and refine a total of 720,000 barrels per day. Chemical plants in the Corpus Christi area that employ substantial numbers of people include Reynolds Metals (900 employees), OxyMar (400 employees), OxyChem Petrochemical (299 employees), E.I. Dupont de Nemours & Company (226 employees), and American Chrome & Chemicals (185 employees). The largest chemical plants in the area together employ approximately 2,206 people (Corpus Christi Chamber of Commerce, 2002).

Government is an important industry sector for the area economy. The military is the single largest employer in the area, with the Corpus Christi Army Depot and Naval Air Station employing 6,181 persons. The Corpus Christi Independent School District is the second largest employer, supplying 5,355 jobs to the area (Corpus Christi Chamber of Commerce, 2002).

Texas Workforce Commission (TWC) Labor Market Information indicates that trade and services comprise the bulk of employment in Nueces County where the total civilian labor force increased 8.6 percent between 1990 and 2000, from 136,056 to 147,857. The unemployment rate remained at approximately 6.6 percent during this period (TWC, 2001).

3.11.2 Recreation and Tourism

3.11.2.1 Recreation

Recreational areas in the study area include a private country club, five relatively small City of Corpus Christi parks, two Nueces County parks, approximately 3 miles of public beaches (149.5 acres), two marinas, and several small public boat ramps. The largest recreational facility, the Padre Isles Country Club, occupies 274.6 acres. It is located immediately west of Padre Island Drive, north of Whitecap Boulevard, and south of SH 361 (Commodores Drive), and features an 18-hole golf course, tennis courts, and a swimming pool. The city parks within the study area are relatively small neighborhood parks and include: Seagull Park, Commodores Park, Cobo Park, Aquarius Park, and Gypsy Park. The Packery Channel County Park occupies 58.1 acres, is owned and managed by Nueces County, and is located northeast of Park Road 22 (Padre Island Drive), and adjacent to Packery Channel. This park is mostly undeveloped and provides parking and public access for fishing and other recreational uses of Packery Channel. The Nueces County Visitor's Center is located adjacent to this park. Padre Balli Park is owned and managed by Nueces County and is located east of Park Road 22, about one-half mile south of Lake Padre. This park features approximately 253.3 acres of land adjacent to the beach (Gulf of Mexico) and is a recreational complex with a pavilion, overnight camping, RV hookups, showers, and covered picnic areas (Corpus Christi Convention and Visitor's Bureau, 2002). Two marinas and a public boat ramp are located on the islands immediately adjacent to JFK Causeway. The City of Corpus Christi manages and maintains all of the beaches (on the Gulf of Mexico) within the study area, except for the section that is adjacent to Padre Balli Park, which is managed and maintained by Nueces County (Cisneros, 2002).

Two government-maintained recreational areas are located south and north of the study area along Mustang Island and North Padre Island. Padre Island National Seashore is located about 10 miles south of Packery Channel and continues south for over 60 miles. It is mostly undeveloped and generally undisturbed except for Malaquite Beach and Bird Island Basin. Mustang Island State Park contains 3,703 acres and begins approximately 1.5 miles north of Packery Channel. Except for a limited number of RV spaces, rest rooms and campsites, this park is also essentially undeveloped. In addition, MHBC, a State-Federal cooperative preserve, provides opportunities for birdwatching, fishing, and crabbing.

The natural resources of the Laguna Madre, although not as heavily utilized as other areas of the Texas coast, still provide extensive recreational opportunities. Activities such as fishing, birdwatching, waterfowl hunting, windsurfing, camping, boating, jet skiing, swimming, shelling, and beach combing provide recreational opportunities that result in tremendous economic benefits for the area. The sport-boat fishing industry supplies the majority of these economic benefits in the Laguna Madre. Several of the bird species found in the Laguna Madre and Rio Grande Valley are found nowhere else in the U.S. and serve as major attractions for birdwatchers from around the world.

3.11.2.2 Tourism

In this section, a report prepared by Hammer, Siler, George Associates (HSGA), conducted in 1997, was used as a basis for estimating the present tourism market and projecting the potential future tourism levels that may occur in the Corpus Christi area without the proposed Project. The HSGA report, titled “Economic Impact Analysis – Packery Channel Project”, was prepared for Nueces County (HSGA, 1997). HSGA estimated the number of visitor-days and tourism spending levels for the Corpus Christi area for 1995 and projected these estimates to 2015. For the purposes of this document, these estimates and projections were recalibrated for the years 2003 to 2023 (corresponding with the probable time frame for the proposed Project).

According to HSGA (1997), travelers to and from the Corpus Christi area spent in excess of $900 million during 1995 in conjunction with their visits to the area. In 1995, nearly 170 million person-trips (any travel with a night away from home or a day trip more than 50 miles one way) occurred in Texas for leisure and business travel purposes. An estimated 4 million person-trips for leisure and business occurred in the Corpus Christi market the same year, a 2.5 percent market share. The Corpus Christi market ranked seventh among the 27 market areas in Texas in terms of such trips. The 4 million trips yielded 11 million person-days of non-local travel to the Corpus Christi area in 1995. More than half of all travel to the Corpus Christi market (56 percent) involved at least one night’s stay, compared with the statewide average of 48 percent (HSGA, 1997).

Corpus Christi’s tourism business visitation market is predominantly intrastate in nature. HSGA (1997) estimated that 70 percent of all visitors to the Corpus Christi area in 1995 were from elsewhere in Texas. By comparison, Texas residents accounted for 62 percent of all such travel on a statewide basis. Nearly half of the region’s annual tourism (49 percent) was generated by residents of four of the State’s metropolitan areas: San Antonio (14 percent), Houston (13 percent), Dallas-Fort Worth (12 percent), and Austin (10 percent). The high degree of intrastate travel provides a source of optimism about future tourism for the region and the potential market which the Corpus Christi area (the study area) and nearby real estate development can serve. Both the Texas economy and its population are expected to experience long-term growth. Based on TWDB population projections (recalibrated for 2003 to 2023), the State's population will increase by nearly 8 million residents between 2003 and 2023. Of the total change in statewide population, nearly 80 percent of the total increase is expected to occur in Corpus Christi's four major intrastate markets. This growth along with that in the remainder of the State, represents a significant potential tourism market for the Corpus Christi area (HSGA, 1997).

Table 3.11-8 provides tourism projections (in number of person-days) that is anticipated for the Corpus Christi area between 2003 and 2023. In order to make the projections, some basic assumptions were made. First, the projections are based on the assumption that 1995 rates of annual visitation in the Corpus Christi area would continue from 2003 to 2023. HSGA (1997) provides separate estimates for the intrastate travel market and the out-of-state travel market. The intrastate estimate of person-days is a function of the 1995 per capita person-day rate (0.446), and the change in Texas population between a specified range of years. For the out-of-state travel market, the number of 1995 person-trips was projected to 2003 and multiplied by the average annual person-day growth rate. Based on these assumptions, the total market growth potential to the Corpus Christi area would be 4,432,841 additional annual person-days between 2003 and 2023.

Table 3.11-9 provides a summary of the projected number of annual person-days and annual tourism-related spending in the Corpus Christi area in 2003 and 2023. The annual tourism spending for 2003 and 2023 was projected from levels provided by the Texas Department of Economic Development (TDED) (2001) for 1990 and 2000. The TDED reported that in 1990 tourism-related spending in Nueces County was an estimated $355.6 million, and in 2000 it was an estimated $585.8 million (6.5 percent) annual increase during the 10-year period (TDED, 2001).[2] Assuming that the growth of annual tourism-related spending in the area would continue at the same rate between 2003 and 2023 (as between 1990 and 2000), then the projected annual tourism-related spending in Nueces County would be $700 million in 2003 and $1,610 million in 2023, or a $910 million (128 percent) increase in annual spending levels during the 20-year period. The estimated number of annual person-days of tourism visitation to the Corpus Christi area would be 11,141,102 in 2003 and 15,573,943 in 2023, or an increase of 4,432,841 annual person-days (39.8 percent) over the 20-year period.

TABLE 3.11-8

PROJECTED DAY VISITORS FOR NORTH PADRE ISLAND
WITHOUT PROPOSED PROJECT, 2003 TO 2023

Market Segment	Per Capita Person-Day Rate	Texas Population Change (2003 – 2023)	Additional Annual Person-Days
A. Intrastate Travel Market	0.446	7,995,429	3,565,961
	2003 Trips (projected from 1995 Trips)	Average Annual Person-Day Growth Rate	
B. Out of State Travel Market	1,344,000	4.3%	866,880
Total Market Growth Potential			4,432,841

Source: HSGA, 1997; TWDB, 2001.

[2] All tourism spending estimates are presented in 2002 dollars. Estimates for tourism spending are presented at the County level, since similar analysis was not available for North Padre Island.

TABLE 3.11-9

SUMMARY OF PROJECTED TOURISM
NUMBER OF PERSON-DAYS AND SPENDING
FOR STUDY AREA WITHOUT PROPOSED PROJECT

2003		2023		Increase from 2003 to 2023	
Number of Annual Person-Days	Estimated Annual Tourism-Related Spending (in Millions of $)	Number of Annual Person-Days	Estimated Annual Tourism-Related Spending (in Millions of $)	Number of Annual Person-Days	Estimated Annual Tourism-Related Spending (in Millions of $)
11,141,102	$700.0	15,573,943	$1,610.0	4,432,841	$910.0

Source: HSGA, 1997.

3.11.3 Land Use

3.11.3.1 Existing Land Use

In this section, land use is described for that portion of the study area that is located on North Padre Island most relevant to the proposed Project (Figure 3.11-2). The study area for this section addressing land use is defined as the area of North Padre Island that is located within the City of Corpus Christi city limits, and is bounded by Packery Channel (west of SH 361) and Zahn Road (east of SH 361) to the north and by the Nueces-Kleberg County boundary to the south. This portion of the study area is 4,111.5 acres in area (excludes open-water areas); it is located entirely within Nueces County, the City of Corpus Christi, and within Nueces County census tract 51.01 (see Figure 3.11-1).

Land use interpretation was based on a review of aerial photography (1995 DOQQ) and TxDOT (1999) urban files for Nueces County, including park coverages. Data from an August 16, 2001, windshield survey of the study area were used to verify interpretations. Land use in the Project area has been classified according to the following categories: recreation, residential (includes single-family homes, apartments, and condominiums), commercial (includes businesses and hotels), mixed development (includes commercial and other land uses), major roadways, beaches, open-water, and vacant land uses. Land use acreages were calculated for each category, and the results are provided in Table 3.11-10.

Residential land use composes 28.2 percent of the study area and is concentrated primarily in three areas. The largest concentration of residential land use is located in areas west of Padre Island Drive and south of JFK Causeway. These neighborhoods include single-family homes and condominiums that are located adjacent to waterways, and include private boat dock access. A much smaller residential neighborhood is located east of Padre Island Drive, immediately south of Packery Channel County Park and southwest of Packery Channel. This neighborhood consists primarily of custom-built single-family homes. Finally, there are single-family homes, condominiums, and apartments that are located adjacent to Lake Padre, mainly on the south and east sides. There are numerous vacant lots in this area that are slated for future residential development.

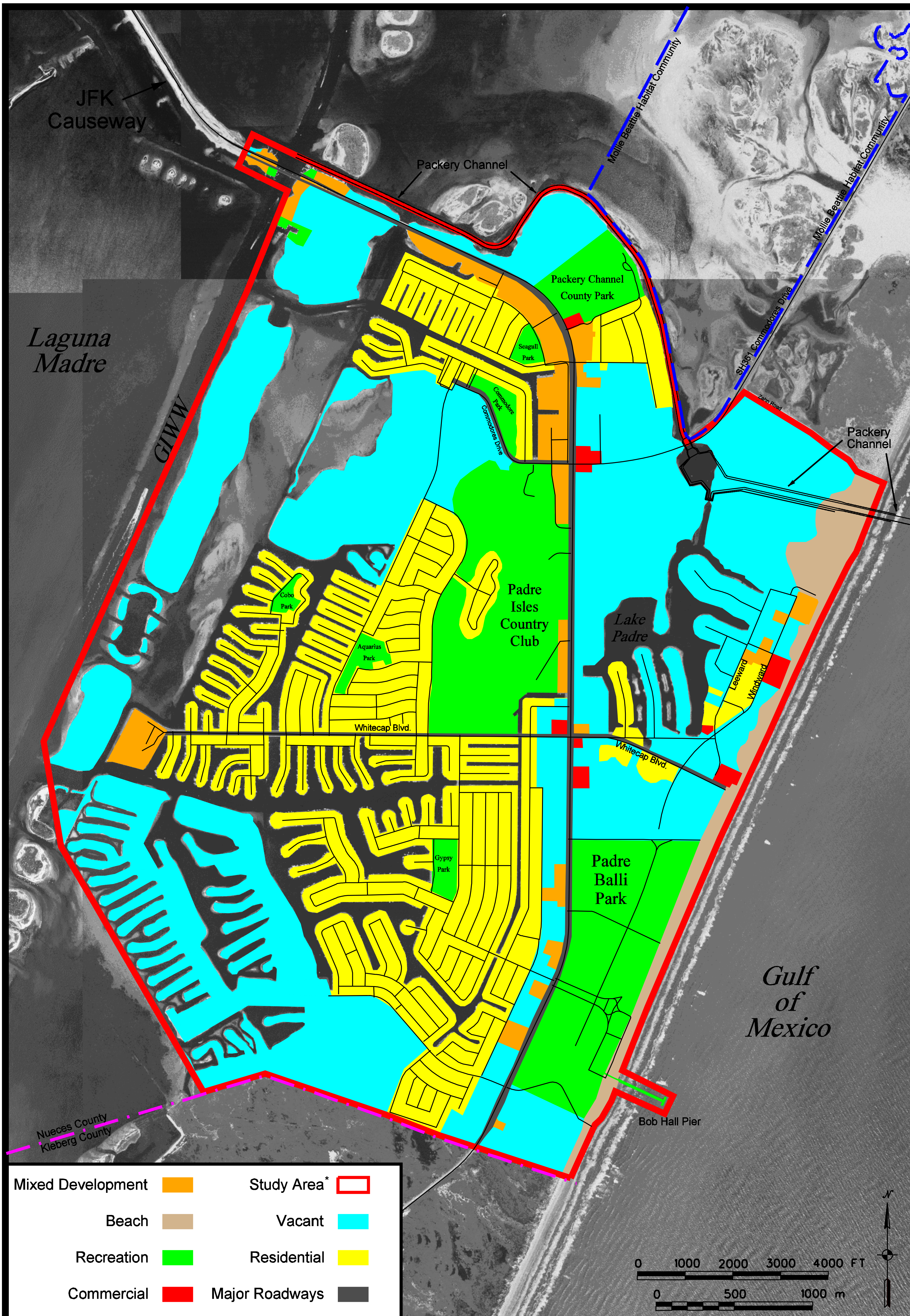

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Figure 3.11-2
Study Area Land Use Map

Prepared for: USACE	
Drawn by: G. Rackley	Date: march 2002
Job No.: 440561	Scale: 1"=1950' for 11"x17" Sheet
File: N:\440561\cad\utm83_14\land_use.dgn	

TABLE 3.11-10
LAND USE ACREAGES WITHIN THE STUDY AREA

Land Use Category	Land Area in Acres	% of Study Area
Residential	1,160.1	28.2%
Commercial	26.1	0.6%
Recreation	650.5	15.8%
Mixed Development	159.3	3.9%
Major Roadways	100.6	2.5%
Beaches	149.5	3.6%
Open-Water	1,310.0	NA
Vacant	1,865.4	45.4%
Total (does not include open-water acreage)	4,111.5	100.0%

Commercial and mixed development together make up 4.5 percent of the study area, and are concentrated primarily adjacent to Park Road 22 and Lake Padre and on the islands immediately adjacent to JFK Causeway. The commercial and mixed development located along Park Road 22 consists primarily of a mix of beach/tourism related shops, real estate companies, restaurants, gas stations, convenience stores, grocery stores, and services. Adjacent to Lake Padre, commercial and mixed-use development is concentrated along Whitecap Boulevard, Leeward Road, and Windward Road, on the south and east sides of the lake and adjacent to the beach. The commercial and mixed development in this area consists primarily of beach/tourist related shops, convenience stores, restaurants, and hotels. On the islands that are immediately adjacent to JFK Causeway, development consists of a mix of restaurants, bait and tackle shops, and a sporting goods shop.

Recreation and beach land uses together comprise 19.4 percent of the study area. Several parks, beaches, and other recreational facilities within the study area are shown on Figure 3.11-2, and are discussed in detail in section 3.11.2. These land uses include a private country club, five relatively small city parks, two county parks, approximately 3 miles of public beaches, two marinas, and several small public boat ramps.

Vacant lands are scattered throughout the region, composing 45.4 percent of the study area. The vacant land located west of the Padre Isles Country Club is likely to be developed as residential. The land located along Park Road 22 is likely to be developed as commercial and mixed development. Vacant areas located in the vicinity of Lake Padre are likely to be developed as commercial, mixed development, and residential development. Vacant lands located on the dredged-material islands (along the western boundary of the study area) are likely to remain undeveloped.

Open-water areas include Lake Padre, the Packery Channel, and a number of waterways that surround residential development throughout the western portion of the study area. Lake Padre is a relatively small man-made lake located immediately south of Packery Channel, and is connected to it at its north end. This lake is surrounded by residential, commercial, mixed development, and vacant land that is slated for future development. Packery Channel, another open-water area, runs from Laguna Madre to the Inner Basin, just east of SH 361, where it connects with Lake Padre. The western portion of the study area contains numerous waterways that are connected to Laguna Madre and surround residential development. These waterways are lined with private boat docks and provide access for small boats into Laguna Madre. Finally, the study area is bordered by Laguna Madre to the west and the Gulf of Mexico to the east.

Transportation in the study area is provided via a network of primary, secondary, and local roads. The JFK Causeway crosses the Laguna Madre, connecting North Padre Island with Corpus Christi. The principle arterial roadway that provides north-south access through the study area is Park Road 22 which connects the Project vicinity with Padre Island National Seashore to the south. Access from North Padre Island to Mustang Island and Port Aransas is provided via SH 361. Access to the Lake Padre shoreline area and the beach is provided via Whitecap Boulevard. Other significant collector roads in the area include Aquarius Street, Windward Drive, Zahn Road, Encantada Avenue, and Sea Pines Drive. Numerous neighborhood streets serve local neighborhoods.

3.11.3.2 Development Trends

The North Padre Island area has a moderate to high potential for future development without the proposed Packery Channel. As discussed in Section 3.11.3, approximately 1,865 acres, or 45.4 percent of the study area, consists of vacant land. Much of this vacant land is located in desirable locations such as the land surrounding Lake Padre, near the beach (along Leeward and Windward roads), or water-front property adjacent to the Laguna Madre.

The demand for new development on North Padre Island, without the proposed Project, will eventually be spurred by two major factors: 1) the demand for housing, and 2) an increase in tourism demand in the area.

In 2000 there were 140 new homes built on North Padre Island; which was a record for the area, exceeding only the previous year at 124 homes built. Much of this growth in housing is driven by baby boomers, primarily from metropolitan areas of Texas, looking for desirable and affordable locations for retirement housing, time-share units, and second homes (*Corpus Christi Caller Times*, 2000). The high proportion of baby boomers in the area is confirmed by recent census figures showing that baby boomer-aged persons (corresponds with the 35 to 54 age cohorts in Table 3.11-5) represented 35.7 percent of the population in the North Padre Island area (Nueces census tract 51.01). This represents a substantially higher proportion than that represented in the City of Corpus Christi, Nueces County, the State, and the U.S. (see section 3.11.1.1) (USBOC, 2000). This demand for retirement housing is only likely to grow as more baby boomers age and seek retirement housing in the area. As more retirees and others move to the North Padre Island area, the demand for local services will grow, as well (*Corpus Christi Caller Times*, 2000).

In recent years, there has been relatively slow growth in commercial development, hotels, and services in the North Padre Island area. However, this is likely to change in the future, as the growing local population provides the market demand for more local services, and as the rise in tourism to the area increases the demand for hotels, restaurants, shopping, and other commercial development (*Corpus Christi Caller Times*, 2000). Tourism to the area is projected to rise steadily in the future primarily as a function of the growing populations in Corpus Christi's main tourism markets (i.e., the major metropolitan areas of Texas) (see Section 3.11.2.2). As these metropolitan areas grow, tourism to the North Padre Island area will grow, and with it, vacant land in the area will be developed. Prime locations, adjacent to the beaches, Lake Padre, and along Park Road 22 will likely be developed first. This is because commercial developers will likely realize greater financial success in areas located adjacent to natural or recreational amenities or adjacent to major arterial roadways for high visibility and access. Furthermore, areas surrounding Lake Padre along Leeward Road, Windward Road, and Whitecap Boulevard have already been subdivided (streets and other infrastructure improvements have been made), and vacant lots in these areas will eventually be built-out with or without the proposed Project as the market demand for such development increases over time.

3.11.4 Environmental Justice

This section presents an Environmental Justice (EJ) analysis for the study area using 1990 Census data. The U.S. Bureau of the Census (USBOC) will likely release the 2000 Long Form (STF3) Census data for the State of Texas in September 2002. The 2000 Long Form data will provide the requisite poverty status data needed for a complete EJ analysis. This section will be updated at that time. Race characteristics of the study area, using 2000 data, are discussed in Section 3.11.1.1.

In compliance with Executive Order (EO) 12898 – Federal Action to Address EJ in Minority Populations and Low-Income Populations – an analysis has been performed to determine whether the proposed Project will have a disproportionate adverse impact on minority or low-income population groups within the Project area. The EO requires that minority and low-income populations do not receive disproportionately high adverse human health or environmental impacts and requires that representatives of minority or low-income populations, who could be affected by the Project, be involved in the community participation and public involvement process.

The data used in this study to determine the potential for disproportionate impacts to low-income and/or minority populations within the Project area are presented in tables 3.11-11 and 3.11-12. Figure 3.11-1 is a map showing the 1990/2000 Census tracts. The information is based on 1990 USBOC state, county, and census tract level data for ethnicity and income.

In terms of ethnicity, the population living within census tracts studied is characterized by some differences, on average, from that of Nueces County and the State. The percentage of African-Americans within the study area (3 percent), on average, was slightly greater than Nueces County (1.3 percent) and slightly lower than the State (4.2 percent). The percentage of Hispanics within the study area (21.1 percent), on average, was substantially lower than Nueces County (50.4 percent), and slightly lower than the State (25.5 percent). The percentage of other races within the study area (2.9 percent), on average, was slightly higher than Nueces County (0.7 percent) and the State (2.2 percent). There is some variation in the racial characteristics of specific study area census tracts which is noteworthy when compared with Nueces County and the State. Nueces County census tract 29 had a substantially higher proportion of African-American persons (12 percent) compared with Nueces County (1.3 percent), but had only a slightly greater proportion compared with the State (11.6 percent).

TABLE 3.11-11

DETAILED 1990 POPULATION CHARACTERISTICS BY STUDY AREA CENSUS TRACTS

Census Tract	Population	Number White	% White	Number African American	% African American	Hispanic Origin	% Hispanic	Number Other	% Other	Number Below Poverty	% Below Poverty
Nueces County											
29	1,865	1,296	69.5%	224	12.0%	271	14.5%	74	4.0%	88	4.7%
30	8,121	5,802	71.4%	260	3.2%	1,804	22.2%	255	3.1%	1,561	19.2%
31	8,688	6,786	78.1%	191	2.2%	1,428	16.4%	283	3.3%	1,110	12.8%
51.01	2,750	2,505	91.1%	32	1.2%	166	6.0%	47	1.7%	149	5.4%
54.06	2,390	1,001	41.9%	0	0.0%	1,353	56.6%	36	1.5%	976	40.8%
Study Area Total/Avg.	23,814	17,390	73.0%	707	3.0%	5,022	21.1%	695	2.9%	3,884	16.3%

Source: USBOC, 1990.

TABLE 3.11-12

DETAILED 1990 POPULATION CHARACTERISTICS BY STATE AND COUNTY

	Population	Number White	Percent White	Number African American	Percent African American	Hispanic Origin	Percent Hispanic	Number Other	Percent Other	Number Below Poverty	Percent Below Poverty
TEXAS	16,986,510	10,291,680	60.6%	1,976,360	11.6%	4,339,905	25.5%	378,565	2.2%	3,074,558	18.1%
NUECES COUNTY	58,749	28,005	47.7%	745	1.3%	29,586	50.4%	413	0.7%	14,686	25.0%

Source: USBOC, 1990.

Nueces County census tract 51.01 had an exceptionally low proportion of Hispanics (6 percent) when compared with both Nueces County (50.4 percent) and the State (25.5 percent).

On average, the percentage of people living below the poverty line within the study area census tracts (16.3 percent), was lower than in Nueces County (25 percent), and the State (18.1 percent). However, Nueces County census tract number 54.06 has a percentage of people living below the poverty line (40.8 percent) that was substantially higher than Nueces County (25 percent), and the State (18.1 percent).

4.0 ENVIRONMENTAL CONSEQUENCES

4.1 ENVIRONMENTAL SETTING

The Project will have no adverse impact on the regional physiography, geology, and climate. The reopening of Packery Channel will change the local topography by removing sand within dune and beach areas. Most new work and maintenance material will be placed onto designated beach areas for nourishment, which will provide some storm damage protection for beachfront development.

There may be a slight increase in water levels in Corpus Christi Bay during a hurricane surge because of the new channel, but the effect is not likely to be significant. Numerical simulations indicate that at normal tides, Packery Channel produces almost no change in the tides within Corpus Christi Bay (PBS&J, 1999b). At higher water levels such as occur in a hurricane surge, the barrier island will be overtopped. Under that condition, the Packery Channel opening will have essentially no effect on water movement in and out of the bay. At intermediate water levels (less than a major surge but more rapid water level change than a normal tide), a slight difference in Corpus Christi Bay produced by opening Packery Channel could be expected. However, this difference would only occur at water levels lower than hurricane surges. At higher water levels where public safety is threatened by hurricane surge, Packery Channel will have no significant effect on flooding.

In the immediate area of Packery Channel, increases in water velocity and related scour can be expected during a surge event as a consequence of the open channel. Historically, this is a washover inlet that is opened by hurricanes and then rapidly closes again. Having the channel open can be expected to allow more water through in the initial stage of a surge event, and that higher flow could accelerate scour in the channel.

4.2 WATER QUALITY

4.2.1 Water Exchange and Inflows

Under the No-Action Alternative, there would be no change in the water exchange patterns in the Upper Laguna Madre. One of the major changes that would be caused by this Project by the opening to the Gulf would be the change in the water exchange patterns in the Upper Laguna Madre. To determine the impact of those changes, a modeling study was conducted that addressed these impacts.

As noted in Section 1.0, a Project Study Plan of Packery Channel was prepared in 1999 (USACE, 1999). In that study, hydrodynamic and salinity modeling was performed to quantify the effects of alternative Packery Channel inlet configurations on salinity levels and tidal ranges in Corpus Christi Bay and the Upper Laguna Madre. The TxBLEND model, developed by the TWDB, was used for the analysis with minor modifications made for the study. Based on the needs of the Habitat Evaluation Procedure (HEP), changes in salinity in southern Corpus Christi Bay and the Upper Laguna Madre under the following three salinity conditions were investigated:

A. Mean salinity throughout the year under average annual conditions

B. Maximum monthly mean salinity under average annual conditions

C. Maximum monthly mean salinity under 80th percentile conditions

Among the three conditions, A is the least saline condition and C is the most saline condition. The model was set up to run with constant flows, tides and winds until at equilibrium, it closely approximated the salinity patterns needed for the HEP. The effect of alternative inlets, none of which corresponded exactly to the proposed Project, was determined by running the model to equilibrium with all other parameters held constant. The without-inlet model was used as the reference case for comparison for all inlet alternatives.

In the 2001 study to evaluate the proposed Project, the effects on salinity levels and tidal ranges were investigated using the same model and following the same approach of the 1999 study. A major difference is that the model was modified to reflect, as a base condition, a planned opening of the JFK Causeway. This change in the base condition was requested by members of State and Federal regulatory agencies.

Modifications to the JFK Causeway are planned to provide a safe and efficient island evacuation route during periods of high tides and tropical storm activity (Hicks et al., 1999). The proposed modification includes a new bridge with a water opening of 2,550 feet just east of Flour Bluff. This bridge is intended to enhance water circulation in portions of the Upper Laguna Madre. The finite element grid of TxBLEND was modified to reflect this planned change in the causeway. At the time of this study, detail design of the cross section of the opening was not available. It was assumed that the water depth at the opening would be similar to the general water depth in the area.

To establish a baseline or reference condition, the model with the causeway modification was run without Packery Channel under the three salinity conditions. The salinities and tidal ranges were compared with those without the causeway modification. Figure 4.2-1 shows the changes in tidal ranges, which are essentially the same for the three salinity conditions. The causeway modification would result in a slight increase in tidal range in the Laguna Madre and a slight decrease in Corpus Christi Bay.

Table 4.2-1 compares the volume of flow in one tidal cycle at a few cross sections along the Laguna Madre before and after the causeway modification. The opening enhances the exchange between Corpus Christi Bay and the Laguna Madre by a small amount. The increases in flow in and out of the Laguna Madre at the Corpus Christi Naval Air Station–GIWW cross section are only 2 to 3 percent. Other sections have the same general pattern of increased flow. Minor differences occur because of differences in the effects of evaporation and inflow points relative to the cross sections. Figure 1-1 indicates landmarks identified in Table 4.2-1.

The configuration of the proposed Packery Channel was based on the set of drawings titled "North Padre Island Storm Damage Reduction and Environmental Restoration Project, Packery Channel" prepared by URS and dated March 2002. The channel has a 1:3 side slope. West of the Inner Basin at SH 361, the channel has a constant base width of 80 feet and a depth of 7 feet below MSL. East of the Inner Basin, the base width increases to 116 feet and the depth increases to 12 feet below MSL.

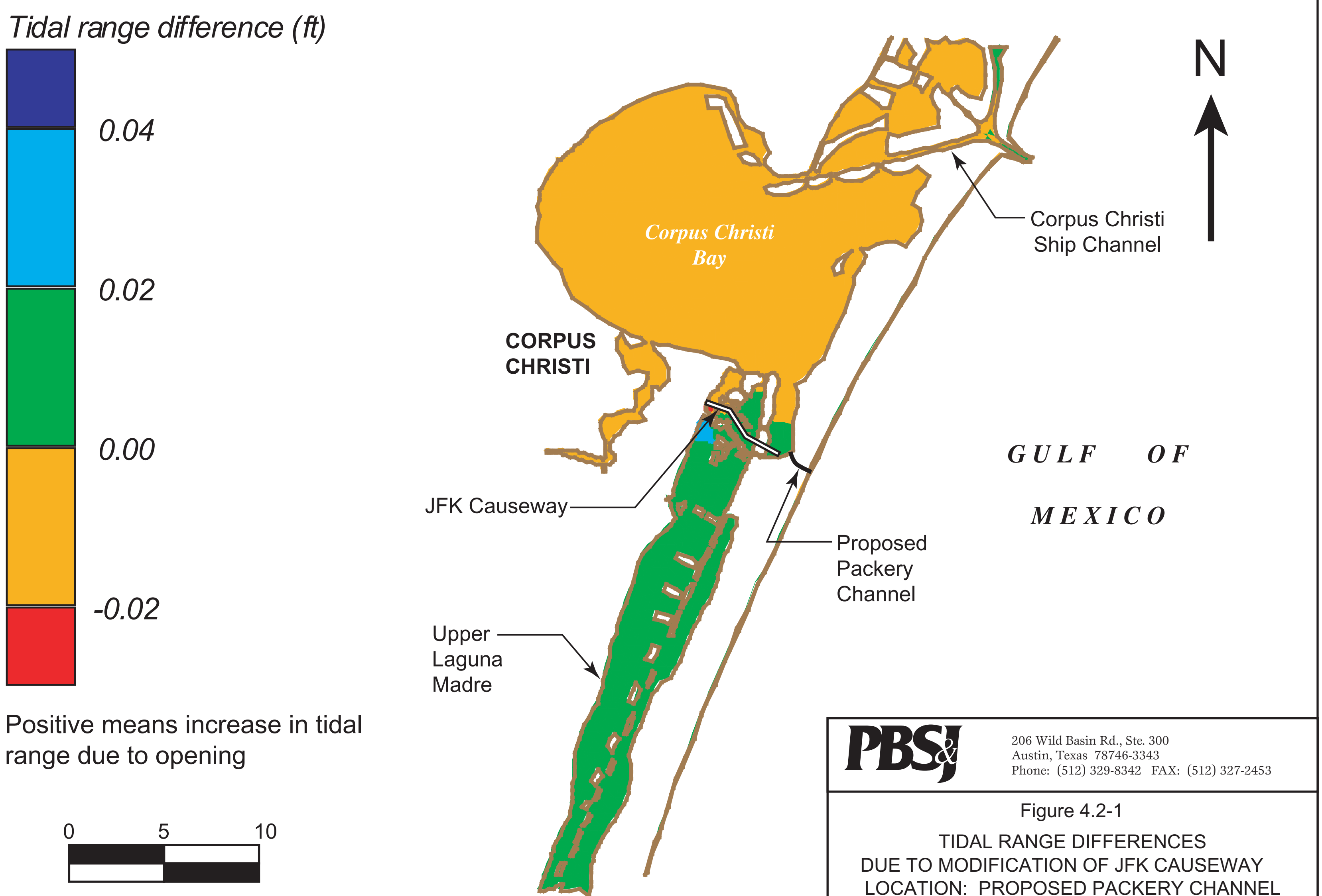

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Figure 4.2-1

TIDAL RANGE DIFFERENCES
DUE TO MODIFICATION OF JFK CAUSEWAY
LOCATION: PROPOSED PACKERY CHANNEL

Prepared for:	
Job No.: 440561	Scale:
Drawn by:	Date: 10/30/01
File: I:\projects\hc1\coe\440561\cad\figure4_2-1.ai	

TABLE 4.2-1
COMPARISON OF FLOW VOLUMES BEFORE AND AFTER MODIFICATION TO JFK CAUSEWAY
(Volume in one tidal cycle, ft^3)

	NAS-GIWW			Pita Island			Bird Island			Green Hill		
	To north	To south	Net [1]	To north	To south	Net [1]	To north	To south	Net [1]	To north	To south	Net [1]
Condition A												
Before removal	2.923E+08	-3.577E+08	-6.54E+07	3.189E+08	-3.200E+08	-1.15E+06	3.170E+08	-3.110E+08	5.94E+06	3.340E+08	-3.275E+08	6.52E+06
After removal	2.999E+08	-3.659E+08	-6.60E+07	3.232E+08	-3.250E+08	-1.84E+06	3.206E+08	-3.153E+08	5.26E+06	3.375E+08	-3.317E+08	5.80E+06
Difference	7.60E+06	-8.14E+06	-5.40E+05	4.356E+06	-5.040E+06	-6.84E+05	3.60E+06	-4.28E+06	-6.84E+05	3.51E+06	-4.23E+06	-7.20E+05
% difference	2.6%	2.3%		1.4%	1.6%		1.1%	1.4%		1.1%	1.3%	
Condition B												
Before removal	2.830E+08	-3.650E+08	-8.20E+07	3.139E+08	-3.214E+08	-7.52E+06	3.104E+08	-3.130E+08	-2.63E+06	3.272E+08	-3.298E+08	-2.63E+06
After removal	2.904E+08	-3.730E+08	-8.27E+07	3.173E+08	-3.258E+08	-8.42E+06	3.139E+08	-3.173E+08	-3.35E+06	3.306E+08	-3.342E+08	-3.56E+06
Difference	7.40E+06	-8.01E+06	-6.12E+05	3.46E+06	-4.356E+06	-9.00E+05	3.53E+06	-4.25E+06	-7.20E+05	3.46E+06	-4.39E+06	-9.36E+05
% difference	2.6%	2.2%		1.1%	1.4%		1.1%	1.4%		1.1%	1.3%	
Condition C												
Before removal	2.782E+08	-3.687E+08	-9.05E+07	3.082E+08	-3.235E+08	-1.53E+07	3.075E+08	-3.112E+08	-3.71E+06	3.253E+08	-3.274E+08	-2.09E+06
After removal	2.852E+08	-3.765E+08	-9.13E+07	3.116E+08	-3.278E+08	-1.62E+07	3.110E+08	-3.155E+08	-4.50E+06	3.288E+08	-3.317E+08	-2.95E+06
Difference	7.02E+06	-7.74E+06	-7.20E+05	3.37E+06	-4.30E+06	-9.36E+05	3.49E+06	-4.28E+06	-7.92E+05	3.47E+06	-4.34E+06	-8.64E+05
% difference	2.5%	2.1%		1.1%	1.3%		1.1%	1.4%		1.1%	1.3%	

[1] Positive flow is to the north.

The channel section east of SH 361 includes 2 feet of advanced maintenance and 2 feet of allowable over depth.

As described in USACE (1999), to avoid using very small elements in modeling the side slope of the trapezoidal channel, the equivalent rectangular section was used. The widths of the equivalent rectangular section west and east of the Inner Basin are 96.4 feet and 151.7 feet, respectively.

Table 4.2-2 shows the flood and ebb volumes at Packery Channel and Aransas Pass (located approximately 17 miles north of Packery Channel). The averages of the flood and ebb volumes for both the Aransas Pass and Packery Channel are similar for the three salinity conditions. The flood volume is slightly larger than the ebb volume because of water evaporation. The three salinity conditions reflect increasing evaporation, so the net volumes into the bay increase as the evaporation rate increases going from conditions A to C. Opening Packery Channel increases both the total flood and total ebb volumes.

Model results with Packery Channel were compared with results without Packery Channel. Figure 4.2-2 shows the changes in tidal range which are essentially the same for the three salinity conditions. There is a slight increase of about 0.01 foot in tidal range in Corpus Christi Bay and a slight decrease of less than 0.01 foot in the Laguna Madre except near Packery Channel. The largest change is at the vicinity of Packery Channel. There is a decrease in tidal range at the vicinity of Packery Channel, with a maximum decrease of about 0.09 foot. The water level in that area is subject to a more direct influence of the Gulf tide when the inlet is opened. Apparently the phase difference (about 90 degrees) between the tide in the vicinity of Packery Channel and the Gulf tide produces the reduction in tidal range.

In the inland areas along the channel tidal currents are now very small. Opening Packery Channel will allow tidal currents to flow that will be substantially larger than those that currently exist. A reasonably foreseeable consequence of the larger tidal currents is some adjustment in the shorelines of the channel.

4.2.2 Salinity

The existing salinity condition is anticipated to remain as is for the No-Action Alternative.

The model described in Section 4.2.1 also yielded results relative to salinity changes from the opening of the JFK Causeway and the proposed Project at Packery Channel. Figures 4.2-3 through 4.2-5 show the changes in tidally averaged salinity due to the opening of the JFK Causeway for the three salinity conditions. In general, the salinity changes are small. Because the increase in southerly flow is slightly more than the increase in northerly flow, there is the effect of moving lower salinity water southward in the upper part of the Laguna Madre, thus decreasing salinity. As described in the 1999 report, to establish the salinity pattern required for the HEP, the model was run with three inflow points at the southern boundary near the mouth of Baffin Bay, with a salinity of 30 ppt. Therefore, as an artifact of the model, the salinity decreases from north to south in the lower part of the Upper Laguna Madre, near Baffin Bay, where the model input 30 ppt water to match historical data throughout the rest of the Upper

TABLE 4.2-2
FLOOD AND EBB VOLUMES

	Volume in one tidal cycle (ft^3)				
	Flood	Ebb	Avg of Flood and Ebb	Net [(1)]	Net/Avg
Condition A					
Aransas Pass	5.764E+09	5.692E+09	5.728E+09	7.21E+07	1.26%
No channel					
Total	5.764E+09	5.692E+09	5.728E+09	7.21E+07	1.26%
Aransas Pass	5.758E+09	5.692E+09	5.725E+09	6.55E+07	1.14%
Packery Channel	8.99E+07	8.29E+07	8.64E+07	6.97E+06	8.06%
Total	5.848E+09	5.775E+09	5.811E+09	7.25E+07	1.25%
Condition B					
Aransas Pass	5.774E+09	5.680E+09	5.727E+09	9.49E+07	1.66%
No channel					
Total	5.774E+09	5.680E+09	5.727E+09	9.49E+07	1.66%
Aransas Pass	5.769E+09	5.680E+09	5.725E+09	8.94E+07	1.56%
Packery Channel	9.10E+07	8.18E+07	8.64E+07	9.16E+06	10.61%
Total	5.860E+09	5.762E+09	5.811E+09	9.86E+07	1.70%
Condition C					
Aransas Pass	5.817E+09	5.635E+09	5.726E+09	1.82E+08	3.18%
No channel					
Total	5.817E+09	5.635E+09	5.726E+09	1.82E+08	3.18%
Aransas Pass	5.811E+09	5.636E+09	5.724E+09	1.75E+08	3.06%
Packery Channel	9.19E+07	8.06E+07	8.62E+07	1.12E+07	13.02%
Total	5.903E+09	5.717E+09	5.810E+09	1.87E+08	3.21%

[(1)] Net = Flood volume - Ebb volume

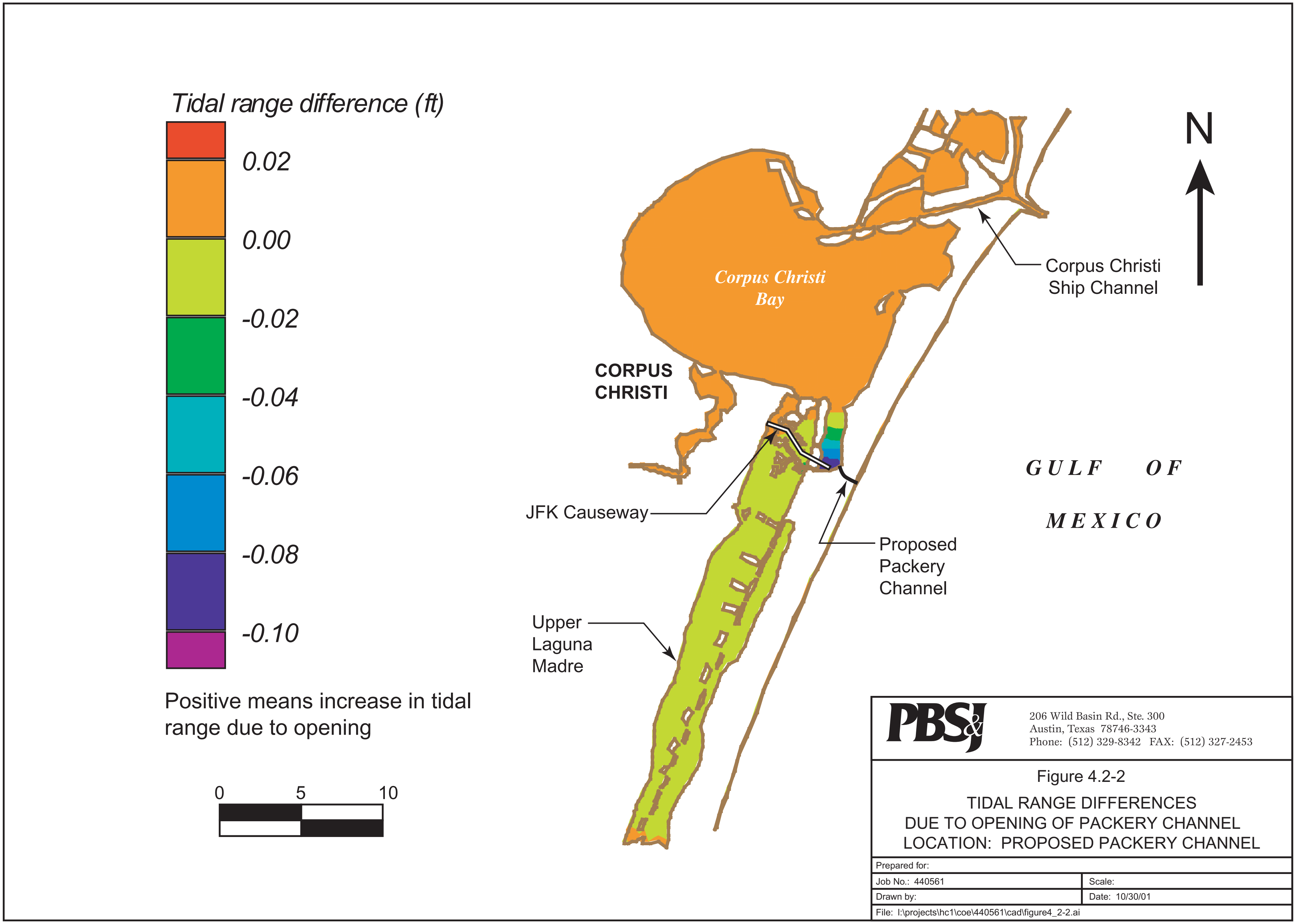

Figure 4.2-2

TIDAL RANGE DIFFERENCES DUE TO OPENING OF PACKERY CHANNEL LOCATION: PROPOSED PACKERY CHANNEL

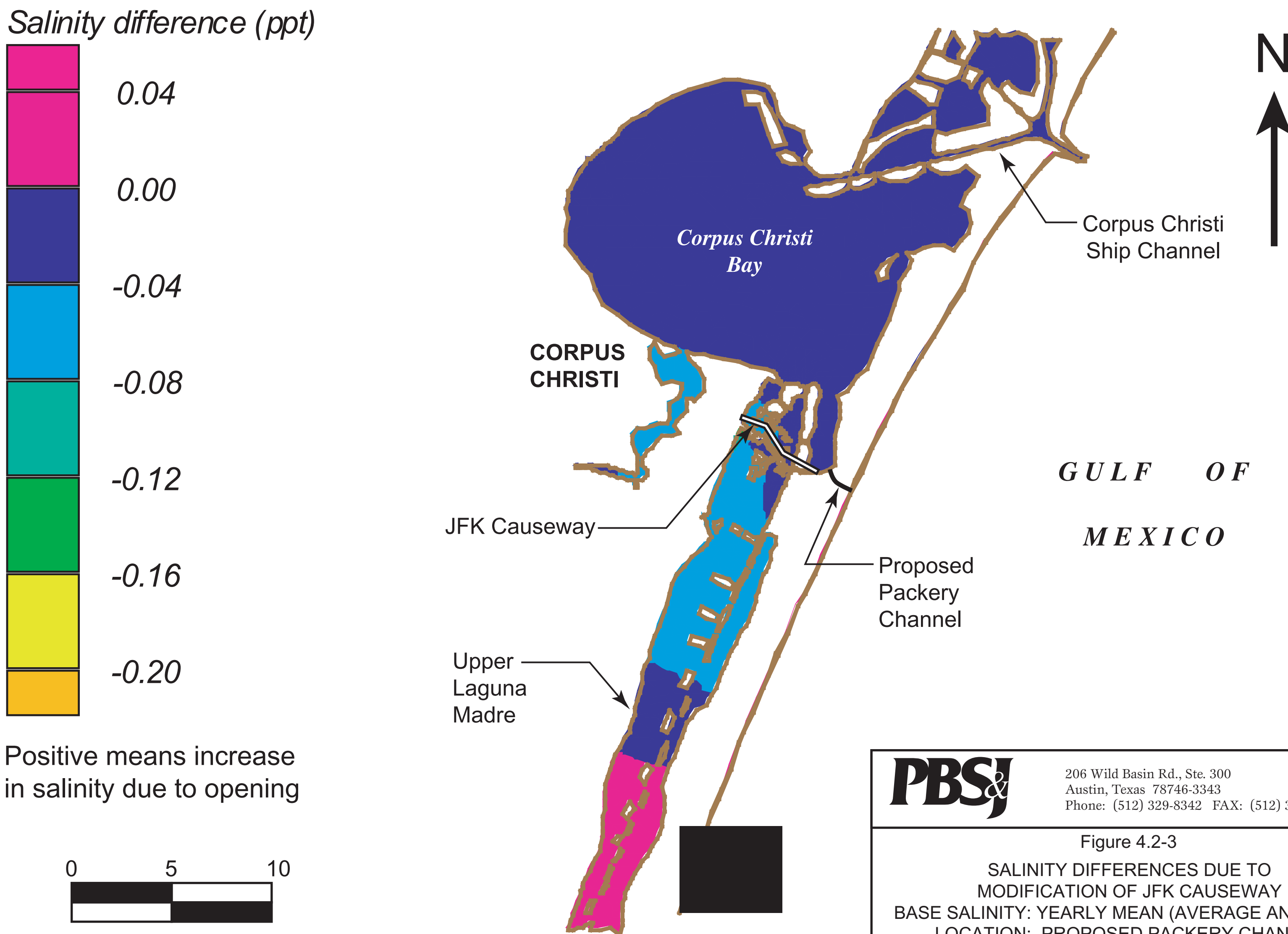

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Figure 4.2-3

SALINITY DIFFERENCES DUE TO MODIFICATION OF JFK CAUSEWAY
BASE SALINITY: YEARLY MEAN (AVERAGE ANNUAL)
LOCATION: PROPOSED PACKERY CHANNEL

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Drawn by:	Date: 10/30/01
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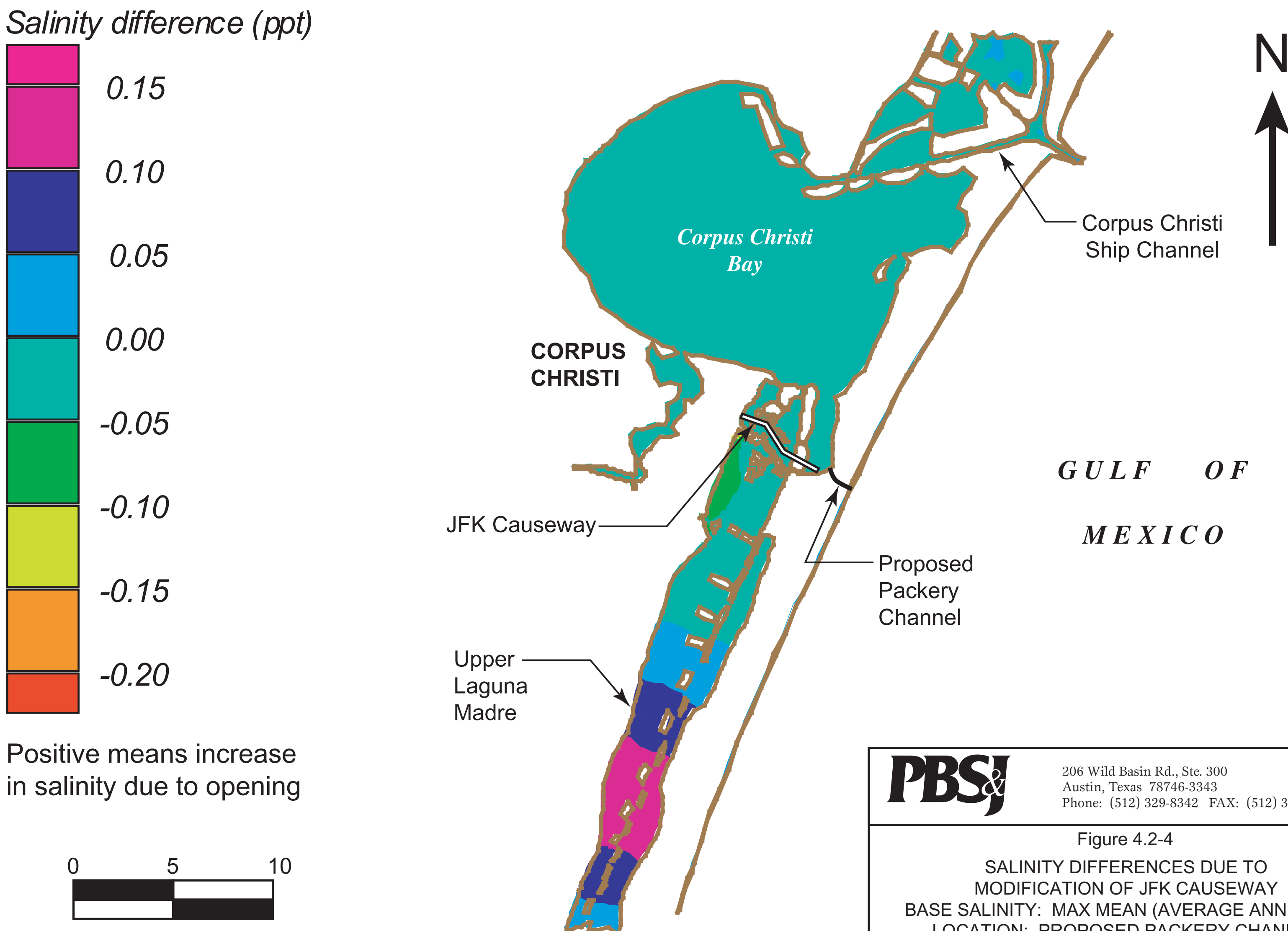

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Figure 4.2-4

SALINITY DIFFERENCES DUE TO MODIFICATION OF JFK CAUSEWAY
BASE SALINITY: MAX MEAN (AVERAGE ANNUAL)
LOCATION: PROPOSED PACKERY CHANNEL

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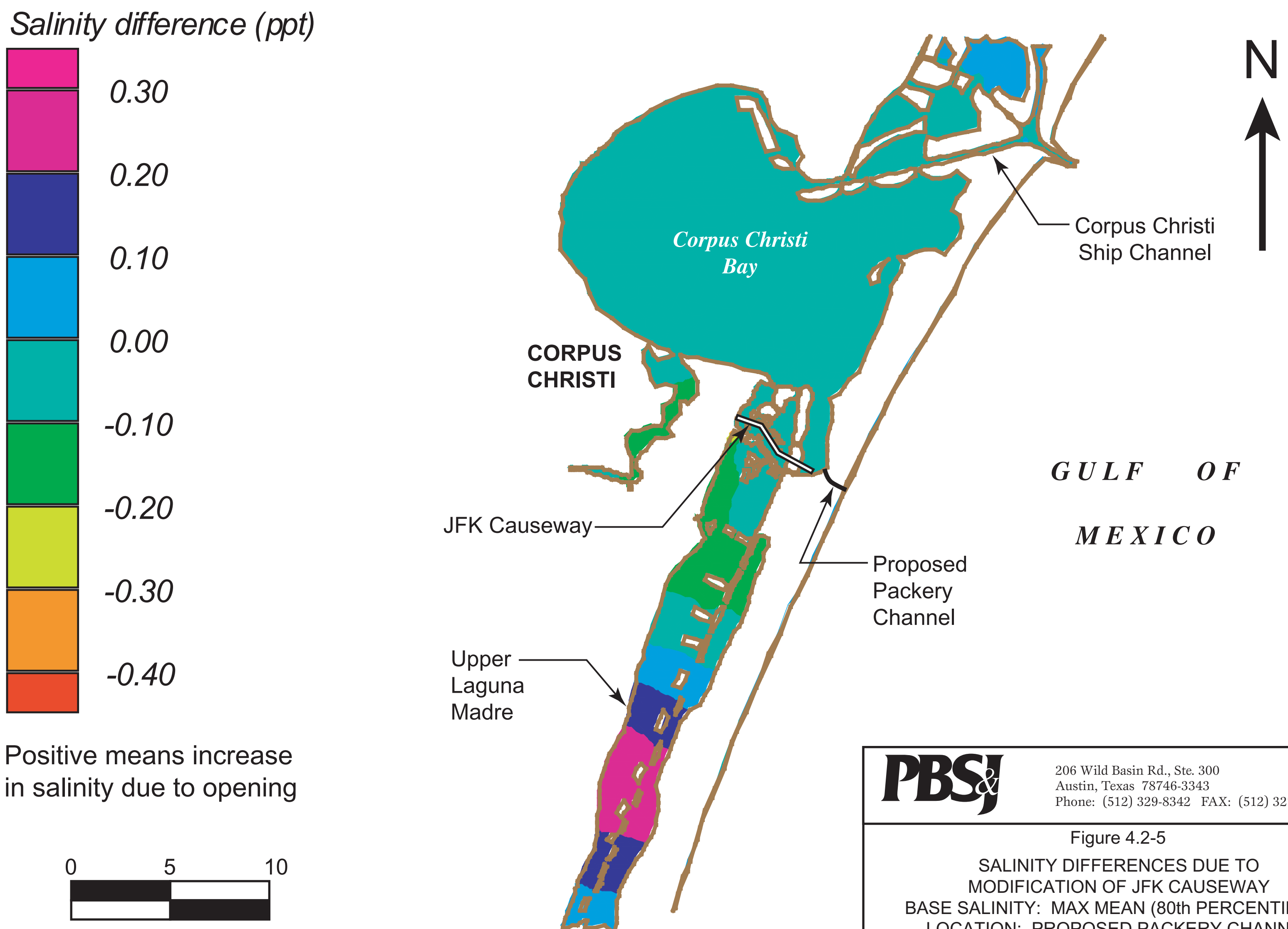

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Figure 4.2-5

SALINITY DIFFERENCES DUE TO
MODIFICATION OF JFK CAUSEWAY
BASE SALINITY: MAX MEAN (80th PERCENTILE)
LOCATION: PROPOSED PACKERY CHANNEL

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Laguna Madre and southern Corpus Christi Bay. The increase in net southerly flow (or decrease in net northerly flow) results in a slight increase in salinity near Baffin Bay. Nevertheless, changes in salinity in the system are generally very small, less than 0.2 ppt in most areas. The TWDB also found that the effect on salinity of removing the entire JFK Causeway was minimal (TWDB, 1997).

Figures 4.2-6 through 4.2-8 show the change in salinity for the three salinity conditions with and without Packery Channel. Under condition A, the salinity in southern Corpus Christi Bay and Upper Laguna Madre is less than the Gulf salinity. Opening the Packery Channel results in more exchange with the Gulf and an increase in the bay salinity. Under conditions B and C, the bay salinity is higher than that in the Gulf. In these cases, the effect of the inlet is to decrease the bay salinity.

Thus, the proposed Project results in a change in salinity of a few ppt in the vicinity of the inlet, and much smaller changes well into Corpus Christi Bay and the Laguna Madre.

4.2.3 Water Chemistry

Under the No-Action Alternative, there would be no water quality impacts except for turbidity associated with wind and wave action and from boat propellers as the channel shoals.

Few impacts to water quality are expected from the proposed Project. While there will be construction dredging, most of the new work material will be used beneficially, and all will be placed upland. Most of the material is sandy (93% overall, 68% in Reach 2), to which contaminants generally do not adhere, and the sample taken in the beach zone in 2001 (Section 3.2.3) showed no cause for concern. There would be turbidity from both construction and maintenance material but the finer material from both construction and maintenance would be placed in upland sites, reducing the potential impacts from turbidity. Sandy maintenance material will be used for beach nourishment and because the proposed channel, except for that reach from the existing turning basin to the Gulf, will only be enlarged slightly (roughly 9% [URS, 2002]), maintenance volumes are expected to be only around 15,000 cy every 5 years (URS, 2002).

Significant detrimental environmental effects to water quality have not been noted in past maintenance operations at the nearby GIWW and are not expected with the preferred alternative.

4.2.4 Brown Tide Impacts

The No-Action and preferred alternative impacts to the brown tide are unknown. Without knowing the complete life cycle of the brown tide, it is not feasible to determine the impacts that it might have from the Project. However, it does not appear that the brown tide is an oceanic species (i.e., it appeared to originate in the Upper Laguna Madre and proliferated more in the Upper Laguna Madre than in the Lower Laguna Madre near the Port Mansfield and Port Isabel connections to the Gulf). Therefore, opening Packery Channel is not expected to result in any change to brown tide frequency, intensity, or distribution.

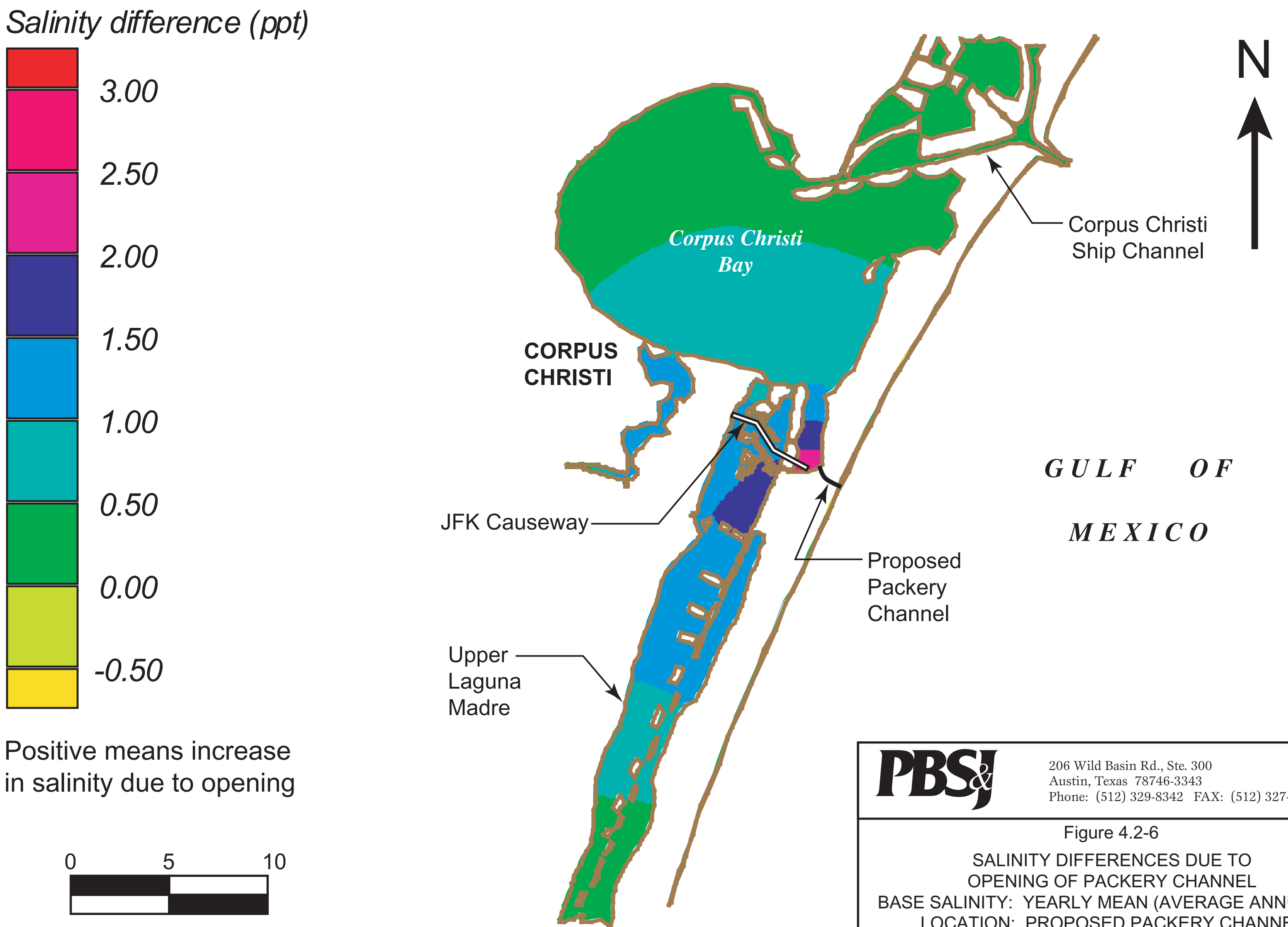

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Figure 4.2-6

SALINITY DIFFERENCES DUE TO
OPENING OF PACKERY CHANNEL
BASE SALINITY: YEARLY MEAN (AVERAGE ANNUAL)
LOCATION: PROPOSED PACKERY CHANNEL

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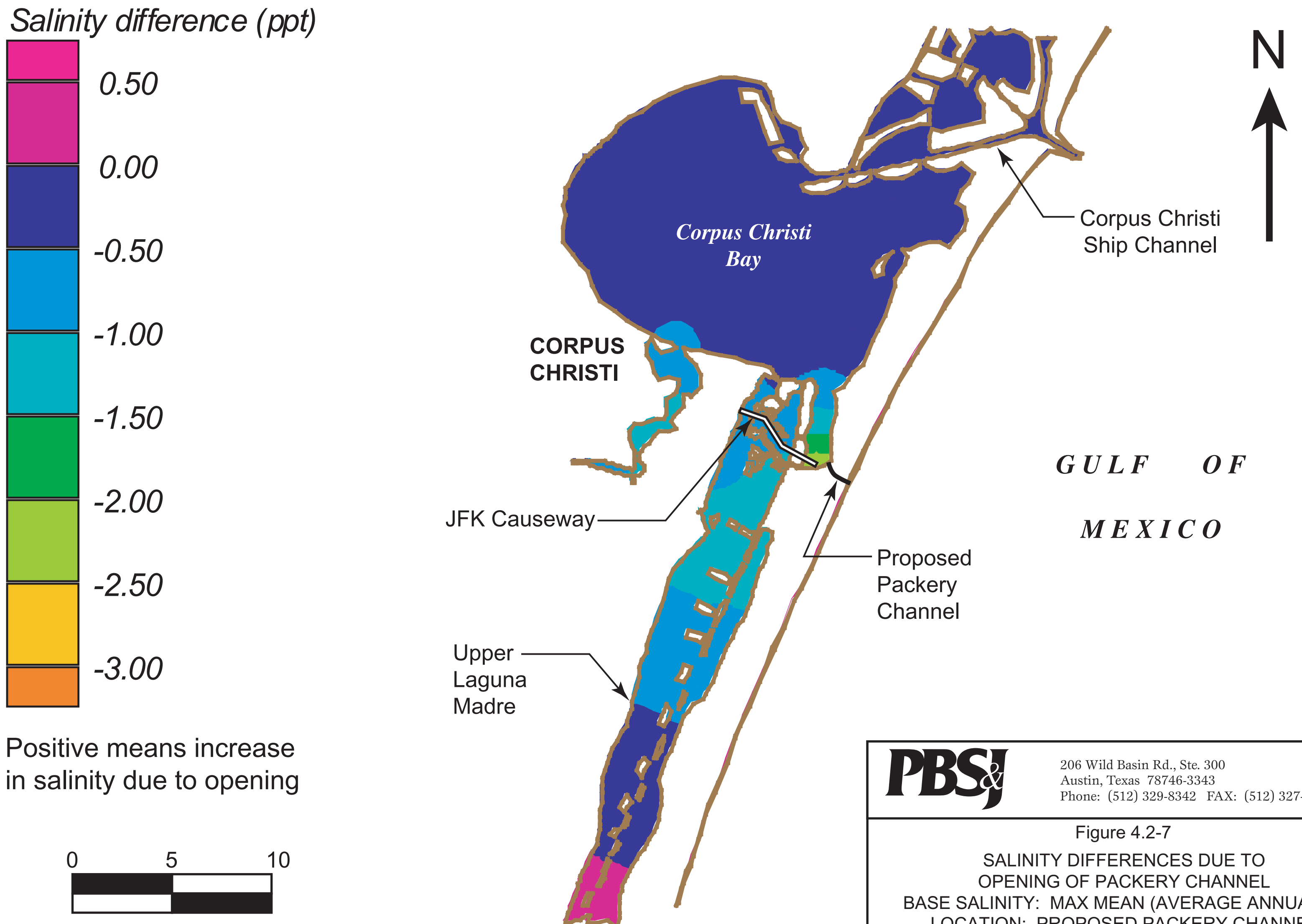

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Figure 4.2-7

SALINITY DIFFERENCES DUE TO
OPENING OF PACKERY CHANNEL
BASE SALINITY: MAX MEAN (AVERAGE ANNUAL)
LOCATION: PROPOSED PACKERY CHANNEL

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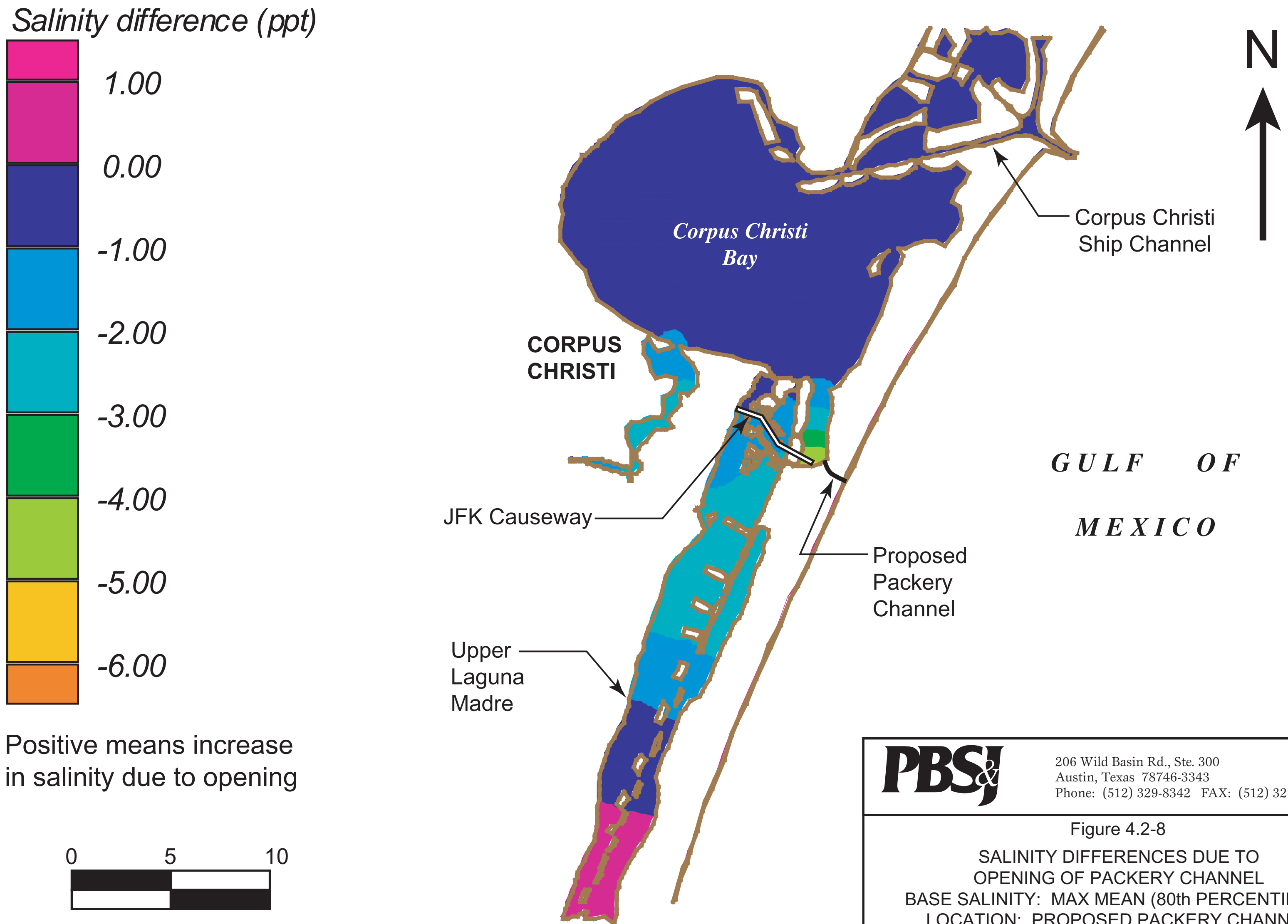

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Figure 4.2-8

SALINITY DIFFERENCES DUE TO OPENING OF PACKERY CHANNEL
BASE SALINITY: MAX MEAN (80th PERCENTILE)
LOCATION: PROPOSED PACKERY CHANNEL

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4.2.5 Red Tide Impacts

The No-Action plan would continue with minimal threat of red tide being introduced into the Laguna Madre. Red tide, an oceanic species, does not appear to have entered through the Aransas Pass and made its way into the Laguna Madre. However, the proposed Project may provide the potential to introduce the red tide into areas of the Laguna Madre that normally do not have the potential to be impacted. Impacts similar to those described in Section 3.2.5 could result.

4.3 SEDIMENT QUALITY

Neither the No-Action Alternative nor the proposed action is expected to have impacts to sediment quality. Opening Packery Channel would not introduce any significant threat of a spill that could impact sediment quality. The material sampled in 2001 represents maintenance material from Reach 2 and construction material from the beach portion of Reach 1. Chemical analysis of these sediment samples indicated no significant undesirable impacts would occur upon placement of the sediments (Section 3.3).

4.4 COASTAL COMMUNITY TYPES

The areal extent (acreage) of the impacts to specific community types is presented in Table 4.4-1. Figures 3.4-2a through 3.4-2e illustrate the approximate location of PAs and plant communities in the immediate area of the proposed Project and shows station numbers associated with the channel alignment.

4.4.1 Mollie Beattie Habitat Community

Under the No-Action Alternative, negative impacts are not expected. The No-Action Alternative will likely mean that the channel will continue to shoal. This will cause changes to the bathymetry of the existing channel and the adjacent areas, and the distribution of the various habitats will change in response to changes in bathymetry. The shoaling of the channel will probably create more areas that could support SAV as the channel depths become shallow enough to support it. The reduction of already minimal tidal currents and possible sedimentation in some of the adjacent areas may provide suitable conditions for the support of estuarine marsh and flats.

Steve Buschang (Buschang, 2002) stated that one of the concerns by the MBHC agencies (GLO, TPWD, FWS) regarding the Packery Channel Project were the potential negative impacts of shoreline erosion adjacent to Packery Channel due to: 1) increased boat traffic and associated boat wakes (i.e., enforceability of "No Wake" zones); and 2) hydrologic changes due to reopening the channel to the Gulf which might increase tidal currents and vulnerability to flooding and erosion due to Gulf storms.

Potential direct impacts of the proposed Project to the MBHC are associated with dredging along Reach 2 and include increased turbidity in adjacent waters and noise from equipment and humans disturbing local wildlife. These negative impacts are considered temporary and would not result

TABLE 4.4-1
PACKERY CHANNEL
POTENTIAL IMPACTS TO COASTAL COMMUNITIES

		Acres Impacted											
		Submerged			Tidal Flats		Channel	Upland	Primary/Sec-		Bay-Side	Gulf-Side	
	Total	Aquatic		Low Salt	Algal	Sand/Mud	Fill	Grass-	ondary Dune		Open	Open	
Location/Description	Acres	Vegetation	High Salt Marsh	Marsh	Flats	Flats	Sands	lands	Complexes	Beach	Water	Water	Comments
PROJECT													
CHANNEL	64.1	2.9	3.7	-	-	0.1	12.1	0.1	1.6	5.1	38.5	8.0	Dredging & bulkheading impacts
JETTIES	1.0	-	-	-	-	-		-	-	1.0	-	2.9	
Subtotal	65.1	2.9	3.7	-	-	0.1	12.1	0.1	1.6	6.1	38.5	10.9	
PLACEMENT AREAS													
PA 1	20.2	-	-	-	-	-	3.9	-	13.5	2.8	-	-	
PA 2	15.5	0.8	4.3	-	-	1.2	0.1	0.2	8.6	0.3	-	-	
PA 3	7.1	1.5	2.9	0.2	0.2	-		2.1	-	-	0.2		
PA 4 (N & S)	46.0	-	-	-	-	-		-	-	46.0	-	-	Beach nourishment.
MMPA	7.5	-	-	-	-	-		7.5	-	-	-	-	
Subtotal	96.3	2.3	7.2	0.2	0.2	1.2	4.0	9.8	22.1	49.1	0.2	0.0	
Total (Project Only)	161.4	5.2	10.9	0.2	0.2	1.3	16.1	9.9	23.7	55.2	38.7	10.9	
RECREATIONAL DEVELOPMENT													
PUBLIC/PARK FACILITIES													
Reach 1 (East of SH 361)													
Underground Utility Casings	0.2	-	-	-	-	0.2		-	-	-	-	-	
Parking Lots	2.5	-	-	-	-	-		-	-	2.5	-	-	
Buildings	0.4	-	-	-	-	-		-	0.3	0.1	-	-	
Access Roads	4.3	-	-	-	-	0.1		-	3.1	1.1	-	-	
Subtotal	7.4	-	-	-	-	0.3	-	-	3.4	3.7	-	-	
Total (Rec. Dev.)	7.4	-	-	-	-	0.3			3.4	3.7	-		
Total (Project + Rec. Dev.)	168.8	5.2	10.9	0.2	0.2	1.6	16.1	9.9	27.1	58.9	38.7	10.9	

in significant long-term implications. Maintenance dredging along this reach will occur approximately once every 5 years; thus, exposure to the dredging activities will be limited.

Secondary impacts associated with the Project may include an increase of public use at the MBHC, resulting in an increase in vehicle traffic, including watercraft and automobiles; and a potential increase in shoreline erosion (as expressed above) associated with boat wakes and/or hydrologic changes due to the reopening of the channel to the Gulf of Mexico.

The likely increase in public activities in the area may result in an increase in the potential for unrestricted use of the MBHC that currently takes place in spite of barriers to vehicle access in sensitive areas. Uncontrolled vehicular traffic, including parking and joy-riding, causes compaction and rutting of habitat and disturbs the area's wildlife as well as its food source. The likely increase in boat traffic, particularly if boat speed limits are not enforced, could contribute to shoreline erosion, increased public use, and the potential for negative impacts to the remote areas of the preserve. In addition, irresponsible and uncontrolled operation of personal watercraft operations degrades habitat. An increase in public use of MBHC may also lead to an increase in discarded or blowing trash, thus providing a detrimental food source to waterfowl and sea turtles. The potential impacts of increased boat traffic and boat wake and URS (2002) erosion modeling are discussed in Section 4.4.1 (Submerged Aquatic Vegetation) and Section 4.4.2 (Coastal Wetlands). With the implementation of proposed actions as presented in the MBHC Management Plan including the installation of parking lots and barriers (GLO and FWS, 1998), much of these human influenced activities have been removed or lessened.

The potential for impacts associated with hydrologic changes includes shoreline erosion caused by increased tidal currents and vulnerability to Gulf storms, especially hurricanes, due to the reopening of the channel to the Gulf of Mexico. These potential impacts are discussed in Section 4.1 (Environmental Setting), Section 4.2.1 (Water Quality, Exchange and Inflows), Section 4.4.1 (Submerged Aquatic Vegetation), and Section 4.4.2 (Coastal Wetlands).

4.4.2 Submerged Aquatic Vegetation (Seagrass)

The No-Action Alternative will not negatively impact SAV. The No-Action Alternative will likely mean that the channel will continue to shoal. This will cause changes to the bathymetry of the existing channel and the adjacent areas, and the distribution of the various habitats will change in response to the changes in bathymetry. The shoaling of the channel will probably create more areas that could support SAV because the water depth will decrease and the existing tidal currents will be reduced. This cannot be quantified.

Although Corpus Christi Bay and the Upper Laguna Madre support several species of SAV, only shoalgrass beds were observed near the footprint of the channel during field visits by PBS&J staff in August and October 2001 and February 2002. Widgeongrass, which is more transient, has been observed previously in this area (PBS&J, 1999a; Dunton, 1994).

Potential impacts from the proposed Project could come from several possible sources: dredging activities (removal or burial including placement areas or, to a lesser extent, by increases in turbidity and light reduction and/or changes in channel side slopes), shoreline protection (bulkheads), changes in salinity, changes in tidal range, and higher energy conditions associated with tidal exchange and vessel traffic. The main areas of impact include:

- West of SH 361 bridge (Reach 2, Stations 75+00–95+00): In an area adjacent to the channel on the north side across from Packery Channel County Park, the SAV beds extend to the edge of the channel in this area, unlike most of the channel that has approximately 10 to 15 feet of an unvegetated area between the SAV and the channel.
- East of SH 361 bridge (Reach 1, Stations 140+00–148+00): The proposed shoreline improvements and dredging of the Inner Basin will remove SAV beds.

Short-term increases to turbidity would be expected during the dredging operations associated with the modifications to the channel and subsequent maintenance. However, recent studies by Dunton (in press) in the Upper Laguna Madre indicate that short-term elevated turbidity and even shallow burial caused by dredging operations may reduce biomass, but not kill shoalgrass. The distribution of this SAV species is primarily a function of light requirements and, in this area, is generally limited to waters less than approximately 4.6 feet (Dunton, 1994; Tunnel and Judd, 2002).

There have been some concerns about impacts to SAV in the part of the channel across from Packery Channel County Park (stations 75+00 to 95+00 on the north side of channel) since the SAV extends to the edge of the existing channel at this location. The edge of the channel is steep in this area, so widening the footprint in this area to achieve 3:1 slope would impact some SAV beds (<0.5 acre). A wider footprint is less likely to impact SAV for the rest of the channel because the slope is more gradual and there are generally 10 feet or more of unvegetated areas between the edge of the channel and the edge of the SAV. The channel across from Packery Channel County Park has been moved slightly (approximately 10 feet) to the south to reduce the area of SAV impacted on the north side of the channel, while avoiding the SAV on the south side of the channel.

The most significant impacts to SAV would result from the proposed changes to the Inner Basin. Proposed activities (construction of bulkheads and dredging) would displace (remove or isolate) approximately 3 acres of continuous to patchy shoalgrass meadows that ring the basin. These vary in width from 15 feet on the eastern shoreline to approximately 100 feet on northern, western and southwestern shorelines where the slope is more gradual.

Potential direct and indirect impacts to seagrass and shoreline marshes comes from changes in existing levels of waves and currents. Koch's (2001) study shows that SAV distribution is limited by high wave energy although a certain level of turbulence may be beneficial to the plant (e.g., by not allowing fine sediment to settle on or epiphytes to attach to SAV leaves). Citing a need for research regarding the hydrodynamic requirements (currents, waves and turbulence) on seagrass, Koch concluded that because there are so many confounding factors, it is difficult to predict which combination will cause a loss of existing seagrass.

Koch's (2001) comparison of existing data indicates that marine flowering plants (shoalgrass was not included) can tolerate current flow velocities ranging from 0.17 to 6.0 feet/second. Erosion modeling analyses performed by URS (2002) suggested that under normal conditions, velocities should remain within the tolerance range of SAV. Average channel velocities under normal conditions (high flow summer) were found to exceed the upper tolerance range for SAV at only one station (40+79); however, URS (2002) suggested this value was a possible over-estimation by the model, based on the other values projected for this station and the lack of such a finding in other modeling at this site. URS (2002) concluded that the erosion potential analysis indicated a low risk of erosion for the channel bed and side slopes. Therefore, changes in current velocities are not expected to impact SAV.

The impacts of watercraft-generated waves on seagrass and shoreline marshes is another area of concern. The direct impact of physical breakage of the plant is more severe for canopy forming (e.g., widgeongrass, Koch's example) SAV species. Canopy forming species are those with most of their biomass near the water surface. Meadow forming species are those with the most biomass near the sediment surface. The shoalgrass beds in the study area form fairly ground-hugging meadows. The breakage of plants exposed to waves is inversely related to current velocity. According to Stewart et al., (1997) as current velocity increases, the plants tend to lie closer to the substrate and are less affected by orbital motion of waves. Koch (2002) found the impact of boat-generated waves on seagrass habitat to be minimal.

URS (2002) used USACE methodology to estimate boat-generated waves to be 2 feet high for Reach 1 (east of SH 361) and 1 foot high for Reach 2 (west of SH 361). URS concluded that if the speed of crafts is controlled to below 4 knots, boat-generated waves would be minimal. This is particularly important from station 90+00 to 132+25 to preserve tidal flats and marsh areas. This includes the shorelines of Packery County Park (southern shoreline of channel) and MBHC (northern shoreline of channel). If boat traffic velocities can not be regulated, URS recommends shoreline protection for the northern and southern shorelines.

As seagrass distribution is limited by wave and current energy, and there are so many contributing and confounding factors, it is difficult to predict which combination would cause a loss of existing seagrass. However, with the relatively small predicted changes in wave and current energy regimes caused by the proposed Project, it is unlikely that there would be a substantial change in the seagrass distribution.

Seagrasses in the study area generally occur only in shallow areas (water depths less than 4.6 feet below MLT). Due to the transient nature of some SAV beds, all areas within the footprint of the channel and Inner Basin area, in water depths less than 4.6 feet MLT, could be considered as the worst-case scenario for direct impacts to SAV. However, current water depth data are not available and, based on field surveys, the maximum SAV impacts are approximately 5.2 acres (includes continuous and patchy SAV). Other SAV beds in the area are either distant or on the opposite side of islands or levees from the proposed dredging or placement activities. Potential indirect impacts include increased vulnerability to storm events.

The predicted changes in salinities and tidal ranges are very small and well within the tolerance and natural range of the common SAV species (Stutzenbaker, 1999) and much smaller than the effects of seasonal tides. So, it is unlikely that they will cause an appreciable change in SAV distribution.

The only beneficial use (BU) for the placement of dredged material occurs south and north of the proposed Gulf jetties for the purpose of beach nourishment, so no SAV habitat would be impacted by a BU project. However, the design of the channel from the Inner Basin to the Gulf would create approximately 5.4 acres of broad shallow (< –2 feet MLT) shelves between the sides of the channel and the bulkheads (northern and southern sides). The shallow water areas may be suitable for natural SAV recruitment, assuming that tidal currents and vessel wakes do not generate excessive energy or turbidity. An additional 0.3 acre of broad shallow shelves will be created at elevations between –2 and –4 feet MLT, yet these areas may be less likely to vegetate due to proximity to the channel and associated stronger currents and potentially higher turbidity. The fact that Packery Channel would not naturally remain open indicates that the expected tidal currents would have relatively low energy. If the vessel wakes are not significantly greater than current conditions in Packery Channel, then they should not be too great for SAV habitat. For example, appropriate shallow water near the GIWW through the Laguna Madre is vegetated.

Potential indirect impacts during construction could be caused by reduced light conditions associated with increased TSS; however; these impacts would be short term and localized. This could be further minimized if dredging is scheduled to avoid seasonally high growth periods (i.e., during the summer).

The predicted change in tidal amplitude (PBS&J, 2001c; PBS&J, 1999b) is less than 0.5 inch in Corpus Christi Bay and the Upper Laguna Madre (decreasing impacts with distance from the proposed channel). Changes of this magnitude would have no significant, if detectable, effect on seagrass beds.

Dredged material produced by the proposed Project will be placed in upland sites (confined and partially confined) or on the beach north and south of the jetties. None of these are expected to impact any areas of SAV.

4.4.3 Coastal Wetlands

The No-Action Alternative will not negatively impact wetlands. The No-Action Alternative will likely mean that the channel will continue to shoal. This will cause changes to the bathymetry of the existing channel and the adjacent areas, and the distribution of the various habitats will change in response to changes in bathymetry. The shoaling of the channel will probably create more areas that could support SAV as the channel depths become shallow enough to support it. The reduction of already minimal tidal currents and possible sedimentation in some of the adjacent areas may provide suitable conditions for the support of estuarine marsh and flats.

As with seagrasses, there are several possible sources of potential negative impacts to wetlands from the proposed Project, including:

- dredging activities (removal or burial and/or changes in channel side slopes);
- shoreline protection (construction of bulkheads, rip-rap at bridge);
- changes in salinity and/or tidal range;

- higher energy conditions associated with tidal exchange and vessel traffic; and
- construction activities associated with the various proposed recreational development (e.g., parking areas, access roads, and boat ramps).

The habitats that are vulnerable to impacts from the proposed activities would only be in the area immediately adjacent to Packery Channel and the Inner Basin. The very small predicted changes in tidal elevation and salinity would have little, if any, detectable impact to any of these habitats. The predicted changes in salinities and tidal amplitudes are very small and well within the tolerance and natural range of the common species (Stutzenbaker, 1999). Also, the predicted changes are less than the effects of seasonal tides. So, although there may be some minor shifts in the location of some populations, it is unlikely that there will be an appreciable change in the overall extent of these habitats.

Shoreline erosion may differ from existing conditions due to changes in tidal levels, current velocity, vessel wakes, and storm events. URS (2002) modeling studies, described above, indicated that the shorelines of Packery County Park (southern shoreline of channel) and Mollie Beattie Habitat Community (northern shoreline of channel) were susceptible to erosion from boat-generated waves if boat speeds were not controlled (<4 knots). However, wave barriers are not considered for either side as the construction activities would cause more damage than the protection they would provide. Based on the erosion potential analysis by URS (2002), areas of potential erosion along the channel bed and side slopes at the bends of the channel (between stations 40+76 and 84+27) were not found to require armoring.

4.4.3.1 Estuarine Marshes

The low salt marsh (smooth cordgrass) in this area includes only an extremely narrow (sometimes just a few plants wide to several feet wide) fringe along the channel shorelines. Some areas have wider patches of this fringe habitat including the north shoreline within the MBHC and south shoreline of the channel adjacent to Packery Channel County Park. These are discontinuous but average approximately 10 feet in width. The southern shoreline (west of SH 361, stations 29+00–37+00) supports a broader area of low salt marsh, up to 30 feet wide. These wetland areas will not be impacted by the channel widening. There are a few small patches of low salt marsh east of SH 361 that include a narrow fringe on the western shore of the Inner Basin and a fringe along two isolated depressions (algal flats) on the south side of the Inner Basin. The bulkheading and dredging in the Inner Basin and PA 3 would impact approximately 0.2 acre of low salt marsh.

The high salt marsh and tidal flats cover much more area than the narrow fringing low salt marshes, but these are located at higher elevations, in general, and would not be affected by the <0.5-inch predicted change in tidal range (PBS&J, 2001c; PBS&J, 1999b). The high salt marsh will be most affected by dredging and the placement of the proposed bulkheads lining the Inner Basin and the gulfward extension of Packery Channel. Channel dredging will negatively impact approximately 3.7 acres.

The area north of the proposed extension of Packery Channel (approximate Station 157+00 to 168+00), in the vicinity of PA 2 and north behind the primary dune complex, is primarily high salt marsh. The approximate area of this habitat that would be impacted by placement of dredged material in PA 2 is 4.3 acres. This undisturbed area is part of a natural low area (i.e., swale) located between the primary and secondary dune complex on the Gulf shoreline and a second row of secondary dunes that are adjacent to SH 361. Most of the community is high salt marsh; however, some areas are occasionally so sparsely vegetated they must be considered tidal flats. The most common species in this community is glasswort. The vegetated flats are the only part of the swale area that likely would be considered jurisdictional wetlands. The potential impacts of the proposed Project to this community would be associated with the construction of the bulkhead along the proposed channel and placement of dredged material north of the bulkhead into PA 2. PA 3 would negatively impact approximately 2.9 acres.

Review of aerial photography (1995 DOQQ) indicates that the recent historical drainage of this area was to the north. The drainage pattern has been modified somewhat by the raised bed of Zahn Road that divides the swale, separating this low wetland community from the wetland communities to the north. Zahn Road is located on the north side of the Project area and provides beach access from SH 361. Two sets of culverts cross Zahn Road. One of these sets includes three culverts (3-foot reinforced concrete pipes (RCPs)) and is located about half way between SH 361 and the beach. These culverts are partially to completely filled with sediment on the south side of the road, and vegetation has established such that the culvert openings are not obvious; however water does apparently make it through this connection, but only during storm or extremely high wind-driven tides (pers. obs., John Adams, TAMU-CBI, 2002). The partial blockage of these culverts may reduce or stop drainage to the degree that the area on the south side of the road fills to capacity, overflows and drains to the south toward Inner Basin, instead of draining to the north. This is indicated by a small, eroded gully on the southern edge of this area. This would likely only happen during storm events or extremely high, seasonal tides.

The primary source of water to this wetland area south of Zahn Road is probably due to precipitation and a high water table. Although this low area occasionally fills to a point that overflows to the south, the primary drainage is to the north, so the proposed bulkhead and placement area associated with the Project should not impact the basic hydrology of the wetland.

The other culvert, a single 3-foot RCP, is located further to the west along Zahn Road. This drainage connection may transfer runoff from the secondary dunes south of the road to the wetland area north of the road, or visa versa during high tidal events.

A total of 11.1 acres of low and high salt marsh communities will be negatively impacted by dredging of the channel and maintenance material placement. No freshwater marsh would be impacted by the proposed Project.

4.4.3.2 Tidal Flats (Including Algal Flats)

The tidal (sand/mud) flats adjacent to the channel are primarily located on the north side of the channel (adjacent to MBHC) and, thus, would not be affected by the proposed Project because they are generally above the predicted change in tidal elevation. However, impacts to approximately 1.3 acres of tidal flats will occur from channel dredging and dredged material placement (PA 2).

Proposed secondary development associated with recreational development, including utility casings placement, may negatively impact an additional 0.3 acre of tidal flats.

In addition to impacts to the above tidal flats, two small, depressional algal flats (0.2 acre) located east of SH 361 on the south side of the Inner Basin would be impacted by the modifications to the Inner Basin of the proposed Project. These are associated with a few small patches of low salt marsh.

4.4.4 <u>Coastal Shore Areas/Beaches/Sand Dunes (including Channel Fill Sands)</u>

The No-Action Alternative will not negatively impact coastal shore areas, including beaches and sand dunes. The No-Action Alternative will allow the channel to continue to shoal. Changes in the bathymetry of the channel and adjacent areas will cause changes in the distribution of the various habitats. These changes would not affect the Gulf shoreline, beaches and existing dune complex.

The proposed channel cut to the Gulf of Mexico would traverse beach and primary and secondary dune habitats. There is no obstruction to the longshore transport of sediment along the shoreline. No beach nourishment program is currently in place. It can be assumed that the findings of the Corpus Christi Ship Channel Improvement Project Shoreline Erosion Project (PIE, 2001) apply to this Project (i.e., the main factors contributing to shoreline erosion in this area are wind-generated waves and sea level rise) based on the similarities of the two projects.

The proposed Project would extend Packery Channel into the Gulf of Mexico. This would involve dredging a new channel from the Inner Basin to the Gulf shoreline and protecting the opening with rock jetties extending approximately 1,400 feet into the Gulf. The channel would remove approximately 16 acres: approximately 5.1 acres of beach and approximately 12.1 acres of unvegetated channel fill sands in the existing shoaled-in washover channel. This washover channel is inundated only during storm events and is thus not considered a tidal flat. Jetty construction would negatively impact approximately 1 acre of beach. The jetties would disrupt sediment transport by longshore currents. Typically, the beach on the downstream side of longshore currents suffers from erosion due to the lack of a sediment supply; however, the placement of dredged material on the north and south side of the channel for beach nourishment (46 acres) would delay the need for sand for some time regardless of the direction of longshore currents and littoral drift. A sand bypass system will be designed to prevent the sand from entering the channel on the updrift side of the channel (URS, 2002), reducing maintenance and nourishing the beach on the down-current side of the jetties.

Beach nourishment, a BU project, will provide a positive impact from placing dredged material on PA 4S and 4N. Approximately 46 acres of beach nourishment is proposed with use of sands from dredge material from construction and maintenance. This will counter the current erosional trend of the shoreline. Approximately 23.7 acres of primary and secondary dune complex would be impacted by the dredging and placement of dredged material. Activities associated with the secondary development of park features and access roads by the City of Corpus Christi may potentially impact 3.4 acres of primary/secondary dune complexes, 3.7 acres of beach, and 0.3 acre of tidal flats. The extent of these impacts is based on preliminary location footprints of parking lots, access roads, and buildings. The City of Corpus Christi has proposed a dune mitigation plan for the relocation and restoration of approximately 5,670 cy of displaced dunes (approximately 1.5 acres) occurring within the channel footprint. The mitigation area is located northeast of the displaced dunes in a depression landward of the foredune ridge (City of Corpus Christi, 2002a).

4.4.5 Upland Grasslands

The No-Action Alternative will not negatively impact upland grassland areas.

The predominant activity associated with the proposed Project that is likely to impact upland grasslands is the placement of dredged material (9.8 acres). The location for the MMPA is not pristine prairie, but includes more of the typical coastal prairie species, as well as some pasture species, including little bluestem and seacoast bluestem, common sandbur (*Cenchrus incertus*), red lovegrass (*Eragrostis secundiflora*), marshhay cordgrass, bushy bluestem (*Andropogon glomeratus*), ragweed (*Ambrosia* spp.), sunflower (*Helianthus* spp.), partridge pea, mistflower (*Eupatorium coelestinum*) and scattered southern wax-myrtle shrubs. Other species reflect the proximity to the shore and dune complex such as camphor daisy (*Haplopappus phyllocephalus*), Gulfdune paspalum (*Paspalum monostachyum*), and Gulf croton. PAs 1 and 2 will impact dune complexes, which are technically considered upland grasslands, although they are described in Section 4.4.4 as part of Coastal Shore Areas/Beaches/Sand Dunes.

4.5 FISH AND WILDLIFE RESOURCES

4.5.1 Finfish and Shellfish Resources

Under the No-Action Alternative, finfish and shellfish communities will continue as described in Section 3.5.1.

Several field studies concerning turbidity from total suspended solids (TSS) associated with dredging operations concluded that dredging had no substantial effects on nekton (free-swimming aquatic species) (Flemer et al., 1968; Ritchie, 1970; Stickney, 1972; Wright, 1978). However, elevated turbidities can suffocate and reduce growth rates in adult and juvenile nekton and reduce viability of eggs (Moore, 1977; Stern and Stickle, 1978). Detrimental effects were generally recognized at TSS concentrations greater than 500 milligrams per liter (mg/L) and for durations of continuous exposure ranging from several hours to a few days. Turbidities exceeding 500 mg/L have been observed around maintenance dredging and placement operations (EH&A, 1980), and such turbidities could potentially affect some aquatic organisms near the active dredges and poorly controlled outflow weirs. May (1973) found that TSS was reduced by 92 percent within 100 feet of the discharge point and by 98 percent at 200 feet, and that concentrations above 100 mg/L were seldom found beyond 400 feet from the placement point. Turbidities can be expected to return to near ambient conditions within a few hours after dredging ceases or moves out of a given area. The benthos at the site, which would have been used as a food source, will be lost. Notwithstanding the potential harm to some individual organisms, no significant impact on nekton populations is anticipated from the construction/maintenance dredging and placement operations associated with the extension of Packery Channel for reasons described below.

The proposed new channel area represents a small increase in habitat for those nekton species common in deeper offshore waters, which periodically invade the bay through the deep channel corridor (Breuer, 1962). Creating a new channel would also result in a small increased feeding and nursery area for demersal fish (Breuer, 1972).

The effects of maintenance dredging for the preferred alternative would generally be the same as those discussed for the construction operation. However, the reduced amount of dredging, relative to construction activities, would result in a reduction of the temporary adverse effects. Maintenance material from Reach 2 would be primarily silt or sandy silt, which settles less readily and causes more turbidity than construction material or maintenance material from Reach 1, which would be largely sand.

A HEP analysis, using the proposed Packery Channel configuration, was conducted to determine whether there would be a change in fish habitat. This was based on the modeling discussed in Section 4.2.1. The HEP analysis conducted for the Packery Channel Alternative (Appendix B) supports the earlier studies conducted by FWS, Nueces County, and for the PSP (PBS&J, 1999b) by showing that habitat units for modeled species with the channel in place would be gained under certain conditions where high salinity would be expected. Five species including brown shrimp, spotted seatrout, red drum, southern flounder, and Gulf flounder (*Paralichthys albigutta*) were selected for HEP analysis. Of the five species selected for Habitat Suitability Index evaluation, the red drum was eliminated, *a priori*, because of food and cover limitations. Under average annual conditions, all species, except for spotted seatrout, lost habitat (Table 4.5-1). This reflected the lower yearly and spring mean salinity scenarios. Only the spotted seatrout, which utilized the maximum monthly mean salinity scenario, showed slight increases in habitat units with the opening of a channel to the Gulf. For the 80th percentile salinity conditions, which represents a short-term, high salinity event that would likely occur every 5 years, all species gained habitat. This reflects the decrease in salinity that would be expected in the Upper Laguna Madre with an opening at Packery Channel. Therefore, based on the HEP analysis focusing on changes in salinity, the conclusion is that under average annual conditions very little environmental effect (positive or negative) would result from the proposed Project.

The increase in shoreline acreage and ease of migration issues were not quantified in this evaluation. For the PSP, it was determined by the resource agencies that a quantification of fish and wildlife resources impacts due to changes in tidal amplitude was not feasible. Tidal inlets serve the basic purpose of allowing exchange of water between bays and the Gulf. However, they also serve as passageways for many marine organisms and are essential to the production of shrimp, crab, red drum, flounder, and other species that spawn in the Gulf, but mature in the bays (Texas Game and Fish Commission (TGFC), 1967). A considerable amount of discussion on the biological aspects of fish passes was conducted in the 1950s and 1960s, led primarily by the TGFC. Simmons (1952 and 1953) authored a four part series entitled “How Fish Use Coastal Passes” and described the migration patterns for spotted seatrout, red drum, flounder, sand trout, black drum, Atlantic croaker, and spot. These discussions led to the following environmental conclusions by Simmons (undated) regarding the value of these passes. Fish passes:

1. Modify habitat, including maintaining salinity.

TABLE 4.5-1

NET CHANGES IN AVERAGE ANNUAL HABITAT UNITS (AAHU)

	AVERAGE ANNUAL CONDITIONS	**80th PERCENTILE**	**AVERAGE ANNUAL CONDITIONS**
Latitude (minute range)	Packery Channel Net Changes (AAHU)	Packery Channel Net Changes (AAHU)	Packery Channel Net Changes (% AAHU)
	YEARLY MEAN - GULF FLOUNDER	YEARLY MEAN - GULF FLOUNDER	YEARLY MEAN - GULF FLOUNDER
50-52	0	0	0.00%
48-50	0	0	0.00%
46-48	0	0	0.00%
44-46	0	0	0.00%
42-44	0	0	0.00%
40-42	0	36	0.00%
38-40	0	60	0.00%
36-38	0	46	0.00%
34-36	-25	51	-0.60%
32-34	-29	29	-0.60%
30-32	-46	25	-1.09%
28-30	-17	0	-0.48%
26-28	-15	0	-0.49%
24-26	0	0	0.00%
22-24	0	0	0.00%
20-22	0	0	0.00%
TOTAL	**-132**	**246**	
	YEARLY MEAN - SOUTHERN FLOUNDER	YEARLY MEAN - SOUTHERN FLOUNDER	YEARLY MEAN - SOUTHERN FLOUNDER
50-52	0	0	0.00%
48-50	0	0	0.00%
46-48	-59	0	-0.31%
44-46	-43	0	-0.28%
42-44	-22	29	-0.19%
40-42	-75	60	-1.32%
38-40	-36	41	-0.61%
36-38	-36	46	-0.91%
34-36	-23	23	-0.60%
32-34	-36	20	-0.83%
30-32	-17	0	-0.46%
28-30	0	0	0.00%
26-28	-27	0	-1.00%
24-26	0	0	0.00%
22-24	0	0	0.00%
20-22	-110721	0	-6342.80%
TOTAL	**-111092**	**218**	
	MAXIMUM MEAN - SPOTTED SEATROUT	MAXIMUM MEAN - SPOTTED SEATROUT	MAXIMUM MEAN - SPOTTED SEATROUT
50-52	0	0	0.00%
48-50	0	0	0.00%
46-48	0	0	0.00%
44-46	0	621	0.00%
42-44	0	1848	0.00%
40-42	0	1005	0.00%
38-40	172	0	2.31%
36-38	195	2567	3.85%
34-36	0	0	0.00%
32-34	0	0	0.00%
30-32	0	0	0.00%
28-30	0	0	0.00%
26-28	0	0	0.00%
24-26	0	0	0.00%
22-24	-61717	0	0.00%
20-22	0	0	0.00%
TOTAL	**-61349**	**6040**	
	SPRING MEAN - BROWN SHRIMP	SPRING MEAN - BROWN SHRIMP	SPRING MEAN - BROWN SHRIMP
50-52	N/A	N/A	NA
48-50	N/A	N/A	NA
46-48	0	0	NA
44-46	0	0	NA
42-44	0	10	NA
40-42	0	228	0.00%
38-40	0	109	0.00%
36-38	0	117	0.00%
34-36	0	0	0.00%
32-34	-7	0	-0.18%
30-32	0	0	0.00%
28-30	0	0	0.00%
26-28	0	0	0.00%
24-26	-38098	0	-1540.73%
22-24	0	0	0.00%
20-22	0	0	0.00%
TOTAL	**-38106**	**464**	

2. Allow immigration (e.g., the movement of larval and post-larval fish, shrimp and crabs into the bays). These migrations are extremely heavy and very valuable; however, "(t)here is no assurance that more passes will increase this influx although the presence of these larval forms all along the Gulf beach indicates they would."
3. Allow emigration (e.g., the movement of large fish, crabs and shrimp out of the bay). Every fish pass study reviewed by Simmons demonstrated that more large fish, shrimp and crabs moved out of the bay than into the bay, but large fish move into the bay in the spring, especially after a cold winter.

TGFC (1967) conducted a review of the biological effects associated with the opening of Corpus Christi Pass. For the TGFC review, the area called Corpus Christi Pass includes a larger area encompassing Packery Channel, Newport Pass, and the old Corpus Christi Pass. All of these passes were opened by Hurricane Carla in 1961; however, all except Packery Channel re-closed within a few days (TGFC, 1967). While open, fish and shrimp moved out into the Gulf in great numbers and this migration was also observed in 1964 when the pass was opened after a high tide washover (TGFC, 1967). TGFC (1967) presented the following summary:

1. When Corpus Christi Pass was open, it provided a good entrance for Gulf spawned food and game fish, shrimp and crabs, and an exit for marine species back out to the Gulf.
2. The available information indicates that Corpus Christi Pass would be used extensively by migrating aquatic organisms and their young. In addition to the desirable species, the pass would also be used and inhabited by catfish, stingrays, sharks and other less-desirable fish.
3. The presence of Corpus Christi Pass may reduce the time that adult fish spend in the bay while trying to emigrate out to the Gulf via Aransas Pass, which is further away.

A more-recent investigation of fish and invertebrate migration in the Laguna Madre was performed with respect to the JFK Causeway project (Holt, 1998). The report provides an overview of the movement patterns and requirements of aquatic organisms in the Laguna Madre. The following summarizes the aquatic organism movement patterns documented in Holt (1998):

1. Nekton (juvenile and adult stages of red drum, spotted seatrout, blue crab, brown shrimp, etc.) are free-swimming organisms and have the ability to move on their own; however extremely strong currents can disrupt movement for some of these organisms. Most of their migration occurs through deeper areas of the bay and channels and rarely over shallow areas.
2. The planktonic stage of many organisms (holoplankton and meroplankton) can last for hours, days or months and, therefore, changes in currents could be significant.
3. More is known about larval stages of fish, crabs, and shrimp than about benthic fauna larval stages. Most recreational and commercial fish, crabs, and shrimp are found in deeper portions of open bays and channels throughout the water column, although they are more abundant in the bottom 3 feet during daylight hours. Only a few larval species are found over seagrasses including gobies and pipefishes, which are seagrass residents. Increased flow rates over seagrass beds would have little effect. If flow rates were increased, there is a possibility that planktonic larvae would have better access to seagrass beds, which would become a better nursery habitat.

4. With regards to invertebrate larvae, their distribution is thought to be throughout the water column, and they are dispersed via currents, with maximum transport occurring in deeper channels where currents are stronger. As with fish larvae, it is possible that increased flow rates over seagrass beds would allow for more widespread larval dispersal.

The changes in circulation and currents produced by Packery Channel would likely cause changes to the existing larval transport process in the Laguna Madre. However, there is not enough evidence to quantify whether these changes would provide net benefits or detriments to the system. These changes in either direction are probably not significant.

The basic question is how valuable would a pass be with respect to a much larger pass (Aransas Pass) located at the northern end of Corpus Christi Bay. Aransas Pass is a deep, jettied pass that is the current route of most shrimp, crabs and fish entering and leaving Corpus Christi Bay and the Upper Laguna Madre (TGFC, 1967). Copeland (1965) and Copeland and Truitt (1966) have shown the value of Aransas Pass for ingress and egress of shrimp, in particular, and fish, in general. Hoese (1965) mentions that the existing passes offer sufficient entry points for juvenile fish and that more passes would simply dilute the flow. However, others argue that increased passes would allow for more larval transport and decreased transport times (about 1 month for some species). The literature suggests that an opening at Packery Channel would provide ease of migration for aquatic organisms. On the same note, the basic requirements for fish migration are typically satisfied by shallow water which would indicate that, for environmental benefits, a stable, deep channel may not be necessary.

4.5.1.1 Recreational and Commercial Fisheries

Under the No-Action Alternative, recreational and commercial fisheries will continue as described in Section 3.5.1.1.

Temporary and minor adverse effects on recreational and commercial fisheries may result from altering or removing productive fishing grounds and interfering with fishing activity. The evaluation of effects on the aquatic resources of the region (Section 4.4.1.3) concluded that no significant reductions of nekton would result from the channel expansion plans. In particular, major species of the nekton assemblage, including the sciaenid fishes and penaeid shrimp, should not suffer any significant losses in standing crop. Recreational and commercial fishing would, therefore, not be expected to suffer from reductions in the numbers of important species.

Repeated dredging and placement operations may temporarily reduce the quality of recreational and commercial fisheries in the vicinity of dredging operations. This may result from decreased water quality and increased turbidity during dredging and loss of attractiveness to game fish in the area resulting from loss of benthic animals. Turbidity caused by dredging will only occur in the immediate vicinity of the dredge during the period of actual construction. The quality of fishing in the locality of the dredging area will improve after construction is completed, similar to the No-Action Alternative. Maintenance dredging operations will also only cause temporary minor affects to the immediate area during the actual dredging process. The estimated days of annual maintenance in

Reach 1 is 7 days. The Reach 2 maintenance schedule accounts for dredging every 5 years for 7 days (Section 4.9).

The extended channel will result in an increase in ocean-going recreational fishing traffic through the Packery Channel. This increase in ocean-going traffic will result in more interference to all recreational and commercial fishing activity taking place in Packery Channel.

The direct effects of construction dredging on bay recreational fishing will be confined to Packery Channel and the section of the GIWW that it intersects. This will be temporary, resulting in local disturbances to both boat and wade-bank fishing particularly along the edges of the channels. After initial construction, disturbed wade-bank fishing areas along the south and north bank of Packery Channel west of SH 361 should return to preconstruction conditions. However, recreational fishing here does not constitute a significant portion of the recreational fishing effort. The constructed jetties resulting from the channel extension and the proposed park amenities will increase the bank fishing area.

4.5.1.2 Aquatic Communities

Under the No-Action Alternative, aquatic communities will continue as described in Section 3.5.1.2.

Turbidity in estuarine and coastal waters is generally credited with having a complex set of impacts on a wide array of organisms (Thompson, 1973; Hirsch et al., 1978; Stern and Stickle, 1978; EH&A, 1978). Turbidity and suspended material can play both beneficial and detrimental roles in aquatic environments. Turbidity tends to interfere with light penetration and thus reduce photosynthetic activity by phytoplankton and seagrasses. Such reductions in primary productivity would be localized around the immediate area of the maintenance dredge operations in Packery Channel, limited to the duration of the plume at a given site. Conversely, the decrease in production, presumably from decreased available light, has been found to be offset by increased nutrient content (Morton, 1977). In past studies of the impacts of dredged material placement from turbidity and nutrient release, the effects are both localized and temporary (May, 1973; Odum and Wilson, 1962; Brannon et al., 1978). Thus, due to the reproductive capacity and natural variation in phytoplankton populations, the impacts of maintenance dredged material placement anywhere within the Project area are not expected to be significant.

Effects of elevated turbidities on the adult stages of various filter-feeding organisms such as oysters, copepods and other species include depression of pumping and filtering rates and clogging of filtering mechanisms (Stern and Stickle, 1978). These effects are pronounced when TSS range from 100 mg/L to 1,000 mg/L and higher, but are apparently reversible once turbidities return to ambient levels.

Dredging represents two problems for aquatic communities: excavation and placement. Excavation removes organisms, but organisms can rapidly recolonize the bottom (Montagna et al., 1998). Placement of construction and maintenance material in the proposed beach nourishment placement site would bury those benthic organisms incapable of escaping or burrowing up through the dredged material. Burial of benthic organisms will occur during initial construction placement, but the material is virgin ocean bottom, similar to that which presently exists in the site, and so recolonization should be rapid.

Repeated dredging in one place may prevent benthic communities from fully developing (Dankers and Zuidema, 1995). Excavation destroys the community that previously existed but creates new habitat for colonization (Montagna et al., 1998). Excavation can actually maintain high rates of macrobenthos productivity (Rhoads et al., 1978). By repeatedly creating new habitat via disturbance, new recruits continually settle and grow. However, these new recruits are always small, surface-dwelling organisms with high growth rates. Large, deep-dwelling organisms that grow slower and live longer are lost to the system. In this way, excavation may not cause a decrease in production, but rather a large shift in community structure (Montagna et al., 1998).

The effects of maintenance dredging would generally be similar to those discussed for construction. However, the reduced volumes and numbers of dredges working would result in a reduction of the temporary adverse effects.

On the other hand, FWS (1997b) states that a permanent reopening of Packery Channel "is expected to once more ensure that live oyster reefs are a feature of Kate's and Deadman's Holes, two popular fishing sites in the Laguna Madre near Packery Channel."

4.5.1.3 Essential Fish Habitat

The No-Action Alternative will have no detrimental impacts to the estuarine habitat in the Project area. The No-Action Alternative will likely mean that the channel will continue to shoal. This will cause changes to the bathymetry of the existing channel and the adjacent areas, and the distribution of the various habitats will change in response to changes in bathymetry. The shoaling of the channel will probably create more areas that could support SAV as the channel depths become shallow enough to support it. The reduction of already minimal tidal currents and possible sedimentation in some of the adjacent areas may provide suitable conditions for the support of estuarine marsh and flats.

EFH impacted for adult and juvenile white shrimp, brown shrimp, red drum, Spanish mackerel, Gulf stone crab, juvenile pink shrimp, and gray snapper in the Project area includes: estuarine marshes, estuarine mud, sand, sand substrates, SAV, and the estuarine water column. There is no shell substrate in the area to be dredged for the proposed plan (only a few scattered, mostly dead oyster reefs exist in Corpus Christi Bay).

Results of water quality analyses (sections 4.2.2, 4.2.3, 4.2.4, and 4.2.5) indicated that the impacts from the proposed Project to water quality, including salinity, turbidity, and red and brown tide patterns in Laguna Madre would not be significant. Small shifts in salinity may occur within portions of the bay but changes are expected to be small, less than 0.2 ppt in most areas. Generally, salinity changes are anticipated to be a few parts per thousand near the proposed inlet, with changes decreasing in intensity further into Corpus Christi Bay and the Laguna Madre. During proposed construction and maintenance activities, turbidity would be increased. The placement of finer materials in upland sites would reduce effects, minimizing the amount of silty materials in the water column. Impacts associated with reopening the Packery Channel to brown tide frequency, intensity, or distribution cannot be determined because of a lack of information regarding the species complete life cycle. However, the brown tide does not appear to be an oceanic species and changes to current brown tide patterns, therefore, are not expected. Reopening the channel could, however, provide a means for the red tide to affect areas of the Laguna Madre that are currently not affected. Overall, no significant detrimental environmental effects to water quality are expected to occur from construction or operation of the proposed Project.

Juvenile brown shrimp and white shrimp will be temporarily and locally impacted by the loss of seagrasses. Red drum are found throughout the Project area in all life stages and will be temporarily and locally impacted from dredging. Juvenile Spanish mackerel nurseries may be impacted temporarily and locally by dredging activities. Adult stone crabs may be impacted temporarily and locally by turbidity, but should not be permanently impacted by the proposed plan. Postlarvae and juveniles of pink shrimp will incur temporary and localized impacts in estuarine areas. Adults inhabiting offshore waters near the Project area may be impacted by temporary turbidity. All life stages of gray snapper occur throughout the Project area and may be temporarily and locally impacted from dredging activities.

The proposed Project will bury approximately 11.1 acres of estuarine marshes when the channel is dredged and the bulkheads are backfilled. Approximately 5.2 acres of SAV will be lost during construction. The channel design allows for the potential recruitment of approximately 5.4 acres of SAV on side shelves of the channel. Proposed SAV mitigation will include approximately 15.6 acres of planted shoalgrass for compensation.

Although temporary impacts may occur during construction and maintenance activities for the proposed Project, HEP analysis of changes in fish habitat for five species (brown shrimp, spotted seatrout, red drum, southern flounder, and Gulf flounder) indicated that under average annual conditions the proposed Project would have very little environmental effect. Reopening Packery Channel would ease migration of species between the bays and the Gulf, serving as passageways for many marine organisms that are essential to species that spawn in the Gulf and mature in the bays. Brown shrimp, white shrimp, pink shrimp, red drum, Spanish mackerel, and gray snapper would benefit from the use of the proposed channel as well as from potential increased rates of flow over seagrass beds. Larvae and juveniles of these five species often occur in estuaries, particularly in grassy areas. Increased flow rates over seagrass beds may provide better access to these areas for planktonic larvae and allow for more widespread dispersal. A more detailed discussion of effects of the proposed Packery Channel opening on salinities and tidal ranges of Corpus Christi Bay and the Laguna Madre is provided in sections 4.2.1 and 4.2.2. The implications of those changes on fisheries are more thoroughly discussed in Section 4.5.1 and in Appendix B.

This DEIS will serve to initiate EFH consultation under the Magnuson-Stevens Fishery Conservation and Management Act. The NMFS will review this DEIS and provide comments to EFH impacts.

4.5.2 Wildlife Resources

The No-Action Alternative would result in no immediate direct impacts to the terrestrial wildlife species or wildlife habitats at or near the proposed Project site. Some of the habitats may change over time, independent of the Project. Commercial and residential development occurring in the area could have an impact on the aquatic community and, thus, the food source of many coastal seabirds. It would be expected that boat traffic in the area would decrease over time with shoaling of the channel.

The primary direct adverse impact of the proposed construction activities on terrestrial wildlife due to the construction of Packery Channel would result from the removal of dune and beach habitat where the channel would enter the Gulf of Mexico. Construction activities might also result in the direct destruction of those organisms not mobile enough to avoid construction equipment. These would potentially include individuals of several species of reptiles, mammals and, if construction occurs during the breeding season, the young of some species, including nestling and fledgling birds. Fossorial animals (i.e., those that live underground), may similarly be negatively impacted as a result of soil compaction caused by heavy machinery. For the most part, mobile wildlife species, particularly adult birds and larger mammals, would avoid the initial construction activity and move into available habitat outside the Project area. Each species, however, is dependent upon available resources such as food, shelter, water, territory, and nesting sites in any given area of habitat (Dempster, 1975). It is assumed, for the purpose of impact analysis, that habitats are at their carrying capacity for the species that live there. Therefore, displaced wildlife populations would be forced into competition with resident populations in adjoining habitats, creating an inevitable decreased birthrate and/or increased mortality rate until populations are reduced to numbers that the habitat can support. Thus, construction activity would ultimately result in a reduction in the local wildlife populations proportional to the amount of habitat preempted.

While dredging activities are unlikely to have a direct impact on terrestrial wildlife species, they may have an indirect impact. Such activities may cause temporary impacts to aquatic communities and habitats, which in turn may indirectly impact seabirds in the area by potentially reducing the availability of the food supply. The increased potential for accidental spills of petroleum products, chemicals, or other hazardous materials during dredging activities, however slight, also poses a potential, although very small, threat to the aquatic community and, thus, the food source of many coastal birds in the area. Phytoplankton and zooplankton assemblages, which make up the foundation of the aquatic food chain, could be affected in the unlikely event of a spill. While adult shrimp, crabs and fish are mobile enough to avoid areas of high concentrations of pollutants, larval and juvenile finfish and shellfish are more susceptible. Increased marine traffic would slightly increase the potential for accidents and spills. The effects, however, would be minor and short term.

The noise of equipment and increased human activity during dredging activities may disturb some local wildlife, particularly seabirds, and especially during the breeding season. Such impacts, however, would be temporary and without significant long-term implications. Salinity effects on terrestrial wildlife are not anticipated.

Several seabird rookeries or colonies occur in the vicinity of the proposed Project. The closest is a least tern colony, located approximately 4,000 feet south of Packery Channel and east of Park Road 22. All of the others are located at least 2 miles from Packery Channel. One occurs on the PAs adjacent to the GIWW, approximately 2 miles north of where Packery Channel joins the GIWW, while another occurs approximately 2 miles west of the junction of the two channels. The great blue heron, great egret (*Ardea alba*), snowy egret, reddish egret (*Egretta rufescens*), cattle egret (*Bubulcus ibis*), and black-crowned night-heron have nested at the northern rookery, while the great blue heron, snowy egret, tricolored heron, reddish egret, laughing gull, gull-billed tern (*Sterna nilotica*), caspian tern (*Sterna caspia*), Forster's tern (*Sterna foresteri*), least tern, and black skimmer (*Rynchops niger*) have nested at the western rookery (GLO, 2000; Texas Colonial Water Bird Nesting Census [TCWNC], 2000; TXBCD, 2001). Given the distance of these rookeries from the proposed Project, the noise and human activity associated with dredging and construction activities is unlikely to impact them, even if the Project actions occurred during the nesting season. It is possible that some individual birds might forage as much as 2 miles from the rookeries. If this is the case, dredging activities that take place in the area during the nesting season may indirectly impact these rookeries on a temporary basis by potentially reducing the availability of the food supply.

Once the initial dredging activities associated with the Project have been completed, only minor additional impacts are anticipated. Maintenance dredging activities would have similar temporary impacts as the initial dredging, but on a lesser scale and for a shorter term. Increased boat traffic would increase the potential for accidental chemical or petroleum product spills. These spills would pose a potential, albeit minor, threat to the aquatic community and, thus, the food source of many coastal birds in the area. Impacts from noise and human activity are unlikely to be a substantial factor, although these impacts may force some mobile species to avoid the immediate vicinity of the Project and move into similar adjacent habitats.

4.6 THREATENED AND ENDANGERED SPECIES

4.6.1 Plants

No Federally/State-listed or Federal SOC plant species are known to occur within 5 miles of the proposed Project activities. Therefore, no impacts to protected or SOC plant species are anticipated from the No-Action Alternative or proposed Project.

4.6.2 Wildlife

The No-Action Alternative would result in no immediate direct impacts to any endangered species or endangered species habitat at or near the proposed Project site, although some of the habitats may change over time, independent of the Project. Potential commercial and residential development occurring in the area could have an impact on the brown pelican and other seabirds, as well as sea turtles with or without the Project going forward. It would be expected that boat traffic in the area would increase with the project, thus increasing the potential for collision with any sea turtles in the area. Increased erosion would also be expected from the increased boat traffic. However, these small potential increases in impacts are not considered to be significant. Decreases in boat traffic would be expected under the No-Action Alternative due to shoaling of the channel.

The closest brown pelican rookery to the proposed Project is located at Pelican Island, approximately 14 miles north (GLO, 2000; TCWNC, 2000; TXBCD, 2001). Therefore, no impacts to nesting brown pelicans as a result of this Project are anticipated. Any non-nesting pelicans occurring in the general area could be impacted indirectly. Dredging activities may cause temporary impacts to aquatic communities and habitats, including increased sedimentation and turbidity, which in turn may indirectly impact seabirds in the area by potentially reducing the availability of the food supply. The increased possibility of accidental spills of petroleum products, chemicals, or other hazardous materials during dredging activities also poses a potential, although small, threat to the aquatic community and, thus, the food source of these individuals. Noise and human activities would likely cause this species to move elsewhere. The increased potential for spills and temporary dredging impacts and noise are not considered to be significant adverse impacts to brown pelicans.

The piping plover and snowy plover (*Charadrius alexandrinus*) have been recorded at several places in the vicinity of Packery Channel (EH&A, 1993b; Shiner, Moseley and Associates, 1994; GLO, 2000; TCWNC, 2000; TXBCD, 2001; PBS&J, 2001b). Both plovers were encountered on a PA along the GIWW approximately 0.5 mile north of the Packery Channel/GIWW junction; snowy plovers were also observed at the entrance to Marker 37, just south of the junction (PBS&J, 2001b). Piping plovers have also been recorded along Packery Channel near the SH 361 bridge (Shiner, Moseley and Associates, 1994; GLO, 2000) and elsewhere along the channel (EH&A, 1993b). The minor changes in salinity and tidal amplitude as a result of the Project are not expected to have a long-term or significant adverse impact on these two plovers.

In Texas, the snowy plover is an uncommon migrant across the state and an uncommon resident along the coast and in north Texas. Population numbers are low, but not significant enough to warrant a Federal or State listing at the present time. Along the Texas coast, habitat for the snowy plover is similar to that of the piping plover.

Critical habitat for the piping plover has recently been designated in Texas, some of which lies within the study area: the northern tip of TX-3; TX-5; TX-6; and part of TX-7. TX-6 and TX-7 are critical habitat units that would be affected by the opening of Packery Channel. The MBHC forms part of TX-6. It is unlikely that a tidal amplitude change of less than 1 inch will be enough to impact piping plover habitat in the study area. Therefore, critical habitat areas TX-3 and TX-5 will not be affected by the Project. Although the channel is adjacent to TX-6, only minor impacts (0.3 acre) to the area are expected from dredging. The greatest impact will involve TX-7. The dredging of Packery Channel will result in the direct removal of approximately 5.9 acres of critical habitat area along the beach in an area used by the public. In addition, dredging and construction activities will likely decrease the attractiveness of this area for foraging plovers. This will be short term, however. Given the amount of other habitat available in the area and the fact that TX-7 reaches all the way to Aransas Pass, this loss may be considered minor. Approximately 24.6 acres of beach nourishment from dredged material placed in PAs 4N and 4S will also temporarily impact the beach area within TX-7. The 24.6 acres is a maximum estimate including both north and south beach placement areas (PAs 4S and 4N) within critical habitat. PA 4N is proposed for maintenance placement, not initial placement. PA 4S will be used for both initial placement and maintenance material. This beach is managed by the City of Corpus Christi and is regularly used for recreation. This stretch of beach is identified as the J.P. Luby Surf Park and, although included in TX-7, is subject to vehicle access and beach activities.

In studies along the Lower Laguna Madre, Drake et al. (1999) found that overall usage of relatively undisturbed beach habitats by piping plovers, including foraging and roosting, was minimal (2.8%). Piping plovers were found only to use beach habitats when other preferred habitats were unavailable, such as when algal and sand flats were inundated. This is considered to be partly due to the prime availability of forage on tidal flats and partly due to the high level of disturbance on beach habitats (Drake et al., 1999). Moreover, FWS (1997b), in consultation regarding a previous permit action for Packery Channel, determined that the reopening of Packery Channel is unlikely to jeopardize the continued existence of the piping plover.

In conclusion, 0.3 acre of TX-6 and 5.9 acres of TX-7 will be permanently lost as critical habitat. An additional 24.6 acres of beach in TX-7 will be occasionally impacted by placement of maintenance material. Given the abundance of algal flats and sand flats in the adjacent critical habitat areas, paired with the heavy recreational and vehicular use of the beach areas in the Project portion of TX-7, impacts to TX-7 from Project dredging and dredged material placement are considered unlikely to jeopardize the continued existence of the piping plover. Because of existing heavy public use and development, the Project area does not possess the constituent elements necessary for other than marginal piping plover use, despite the inclusion of this area in TX-7 as critical habitat.

No known nesting colonies of the white-faced ibis, a Federal SOC and State-threatened species, occur within 2 miles of the proposed Project. While the State-threatened reddish egret has been recorded from rookeries located approximately 2 miles north and 2 miles west of the junction of Packery Channel with the GIWW (GLO, 2000; TCWNC, 2000; TXBCD, 2001), given the distance of these rookeries from the proposed Project, the noise and human activity associated with dredging and construction activities is unlikely to impact them, even if the Project actions occurred during the nesting season. No impacts to these two species as a result of the Project are anticipated, although the increased possibility of spills poses a potential, although minor, threat to the nekton community and, thus, the food source of the white-faced ibis and reddish egret. Therefore, there are no significant adverse impacts to the species expected as a result of Project construction and maintenance.

Four species of sea turtle, Kemp's Ridley, loggerhead, green, and hawksbill, and the Texas diamondback terrapin have been recorded from Corpus Christi Bay (Shaver, 2000) and the Upper Laguna Madre (EH&A, 1993a). If present in the area, these turtles may be in danger of being sucked into a hopper dredge during dredging. However, cutterhead dredges do not pose this threat to sea turtles. Hopper dredges move much more rapidly than pipeline dredges and “can entrain and kill sea turtles, presumably as the drag arm of the moving dredge overtakes the slower moving turtle” (NMFS, 1998). However, cutterhead dredges move very slowly and can be avoided by all species of sea turtles. Studies have indicated that cutterhead dredges, since they act on only small areas at a time, do not impact sea turtles (NMFS, 1998). Since all dredging of the proposed Packery Channel will be performed by cutterhead dredges, or hopper dredges with turtle-deflecting dragheads, screens, and turtle observers, no impacts to sea turtles are anticipated from dredging. Dredging activities could also have an impact on these species through an increase in sedimentation and turbidity. The sedimentation may impact food sources for the turtles and the turbidity could affect primary productivity. This would be short-term, however. The increased potential for spills, although unlikely, could pose a threat to turtles both directly and indirectly through their food source. While adult sea turtles may be mobile enough to avoid areas of high concentrations, hatchling, post-hatchling, and juvenile turtles in the area would be more susceptible. Increased marine traffic may result in a higher incidence of collision with sea turtles. Nesting habitat for sea turtles is confined to the Gulf beaches. Removal of beach at the mouth of Packery Channel would result in a very small loss of nesting habitat. However, given that nesting is sporadic, the area is already disturbed, and large areas of similar habitat is available, nesting is not likely to be impacted through habitat loss. If dredging activities in this area occur during the nesting season, noise and human activity may cause any potential nesting females to move elsewhere. Nesting loggerheads and green sea turtles could particularly be disturbed if construction were to occur at night; however, these impacts are not considered to be significantly adverse.

The Gulf salt marsh snake, a Federal SOC, has been recorded from Oso Bay (TXBCD, 2001), and thus may occur in other marshes in the Project vicinity. The minor changes in salinity and tidal amplitude as a result of the Project are expected to have no impact on this snake.

While the West Indian manatee has been recently sighted in Corpus Christi Bay, such occurrences are rare. Should a manatee wander into the Project area, the greatest threats to it would be from boat traffic or dredging operations. However, due to its rare occurrence, the Project is not expected to have any significant impact on this species. Whales occur in offshore waters and similarly would not be impacted by the proposed Project.

Once the initial dredging activities associated with the Project have been completed, little further impact is anticipated. Maintenance dredging activities would have similar temporary impacts as the initial dredging, but on a much lesser scale and for a shorter term. An increase in boat traffic would increase the potential for collision mortality of sea turtles, as well as the potential for accidental spills. Impacts from noise and human activity are unlikely to be a factor. Sea turtles, particularly the green sea turtle, are likely to be attracted to feeding opportunities at the proposed jetties, where they could be exposed to additional risks from boat traffic, fishing activities, tangled fishing lines, accumulated plastic debris, and contaminants. On the other hand, the jetties and bulkheads would provide additional foraging habitat for green sea turtles by providing a substrate on which algae could grow. Furthermore, the open channel might facilitate passage by turtles between the open Gulf of Mexico and feeding areas in the seagrass beds of the Laguna Madre.

4.6.3 Fish

The No-Action Alternative will have no impacts on the listed candidate species. The preferred alternative appears to have no significant detrimental affect on the listed candidate species. Though most of the candidate species are not likely to occur in the area, the channel extension into the Gulf of Mexico could be beneficial to the dusky shark, sand tiger, night shark, goliath grouper, and Warsaw grouper. The change in the bathymetry has the potential to aggregate fish, which would be a food source to the species. The extended channel area represents an increase in habitat for those nekton species common in deeper offshore waters which periodically invade the bay through the deep channel corridor (Breuer, 1962). Though the TXBCD State-threatened opossum pipefish is not common in the area, this fish has been reported in low salt marshes and in *Sargassum* mats in the Gulf of Mexico (Hoese and Moore, 1998). Due to minimal disturbance to low salt marshes by this Project, no adverse affects are expected to the opossum pipefish.

4.6.4 Summary

In summary, while there are potential impacts to several endangered or threatened species, the potential is low and no significant adverse impacts to any listed species or their habitat is expected. More detail on Federally listed species is provided in the Biological Assessment (BA) (Appendix C), inclusion of which initiates consultation under the ESA.

4.7 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTES

The HTRW assessment determined that several regulated facilities exist in the Project area. However, only one of the reported facilities (Marker 37) is located within one-quarter mile of Packery Channel. None of the regulated facilities appear to pose a significant environmental concern for the Project.

Marker 37, a marina identified as a LUST site, is located on the shoreline of the Laguna Madre approximately 1,300 feet south of Packery Channel and the JFK Causeway. The TNRCC reports that no receptors are threatened; therefore, the LUST site does not likely pose an environmental concern for the Project. According to regional TNRCC personnel, the release from the UST system was reported in January 1999, but TNRCC has not been notified of any other action from the operator.

There is one pipeline reported to cross the existing Packery Channel at the SH 361 bridge. The pipeline is reported to be an inactive line owned by the City of Corpus Christi, Texas. In addition, the nearest well is located adjacent to the existing channel near channel station 65+00. The well is directional and is reported to be an active gas producer.

The No-Action Alternative would result in continued use of the channel by recreation boats until channel shoaling prevents access. Small spills and leaks are expected from pleasure-craft using the channel in addition to occasional spills or leaks during maintenance dredging, however minimal impacts to the environment are expected.

The impacts from hazardous material use and handling during dredging activities associated with the proposed Project pose a minimal risk of impacts to the environment. Typical impacts may include minor leaks or spills of fuels and lubricants associated with excavation and dredging equipment. Onsite spill response and cleanup capabilities will also minimize the potential for impacts. These impacts would likely be minimal and typically do not pose a major risk to the environment. The owners of the gas well and the pipeline should be notified of proposed dredging activities; however, the proposed Project is not expected to adversely impact the production or transportation of petroleum in the vicinity of the Project.

There are no reported impacts to the environment from historical operation of the existing channel. Boat traffic along the proposed channel will be limited to pleasure-craft and some commercial vehicles and as a result should not result in major impacts to the environment.

Based on the findings of the HTRW assessment, no HTRW sites have directly impacted the Project area. Therefore, the probability of increased project costs and/or lost time from discovery and remediation of any contaminated materials within the study area is considered low.

4.8 IMPACTS ON CULTURAL RESOURCES

No impacts to known cultural resource sites have been identified for the No-Action Alternative.

The proposed project construction footprint and immediately adjacent areas were surveyed for cultural resources, including terrestrial survey, shovel testing, and remote-sensing survey of both selected terrestrial and marine impact areas. Archival and records research was conducted. The surveys and records review identified a total of twenty recorded sites adjacent to and within 500 feet of the Project area shoreline (Table 3.8.1). Only one of the previously recorded cultural resource sites may be directly impacted by the Project. Prehistoric Site 41NU6 is a thin surface scatter of Rockport phase materials that has been extensively modified by natural elements and anthropogenic changes. The site, located in PA 3, is not recommended as eligible to the NRHP and the SHPO has concurred in this finding. Site 41NU225 was identified during survey for this project near MMPA. The MMPA was redesigned to avoid the site and a determination of NRHP eligibility was not pursued. The SHPO has concurred in this finding, and no further cultural resource work or coordination is required for this project.

4.9 AIR QUALITY

For the No-Action Alternative, the use of the channel by recreation boats will continue with some decrease in traffic due to potential shoaling in the channel.

Impacts to air quality would result during construction primarily from the combustion of diesel fuel during dredging and placement operations resulting in air emissions of nitrogen oxides (NO_x), CO, volatile organic compounds (VOC), PM, and SO_2. The amount of fuel combustion emissions would be directly related to the type and size of equipment and the amount of dredging required. During placement of dredged material, a bulldozer will also be used to grade the sand piled in front of the discharge pipe. The total volume of new dredged and excavated material was estimated at 810,000 cy by URS (2002). This number includes 56,200 cy of material that must be excavated from PA 1 before dredged material can be placed in it. Therefore, it is 56,200 cy greater than the 753,800 cy total for new work dredged material presented elsewhere in this DEIS.

Based on the construction schedule, the construction dredging would be completed in segments using portable dredging equipment. For purposes of this evaluation, the dredge equipment was assumed to be a portable dredge with a maximum pump capacity of 1,280 horsepower using a 20-inch-diameter (suction) pipeline and cutter (Ellicott, 2002). The estimated duration of each dredging event was based on the estimated total volume of dredged material and an assumed production capacity for the dredging equipment developed in consultation with the USACE. The capacity of the dredging equipment will vary with pipeline diameter, reach, and the consistency of the material, etc.

Based on these assumptions, the duration of the dredging event was estimated by dividing the total volume of material to be dredged by the dredge production capacity, assuming continuous operation for 20 hours per day, as follows:

(Dredge volume, cy / dredge capacity, cy per hour) = hours per event

(Hours per event / 20 hours per day) = days per event

The duration of the construction dredging activities is estimated at roughly 174 days based on production rates varying from 175–600 cy/hour, depending on grain size, and assuming 20-hour dredging days. The estimated volumes, duration, and air contaminant emissions were estimated for each segment as summarized in Table 4.9-1.

TABLE 4.9-1

CONSTRUCTION DREDGING EMISSIONS

Dredging and Placement Area	Volume of Dredged Material (cubic yards)	Estimated Duration (days)	Estimated Emissions Per Event (tons)				
			PM_{10}	SO_2	NO_x	VOC	CO
Reach 2 (PA 1)	128,800	37	0.77	2.07	17.97	0.87	4.16
Excavation of PA 1	56,200	7	0.02	0.05	0.33	0.03	0.12
Reach 1 & 2 (PA 2)	76,000	6	0.13	0.36	3.09	0.15	0.72
Reach 1 & 2 (PA 3)	60,400	7	0.14	0.38	3.28	0.16	0.76
Reach 1 & 2 (PA 4)*	488,600	117	2.61	6.88	58.96	2.99	13.99
TOTAL	810,000	174	3.67	9.74	83.63	4.20	19.75

* Emissions estimate assumes concurrent placement of 56,200 cy of excavated material from PA 1.

It is expected that air contaminant emissions from construction dredging and placement activities will result in minor short-term impacts on air quality in the immediate vicinity of the dredged site. Each dredging location would be relatively independent of each other, although, there may be some overlap. In addition, these activities are considered one-time activities (i.e., the construction dredging activities would not continue past the date of completion). As a result, the impact on ambient air from construction dredging emissions would be of generally intermittent and of relatively short-term duration. VOC and NO_x could combine under the right conditions, in a series of photochemical reactions, to form ozone, possibly increasing ozone concentrations in the region. However, these reactions would take place over a period of several hours with maximum concentrations of ozone often further downwind of the precursor sources. Placement of dredged material may result in a small increase in fugitive dust emissions. These emissions would be minimized due to the moisture content of the dredged material. Due to the phased, one-time construction dredging, it is expected that there will be no long-term impacts to air quality in the area.

A certain amount of routine dredging would be required to maintain the channel at depth. Maintenance dredging would occur along the channel in different segments with each segment being relatively independent of the other. In addition, the frequency of dredging would be different for each segment. Sand bypassing would also be required to prevent sand being moved up and down the beach from entering the channel and forming shoals. Sand would be pumped from one side of the inlet to the other via a pipe underneath the channel. The estimated volumes, frequency, duration, and resulting air contaminant emissions from these operations were estimated as shown in Table 4.9-2.

Air contaminant emissions from these activities would occur primarily from the combustion of diesel fuel used in the maintenance equipment. It is expected that air contaminant emissions from these maintenance dredging and placement activities will result in minor short-term impacts on air quality in the immediate vicinity of the dredging site.

Although the duration of a maintenance dredging event may occur over several days within a year, the frequency of the maintenance dredging for each reach will vary from once per year to once every 5 years. In addition, each dredging location will be relatively independent of the other.

As previously noted, VOC and NO_x could combine under the right conditions to form ozone, possibly increasing the concentration of ozone in the region. However these reactions would take place over a period of several hours with maximum concentrations of ozone often further downwind of the precursor sources. The estimated emission rates for these and the other products of combustion are relatively minor and would be intermittent and of relatively short-term duration for each segment. Placement of dredged material may result in a small increase in fugitive dust emissions. These emissions would be minimized due to the moisture content of the dredged material. Therefore, emissions from the maintenance activities are not expected to result in a serious impact to the regional air quality.

The construction of bulkheads, roadways, parking areas, walkways, and recreational areas would result in potential air quality impacts from the associated construction equipment and activities. Air contaminants from combustion products (NO_x, CO, PM, SO_2 and VOC) would be emitted by gasoline and diesel fueled construction equipment operated at the site. The construction activities would also generate fugitive dust. The impact of the fugitive dust and the combustion emissions on ambient air quality are expected to be of short-term duration and relatively minor.

As a result of the Project, it is expected that waterborne traffic of recreation boats and associated vehicular traffic in the immediate vicinity will increase. This will result in an increase in air emissions for the area from refueling and the combustion of fuel fired in these vehicles and vessels. Emissions from vehicular traffic may create localized areas of increased emissions. Emissions produced while the vehicles, boats, and vessels are underway would be dispersed as a mobile source and hence ambient concentrations would be lessened.

Atmospheric dispersion modeling of emissions was not performed. There are dispersion modeling tools available to estimate local air quality impacts; however, these models are most accurate at estimating impacts from those facilities from which emissions occur at well-defined, stationary emission points. In the case of this Project, local dispersion of emissions cannot be characterized with a degree of accuracy because they would be emitted from a variety of mobile sources that would operate intermittently and at different locations. Additionally, the level of activity would be variable.

TABLE 4.9-2

MAINTENANCE DREDGING/SAND BYPASSING EMISSIONS

Dredging and Placement Area	Volume of Dredged Material Per Event (cubic yards)	Estimated Frequency of Event (years)	Estimated Duration Per Event (days)	Estimated Emissions Per Event (tons)					Volume of Dredged Material Over 50-Year Project Life (cy)	Estimated Duration Over 50-Year Project Life (days)	Estimated Emissions Over 50-Year Project Life (tons)				
				PM_{10}	SO_2	NO_x	VOC	CO			PM_{10}	SO_2	NO_x	VOC	CO
Reach 1 (PA 4)	54,750	1	7	0.14	0.39	3.34	0.16	0.77	2,737,500	350	7.0	19.5	167	8.0	38.5
Reach 2 (MMPA)	15,000	5	4	0.08	0.21	1.83	0.09	0.42	150,000	40	0.8	2.1	18.3	0.9	4.2
Reach 2 and Inner Basin (PA 4)	17,000	5	3	0.07	0.19	1.66	0.08	0.38	170,000	30	0.7	1.9	16.6	0.8	3.8
Sand Bypass *	160,000	1	67	0.35	0.33	4.96	0.40	1.07	8,000,000	3,350	17.5	16.5	248	20	53.5
TOTAL									11,057,500	3,770	26.0	40.0	449.9	29.7	100.0

* Assumed 12 hours per day; 200 cy per hour.

Regional dispersion models available to characterize VOC and NO_x, and both ozone O_3 precursors, are not intended to estimate a specific project's contribution to regional O_3 concentrations. Therefore, regional dispersion models would not be useful in estimating the Projects construction and operational impact on regional O_3 concentrations.

Airshed pollutant loading determined by the magnitude of emissions expected to result from the channel dredging and placement activities compared with area emissions can be used to estimate air quality impacts of the criteria pollutants. Based on available air emissions provided on the EPA's AIRData website (EPA, 2002), the following tables 4.9-3 and 4.9-4 provide a summary of peak air emissions for Nueces County and San Patricio County in comparison with those from the proposed Project. The emissions data are available for area plus mobile source and point source emissions based on emissions inventory information for 1999. This emissions inventory provides a basis from which to compare the proposed Project emissions.

As shown in Table 4.9-3, construction dredging and placement activities for the proposed Project would result in an increase in emissions above those resulting from existing sources in the Nueces/San Patricio County area. Emissions of each air contaminant are expected to result in a less than 1 percent increase over existing emissions. As shown in Table 4.9-4, emissions during maintenance dredging are also estimated to contribute less than 1 percent to total existing emissions for these counties.

TABLE 4.9-3

SUMMARY OF PEAK AIR EMISSIONS FROM CONSTRUCTION DREDGING AND PLACEMENT ACTIVITIES COMPARED WITH NUECES AND SAN PATRICIO COUNTY EMISSIONS FOR 1999

Air Contaminant	Area and Mobile Source (tpy)	Point Source (tpy)	Total (tpy)	Estimated Peak Project Dredging Emission * (tpy)	Peak Construction Emissions % of Nueces County Emissions
NO_x	29,342	32,739	62,081	83.6	0.13
VOC	26,495	8,601	35,096	4.20	0.01
CO	119,655	9,465	129,120	19.8	0.02
SO_2	6,067	7,932	13,999	9.74	0.07
PM_{10}	41,227	1,748	42,975	3.67	0.009

Source: EPA, 2002.

* Assumes all construction dredging will occur in 1 year.

The TNRCC and EPA's air quality permitting program applies to stationary sources of air emissions and would, therefore, not apply to emissions from the dredging activities. However, emissions are expected to comply with the NAAQS, designed to be protective of public health and the public welfare, and the rules and regulations of the EPA and the TNRCC promulgated in support of the TNRCC State Implementation Plan, in accordance with the Clean Air Act as amended in 1990.

TABLE 4.9-4

SUMMARY OF AIR EMISSIONS FROM MAINTENANCE DREDGING ACTIVITIES COMPARED WITH NUECES AND SAN PATRICIO COUNTY EMISSIONS FOR 1999

Air Contaminant	Area and Mobile Source (tpy)	Point Source (tpy)	Total (tpy)	Estimated Peak Project Dredging Emission * (tpy)	Peak Emissions % of Nueces County Emissions
NO_x	29,342	32,739	62,081	11.8	0.02
VOC	26,495	8,601	35,096	0.73	0.002
CO	119,655	9,465	129,120	2.64	0.002
SO_2	6,067	7,932	13,999	1.12	0.008
PM_{10}	41,227	1,748	42,975	0.64	0.0015

Source: EPA, 2002.

* Assumes all maintenance events may occur during the same year.

4.10 NOISE IMPACTS

The No-Action Alternative without maintenance dredging will lessen impacts to sensitive receptors. In general, sensitive receptors include residences, schools, churches, parks, and other facilities that use, and are dependent to some extent on, relatively quiet sound environments. The closest sensitive receptors (residences) within the Project boundary currently exist at approximately 150 feet from the western shoreline between stations 110+00 and 130+00. Impacts to the noise environment within the Project area are expected during construction and maintenance dredging activities. The dominant source of noise from most construction equipment and machinery is the engine, usually diesel, with insufficient muffling devices. Noise emission levels of a diesel-powered cutterhead dredge similar to one that would be used for the Project have been recorded at approximately 79 dBA, at a distance of approximately 160 feet (USACE, 2002). It is expected that the above-mentioned residential receptors will be exposed to approximately the same noise emission levels as dredging activities that have occurred in the channel adjacent to them.

The sensitive receptors adjacent to the channel in the 2,000-foot section of Reach 2 will be exposed to the initial dredging noises during construction for a relatively short-term and temporary period (approximately 7 to 10 days). The dredging of the entire channel and placement of dredged material may last approximately 164 days (see tables 4.9-1 and 4.9-2). Maintenance for Reach 2 is estimated at approximately 7 days every 5 years, roughly 1 to 2 of which would be between stations 110+00 and 130+00. Project related dredging would be considered a significant impact to the residential receptors during this time period only. To lessen the impact, Project-related dredging should occur during daytime hours (7:00 a.m. – 7:00 p.m.), as opposed to nighttime hours when sensitivity to noise increases. Installation of proper muffling and quieting devices on all equipment will also reduce Project noise impacts.

Approximately 46 days of dredging is expected to occur within Reach 1 during annual maintenance. The majority of the maintenance dredging in Reach 1 will occur between stations 168+00 and 198+00 where 70 percent of the material will accumulate (URS, 2002). In addition, sand bypassing operations that will be located on the beach adjacent to the jetties is proposed as an annual occurrence and may include approximately 67 days of operation based on 12-hour days. Project noise impacts are not anticipated within Reach 1, as there are no sensitive receptors located in close proximity to Project activities.

To a lesser extent, noise impacts may increase as proposed park-related facilities located throughout the Project's reach are completed. The increased traffic at numerous recreational facilities that will include public boat ramps, RV sites, and parking spaces could create seasonal impacts. Also, increased boat traffic within the channel may increase the existing noise environment during daytime hours. However, excessive noise is generally related to the excessive speed of high performance and offshore boats. The maximum speed restrictions within the channel would lessen potential impacts. It is not expected that any extended disruptions of normal activities will be experienced in these noise sensitive areas.

4.11 SOCIOECONOMIC RESOURCES

Construction of the proposed Project would provide an increase in recreational and tourism opportunities within the vicinity of the Project area. Boat access to the Gulf via the channel would result in increases in sport fishing and boating activities in the area. In addition to the proposed Packery Channel, the City of Corpus Christi has proposed recreational developments to be located adjacent to the proposed Packery Channel. However, this recreational development is not part of the Federally cost-shared project, and is addressed in the DEIS as secondary development. Proposed recreational development would be built in two phases: the Phase 1 proposed recreational development would be located east of SH 361, and the Phase 2 proposed recreational development would be located west of SH 361.

Increased recreation and tourism would translate into increased local tourism-related spending, an increase in local employment opportunities and tax revenues, and increased secondary private development. With the proposed Project, the North Padre Island area would accelerate towards an urbanized resort-town character at a more rapid pace than under the No-Action Alternative. Existing open space, in the form of vacant private property, would be converted to secondary private development at a more rapid pace if the proposed Project and the proposed recreational development are built. Proposed Project details were provided by the City of Corpus Christi, the local Project sponsor. Population impacts that would occur as a result of the proposed Project, the proposed recreational development, and the secondary private development were predicted, based in part on a previous study conducted by HSGA (1997). Population changes predicted by HSGA were used to develop population projections that are consistent with a revised construction schedule. The changes in Nueces County population predicted by HSGA were added to baseline population projections obtained from the TSDC. The baseline population projections were based on the assumption that population migration rates within Nueces County would be the same, on average, as they were between 1980 and 1990. Also, it was assumed that construction of the proposed Project would begin in 2003. Changes in the construction schedule would result in minor changes to the timing and magnitude of the impacts described here, but the overall impacts would not be dramatically different. Employment impacts were also predicted, based in part on impacts identified in the HSGA report. Changes in employment were recalibrated to reflect a modified construction schedule. Recreation and tourism impacts were developed by projecting visitor day rates discussed in the HSGA report, and using population projections for the State provided by the TWDB. A windshield survey of the proposed Project area was conducted on August 16, 2001, as a source of information for the land use section. Land use and local tax (tax increment financing) impacts were developed from proposed Project details provided by the City of Corpus Christi, and from a report prepared by the Economic Research Associates (ERA) (2000).

4.11.1 Population, Employment and Economics

Under the No-Action Alternative, the population in Nueces County is projected to be 436,857 in the year 2023 (TWDB, 2001). Under this alternative, the study area would not experience an increase in employment related to the proposed Project, or from jobs created through secondary private development of the area (restaurants, hotels, real estate, construction, retail shops).

The proposed Project is not likely to directly affect population in the study area, or within Nueces County. However, the effects of secondary private development, in the form of commercial, office and residential development, which would likely occur as a result of the proposed Project, would affect area population and employment. Construction and operation of the proposed Packery Channel and the proposed recreational development would generate a small increase in local employment opportunities. Additionally, the secondary private development, which would follow, would provide an increase in employment opportunities in the immediate area. Based, in part, on population predictions identified by HSGA (1997) and using population projections developed by TWDB, population impacts within Nueces County have been identified and are presented below in Table 4.11-1.

TABLE 4.11-1

PROJECTED POPULATION EFFECTS, NUECES COUNTY, TEXAS
PROPOSED PACKERY CHANNEL AND SECONDARY PRIVATE DEVELOPMENT

	2003	2008	2013	2018	2023
With Proposed Project and Secondary Private Development	345,153	366,201	390,508	416,460	442,045
No-Action Alternative	345,153	366,105	388,822	412,606	436,857
Difference	0	96	1,686	3,854	5,188
Percentage Difference over No-Action Alternative	0.00%	0.03%	0.43%	0.93%	1.19%

Source: HSGA, 1997; TWDB, 2001.

Most of this increase in population (over No-Action population estimates) would be concentrated on North Padre Island near the proposed Project area. The proposed Project and the proposed recreational development (see Section 3.11.3) are expected to provide an impetus for housing, hotel/motel, office, recreation and commercial development within the general vicinity of the proposed Project. This secondary private development, including an increase in job opportunities and an increase in tourism in the area, would provide an impetus for a small influx of new residents to this area, an estimated 1.19 percent increase over the No-Action Alternative by 2023. The relatively minor increase in population would occur in the general vicinity of the study area and would do so largely to take advantage of new job opportunities in the tourism, hotel, fishing, boating, restaurant, and service sector industries. Also, the allure of housing located near the proposed recreational development would draw new residents to the area. This relatively small population increase would slightly increase the demand for public services such as school facilities, police, fire, and emergency services, and on public infrastructure.

The proposed Project alone would generate a small increase in employment within the area. Direct jobs would include employment for dredging, engineering, and construction companies in the short-term. Also, a small amount of on-going operations and maintenance dredging employment would be created in the long term. The proposed recreational development would provide employment opportunities for a relatively small number of people for the on-going operations of the public park facilities.

Secondary private development associated with the proposed Packery Channel improvements would have a much more substantial effect on short- and long-term employment in the area. The incremental gains in employment would likely begin in 2003 with the start of construction of the proposed Project. New construction and the indirect effects on related industries would constitute most of the employment impact over the first several years. The peak construction sector impacts would occur in 2011 and 2014 when several large multi-family residential projects are likely to be built (HSGA, 1997). See Table 4.11-2 for estimated employment impacts for the proposed Project, and anticipated secondary private development.

TABLE 4.11-2

EMPLOYMENT EFFECTS – SELECTED INDUSTRY GROUPS, NUECES COUNTY
PROPOSED PACKERY CHANNEL AND SECONDARY PRIVATE DEVELOPMENT

	2003	2008	2013	2018
Construction	232	680	322	178
Retail Trade & Services	200	1,724	2,484	2,778
All Other Industries*	22	323	461	562
Total New Jobs	454	2,727	3,267	3,518

* Includes manufacturing, mining, utilities and transportation, finance, wholesale trade, and government.

Source: HSGA, 1997.

Over time, the number of jobs in retail trade and services would expand in response to the development and marketing of the proposed recreational development and secondary private development. Other sectors of the economy would benefit through increased sales, productivity and employment.

New jobs, increases in industrial sales and output, and added state and local government tax revenues generated by the proposed Project and secondary private development would result in a positive effect on aggregate personal income in Nueces County. Increases in aggregate personal income would reflect the combined effects of the projected increase in employment and increases in average earnings per worker.

With completion of the proposed Project and the secondary private development, total personal income would increase by approximately $206 million (2001 dollars) annually by 2023. In addition, by 2023 an additional (approximate) $13.8 million in annual wages and salaries would be earned by individuals working in Nueces County but living elsewhere. This estimate is based on historical commuting/residency patterns in the Corpus Christi metropolitan area. Total personal income and annual wages would have modest gains in the beginning years of secondary private development, followed by larger increases as development progresses and increasing numbers of tourists are attracted to the area (HSGA, 1997).

4.11.2 Tax Increment Finance District

In order to pay for the proposed Packery Channel and the proposed recreational development, the City of Corpus Christi plans to pay the local share (approximately $11.3 million) through a system of tax increment financing (TIF) within a 1,930-acre area of land on North Padre Island, known as the Padre Island TIF District (hereafter the TIF District).[3] The Federal Government would pay approximately $19.5 million of its share of the proposed Project. Within the TIF District the portion of the property taxes that represents new growth in property values (the "increment") would be collected to pay off bonds that are sold to pay for the local share of the proposed Project and the proposed recreational development. The property tax rate within the TIF District would not be any greater than the rates outside of the TIF District (approximately $0.062 for every $100 of assessed property value). The developers of private lands adjacent to the proposed Packery Channel would purchase the bonds and would take any potential risk on the bonds. The theory is that construction of the proposed Project and proposed recreational development would generate higher tax revenues due to secondary private development, and that without the proposed Project as the stimulus, the increased tax revenues would not occur (City of Corpus Christi, 2002b; Utter, 2002; ERA, 2000).

Within the TIF District the following entities have agreed to contribute 100 percent of their tax increment: the City of Corpus Christi, Nueces County, and the Nueces County Hospital District. Del Mar College has agreed to contribute a portion of its tax increment and the Flour Bluff ISD and the Flour Bluff Fire District have elected not to participate (City of Corpus Christi, 2000a). The ERA report presents two scenarios related to the success that the TIF District would have for raising revenue: the "Conservative" scenario and the "Opportunity" scenario. These two scenarios are tied to the degree to which vacant land within the TIF district is developed within an 18-year time frame (as described by "Conservative" and "Opportunity" scenarios in section 4.11.3.5 Secondary Private Development). The "Conservative" scenario indicates total cumulative TIF revenue between 2003 and 2020 would be $90 million, and the "Opportunity" scenario cited in the report, indicates total cumulative TIF revenue of

[3] The TIF District includes most of the vacant land (and some currently developed land) on North Padre Island, that is within the City of Corpus Christi's city limits (including some land that is immediately north of the study area). The TIF District does not include any residential properties.

approximately $139 million for the same period. Under either the "Conservative" or "Opportunity" scenarios, the TIF revenues collected within the TIF District would easily pay off the bonds for the proposed Project and the proposed recreational development (that are worth approximately $11.3 million).

4.11.3 Recreation and Tourism

Recreation and tourism visitation and spending in the Corpus Christi area for the No-Action Alternative would be as discussed in Section 3.11.2. The following provides a summary of the results from that section:

Based on projections derived from the HSGA report, under the No-Action Alternative, the number of annual person-days of visitors to the Corpus Christi area would be 11,141,102 in 2003 and 15,573,943 in 2023, or an increase of 4,432,841 (40.0 percent) during the 20-year period. Estimated tourism-related spending in the Corpus Christi area would be approximately $700 million in 2003, and $1,610 million by 2023, or an increase of $910 million (130 percent increase) during the 20-year period.

Completion of the proposed Project, along with the proposed recreational development, and secondary private development would attract more visitors to the North Padre Island area. This increase in tourism in the area can be divided into two major groups: day visitors and over-night visitors (see Table 4.11-3). The number of day-trips to the Corpus Christi area would increase primarily as a result of an increase in boating, fishing, and beach/water-based recreation. Based on projections derived from the HSGA report, there would be an estimated 214,321 annual person-days of day visitors to the North Padre Island area by 2023; making up 20 percent of all annual person-days of visitation to the area. This increase in day visitors to the area would likely consist of 76.7 percent tourists, 11.7 percent anglers, and 11.5 percent boaters. The vast majority of the increase in tourism to the area would consist of over-night visitors (80 percent). By 2023 the projected number of annual person-days attributable to over-night visitors would reach 859,651. By 2023 the total number of visitor-days attributable to both day and over-night visitors would be an estimated 1,073,972. The total number of visitor days attributable to the proposed Project and secondary private development in 2023 represents a 6.9 percent increase to the annual number of person-days of visitation in all of Nueces County under the No-Action Alternative; which has an estimated 15,573,943 person-days of visitation in 2023 (HSGA, 1997).

As a direct result of the increase in tourism to the North Padre Island area, there would be an increase in visitor spending (see Table 4.11-3). Assuming an average of $83.00 spent locally per visitor-day, the local economy would benefit from an estimated $42,539,000 in annual visitor spending by 2008 and $89,140,000 in annual visitor spending by 2023. This increase in visitor spending represents a 6.1 percent increase over 2008 baseline (without the proposed Project) projections, and a 5.5 percent increase over 2023 baseline projections (for Nueces County).

TABLE 4.11-3

ADDITIONAL ANNUAL PERSON-DAYS TO
NORTH PADRE ISLAND WITH PROPOSED PROJECT
AND SECONDARY PRIVATE DEVELOPMENT, 2003 TO 2023

	Annual Person-Days				
	2003	2008	2013	2018	2023
Day Visitors					
Tourists	0	117,067	131,115	146,849	164,470
Anglers	0	17,902	20,050	22,456	25,151
Boaters	0	17,581	19,691	22,054	24,700
Day Visitor Subtotal	0	152,550	170,856	191,359	214,321
Overnight Visitors	0	359,964	704,810	832,381	859,651
Total Visitor-Days	0	512,514	875,666	1,023,740	1,073,972
Total Annual Visitor Spending (in millions of $)	$0	$42,539	$72,680	$84,970	$89,140

Source: HSGA, 1997.

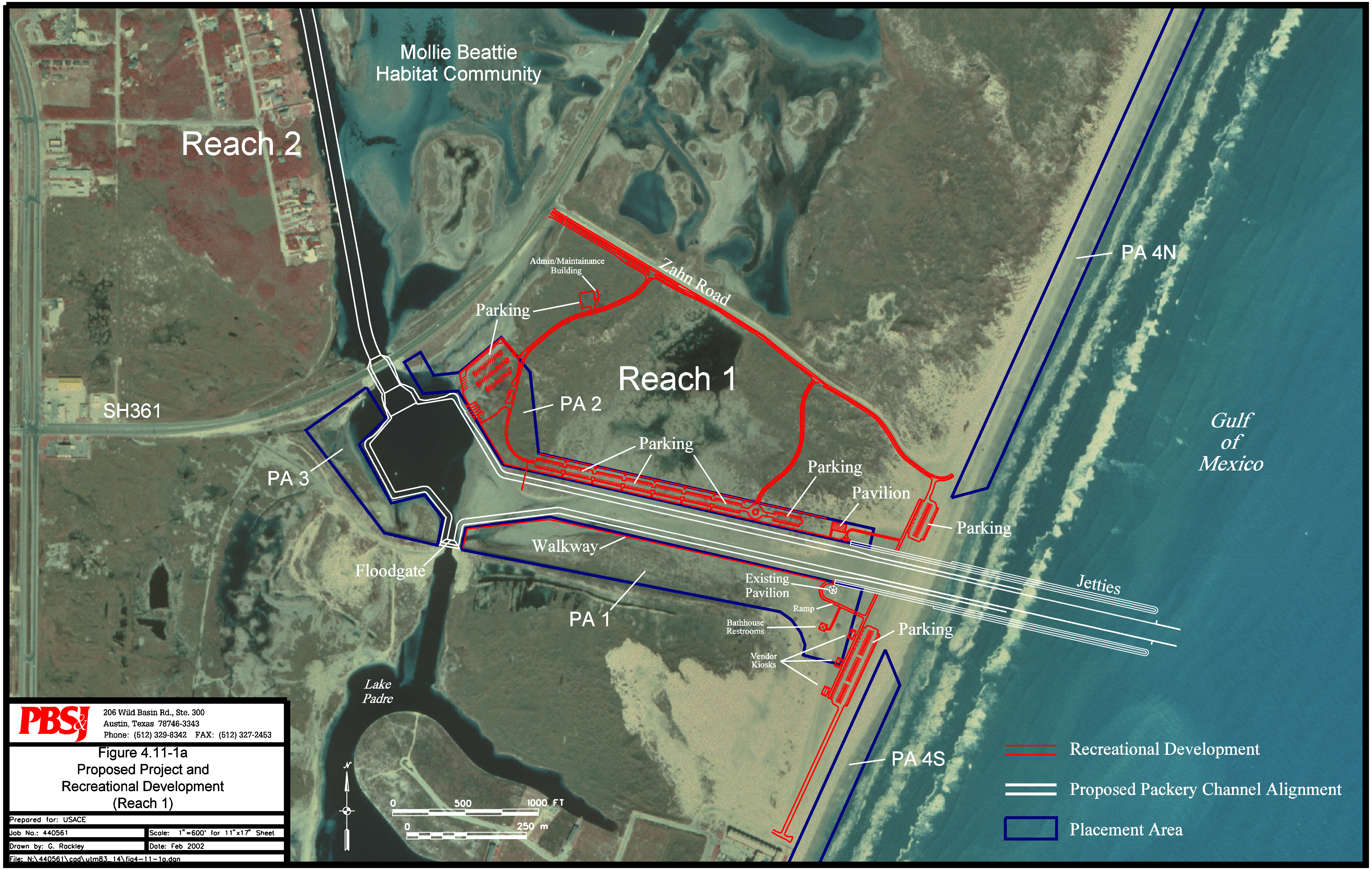
Some North Padre Island residents may feel that there would be an adverse impact on recreation in the area from implementation of the proposed Project. This is because area beaches would be more crowded with tourists over-time, recreational fishing areas would be more crowded over-time, and tracts of land that are currently vacant (and provide a form of open-space) would become more rapidly developed than in the No-Action Alternative. Also, with the secondary private development associated with the proposed Project, urban encroachment and more people in the area may have an adverse effect on birding in the North Padre Island area. Local residents who are accustomed to viewing birds along the existing Packery Channel and in other locations may have to travel to relatively less urbanized locations for better birding opportunities.

4.11.4 Land Use

Under the No-Action Alternative, none of the proposed Project, or proposed recreational development outlined below would occur in the North Padre Island area. Also, secondary private development in the North Padre Island area would not occur as rapidly or to the same extent as it would with the proposed Project. Under the No-Action Alternative future land use would be as described in Section 3.11.3.2.

4.11.4.1 Packery Channel Direct Construction Impacts to Land Use

Construction of the proposed Packery Channel (figures 4.11-1a and 4.11-1b) would clearly result in a change of land use on and adjacent to the site. The proposed Packery Channel extension would negatively impact channel fill sands flats, beach/shoreline, and water. At the Gulf channel entrance, two jetties would extend approximately 1,400 feet into the Gulf. Bulkhead construction would line the channel east of SH 361 to the jetties for shoreline stabilization (for more information on the



PBSJ
206 Wild Basin Rd., Ste. 300
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Figure 4.11-1a
Proposed Project and
Recreational Development
(Reach 1)

Prepared for: USACE
Job No.: 440561
Scale: 1"=600' for 11"x17" Sheet
Drawn by: G. Rockley
Date: Feb 2002
File: N:\440561\cad\utm83_14\fig4-11-1a.dgn

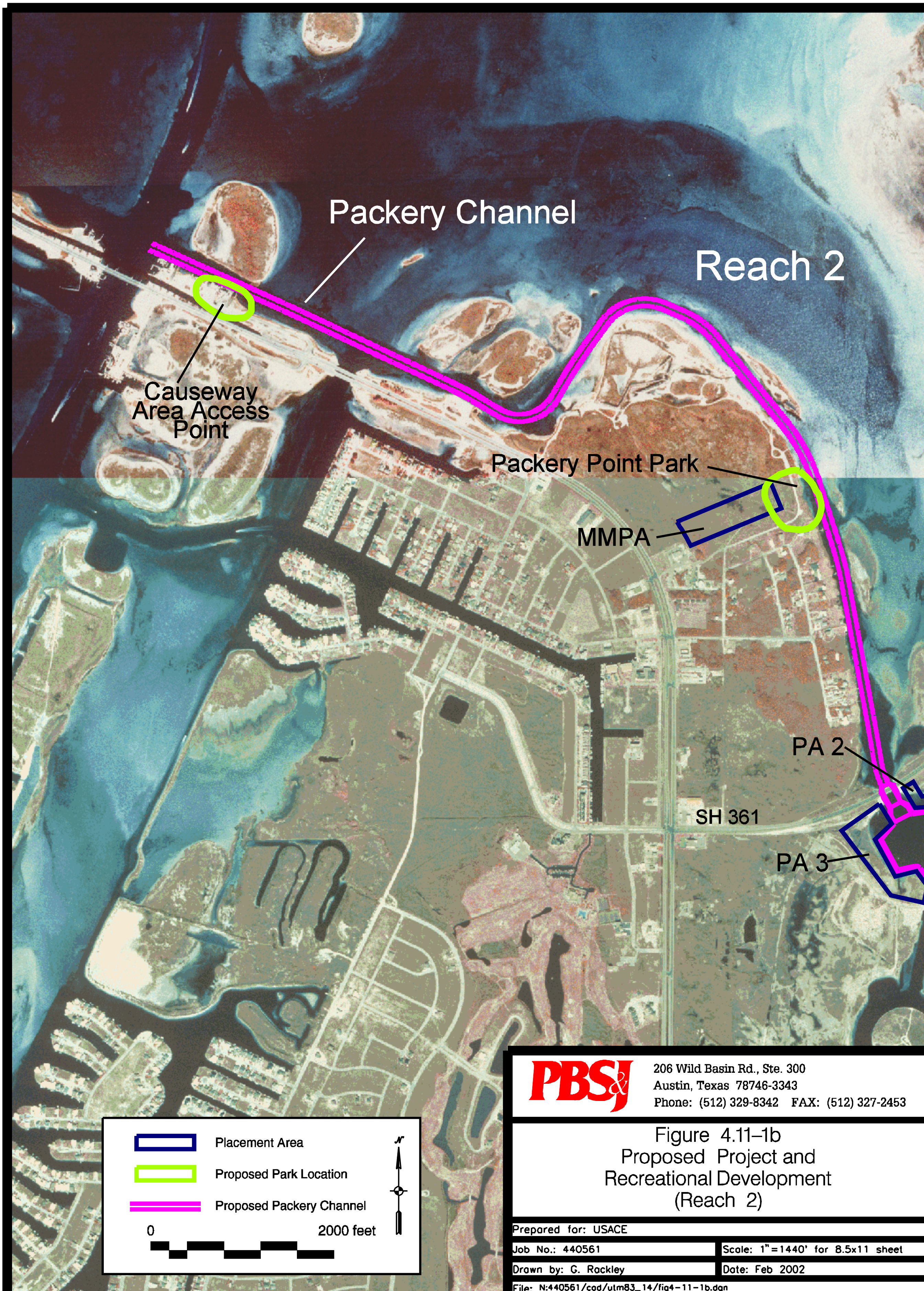

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Figure 4.11–1b
Proposed Project and
Recreational Development
(Reach 2)

Prepared for: USACE

Job No.: 440561 | Scale: 1" = 1440' for 8.5x11 sheet

Drawn by: G. Rackley | Date: Feb 2002

File: N:440561/cad/utm83_14/fig4-11-1b.dgn proposed Project, see Section 1.2). Potential impacts from the proposed public facilities would encompass approximately 7.4 acres of undeveloped land, with potential impacts to primary/secondary dune complexes and beach areas. Table 4.4-1 presents specific details about the number of acres affected by the proposed Project. Utility line casings would be buried underneath the proposed Packery Channel.

4.11.4.2 Proposed Dredged Material Placement Areas

The proposed Project will include placement of dredged material in five PAs located adjacent to the channel and in Packery Channel County Park. Land use impacts for each of the PAs are provided in the following paragraphs, and the locations for each are shown in Figure 4.11-1a.

PA 1, located on the south side of Packery Channel, covers an area of approximately 20.2 acres. This land is located just west of the J.P. Luby Surf Park (Nueces County Beach) and is currently undeveloped. Approximately one-fourth of the land used for PA 1 consists of channel fill sands, and the remaining portion of the area consists of primary and secondary dune complexes and beach.

PA 2 is located on the north side of the proposed Packery Channel and encompasses approximately 15.5 acres. It is located just west of the J.P. Luby Surf Park (Nueces County Beach) and is currently undeveloped. Slightly over one-half of the land used for PA 2 consists of a primary and secondary dune complexes with some upland grasslands and beach, and the remaining area is in high salt marsh vegetation, tidal flats, channel fill sands, and SAV.

PA 3, on the southwest side of the proposed Packery Channel, encompasses approximately 7.1 acres. This land is located along the southwestern shore of the existing Packery Channel and is located immediately south of the SH 361 bridge. This area is undeveloped and consists of high and low salt marshes, tidal flats, SAV, and upland grasslands. Land use impacts from this PA are considered negligible and would be a necessary component of the proposed Packery Channel improvements.

PA 4N and PA 4S are located along the beach immediately north and south of the proposed Packery Channel jetty structures. This PA would be used to replenish beach sand and would cover approximately 27.1 acres of the existing beach area on the south side of the proposed south jetty structure, and approximately 19 acres of the beach area on the north side of the proposed north jetty structure. The fill material for PA 4 would consist of sand of appropriate grain size, from channel construction, maintenance, and sand bypass.

These beach areas are managed and maintained by the City of Corpus Christi and are regularly used for recreation. This placement of dredged material along the existing beach would extend the beach shoreline and would generally improve the quality of the beach experience over time. However, these beach areas would be restricted to the public during the construction phase of the proposed Project for a duration of approximately 117 days (assuming 20-hour dredging days). Then, during annual maintenance dredging events, dredged material (from Reach 1 of the channel) would be placed at either PA 4N or PA 4S (depending on which beach area has the greater sand deficit) for a duration of approximately 7 days, with public access restricted during this period. Also, once per year, dredged material would be placed through the sand bypass system at PA 4 for a duration of approximately 67 days, with public access restricted during this period. Approximately once every 5 years, dredged material from Reach 2 and the Inner Basin would be placed at PA 4 for a duration of approximately 3 days, with public access restricted during this period (these beach restriction estimates are based on construction duration estimates provided in Section 4.9). All estimates of the duration of maintenance dredging events are based on a 12-hour-per-day schedule. The final design of the sand bypass system associated with the channel jetties has not been completed to date; however, the design will meet all safety standards suitable for public access and enjoyment of the beaches adjacent to the jetties. The presence of the dredges will cause temporary, minor visual impacts to those in adjacent viewsheds.

The MMPA is located on unimproved land within Packery Channel County Park, located northeast of Park Road 22 and west of the existing Packery Channel. This MMPA consists of partially disturbed upland grasslands and would cover an area of approximately 7.5 acres. The dredged material for the MMPA would come from ongoing maintenance dredging of the channel and would be fully contained behind a levee. Land use impacts from this PA are considered negligible.

4.11.4.3 Secondary Development Impacts

Under the No-Action Alternative, the future residential and commercial development growth rate is likely to be moderate to high as discussed in Section 3.11.3.2. Future secondary public and private development in the area is likely to be driven by a few major factors:

1) The large amount (45.4 percent) of vacant land located in desirable locations within the study area adjacent to natural and recreational amenities; and
2) An increasing intrastate baby boomer population, and others seeking retirement and/or vacation housing in the area. This inmigrant population will increase the demand for services, offices and other commercial development.

Projected increases in tourism without the proposed Project, primarily from the intrastate travel market, would provide the impetus for development of hotels, restaurants, shops, and other commercial development.

Proposed Recreational Development by the City of Corpus Christi

The City of Corpus Christi proposes recreational development in conjunction with the Packery Channel Project. Recreational development is not part of the Federal cost-shared project. Recreational development will be pursued by the City in two phases. The Phase I recreational development will be located east of SH 361, and the Phase 2 proposed recreational development will be located west of SH 361.

The Phase 1 proposed recreational development by the City of Corpus Christi will include construction of parking lots, access roads, a pavilion, walkways along the channel and on the jetties with access ramps and stairs, vendor kiosks, a bathhouse/restroom facility, a small maintenance/

administration building, and a boat ramp. Also, water, wastewater, and electrical lines that would serve the proposed recreational development would be buried underground and would be contained completely within the proposed recreational development area. The water, wastewater and electrical lines that would serve the proposed recreational development would tie into existing lines located within the ROW of SH 361. Also, a force-main lift station would be built within the proposed recreational development area to pump wastewater off site (Trejo, 2002). A large portion of the parking area would be located on PA 2. Additional parking is proposed on the beach north and south of the jetties. All of these proposed recreational development would be located adjacent to the proposed Packery Channel in Reach 1 (see Figure 4.11-1a).

The proposed recreational development (excluding the proposed Packery Channel improvements) would impact approximately 14.2 acres of land, of which approximately 7.4 acres are outside of proposed dredged material PAs. The areas outside of the proposed PAs consist primarily of primary and secondary dune complexes and beach areas with a small amount of tidal flats. Overall, approximately 4.3 acres of roads, 2.5 acres of parking lots, and approximately 0.4 acre of buildings would be built in these areas. A small disturbance in tidal flats (0.2 acre) would occur with the construction of underground pipeline casings for the City of Corpus Christi.

In Phase 2 development at Packery Channel County Park (identified as Packery Point Park) and at the Causeway Area Access Point will be pursued (see Figure 4.11-1b). These park facilities are proposed for the future, and the schedule and schematics have not been developed to date. Packery Channel County Park is currently undeveloped and consists of upland grassland and partially disturbed land. The proposed recreational development in this area would be known as Packery Point Park and may potentially include public boat ramps and support facilities, parking to support boat ramps with space for 300 vehicles/trailers, shade structures, and public restrooms. The Causeway Access Point area is located in an area of highly disturbed land, adjacent to the JFK Causeway and the western extent of the existing Packery Channel. The proposed recreational development at the Causeway Access Point area may include renovation of existing boat ramps, two additional boat ramps and support facilities, and improvement to existing parking (adding space for 100 vehicles/trailers). The specific design of these park amenities have not been defined to date.

Private Development

Secondary private development land uses anticipated with the proposed Project have been identified in a report prepared by the ERA (2000). Also, the City of Corpus Christi planning staff provided additional details pertaining to future land development in the North Padre Island area (Utter, 2002; Raasch, 2002; Saldonia, 2002). Much of the secondary private development related to the proposed Project would likely occur in areas of vacant land located adjacent to Lake Padre, along Park Road 22 – Padre Island Drive, along Whitecap Boulevard, along Leeward Road and Windward Road east of Lake Padre (essentially areas of vacant land within the TIF District). Much of the vacant land on the south and southeast sides of Lake Padre already have fully developed water, wastewater, electrical lines, curb, gutter, and storm sewers. In other areas, such as the north, northeast, and east sides of Lake Padre, infrastructure would have to be built to serve future secondary private development (Trejo, 2002).

The ERA report provides details about future secondary private development within the TIF district that would occur in response to the proposed Project and the proposed recreational development being built. The ERA report provides two scenarios, the “Conservative” scenario, and the “Opportunity” scenario. Under the “Conservative” scenario, the following land uses would likely be built within the 1,930-acre TIF district within an 18-year time frame (ERA, 2000):

- 1,700 dwelling units (including condominiums, timeshare units, hotel rooms, and apartments). ERA is assuming 1,200 hotel rooms and 500 residential dwelling units.
- 150,000 square feet of commercial space (including retail, entertainment and restaurant projects).
- A new amusement attraction, assumed to be a water park.

Under the “Opportunity” scenario, the following land uses would likely be developed within the TIF district within an 18-year time frame:

- 3,000 dwelling units (including condominiums, timeshare units, hotel rooms, and apartments). ERA is assuming 2,000 hotel rooms and 1,000 residential dwelling units.
- 300,000 square feet of commercial space (including retail, entertainment and restaurant projects).
- A new amusement attraction, assumed to be a water park.

Also, based on communication with City of Corpus Christi staff, both the “Conservative” and “Opportunity” scenarios would include a marina to be located on Lake Padre that would accommodate between 400 to 800 boat slips and may include shops and a restaurant (Utter, 2002).

With the proposed Project the North Padre Island area would accelerate towards an urbanized resort-town character at a more rapid pace than under the No-Action Alternative. Existing open space, in the form of vacant private property, especially within the 1,930-acre TIF District, would be converted to secondary private development at a more rapid pace if the proposed Project and the proposed recreational development are built. However, the proposed land uses would not separate any existing neighborhoods, and would be unlikely to have an adverse affect on community cohesion.

4.11.4.4 Transportation Impacts

The increased number of visitors to the North Padre Island area as a result of the proposed Project, proposed recreational development and secondary private development would produce some changes in traffic patterns and volume to the transportation infrastructure within the North Padre Island area. Roadways likely to have the greatest impact would be Park Road 22 – Padre Island Drive, SH 361, Zahn Road, Whitecap Boulevard, Leeward Road, Windward Road. Under the No-Action Alternative arterial roads within the study area would become more congested over time as the area becomes more urbanized, but at a slower pace than if the Project were constructed.

4.11.5 Environmental Justice

Under the No-Action Alternative, no EJ effects (positive or negative) would occur within the Project area.

The EJ analysis for the study area was performed using 1990 Census data. This section will be updated after September 2002 when the USBOC is expected to release the 2000 Long Form (STF3) Census data for the State of Texas. The 2000 Long Form data will provide the requisite poverty status data needed for a complete EJ analysis. Race characteristics of the study area, using 2000 data, are discussed in Section 3.11.1.1. The following paragraphs discuss the potential for EJ impacts using 1990 Census data.

Within the study area, ethnicity and poverty figures are generally consistent with those of the region with only one notable exception: Nueces County census tract number 54.06. This is a large census tract, which encompasses much of southeastern Corpus Christi. This census tract is located south of Oso Creek and is bordered on the east by Oso Bay. It does not include any areas of North Padre Island. This census tract has a percentage of persons living below the poverty line (40.8 percent) that is substantially higher than in Nueces County (25.0 percent), and the State (18.1 percent). However, this does not constitute a disproportionate impact under EO 12898, since there are no disproportionately high and adverse human health or environmental effects that would accrue to the population living in this census tract. Generally speaking, the persons living below the poverty line within this census tract would experience slightly improved economic conditions from the proposed Project. These benefits would be manifested mainly in an increase in economic output, jobs, and tax base within the general vicinity of the proposed Project.

No low-income or minority populations have been identified to experience disproportionately high and adverse human health or environmental effects as a result of the proposed Project.

4.12 ANY ADVERSE ENVIRONMENTAL IMPACTS WHICH CANNOT BE AVOIDED SHOULD THE PROPOSED PROJECT BE IMPLEMENTED

The proposed Project will result in adverse impacts to the benthos and fish habitat from dredging. During the dredging of the existing and proposed channel, bulkhead construction, and placement of new work material, there will be a negative impact to 5.2 acres of SAV, 0.2 acre of low salt marsh, 10.9 acre of high marsh, 23.7 acres of primary and secondary dunes, 1.5 acres of tidal flats, and 55.2 acres of beach. Approximately 16.1 acres of channel fill sands (shoaled-in area of former washover channel) will be dredged or impacted by placement of dredged maintenance material. Channel and jetty construction will destroy 6.2 acres of piping plover critical habitat and impact an additional 24.6 acres in PA 4S and 4N by intermittent placement of new work and maintenance dredged material. Proposed secondary recreational development by the City of Corpus Christi will potentially affect 0.3 acre of tidal flats, 3.4 acres of primary and secondary dune complexes and 3.7 acres of beach.

4.13 ANY IRREVERSIBLE OR IRRETRIEVABLE COMMITMENTS OF RESOURCES INVOLVED IN THE IMPLEMENTATION OF THE RECOMMENDED PLAN

The labor, capital, and material resources expended in the planning and construction of this Project are irreversible and irretrievable commitments of human, economic, and natural resources. The loss of the aforementioned seagrass, salt marsh, beach area, and critical habitat is irreversible. However, the loss of seagrass habitat can be mitigated and compensated for through the channel design. The development of a benched area above the channel bottom may potentially support a 5.4-acre area suitable for seagrass recruitment. The removal of primary and secondary dune communities will be partially mitigated by dune construction as part of the Project. Loss of piping plover critical habitat is offset by creation and regular nourishment of enlarged beach habitat north and south of the jetties in PAs 4S and 4N.

4.14 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The proposed Project will eliminate approximately 38.5 acres of shallow bay bottom habitat along the existing channel and 11 acres of Gulf bottom, 5.2 acres of SAV, and 11.1 acres of high and low salt marsh. Productivity of the sites removed during construction would be permanently lost from the ecosystem. The shallow water habitat created in the channel design provides potential for seagrass recruitment, thus loss would be a short-term loss. Although bottom habitat along the existing channel will be removed, recovery of newly created benthic habitat on the channel bottom is expected over a short-term. However, there will be a time lag before the habitat becomes established and ecologically functional. There will be a temporary loss of productivity during that interim period.

4.15 MITIGATION

According to CEQ regulations, mitigation includes the following:

(a) Avoiding the impact altogether by not taking a certain action or parts of an action.

(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.

(c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.

(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.

(e) Compensating for the impact by replacing or providing substitute resources or environments.

4.15.1 <u>Avoidance/Minimization</u>

The channel location was adjusted toward the south several feet in order to avoid impacts to submerged aquatic vegetation. The design of the channel width in Reach 2 was based on minimizing the dredging while allowing for expected traffic use and vessel size. Reach 1 is using an historic washover pass to the Gulf, thus minimizing resource impacts.

4.15.2 Rectification

All natural areas temporarily disturbed by equipment, temporary roads, or material will be restored to original condition.

4.15.3 Reduction

To prevent unnecessary disturbance, certain natural areas within the Project boundaries and outside the limits of permanent work will be protected during construction activities (URS, 2002). The boundaries of the areas designated as off-limits will be identified by marking or fencing. These areas support coastal communities of primary and secondary dune complexes, beach, high salt marsh, and tidal flats. One of two identified areas extends north from PA 2 to Zahn Road (the first beach access road from SH 361 north of the channel) (Figure 4.15-1). The second designated area occurs southeast of PA 1 between the floodwall and PA 4S. Further in the development process, the boundary area north of PA 2 will be adjusted to accommodate recreational development as proposed by the City of Corpus Christi.

4.15.4 Compensation

Beach nourishment is proposed for PAs 4N and 4S, two areas located north and south of the proposed jetties. Sand dredged from the proposed channel will be deposited on the beach to aid in restoration of the eroded shoreline. New work dredged material will initially be placed in an approximately 27-acre area south of the jetties and east of the seawall. North of the jetty an approximately 19-acre area is proposed for placing sandy maintenance material, if accretion occurs south of the jetties. The beach nourishment at PA 4S will include an approximately 220-foot-wide berm that will extend the beach shoreline seaward approximately 100 to 150 feet. A sloping transition zone from the sand berm seaward will extend approximately 700 feet.

There will be impacts to critical dunes and/or dune vegetation. Approximately 1.5 acres representing 5,670 cy of sand will be displaced and mitigated. In the City of Corpus Christi's Dune Protection Permit Application to the GLO (City of Corpus Christi, 2002a), it notes that 5,670 cy of displaced dunes (approximately 1.5 acres) will be mitigated by relocating the displaced dunes to a site immediately northeast of PA 2 and south of Zahn Road into a depressional area landward of the existing foredune ridge (Figure 4.15-1). The 5,670 cy of critical dunes will be restored to approximate the natural position, sediment content, volume, elevation, and vegetative cover (City of Corpus Christi, 2002a). The City of Corpus Christi proposes to revegetate using native species that will provide the same or greater protective capability as the surrounding natural dunes. Any dune areas temporarily disturbed during the relocation will be included in the revegetation effort.

The proposed Packery Channel Project is expected to impact a maximum of 5.2 acres of seagrass, but the channel design will include approximately 5.4 acres of shallow-water seagrass habitat on side benches for seagrass recruitment. Additionally, coordination with the FWS will propose 3 to 1

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Figure 4.15-1
Dune Mitigation and
Natural Area Sites

Prepared for: USACE		Drawn by: G. Rockley	Date: March 2002
Job No.: 440561	Scale: 1"=1190' for 8.5"x11" Sheet	File: N:\440561\cad\utm83_14\fig4-15-1.dgn	

mitigation for the impacts to seagrass from the Project accounting for approximately 15.6 acres to be planted. Since there is a vast amount of seagrass in the Upper Laguna Madre near the proposed Project, planting seagrass in an area of Corpus Christi Bay where seagrass is scarce will be suggested to the FWS, perhaps to coincide with CCSCCIP mitigation. This would provide a larger seagrass meadow in one place as a result of mitigation from the two projects. The conditions that would apply to seagrass mitigation follow.

4.15.5 Mitigative Procedures/Conditions for Seagrass Transplanting Efforts

1. After it is determined that the sediment conditions are correct, based on a survey in the candidate mitigation site area, an appropriate location for the mitigation plantings will be selected, preferably adjacent to CCSCCIP mitigation within the eastern portion of the proposed BU Site GH. Site GH, located within northern Corpus Christi Bay, is a rectangular site to be placed in open water adjacent to the south side of the proposed La Quinta Channel extension and west of PA 13 at the terminus of the existing La Quinta Channel. The mitigation area will be planted with shoalgrass.

2. Transplant source areas will be identified and applicable permits obtained from TPWD and/or GLO and/or private landowners. Staking of the approved transplant harvest areas will be in accordance with applicable permits.

3. Shoalgrass planting may be conducted between mid-March and mid-June, or between mid-September and mid-October. Plantings outside of these times will need to be coordinated between the USACE, FWS, TPWD, NMFS and the non-Federal sponsor at least 2 weeks prior to commencement of those plantings. The transplanting technique will be coordinated with the USACE, NMFS, FWS, TPWD and the non-Federal sponsor when the specific location and configuration of the mitigation site is being established. Initial shoalgrass planting shall be done within 1 year of completion of the mitigation site or during the first suitable planting time following the determination that the site is conducive to transplant survival. The location of the mitigation site will be marked by PVC pipe.

4. A planting unit will consist of live shoalgrass material contained in a 3-inch-diameter plug. No more than three 3-inch-diameter plugs of source material per square yard will be obtained from the designated transplant source areas. Incidental damage to source areas will be avoided. Alternate harvest techniques may be considered but they will require prior coordination with USACE, NMFS, FWS, TPWD and the non-Federal sponsor and, as necessary, permitted through TPWD and/or GLO and/or private landowners.

5. A transplant survival survey of the planted site will be conducted between 60 and 90 days after completion of the initial planting effort. Using acceptable survey methods, a minimum of 15% of all transplant units will be surveyed for the initial transplant survival survey. A written report detailing the survival results shall be submitted to the USACE within 30 days of survey completion. The report will be distributed by the USACE to the NMFS, TPWD, FWS and the non-Federal sponsor. If at least 50 percent survival is not achieved, then the resource agencies shall be consulted to determine if the site should be modified prior to initiating a replanting effort. If it is determined that site modifications are not

necessary and that the site should be replanted, then replanting shall commence within 30 days (or within the next suitable planting period) once the agency-coordinated decision to replant the site has been made.

6. At least six transects will be established for the purposes of pre-construction, pre-plant plant elevation, or existing-bed condition surveys, and for post-planting monitoring surveys. The ends of each transect will be marked by PVC pipe. More transects may be established, depending on the size or shape of the site selected, the transplanting plan, and/or planting schedule. A minimum of two transects outside of the mitigation site in nearby seagrass beds and a minimum of four transects that cross the mitigation site are to be established and surveyed. The number and configuration of transects within the planting area will be coordinated with the USACE, NMFS, FWS, and TPWD and the non-Federal sponsor after the size and configuration of the mitigation site has been established.

7. All transects located within the mitigation site shall be surveyed post-planting, at 6 months, 1 year, 2 years, and 3 years to determine success of mitigation. To determine success, three samples will be taken at 10-foot intervals along the transects; one on the interval and one three feet to each side of the interval. Seagrass will be identified to species. Coverage of seagrasses will be to species and will be calculated by using the frequency of occurrence of live seagrass at each sample along the transect. In addition to the percentage of vegetative cover, the monitoring surveys at all transects will note water depths (elevation) and any unusual sediment variations or other deposits.

8. If two years following planting, the mitigation site is not as least 70 percent covered with shoalgrass, an additional planting effort will be made and those areas of the site not vegetated will be replanted to original specifications. The occurrence of manatee grass, if any, can be included in meeting the 70 percent coverage requirement.

9. The mitigation effort will be considered successful if the mitigation site is 70% covered by shoalgrass and/or manatee grass within three years following shoalgrass planting and if at least 48% of the total vegetative coverage is shoalgrass. If the mitigation is determined to be unsuccessful at the end of the three-year monitoring period, the Federal sponsor will be required to consult with the USACE, NMFS, FWS, TPWD and the non-Federal sponsor in order to determine if corrective measures are warranted. If it is apparent that the site is unlikely to support seagrass vegetation, a determination may be made to re-locate the mitigation project.

10. Some seagrasses currently exist near the proposed beneficial use Site GH in Corpus Christi Bay. A survey using the transects established outside the mitigation area will be performed prior to constructing Site GH. The survey shall use a method similar to that used for the transects within the mitigation area and will also obtain information on the areal extent of the existing grassbeds. One purpose of the survey in the nearby seagrass beds is to obtain data to aid in the selection of the planting area within the mitigation site. This survey will be repeated within 30 days of completing construction of those portions of Site GH that could reasonably affect the existing nearby seagrass beds. If the survey

results show that impacts have occurred to the existing seagrass beds, then the results will be provided within 30 days of completion of the survey to the USACE, TPWD, FWS and NMFS and the non-Federal sponsor. These agencies will be consulted in order to determine an appropriate course of action to restore and/or mitigate the impacts.

11. The Federal sponsor will prepare monitoring reports detailing all required surveys. These monitoring reports will be submitted to the FWS, TPWD, and NMFS and non-Federal sponsor within 60 days of survey completion.

4.16 ENERGY AND NATURAL OR DEPLETABLE RESOURCE REQUIREMENTS AND CONSERVATION POTENTIAL OF VARIOUS ALTERNATIVES AND MITIGATION MEASURES

NEPA regulations in 40 CFR 1502.16 (e) and (f) require a discussion of project energy requirements and natural or depletable resource requirements, along with conservation potential of alternatives and mitigation measures in an EIS.

Under the No-Action Alternative, without maintenance dredging, and expected channel shoaling, the energy requirements for maintaining the existing portion of Packery Channel and the navigation requirements for energy (fuel) for recreational boating will decrease. Air quality impacts are likely to decrease.

The proposed Project is expected to reduce energy (fuel) requirements for recreational boaters using the Gulf of Mexico for fishing, since they will not have to trailer boats to the beach or travel in boats north approximately 17 miles to Aransas Pass.

Energy (fuel) will be required to construct the improved channel, but this is a short-term impact. Energy to maintain the improved channel is expected to increase significantly with the increase in shoal material expected for this larger channel, for maintaining the new portion of the channel, and for the sand bypass system. This increase in fuel requirement is not likely to be offset by fuel savings for the shorter boat trips to the Gulf. Air quality impacts would increase with the increased channel maintenance relative to the No-Action Alternative. There would also be an increase in local air quality impacts from the increase in recreational boating in the area, but this should be offset by reductions in other areas.

5.0 CUMULATIVE IMPACTS

5.1 INTRODUCTION

Cumulative impact has been defined by the President's Council on Environmental Quality as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or persons undertakes such action." Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. Impacts include both direct effects, which are caused by an action and occur at the same time and place as the action, and indirect effects, which are also caused by the action and occur later in time or are farther removed in distance, but which are still reasonably foreseeable. Ecological effects refer to effects on natural resources and on the components, structures, and functioning of affected ecosystems, whether direct, indirect, or cumulative.

Cumulative effects can result from many different activities including the addition of materials to the environment from multiple sources, repeated removal of materials or organisms from the environment, and repeated environmental changes over large areas and long periods. More complicated cumulative effects occur when stresses of different types combine to produce a single effect or suite of effects. Large, contiguous habitats can be fragmented, making it difficult for organisms to locate and maintain populations between disjunct habitat fragments. Cumulative impacts may also occur when the timings of perturbations are so close that the effects of one are not dissipated before the next occurs, or when the timings of perturbations are so close in space that their effects overlap.

5.1.1 Assessment Methodology

Parameters for past, present, and reasonably foreseeable future projects viewed as pertinent to the future condition of the Upper Laguna Madre and Corpus Christi Bay were included in this assessment and include biological, physical, chemical, socioeconomic, and cultural attributes. Projects evaluated in this assessment include the following:

Reasonably foreseeable future actions:

- Corpus Christi Ship Channel 52-foot Improvement Project
- Raising the JFK Causeway
- La Quinta Gateway Project
- Joe Fulton International Trade Corridor

Past or present actions:

- Corpus Christi Ship Channel 45-foot Project
- Rincon Channel Federal Assumption of Maintenance
- Gulf Coast Strategic Homeport Naval Station Ingleside-Corpus Christi, Texas
- Mine Warfare Center of Excellence-Corpus Christi Bay, Texas

Impacts to specific resource categories were addressed in a more qualitative manner depending on the degree of information provided in each document reviewed. Direct impacts that could be quantified in acreage were presented when information was available. Resources addressed in this assessment include: biological/ecological resources (wetlands, benthic habitat/bay bottom, terrestrial habitat, SAV, plankton, finfish/shellfish, terrestrial wildlife, threatened and endangered species, EFH, tidal flats, open-water habitat, oyster reef habitat, and coastal shore areas/beaches/sand dunes); physical/chemical resources (air quality, noise, topography/bathymetry, water quality/turbidity, sediment quality, salinity, freshwater inflows and circulation/tides); and cultural/socioeconomic resources (recreation, commercial and recreation species, ship accidents/spills, oil and gas production on submerged lands, cultural resources, public health/safety, and parks and beaches). It should be noted that because of the diverse mix of documents that were reviewed for cumulative impacts and because of the fact that not all documents used the same definitions or even the same categories of resources, it was sometimes necessary to lump or modify categories so that the quantities in this section may not be exactly comparable with those presented in sections 3 and 4 of this DEIS. However, every attempt has been made to make this section internally consistent, so that all projects included in Cumulative Impacts are evaluated comparably.

5.1.2 Evaluation

Cumulative effects were determined by reviewing impacts as described in the Project documents and determined from recent habitat information obtained from Section 4.0. Acreage of each habitat in the study was determined from each of the documents, if available (see Table 5.1-1). No attempt was made to verify or update published documents, nor were reviewed documents verified for current ongoing projects. In addition, no field data was collected to verify project impacts described in reviewed documents. This analysis recognizes that some of the projects assessed are undergoing revisions that may alter their environmental impact.

A qualitative discussion of biological/ecological, physical/chemical, and cultural/ socioeconomic resources was accomplished using the information published in the reviewed documents. If acreages were available, they were summed for each habitat to obtain a cumulative acreage impact (Table 5.1-1). The following is a brief description of the evaluated projects.

5.2 REASONABLY FORESEEABLE FUTURE ACTIONS

5.2.1 Corpus Christi Ship Channel-Channel Improvement Project (CCSCCIP)

This Project proposes to deepen the Corpus Christi Ship Channel (CCSC) system from the current depth of –45 feet MLT to –52 feet MLT to accommodate larger vessels, increase shipping efficiency, and enhance navigation safety. The channel begins at deep water in the Gulf of Mexico about 4.3 miles offshore, passes through the jettied inlet at Aransas Pass and extends about 21 miles westward to Corpus Christi. Continuing west, the channel extends about 8.5 miles through the harbor area before terminating at the Viola Turning Basin. This channel ranks fifth in the nation for tonnage shipped in ocean-going vessels, and in Texas only the Houston Ship Channel handles more tonnage.

TABLE 5.1-1
CUMULATIVE IMPACTS

Project	Packery Channel	Raising Kennedy Causeway	Joe Fulton International Trade Corridor	La Quinta Gateway Project	Rincon Channel Federal Assumption of Maintenance	Gulf Coast Strategic Homeport Naval Station Ingleside	Mine Warfare Center of Excellence	Corpus Christi Ship Channel 52-foot Project	Total
RESOURCE IMPACTS									
Topography/Bathymetry	3.5 statute miles	0.9 statute miles	NI	32 acres	NI	8.4 statute miles	NI	43 statute miles	32 ac / 55.8 statute miles
Shore/Beach/Dunes	86 ac	NI	NI	0.7 statute mile	NI	NI	NI	NI	86 ac / 0.7 statute mile
Salt Marsh	11.1 ac	11.5 ac	NI	1.7 ac	NI	1.2 ac	NI	NI	25.5 ac
Flats	1.8 ac	NI	NI	NI	NI	112 ac	NI	NI	113.8 ac
Open Water	3.1 ac	NI	NI	NI	NI	NI	NI	NI	3.1 ac
Oyster Reef	NI	NI	NI	NI	NI	NI	NI	NI	
Upland Wetlands	NI	NI	11.2 ac	NI	NI	38.6 ac	NI	NI	49.8 ac
Shallow Bay Bottom Habitat (0 to –12 MLT)	38.5 ac	NI	NI	27.5 ac	20 ac	207 ac	18 ac	40 ac (0 to –4 MLT)/ 359 ac (–4 to –12 MLT)	351/359 ac
Gulf of Mexico Bottom Habitat	11 ac	NI	NI	NI	NI	NI	NI	526 ac	537 ac
Terrestrial Habitat	49.7 ac	NI	45 ac	295 ac (excludes cropland)	NI	614 ac	NI	NI	1,003.7 ac
Submerged Aquatic Vegetation (SAV)	5.2 ac	NI	NI	2.9 ac	NI	1.1 ac	3.5 ac	5 ac	17.7 ac
Essential Fish Habitat (subtotal of salt marsh, flats, shallow bay bottom habitat, and SAV)	56.6 ac	11.5 ac	NI	32.1 ac	20 ac	321.3 ac	21.5 ac	404 ac	867 ac
MITIGATION/BENEFITS *									
Upland Habitat	NI	NI	NI	NI	5 ac	NI	NI	120 ac	125 ac
Bay Bottom Habitat	18 ac	5 ac	NI	NI	NI	NI	NI	NI	23 ac
Shallow-Water Habitat	5.4 ac	11 ac	NI	NI	NI	5.5 ac	NI	935 ac	956.9
Submerged Aquatic Vegetation	15.6 ac	NI	NI	8.6 ac	NI	1.6 ac	10 ac	15 ac	50.8 ac
Wetlands (salt marsh, brackish, fresh)	NI	NI	NI	5.3 ac	28 ac	42 ac	NI	26 ac	101.3 ac

TABLE 5.1-1 (cont'd)

Project	Packery Channel	Raising Kennedy Causeway	Joe Fulton International Trade Corridor	La Quinta Gateway Project	Rincon Channel Federal Assumption of Maintenance	Gulf Coast Strategic Homeport Naval Station Ingleside	Mine Warfare Center of Excellence	Corpus Christi Ship Channel 52-foot Project	Total
Beach Nourishment	46 ac	NI	NI	NI	NI	NI	NI	NI	46 ac
Dune Mitigation	5,670 cy (1.5 ac)	NI	NI	NI	NI	NI	NI	NI	5,670 cy (1.5 ac)
SOCIOECONOMICS									
Environmental Justice	NI	NI	NI	NI	NI	NI	NA	NI	NI
Community Cohesion	NI	NI	NI	NI	NI	NI	NA	NI	NI
Relocations	NI	1 business	NI	NI	NI	NI	NA	NI	1 business
Demand for Housing Units	3,150	NA	NA	4,600	NA	3,700	NA	Negligible	11,450
Population Increase	5,200	NA	NA	9,000	NA	14,900	NA	Negligible	29,100
BENEFITS									
Temporary (Construction Phase)									
Employment (avg. annual)	350	1,700	100	4,250	NA	535	NA	370	7,305
Wages (avg. annual)	NA	$26.9 M	NA	$210 M	NA	NA	NA	$1.1 M	$238 M
Total Output (avg. annual) (Nueces and San Patricio counties)	NA	$114.3 M	NA	$460 M	NA	NA	NA	$23 M	$597 M
Indirect Business Tax Impact (avg. annual)	NA	NA	NA	$15 M	NA	NA	NA	$900,000	$15.9 M
Permanent									
Employment (avg. annual)	2,500	NI	90	6,400	NA	8,470	NA	71	17,530
Wages (avg. annual)	$220 M	NI	$38 M	$233.4 M	NA	$150 M	NA	$21,000	$641.4 M
Total Output (avg. annual) (Nueces and San Patricio counties)	NA	NI	$115 M	$680 M	NA	NA	NA	$85,000	$795.1 M
Indirect Business Tax Impact (avg. annual)	NA	NI	$3.7 M	$21.8 M	NA	NA	NA	$3,700	$25.5 M

NI = No impacts; NA = Not Available; M = million (dollars).

* Except for CCSCCIP, all gains in the Mitigation/Benefits section of this table are from mitigation. For CCSCCIP, the only mitigation is the 15 acres of submerged aquatic vegetation; all others are from beneficial uses. Mitigation is determined based on Habitat Suitability Indices, while others were based on ratios to direct impacts.

The preferred alternative for this Project would include deepening the CCSC from –45 feet MLT to –52 feet MLT, plus advanced maintenance and allowable over-depth. Depths will be increased approximately 10,000 feet into the Gulf of Mexico. The CCSC between Port Aransas to the Harbor Bridge will be widened to 530 feet. The La Quinta Channel will extend 7,200 feet at a depth of –39 feet MLT and a width of 400 feet including a turning basin. In addition, a 200-foot-wide barge shelf (–12 feet MLT) on both sides of the ship channel will be constructed from La Quinta junction to the Harbor Bridge.

5.2.2 JFK Causeway

The JFK Causeway is located in southeast Nueces County in the City of Corpus Christi on the northern end of the Laguna Madre, providing a connection between the mainland and North Padre Island. The current causeway is approximately 4 feet above MSL with a 3,280-foot-long high bridge, that provides a clear roadway width of 54 feet, including a divided four-lane road with a concrete median barrier and a vertical clearance of 80 feet above the water's surface.

The proposed Project would raise the existing Park Road 22 (JFK Causeway) to a minimum of 9 feet above MSL from O'Connell Street on the mainland to a point 1,740 feet east of Aquarius Drive on Padre Island. The new bridge would be 2,850 feet long with a 2,550-foot water opening at the west end of the Causeway. No new through lanes would be added by the Project, and the existing two lanes in each direction would remain upon completion of the Project. Between O'Connell Street and the Laguna Madre, the existing four-lane divided highway would be converted to an urban freeway with four main lanes and frontage roads to provide access to abutting properties. A turnaround at the western bank of the Laguna Madre would aid local traffic access. During construction, one lane in each direction would remain open to traffic. The westbound traffic lanes would be completed first to ensure safe evacuation in case of an emergency during construction. The GIWW high bridge would not be modified as part of this Project since it is already well above the 9-foot minimum elevation needed for safe evacuation during storm events. (Hicks et al., 1999)

5.2.3 Joe Fulton International Trade Corridor

The Joe Fulton International Trade Corridor (JFITC) is a proposed intermodal project to connect road, rail and marine traffic between Interstate Highway 37 (IH 37) and U.S. Highway 181 (US 181). The proposed Project area is located along the Port of Corpus Christi Inner Harbor in Nueces County, Texas, and is located north of the City of Corpus Christi, south of Nueces Bay, and west of Corpus Christi Bay. It would result in the construction of a two-lane roadway (one 12-foot lane in each direction and 10-foot shoulders) approximately 11.8 miles in length and a railroad corridor approximately 6 miles in length, parallel to a portion of the proposed roadway.

The JFITC would provide improved road and rail access to existing facilities on the north side of the Inner Harbor from the Tule Lake Lift Bridge to US 181. It would also facilitate development of approximately 1,100 acres of Port of Corpus Christi Authority (PCCA) and Driscoll Foundation land between the Lift Bridge and Carbon Plant Road/IH 37. The new rail link would provide alternative service to the north bank area, eliminating the need for all rail traffic to pass over the Lift Bridge. The proposed road would provide alternative routing for industrial vehicles between US 181 and IH 37 and PCCA facilities, thus eliminating the need for traffic to traverse the downtown Corpus Christi area and the Harbor Bridge. The proposed route would become the designated hazardous materials route and would also provide an alternative for general traffic, including hurricane evacuation traffic from areas east of Corpus Christi Bay, independent of the Harbor Bridge and the Lift Bridge (Shiner, Moseley and Associates et al., 2001).

5.2.4 La Quinta Gateway Project

The proposed La Quinta Gateway project involves the construction and operation of an intermodal container terminal and associated deep draft docking facility. The Project would be located on PCCA-owned property (approximately 1,114 acres) in San Patricio County, Texas, between Reynold's Metals Company to the east, SH 361 and the City of Gregory to the north, US 181 and the North Shore Country Club Estates to the northwest and west, respectively, and Corpus Christi Bay to the south. The Corpus Christi Bay portion of the site is in Nueces County, Texas.

The proposed cargo facility for the La Quinta Gateway project would be constructed over three phases to include: highway access via improvements to SH 35 and US 181, rail access via the Union Pacific Railroad right-of-way (ROW), water access via extension of the La Quinta Channel and a new 1,500-foot turning basin, a 245-acre marine terminal with stacked container and wheeled storage areas, a 3,700-linear-foot container wharf capable of accommodating three post-Panamax containerships simultaneously, nine gantry cranes with a boom reach capable of handling loading/off-loading activities, a 75-acre intermodal rail terminal along the east edge of the La Quinta property, four 6,000-foot loading tracks, a warehousing and distribution facility, and two dredged material PAs totaling nearly 300 acres, including a 100±acre buffer zone located along the western boundary of the site (PCCA, 1999). Approximately 819 acres of the 1,114-acre Project area is in row crop production, while 295 acres is predominantly brushland used for grazing.

5.3 PAST OR PRESENT ACTIONS

5.3.1 Corpus Christi Ship Channel 45-Foot Project

The existing channel extends from deep water in the Gulf of Mexico through a jettied entrance channel in Aransas Pass to Harbor Island and across Corpus Christi Bay to a land-locked channel south of Nueces Bay. A branch channel to La Quinta extending from the main channel along the north shoreline of Corpus Christi Bay is included in the Project. According to the USACE (1975) the Corpus Christi Ship Channel was deepened from the existing 40-foot depth to an authorized depth of 45 feet. The 40-foot dimensions were authorized by the Rivers and Harbors Act of 1958, and the 45-foot dimensions were authorized by the Rivers and Harbors Act of 1968.

The 45-foot project provides maintenance dredging of the CCSC to authorized dimensions. Maintenance dredging is required periodically to ensure sufficient carrying capacity in the channels for efficient and safe movement of commercial navigation. Shoaling within the channels would seriously hamper or halt deep-draft shipping within 2 or 3 years if maintenance dredging were discontinued. The outer bar and jetty channel to Harbor Island are normally maintained by a hopper dredge, with the dredged material placed in a designated open water PA in the Gulf of Mexico. The remaining portions of the CCSC are maintained by hydraulic pipeline dredge. Materials dredged from the landlocked portion of the channel south of Nueces Bay are placed in UCPAs. Variations of these procedures could occur as a result of improvements in dredging techniques and equipment or possible emergency conditions.

Resource impact evaluation of the 45-foot project was not conducted due to the proposed impacts of the CCSCCIP.

5.3.2 Rincon Canal Federal Assumption of Maintenance

The USACE proposed to assume responsibility for maintenance of the Rincon Canal and Canal A in Corpus Christi Bay and the Rincon Industrial Park (RIP), and to use the dredged material for BU sites in the Project area, where possible.

The Corpus Christi Rincon Canal System (CCRSC) is composed of several connecting channels constructed between 1967 and 1974. The Rincon Canal, a channel measuring 100 feet in width, 12 feet in depth, and 14,256 feet in length, connects the CCSC to the RIP. The canal passes under US 181/Nueces Bay Causeway east of the northern end of the RIP. The CCSC serves as a connection between the CCRSC and the GIWW. The RIP is served by Canal A (150 feet in width, 12 feet in depth, and 4,980 feet in length), and Canals B and E, all of which connect to the Rincon Canal. Rincon Canal and Canal A compose that part of the system proposed for assumption of maintenance dredging by Federal entities. The proposed BU sites are located in Nueces County along the southwestern margin of Corpus Christi Bay, adjacent to the City of Corpus Christi and the RIP, which is part of the PCCA.

The channels are currently maintained using a cutterhead pipeline dredge. No changes in historical dredging practices would be proposed as a result of this action (USACE, 2000).

5.3.3 Gulf Coast Strategic Homeport Naval Station Ingleside (Naval Station Ingleside)

The U.S. Navy proposed a strategic homeporting action for 27 battleship surface vessels at eight locations on the U.S. Gulf Coast, including Naval Station Ingleside, Texas. Very little information was available regarding the execution of this Project. Of the proposed actions, only dredging of navigation channels and turning basins are known to have occurred in the region. Additionally, waterfront facilities were constructed to support the homeported vessels. The following information is taken largely from the project EIS (U.S. Navy, 1987).

The Naval Station Ingleside project site is located in and adjacent to the CCSC, from La Quinta to Harbor Island. Approximately 8.4 mi of the CCSC was proposed to be widened from 500 to 600 feet. The CCSC was to be hydraulically dredged to a depth of –46.5 feet MLT. A 105-acre turning basin was to be dredged to a depth of –41 feet MLT in the western 42 acres and –46.5 feet MLT in the eastern 63 acres. Dredging depths include 2 feet advance maintenance and 2 feet allowable overdepth.

Approximately 13.2 million cy (MCY) of material was proposed to be dredged, including 5.9 MCY from the CCSC and 7.3 MCY from the turning basin. Maintenance dredging is expected to occur every 5 years with an estimated volume of 6.4 MCY of material being removed from the CCSC and 6.5 MCY of material being removed from the turning basin over the 50-year life of the Project. The dredged material was proposed to be hydraulically removed and pumped to USACE-designated placement sites (U.S. Navy, 1987).

5.3.4 Mine Warfare Center of Excellence

Dredging approximately 400,000 cy for the U.S. Navy facilitated the construction of a Magnetic Silencing Facility (MSF) for use by the Mine Warfare Center of Excellence at Ingleside, Texas. This MSF is required to measure the magnetic signature of the mine warfare ships for utilization in mine warfare training. Construction of an entrance channel, turning basin and slip was required for the Avenger and Osprey Class Naval Vessels.

The entrance channel measured 150 feet wide and approximately 700 feet in length and will be dredged to –17 feet MLW. The turning basin measured 500 feet by 500 feet and was dredged to –17 feet MLW. To allow for placement of the MSF, a corridor measuring 520 feet by 270 feet was dredged to –25 feet MLW. The MSF consists of piers and sensor tubes. Two piers 300 feet in length were constructed parallel to one another 66 feet apart to allow docking of naval vessels between them. A walkway measuring 800 feet in length connects these piers to the shoreline.

An additional small craft pier was constructed adjacent to Naval Station Ingleside and CCSC. The pier measures 600 feet in length and accommodates utility boats used to support the mine warfare exercises and existing boats assigned to the station. The small craft pier facilities are near Naval Station Ingleside, San Patricio County, Texas. The dredging portion of the Project was performed at the confluence of the Jewel Fulton Canal and La Quinta Channel west of Ingleside, Texas (U.S. Navy, 1987).

5.4 RESULTS

5.4.1 Ecological/Biological Resources

Biological and ecological resources will experience a temporary net negative impact from increased turbidity associated with the dredging and dredged material placement required in the majority of the projects evaluated. Temporary disturbance of bay bottom due to open bay placement and channel dredging is anticipated to provide temporary negative impacts to benthos and SAV. Loss of vegetated areas due to construction is expected to reduce food and nutrient sources. However, mitigation and beneficial use areas will ameliorate those impacts.

Long-term positive impacts, particularly from the CCSCCIP, are anticipated from the creation of shallow water habitat, SAV, marsh habitat and shallow aquatic habitat that will increase nursery habitat for finfish/shrimp and provide rich substrate for benthic organisms. Within the region, birds will benefit by the periodic placement of dredged material on existing upland sites due to creation of temporary barren nesting substrate. However, construction operations attributed to almost all evaluated projects may disturb nesting activity. Mammals, reptiles/amphibians, and terrestrial vegetation will be negatively impacted, by placement of material on existing upland placement sites though some benefit may be realized from creation of marsh and barren nesting substrate on existing placement sites. Although wetland vegetation will be negatively impacted where wetlands are damaged or destroyed by Project construction, marsh creation projects will benefit wetland vegetation, resulting in an overall positive cumulative impact in the general study area. Except for the CCSCCIP, all gains in the Mitigation/Benefits section of Table 5.1-1 are from mitigation. For CCSCCIP the only mitigation is for SAV; all others are from beneficial uses.

5.4.1.1 Wetlands (Fresh, Brackish, Salt Marsh)

Approximately 64.2 acres of direct negative impacts to wetlands (fresh, brackish, or salt marsh) are expected from the reviewed projects, excluding the Packery Channel Project. Packery Channel may negatively impact approximately 11.1 acres of salt marsh due to channel construction. Creation of 28 acres of salt marsh was proposed for the Rincon Canal Project; 42 acres for Naval Station Ingleside; 26 acres of BU for the CCSCCIP; and 5.3 acres for La Quinta, for a total of 101.3 acres. A net gain of 26 acres for the Corpus Christi Bay area is predicted, based on the above totals.

According to studies conducted within the CCBNEP study area (that includes Aransas Bay, Corpus Christi Bay, and the Upper Laguna Madre) (White et al., 1998), marsh habitat constitutes approximately 97 percent (116,041 acres) of total vegetated wetland areas (119,425 acres) including marshes, scrub-shrub, and forested wetlands. Some of the findings in these studies reveal that salt and brackish marshes comprise approximately 48 percent of the marsh system. As presented in these studies, the trend in vegetated wetlands is one of net gain from the 1950s to 1992 (including photointerpretation inconsistencies). However, loss of marsh habitat has resulted from agricultural or urban land conversion with additional loss due to dredging, filling and draining. According to the studies, the greatest changes in habitat between the 1950s to 1979 has occurred in tidal flats due to permanent inundation The response to permanent inundation has primarily resulted in conversion to open water or seagrass beds. Some losses included conversion to smooth cordgrass marshes along the upper reaches of the tidal flats that became more frequently flooded. According to the CCBNEP studies (White et al., 1998), some of the largest losses in tidal flats was in the Corpus Christi/Nueces Bay-Laguna Madre system.

5.4.1.2 Finfish/Shellfish

Shallow water nurseries and spawning grounds are sensitive sites within the vicinity of the study area. Shrimp and finfish production would be temporarily displaced due to dredging activity and open water placement of dredged material, and periodic loss of production would occur during maintenance dredging. These areas may recover after activity has ceased, but the quality of the habitat may be reduced by repeated placement of dredged material. Dredging and placement activity will increase turbidity, which may impede gill function in finfish and shrimp not able to leave the area. Although turbidity studies indicated that dredging had no substantial effects on nekton (Flemer et al., 1968; Ritchie, 1970; Stickney, 1972; Wright, 1978), elevated turbidities can suffocate and reduce growth rates in adult and juvenile nekton and reduce viability of eggs (Moore, 1977; Stern and Stickle, 1978). Turbidities can be expected to return to near ambient conditions within a few hours after dredging ceases.

Benthos at the site, which would have been used as a food source, will be lost. Damage to marshes from placement of dredged material will reduce nursery areas available for finfish and shrimp. Potential contaminants (trace metals, TOC, or TPH) that may be in bottom sediments will be retained when dredging occurs, potentially exposing finfish and shrimp to contaminated materials. These potential impacts are associated with all dredging projects reviewed.

Shallow bay bottom habitat (0 to –12 MLT) will be impacted by the following projects: La Quinta Gateway (27.5 acres), Rincon Channel Federal Assumption of Maintenance (20 acres), Naval Station Ingleside (207 acres), and the Mine Warfare Center of Excellence (18 acres), and the CCSCCIP preferred alternative (399 acres). The CCSCCIP is the only project that identifies shallow bay depth differences; thus, all other reviewed projects impacts of shallow bay habitat are assumed at occurring between 0 to –12 MLT. Here the CCSCCIP impacts (399 acres) are combined. Packery Channel will negatively impact 38.5 acres of shallow bay bottom habitat. Realized benefits from Packery Channel will include 23.4 acres of shallow bay bottom habitat, 16 acres for JFK Causeway, and 5.5 acres of Naval Station Ingleside. BU sites for the CCSCCIP preferred alternative will create approximately 935 acres of shallow water habitat. A net gain of approximately 269.9 acres of shallow water and bay bottom habitat will occur from mitigation and beneficial uses for the reviewed projects. As presented in Section 5.4.1.1, a net gain of 26 acres of wetland habitat is estimated. The proposed new Packery Channel represents a small increase in habitat for those nekton species common in deeper off-shore waters (Breuer, 1962), resulting also in small, increased feeding and nursery areas for demersal fish (Breuer, 1972). Approximately 537 acres of Gulf of Mexico ocean bottom are expected to be negatively affected by the combined Packery Channel Project (11 acres) and the CCSCCIP preferred alternative (526 acres).

Possible impacts associated with the JFITC include runoff from the completed roadway and potential spills of toxic materials due to vehicle accidents that could degrade water quality along the alignment of the road. No consensus in the value has been assessed to the reopening of Packery Channel in reference to the routing of shrimp, crabs, and fish. Although the opening would provide ease of migration for aquatic organisms; the existing passes offer sufficient entry points for juvenile fish, according to Hoese (1965), Copeland (1965), and TGFC (1967).

5.4.1.3 Terrestrial Habitat

Terrestrial habitat as identified here includes upland grasslands, dunes, and channel fill sands (unstable washover sands). Terrestrial habitat present on any placement sites will be covered by deposition of the maintenance materials as a result of those reviewed projects requiring dredging activities. The vegetation that thrive on disturbed soils are likely to return after placement. These species are not anticipated to make significant contributions as food or detrital sources. The following projects will cause a total impact of 1,003.7 acres to terrestrial vegetation: JFITC (45 acres), La Quinta Gateway Project (295 acres), and Naval Station Ingleside (614 acres). Approximately 819 acres of cropland potentially impacted by the La Quinta Gateway project is not included as terrestrial habitat. Terrestrial vegetation found in the vicinity of the JFK Causeway will be destroyed during construction of the elevated bridge and causeway; however, the upland areas within the road ROW will continue to provide habitat for opportunistic species. Projects providing upland habitat include 5 acres created for the Rincon Channel Federal Assumption of Maintenance and a 120-acre upland site for the CCSCCIP preferred alternative.

For the Packery Channel Project, approximately 49.7 acres of primary and secondary dune complexes and upland grasslands will be covered by dredged material in four new PAs. Table 4.4-1 presents the impacts by vegetation community. The City of Corpus Christi (2002a) proposes to mitigate 5,670 cy (approximately 1.5 acres) of displaced dunes occurring within the critical dune area (1,000 feet of the mean high tide line) by restoring and revegetating dunes to a nearby location.

Though an approximate net loss of terrestrial habitat totals 877.2 acres among all of the reviewed projects, the CCSCCIP provides the greatest upland habitat benefit.

5.4.1.4 Terrestrial Wildlife (mammals/reptiles/amphibians)

The general study area, being mostly aquatic, is not considered high quality mammal or reptile and amphibian habitat; however, terrestrial species will be negatively affected by placement of dredged material on upland disposal sites or construction on undisturbed upland areas. Habitat which attracted them will be covered, resulting in death to any slow moving or non-motile species while others will be displaced. However, after dewatering for the upland disposal sites, the habitat will likely be revegetated with opportunistic species followed by recolonization by opportunistic, mobile wildlife species.

5.4.1.5 Threatened and Endangered Species

No impacts to threatened or endangered species are anticipated based on information presented in the reviewed projects in the general study area. The Biological Assessment (BA) for this Project is presented in Appendix C. Piping plover critical habitat will be affected by the dredging of Packery Channel. Approximately 6.2 acres of critical habitat (predominantly a recreation area) will be removed by channel and jetty construction. In addition, 24.6 acres of beach nourishment will be placed on critical habitat to aid in shoreline erosion. This placement is considered a temporary impact to foraging piping plovers. These impacts, considered in total, are not considered to be significantly adverse to the birds or the critical habitat.

5.4.1.6 Benthic Habitat/Bay Bottoms

Organisms present on open-bay bottom will be temporarily affected by the reviewed projects due to excavation and placement of dredged material. Dredging activity in association with the majority of the reviewed projects may temporarily reduce the quality of benthic habitat from increased turbidity. However, a 265-acre net gain will occur when considering mitigation and beneficial uses for bay bottom and shallow-water habitat, SAV, wetlands (salt marsh), and flats (see sections 5.4.1.1, 5.4.1.2, 5.4.1.9, and 5.4.1.10). Negative impacts associated with the loss of Gulf of Mexico ocean bottom will occur due to the dredging of Packery Channel (11 acres) and the CCSCCIP preferred alternative (526 acres). Beach placement of sands from dredging of Packery Channel will temporarily affect approximately 46 acres of benthic habitat. Most organisms present in areas covered for open-water placement sites will be permanently lost; however, recovery may occur after placement is completed. Recent studies in Corpus Christi Bay (Ray and Clarke, 1999) have indicated that recovery occurs at open-bay placement sites in less than 1 year. Smaller meiobenthic organisms are particularly resilient to sediment disturbances (Sherman and Coull, 1980). Opportunistic populations may colonize newly created benthic habitat reducing its value to foraging species, but are often replaced by more competitive and stress-tolerant species as conditions become more stable. Created marsh is expected to provide rich substrate for benthic populations to develop.

Toxic materials may be present in roadway runoff, which will negatively affect the benthos in the immediate vicinity of the JFITC and the JFK Causeway. Piers constructed to support the JFK Causeway and bridge are expected to be colonized by animals such as barnacles, oysters, and limpets, providing habitat for crabs, shrimp, small fish, and other marine organisms.

Aside from natural disturbances to the bay bottoms from storms, floods, freezes, and droughts, bay bottom loss is caused by anthropogenic activities including shrimp trawlers, channel dredging, chemical spills, and commercial and recreational boat operations. Total loss or historical data for losses in the CCBNEP by shrimp trawlers are not available, according to studies presented by Montagna et al. (1998). However, shrimp landings since 1972 comprise a much higher degree of magnitude within the Aransas Bay System than Corpus Christi Bay System and the Upper Laguna Madre, thus, reflecting a greater degree of trawl damage to the bay bottoms in the former area. Concerning the impacts associated with dredged bay bottoms for shipping channels, the historic trend, according to Montagna et al., (1998) has decreased since 1946, since the initial dredging for the GIWW. Although a decline of recreational boat traffic has occurred in the Upper Laguna Madre, an increase in recreational boat traffic in Aransas Bay and Corpus Christi Bay has occurred since the 1970s, resulting in relatively minor impact to open bay bottoms (Montagna et al., 1998). Based on studies for the CCBNEP (Montagna et al., 1998), few data regarding the degree of propeller scarring have been recorded. In addition, commercial shipping contributes to disturbance by eroding bay and channel margins and releasing contaminants, yet no data are assigned to these impacts.

5.4.1.7 Plankton

Increased turbidity during dredging will decrease light transmittance necessary for photosynthesis of phytoplankton. Increased turbidity may also negatively affect zooplankton by damaging their filtering mechanism and impeding respiration. These effects will only occur in the immediate vicinity of the dredge during the period of actual construction. Therefore, no long-term effects are expected.

Toxic materials released during construction of the projects reviewed or due to traffic accidents on the JFK bridge may have an adverse effect on plankton populations. However, data are not available to provide a quantitative analysis of the potential problem.

5.4.1.8 Essential Fish Habitat

Section 305(b)(1)(A and B) of the Magnuson Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act, 16 U.S.C 1801 et seq.), as amended, requires that the Regional Fishery Management Councils submit, by October 11, 1998, amendments to their Fishery Management Plans that identify and describe EFH for species under management. The act also requires identification of adverse impacts on EFH and the actions that should be considered to ensure that EFH is conserved and enhanced.

Based on direct impacts (867 acres) to submerged aquatic vegetation, salt marsh, shallow bay bottom habitat, and flats identified in the reviewed projects, the net gain from proposed mitigation and beneficial use areas amounts to approximately 265 acres, with the majority of this proposed by shallow water habitat. Given the size of this bay system, and the net gains from the projects, EFH will not be adversely affected.

5.4.1.9 Submerged Aquatic Vegetation

Based on the results of the document reviews, SAV will experience an area-wide increase. Approximately 935 acres of potential SAV habitat will be created in the BU site for the CCSCCIP. Four projects account for approximately 12.5 acres of negative impacts to SAV in the general vicinity. These include La Quinta Gateway Project (2.9 acres), CCSCCIP (5 acres), Naval Station Ingleside (1.1 acres), and Mine Warfare Center of Excellence (3.5 acres). Negative impacts to seagrass habitat by these projects will be mitigated.

Approximately 5.2 acres are to be negatively impacted for the Packery Channel Project. The design of the channel from the Inner Basin to the Gulf includes approximately 5.4 acres of broad shallow shelves to be created between the sides of the channel and the bulkheads. These areas may be suitable for natural SAV recruitment, assuming that conditions caused by tidal currents and vessel wakes are not too high in energy or turbidity. Coordination with the FWS will occur to discuss 3 to 1 mitigation for the impacts to seagrass for the Packery Channel Project. The 3 to 1 ratio will account for approximately 15.6 acres of seagrass to be planted. Overall with SAV mitigation, a potential net gain of 33.1 acres of SAV will be created by the reviewed projects.

As presented in the CCBNEP studies by Pulich et al. (1997), the Laguna Madre system has seen many changes since the 1950s, primarily in response to salinity changes. A summary of studies identified in the CCBNEP(Pulich et al., 1997) provide seagrass data results. In the Upper Laguna Madre from 1967 to 1988, shoalgrass increased; but from 1988 to 1994, shoalgrass decreased up to 60 percent with manateegrass becoming established in the northern part. Decreases since 1990 in the Upper Laguna Madre have been attributable to brown tide which reduces water clarity. Between 1958 and 1994, there has been an indication of an expansion of shoalgrass and widgeongrass on the backside of Mustang Island (Pulich et al., 1997). According to Pulich et al. (1997), general trends have shown that seagrass dynamics are highly variable with localized changes.

5.4.1.10 Tidal Flats (Sand/Algal)

Of the projects reviewed, the Naval Station Ingleside project identifies impacts to 112 acres of low-quality sand flats. Packery Channel may impact approximately 1.8 acres of tidal flats that includes 0.3 acre of proposed recreational developments. No mitigation has been proposed for any of the projects reviewed for tidal flats.

5.4.1.11 Open-Water Habitat

A loss of deep-bay open-water habitat is anticipated from the conversion to shallow-water marsh habitat and islands in the BU sites associated with the aforementioned CCSCCIP. The construction of Packery Channel will cause the loss of approximately 3.1 acres for jetty construction and dredged material placement. The benefit of BU sites outweighs the impact of loss of open-water due to the high productivity to be created in these areas.

5.4.1.12 Oyster Reef Habitat

No impacts to oyster reef habitat were indicated by the reviewed projects nor with Packery Channel, except the potential favorable impact noted in Section 4.5.1.2 from opening Packery Channel.

5.4.1.13 Coastal Shore Areas/Beaches/Sand Dunes

Impacts to coastal shore areas/beaches/sand dunes were not indicated by the reviewed projects. However, the Packery Channel Project will potentially impact approximately 86 acres of shore areas/beaches/sand dunes for channel construction, material placement, and park features. An additional 46 acres of beach may be covered by sand for beach nourishment. Secondary park development will result in approximately 7.4 acres of potential impact to these natural communities. The City of Corpus Christi proposes to relocate 5,670 cy of dunes (encompassing approximately 1.5 acres) to a depressional area landward of the foredune ridge.

5.4.2 Physical/Chemical Resources

Increases in both upland and submerged elevations from dredged material placement due to the reviewed projects are expected to change local circulation patterns.

5.4.2.1 Topography/Bathymetry

Minor changes in channel configuration is anticipated in several of the evaluated projects as a result of dredging activities to increases in depth and width. Periodic placement of maintenance material on open-water, unconfined PAs will temporarily decrease water depth in those areas until currents and wave action erode the dredged material away. Surface elevation will increase due to replacement of open bay with created marshes as BU sites and with the building of structures for reviewed projects. Projects impacting topography/bathymetry include Packery Channel (3.5 miles), JFK Causeway (0.9 mile), La Quinta Gateway Project (32 acres), Naval Station Ingleside (8.4 miles), and CCSCCIP (43 miles).

5.4.2.2 Noise

Noise impacts included in those projects associated with dredging will include operation and maintenance noise. This impact will be temporary, will move up and down the Project area depending on the section being dredged. An increase in recreational boat traffic at Packery Channel will likely increase the noise level in the Project vicinity.

5.4.2.3 Air Quality

Objectionable odors may result from the dredging of sediments containing high concentrations of organic matter in those reviewed projects requiring dredging. Temporary and intermittent maintenance dredging activities would emit NO_x and CO primarily. During operation, pollutants expected to be emitted include NO_x, CO, VOC, PM, SO_2, and hydrocarbons. No reviewed projects are anticipated to violate the NAAQS.

5.4.2.4 Water Quality/Turbidity

Contaminants originating from the Inner Harbor and contained in material displaced or dredged from the upper Corpus Christi Bay will be contained in PAs. Monitoring and management of the effluent from these sites will control the reintroduction of contaminants to the environment. All reviewed projects will comply with the requirements of NPDES during construction of the projects.

Water quality in the general study area is expected to temporarily degrade through increased turbidity and release of bound nutrients due to dredging and placement operations. This is true of all projects involving dredging and dredged material placement. No projects reviewed cited concerns with sediment contamination, including the proposed Project.

Dredging and placement at proposed open-water and upland PAs may increase suspended solids, release contaminants, if present, and bound nutrients, and deplete oxygen. This impact is temporary and, except for turbidity, mostly insignificant. If degradation occurs, the area of impact should return to existing conditions upon completion of dredging. Continued use of open-water PAs may provide a source of continuing turbidity due to erosion of dredged material by currents and wave action. Turbidity will occur in the immediate vicinity of the cutterhead dredge, near the point of open-water placement, and from runoff from construction sites during highway projects but not in equal concentrations.

A slight impact to water quality may occur as a result of vehicular use of the JFITC and the elevated JFK Causeway. Stormwater runoff, which may contain oil and grease may also have minimal impacts to water quality.

5.4.2.5 Sediment Quality

None of the reviewed projects identify sediment quality problems. According to Warshaw (1975), the sediment quality in the Laguna Madre was considered very good, since no significant industrial discharges were present and the GIWW traffic was light at that time. More recent sediment investigations by Barrera et al. (1995) reported that most sediments throughout the Upper Laguna Madre have only low levels of trace metal contamination, except for certain areas, and that sediment quality is still good. These areas in the Upper Laguna Madre involved relatively elevated levels of arsenic, boron, cadmium, copper, lead, mercury and zinc. EH&A (1998) demonstrated that contaminants adhere to the small particles of clay and silt rather than the larger sand particles that are predominant along the channel. Results of sediment sampling in Packery Channel found no constituents of concern. Potentially contaminated sediments from the Inner Harbor reach of the CCSCCIP will be placed in UCPAs.

Monitoring and management of the effluent from these sites will control reintroduction of these contaminants to the environment. In general, none of the projects examined, singly or as a group, are expected to significantly impact sediment quality.

5.4.2.6 Salinity

Existing salinity condition is anticipated to be maintained as a result of dredging and maintenance of the majority of projects reviewed. Possible changes in hydrodynamics from the proposed JFK Causeway and Packery Channel may cause localized changes, yet will not change the salinity structure of the Upper Laguna Madre or Corpus Christi Bay, as a whole (Hicks et al., 1999; TWDB, 1997). The proposed Packery Channel Project may result in a change in salinity of a few parts per thousand in the vicinity of the inlet, and much smaller changes well into Corpus Christi Bay and the Upper Laguna Madre.

5.4.2.7 Freshwater Inflows

No alteration to freshwater flow is anticipated from the proposed Packery Channel Project or from any projects reviewed in this analysis.

5.4.2.8 Circulation/Tides

Temporary, minor changes in circulation in the vicinity of open-water PAs containing newly placed materials are expected upon construction dredging and with the maintenance dredging process. Circulation is expected to return to existing conditions when the majority of the material has eroded away. No changes in turnover and tides are expected as a result of dredging the reviewed projects. Hicks et al. (1999) predicts a small, localized effect in hydrodynamics as water is allowed to move through a 2,550-foot water opening in the proposed JFK Causeway, rather than the present exchange through Humble Channel and the GIWW only. Opening of Packery Channel with the new inlet design will result in a slight increase (0.01 foot) in tidal range in Corpus Christi Bay and a decrease of generally less than 0.01 foot in tidal range in the Laguna Madre.

5.4.3 Cultural/Socioeconomic Resources

Socioeconomic impacts relate mainly to an increase in population, an increase in demand for housing, and impacts to land use. These impacts would occur in Nueces and San Patricio counties primarily in the following communities: Corpus Christi, Portland, Ingleside, Ingleside On-the-Bay, and Aransas Pass. The population increase that would result from the projects reviewed would be approximately 29,000 (assuming complete build-out of all projects). This increase in population would provide the impetus for a local demand of approximately 11,450 housing units. One business would be relocated as a result of the construction associated with the JFK Causeway. No EJ or community cohesion impacts would result from any of the projects reviewed. Land use impacts include development of approximately 1,300 acres of vacant land in San Patricio County, expanded roadways and rail-lines on the north side of the Corpus Christi Bay and within the Inner Harbor area of Corpus Christi. The Packery Channel Project would impact approximately 25 acres of currently vacant land, although approximately 20 of these acres would be converted to public parkland (including parking and minor structures). Cumulative impacts related to an increase in visitor usage of parks and recreational areas was not included, as these impacts were not addressed in any of the documentation prepared for any of the reviewed projects.

Socioeconomic benefits in Table 5.1-1 are grouped into construction (temporary) and those that would occur after Project construction is complete (permanent). The projects that were reviewed would provide an increase in annual employment of approximately 7,305 jobs (includes indirect and induced jobs), and wages for these jobs would be approximately $238 million annually. Total economic output within San Patricio and Nueces counties would be approximately $597 million annually, and indirect business taxes for local and State government would be $15.9 million annually. After completion on all reviewed projects, there would be an increase in annual employment of approximately 17,530 annual jobs, and wages for these jobs would be approximately $641.4 million annually. Total economic output within San Patricio and Nueces counties would be approximately $795.1 million, and indirect business taxes for local and State government would be $25.5 million annually.

Secondary effects would occur as a result of the reviewed projects. Increased development of North Padre and Mustang islands is anticipated as a result of improved access due to the JFK Causeway. The proposed Packery Channel Project would also increase tourist and recreational usage in the North Padre Island area. Economic development in this area is anticipated to result in increased commercial and residential development on North Padre Island. Within the projects reviewed transportation access will be improved with new channel development and maintenance of existing channels. Transportation safety will be improved in all channel projects and hurricane evacuation for Padre Island will be improved due to the JFK Causeway project.

5.4.3.1 Cultural Resources

None of the reviewed projects conflict with sites currently listed on the NRHP or are designated as SALs, nor does the proposed Packery Channel Project.

5.4.3.2 Oil and Gas Production on Submerged Lands

Current oil and gas pipelines are placed to accommodate existing channel dimensions. The majority of the reviewed project documents did not address oil and gas production; however, no change in oil and gas production is anticipated as a result of the projects evaluated.

5.4.3.3 Ship Accidents/Spills

The potential for accidental releases related to an increase in vessel traffic with the channel improvement or maintenance projects reviewed will exist; however, spill prevention plans can minimize impacts. The opening of Packery Channel would also potentially increase the occurrence of minor leaks and spills with the increase of recreational boating activities.

5.4.3.4 Recreation

The Corpus Christi Bay area is widely used by recreational fishermen and boaters. Turbidity associated with dredging and placement is anticipated to temporarily affect local fisheries in small portions of the general study area. Restricted areas are likely to be associated with the U.S. Navy projects (Naval Station Ingleside and Mine Warfare Center). Channel improvement projects like those reviewed provide greater access to and throughout the bay for recreational fishermen and boaters. Increased tourism would likely be a response to the opening of Packery Channel and the development of ancillary park facilities. Cumulative impacts associated with aquatic habitat are addressed in sections 5.4.1.2, 5.4.1.6, and 5.4.1.8.

5.4.3.5 Public Health/Safety

No negative impacts to public health are expected from the reviewed projects. The primary purpose of elevating the JFK Causeway to a minimum of 9 feet above MSL is to enhance public safety, particularly during natural emergencies such as hurricanes. Safety impacts to other reviewed projects were not indicated except for the improved safety in the CCSCCIP from channel widening.

For the Packery Channel Project, there may be a slight increase in flooding in Corpus Christi Bay during a hurricane surge, but the effect is not likely to be significant. Numerical simulations indicate that at normal tides, Packery Channel produces almost no change in the tides within Corpus Christi Bay (PBS&J, 1999b). At higher water levels such as occur in a hurricane surge, the barrier island will be overtopped. Under that condition the Packery Channel opening will have essentially no effect on water movement in and out of the bay. At the higher water levels where public safety is threatened by hurricane surge, Packery Channel will have no significant effect on flooding.

5.4.3.6 Parks and Beaches

The MMPA, encompassing approximately 7.5 acres, will be located in an undeveloped portion of Packery Channel County Park. Approximately 6.1 acres of beach area will be removed due to construction of the channel through the beach toward the Gulf. Beach nourishment will be placed over approximately 46 acres of beach to enhance the eroded shoreline. Public access to the channel and the jetties has been proposed as secondary development to the Project to provide additional recreation opportunities in the area, including parking areas and walkways, boat ramps, bathhouse/restroom facilities and vendor kiosks.

The documentation for the projects evaluated for this section did not indicate any adverse impacts to parks or beaches, with the exception of the Packery Channel Project. For the Packery Channel Project, beach will be removed due to channel construction, and beach nourishment in two areas will temporarily prevent use by the public.

An increase in visitation to parks and beaches in the Corpus Christi area, while not evaluated, can be easily inferred from the population increases predicted for the evaluated projects. The cumulative increase in population within Nueces and San Patricio counties from the full build-out of all of the projects would be approximately 29,100 people (Table 5.1-1). In addition, the Packery Channel Project would provide the impetus for an additional 4.4 million annual person-days of visitation to the Corpus Christi area. An increase in the local population and an increase in tourism to the area can be assumed to increase visitation to local parks and beaches.

5.4.3.7 Commercial and Recreation Species

Many commercially and recreationally important species of shrimp and finfish are common in the general study area, specifically, red drum, spotted seatrout, black drum, mullet, southern flounder, brown shrimp, and pink shrimp. These species will be adversely affected by the removal of nursery habitat due to dredging of marsh and seagrass habitat or open-bay bottom foraging habitat. Temporary and minor adverse effects on commercial and recreational fisheries may result from altering or removing fishing grounds and interfering with fishing activity. However, Packery Channel expansion plans should not significantly reduce the nekton standing crop. BU areas for the CCSCCIP will create approximately 935 acres of potential wetland/seagrass/bay bottom habitat to provide a positive impact from the negative impacts associated with the various projects reviewed.

5.5 CONCLUSIONS

Cumulative impacts due to past, existing, and reasonably foreseeable future projects, along with the proposed Project, were found to produce a net positive cumulative impact in the Project area. Although some parameters would experience negative impacts, most would be temporary and minor. Benefits realized through protection of seagrass and marsh habitat and creation by other projects, particularly the proposed CCSCCIP, resulted in a net positive impact assessment.

Economic growth would be expected at completion of the proposed reviewed projects in the shipping, transportation, and recreation sectors. The Packery Channel Project would particularly provide an increase in recreational and tourism development along with commercial and residential development, thus affecting the area's population and employment.

6.0 COMPLIANCE WITH TEXAS COASTAL MANAGEMENT PROGRAM (CMP)

6.1 INTRODUCTION

The Texas Coastal Management Program (CMP) was submitted to NOAA for review pursuant to §306 of the Federal Coastal Zone Management Act of 1972, as amended, 16 U.S.C. 1451 et seq. The Office of Ocean and Coastal Resource Management approved the CMP in 1996. Federal approval of the CMP requires that Federal actions occurring within the CMP boundary be consistent with the goals and polices of the CMP. To show compliance, Federal agencies responsible for these actions must prepare a consistency determination and submit it to the State for review. This consistency determination for channel improvements was prepared in accordance with the CMP, Final EIS, dated August 1996. Details of the Project, as well as environmental impacts, are presented in previous sections of this DEIS and will be referenced in this determination.

6.2 IMPACTS ON COASTAL NATURAL RESOURCE AREAS

The CMP's regulatory program focuses on management of 16 areas of particular concern identified as coastal natural resource areas (CNRAs) that are associated with coastal resources considered valuable, vulnerable, or unique. Several of the CNRAs listed in 31 TAC §501.3 are found reasonably close to the areas discussed in this DEIS. Each CNRA near the Project is briefly described, including the associated impacts, below.

6.2.1 Waters of the Open Gulf of Mexico

Waters of this CNRA include all those that are part of the Gulf of Mexico within the territorial limits of the State, including fishery habitat and resources, therein. The eastern terminus of the proposed alignment of Packery Channel will exit into the Gulf of Mexico. This outlet is not expected to result in adverse impacts to waters or fisheries within the open Gulf aside from minor, temporary negative effects from turbidity during the initial channel dredging and subsequent annual maintenance dredging, and placement of the jetty (2.9 acres).

6.2.2 Waters Under Tidal Influence

Waters under tidal influence include those waters mapped by TNRCC as such, including coastal wetlands. According to mapping provided by the Texas Coastal Coordination Council (1996), all waters near the Project are considered to be tidally influenced. Although changes in tidal range of approximately +0.01 foot in Corpus Christi Bay, –0.01 foot in Laguna Madre, and –0.09 foot in Packery Channel at Laguna Madre are estimated, the effects of these changes are expected to be minimal. Only approximately 0.2 acre of open water will be filled during the placement of dredged material at PA 3, and about 49.4 acres of open water underlie the footprint of the channel. The primary impacts to tidally influenced waters and wetlands, such as turbidity, will result from dredging and placement activities during the initial construction phase and during periodic maintenance. However, the release of suspended solids will be minimized according to requirements of the State §401 Certification. Impacts to coastal wetlands are addressed in Section 6.2.4.

6.2.3 Submerged Lands

Submerged lands are those lands under tidally influenced waters or under waters of the Gulf of Mexico, independent of whether they are State-owned. The length of Reach 2 and the Inner Basin are considered submerged lands. Impacts to these areas will be minimized, since the Project follows an existing channel along this reach.

6.2.4 Coastal Wetlands

The primary impacts to coastal wetlands will be caused by the loss of approximately 11.1 acres of high and low salt marsh. These habitats will be most affected by the proposed bulkhead construction and placement associated with changes to the Inner Basin and the gulfward extension of Packery Channel.

6.2.5 Submerged Aquatic Vegetation

This navigation project is located near areas characterized as having large expanses of seagrasses. Approximately 5.2 acres of SAV within the footprint of the channel and dredged material placement areas may be lost. The alignment was shifted during the conceptual stages of the Project to minimize direct impacts to SAV. Turbidity associated with dredging may temporarily reduce light conditions during high growth seasons. Dredged material placement, however, will be placed in upland sites (confined and partially confined) or on the beaches north and south of the jetties and is not expected to impact SAV.

6.2.6 Tidal Flats (Sand and Mud)

Tidal sand and mud flats are unvegetated (including those with algal mats) intertidal flats that are periodically exposed and flooded by tides. Much of the area north of the SH 361 bridge is considered tidal sand or mud flats and also contain algal mats. Since the existing channel lies adjacent to these CNRAs, impacts to these areas are expected to be minimal. However, within the proposed channel to be dredged approximately 1.5 acres of tidal flats are expected to be negatively impacted. An additional 0.3 acre of tidal flats would be negatively affected by proposed recreational development.

6.2.7 Oyster Reefs

Several significant oyster reefs exist in the Corpus Christi-Nueces Bay System, although they are absent from the Upper Laguna Madre (CCS, 1996). Therefore, adverse impacts to oyster resources are not expected to occur as a result of dredging and dredged material placement operations.

6.2.8 Hard Substrate Reefs

This CNRA includes rocky outcrops and serpulid worm reefs, living and dead, found in intertidal or subtidal areas. There are no naturally occurring hard substrate formations in the vicinity of the Project. The closest rock outcrop is located just north of the City of Aransas Pass and is crossed by the GIWW. The closest serpulid worm reefs are located farther south in the Laguna Madre and Baffin Bay.

6.2.9 Coastal Barriers

Undeveloped areas on barrier islands, peninsulas, or other protected areas designated by FWS maps are considered coastal barrier resources. One coastal barrier area, Mustang Island (Coastal Barrier Resources System unit #TX-15P, as mapped by FWS), will be impacted by the Project. Mustang Island is located north of the proposed alignment of Packery Channel. TX-15P will be impacted by the placement of dredged material at PA 2, PA 4N, and the MMPA, in addition to the construction of proposed recreational features and amenities. The portion of the Mustang Island coastal barrier resource to be affected by the Project is confined within largely undeveloped wildlife preserve areas and a small portion of a Nueces County beach park. PA 4N will be the site of beach nourishment with sandy material dredged from the construction and up-drift of the jetties.

6.2.10 Coastal Shore Areas

Coastal shore areas are within 100 feet landward of the high water mark on submerged land. These resource areas function as buffers, protecting upland habitats from erosion and storm damage and adjacent marshes and waterways from water quality degradation. This type of CNRA is found landward of Packery Channel along Reach 2 as well as surrounding the Inner Basin. Land along Reach 2 should not be impacted by the Project. Dredged material will be placed on the coastal shore areas adjacent to all lands along Reach 1, including PA 4. Adverse impacts to coastal shore areas are expected to be minimal.

6.2.11 Gulf Beaches

Gulf beaches border the Gulf of Mexico and extend inland from the line of mean low tide to the natural line of vegetation. The area of North Padre Island flanking Packery Channel as it exits into the Gulf, including PA 4N and PA 4S, covers Gulf beaches. Aside from the channel that will be dredged, the Gulf beach underlying PA 4 will be nourished with sand from the construction and up-drift from the jetties. This will help to abate historic erosion along North Padre Island's Gulf beach. Approximately 9.2 acres of beaches will be directly impacted by the dredging of the channel and placement of dredged maintenance material. Approximately 46 acres of beach nourishment is proposed; thus, a temporary impact will occur to the beach area when sand placement occurs. Potential secondary public park improvements may impact 3.7 acres of beach.

6.2.12 Critical Dune Areas

Critical dune areas include those dunes within 1,000 feet of the mean high tide line. The portions of Packery Channel, PA 1, PA 2, and associated recreational facilities that fall within this zone will result in displacement of critical dune areas. However, the utilization of an existing washover minimizes the impacts to dunes from the Project. The City of Corpus Christi (2002a) proposes to relocate approximately 5,670 cy of dunes (approximately 1.5 acres) to a depressional area between PA 2 and Zahn Road landward of the foredune ridge.

6.2.13 Special Hazard Areas

Special hazard areas are areas designated by the administrator of the Federal Insurance Administration under the National Flood Insurance Act as having special flood, mudslide, and/or flood-related erosion hazards. The Project is within special flood hazard areas mapped within 100-year coastal floodplain with velocity and 100-year floodplain (FEMA, 1985). Potential development associated with the opening of Packery Channel will likely occur.

6.2.14 Critical Erosion Areas

These areas are those Gulf and bay shorelines that are undergoing erosion and are designated by the Commissioner of the General Land Office under Texas Natural Resources Code, §33.601(b). The closest critical erosion area is found in Aransas Bay north of the Project area; thus the Project is not expected to affect any designated critical erosion areas.

6.2.15 Coastal Historic Areas

This CNRA consists of sites listed or eligible for listing on the NRHP and SALs. Compliance with the CMP regarding coastal historic areas is accomplished through procedures established by Section 106 of the National Historic Preservation Act of 1965 (NHPA), as amended. These coastal historic sites, as well as non-coastal historic sites, are discussed in Section 3.8 of this DEIS, with impacts discussed in Section 4.8.

6.2.16 Coastal Preserves

This natural resource includes only State-owned lands, including wildlife management areas and parks, that are identified as coastal by TPWD. Three State-owned lands in the general project area include: 1) Mustang Island State Park located within Coastal Barrier Resources unit #TX-15P, north of the Project; 2) Redhead Pond Wildlife Management Area, a small area located on the mainland side of the Laguna Madre south of the JFK Causeway; and 3) MBHC which occurs just north of the existing Packery Channel. Based on their distance from the Project, impacts are not expected to occur from dredging or dredged material placement to Mustang Island and Redhead Pond Wildlife Management Area. MBHC, just to the north of SH 361, is an important wildlife area managed by the GLO with the support of the management team (TPWD, FWS, and the National Audubon Society). MBHC encompasses much of piping plover critical habitat unit TX-6. The existing Packery Channel (Reach 2) occurs immediately south of the MBHC. The boundary between MBHC and the existing Packery Channel is not readily discernible; however, the proposed widening and deepening of the existing channel will occur within current limits of the channel. Potential negative impacts to MBHC are associated with the dredging process and will include turbidity in the water and noise from equipment and humans. These direct impacts are considered temporary and, thus, would not result in significant long-term implications. Potential shoreline erosion adjacent to Packery Channel due to increased boat traffic and wakes and hydrologic changes due to reopening the channel to the Gulf are a concern. Secondary impacts may include an increase in public use of MBHC due to the construction of Packery Channel resulting in an increase in vehicle traffic, including watercraft and automobiles.

6.3 COMPLIANCE WITH GOALS AND POLICIES

The following goals and policies of the CMP were reviewed for compliance. A summary of actions designed to comply with the specific requirements are presented in Appendix A.

§501.14(h)	Development in Critical Areas
§501.14(i)	Construction of Waterfront Facilities and Other Structures on Submerged Lands
§501.14(j)	Dredging and Dredged Material Disposal and Placement
§501.14(k)	Construction in the Beach/Dune System
§501.14(m)	Development Within Coastal Barrier Resource System Units and Otherwise Protected Areas on Coastal Barriers
§501.15	Policy for Major Actions

6.4 ENVIRONMENTAL BENEFITS

Beach nourishment will provide a positive impact from placing dredged material on the shoreline. This will counter the current erosional trend of the shoreline. Placement of this sandy material will provide some storm protection, add public beach areas, and sustain forage habitat for piping plovers.

6.5 CONSISTENCY DETERMINATION

The Project addressed in this DEIS has been reviewed for consistency with the goals and policies of the CMP. CNRAs in the Project area are identified and evaluated for potential impacts from activities associated with the Project. Based on this analysis, the USACE finds that the Project discussed in the DEIS is consistent with the goals and policies of the CMP to the maximum extent practicable.

Appendix A provides a summary of actions designed to comply with the specific requirements of §501.14(h–k, and m).

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Date

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Leonard D. Waterworth
Colonel, U.S. Army Corps of Engineers
District Engineer

7.0 CONSISTENCY WITH OTHER STATE AND FEDERAL REGULATIONS

This DEIS has been prepared to satisfy the requirements of all applicable environmental laws and regulations and has been prepared using the CEQ's NEPA regulations (40 CFR Part 1500) and the USACE's regulation ER 200-2-2 (Environmental Quality: Policy and Procedures for Implementing NEPA, 33 CFR 230). The following section presents a summary of environmental laws, regulations, and coordination requirements applicable to this DEIS.

NATIONAL ENVIRONMENTAL POLICY ACT

This DEIS has been prepared in accordance with CEQ regulations in compliance with NEPA provisions. All impacts on terrestrial and aquatic resources have been identified.

NATIONAL HISTORIC PRESERVATION ACT OF 1966

Compliance with the NHPA of 1966, as amended, requires identification of all NRHP-listed or NRHP-eligible properties in the Project area and development of mitigation measures for those adversely affected in coordination with the SHPO and the Advisory Council on Historic Preservation. Consultation has been initiated with the SHPO, and a research design for the additional terrestrial archeological survey with shovel testing, terrestrial remote sensing, and underwater remote sensing has been submitted.

CLEAN WATER ACT

Sections 401 and 404 of the act apply to the proposed alternative and compliance will be achieved. A discussion based on the Section 404(b)(1) guidelines is included in this DEIS. The Section 404(b)(1) evaluation is presented in Appendix E.

In Texas, Section 401 of the Clean Water Act, the State Water Quality Certification Program, is regulated by the TNRCC. The TNRCC provides a Section 401 certification to the USACE indicating that activities in wetlands and other waters under State jurisdiction comply with the State's water quality requirements. A 401 State Water Quality Certification will be obtained from the TNRCC and will be enclosed in the FEIS.

Previous USACE permits issued for dredging the channel and installation of bulkheads and jetties do not apply.

ENDANGERED SPECIES ACT OF 1973

Interagency consultation procedures have been undertaken. A BA describing the study area, Federally listed endangered and threatened species likely to occur in the area (as provided by the FWS and NMFS), and potential impacts on these listed species (see Appendix B) has been presented to the FWS for review. The results of the assessment and agency comments will be published as an attachment to the FEIS. The NMFS has guidelines to protect sea turtles when hopper dredges are being used. These guidelines will be followed.

FISH AND WILDLIFE COORDINATION ACT OF 1958

This act requires the FWS to prepare an official Fish and Wildlife Coordination Act Report (CAR). The CAR will be included in the FEIS as part of the Coordination Section.

FISHERY CONSERVATION AND MANAGEMENT ACT OF 1996

Congress enacted amendments to the Magnuson-Stevens Fishery Conservation and Management Act (PL 94-265) in 1996 that established procedures for identifying EFH and required interagency coordination to further the conservation of Federally managed fisheries. Rules published by NMFS (50 CFR Sections 600.805 – 600.930) specify that any Federal agency that authorizes, funds or undertakes, or proposes to authorize, fund, or undertake an activity that could adversely affect EFH is subject to the consultation provisions of the above-mentioned act and identifies consultation requirements.

EFH consists of those habitats necessary for spawning, breeding, feeding, or growth to maturity of species managed by Regional Fishery Management Councils in a series of Fishery Management Plans. Sections 3.5.1.3, 4.5.1.3 and 5.4.1.8 of the DEIS were prepared to address EFH in the Project area and meet the requirements of the act.

COASTAL BARRIER IMPROVEMENT ACT OF 1990

This act is intended to protect fish and wildlife resources and habitat to prevent loss of human life and to preclude the expenditure of Federal funds that may induce development on coastal barrier islands and adjacent nearshore areas. Certain exceptions exist which allow for such expenditures. Less than 600 acres have been designated for protection under the act. The Federal Emergency Management Agency (FEMA) provides a list of these Coastal Barriers Resources Systems Units for protection. The proposed Project is exempt from the prohibitions identified in the act.

MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT

This 1972 act requires a determination that dredged material placement in the ocean will not reasonably degrade or endanger human health, welfare, or amenities or the marine environment, ecological systems, or economic potentialities (shellfish beds, fisheries, or recreational areas). All construction material will be placed onto upland areas.

FEDERAL WATER PROJECT RECREATION ACT

This 1995 act requires consideration of opportunities for outdoor recreation and fish and wildlife enhancement in planning water resource projects. Proposed park features have been identified adjacent to Packery Channel to allow for additional access to (and use of) the channel.

EXECUTIVE ORDER 11988, FLOODPLAIN MANAGEMENT

This EO directs Federal agencies to evaluate the potential effects of proposed actions on floodplains. Such actions should not be undertaken that directly or indirectly induce growth in the floodplain unless there is no practical alternative. The Project is within areas designated as 100-year coastal flood with velocity and 100-year flood (FEMA, 1985). Potential development associated with the opening of Packery Channel will likely occur.

EXECUTIVE ORDER 11990, PROTECTION OF WETLANDS

This EO directs Federal agencies to avoid undertaking or assisting in new construction located in wetlands, unless no practical alternative is available. The preferred alternative has been analyzed for compliance with EO 11990. The proposed Project will impact the following: wetlands (7.4 acres), SAV (4 acres), algal mats (0.4 acre), and sand/mud flats (26.1 acres).

TEXAS COASTAL MANAGEMENT PROGRAM

Appendix A addresses the compliance of the proposed Project addressed in this DEIS with the CMP.

CEQ MEMORANDUM DATED 11 AUGUST 1980, PRIME OR UNIQUE FARMLANDS

There will be no impacts to prime and unique farmlands from the proposed Project.

EXECUTIVE ORDER 12898, ENVIRONMENTAL JUSTICE

This EO directs Federal agencies to determine whether the proposed Project will have a disproportionate adverse impact on minority or low-income population groups within the Project area. The proposed Project will not significantly affect any low-income or minority population.

CLEAN AIR ACT OF 1972

This act is intended to protect and enhance the quality of the nation's air resources, to initiate and accelerate research and development to prevent and control air pollution, to provide technical and financial assistance for air pollution prevention and control programs, and to encourage and assist regional air pollution prevention and control programs. The preferred alternative is in compliance with this act.

This Project is in Nueces County, which is an attainment area for air quality. A Clean Air Act conformity analysis for the Project is not required.

MARINE MAMMAL PROTECTION ACT of 1972

This act, passed in 1972 and amended through 1997, is intended to conserve and protect marine mammals, establish a Marine Mammal Commission, establish the International Dolphin Conservation Program, and establish a Marine Mammal Health and Stranding Response Program. The proposed action will be in compliance with this act, so that certain species and population stocks of marine mammals will not be diminished beyond the point at which they cease to be a significant functioning element in the ecosystem of which they area a part, nor below their optimum sustainable population level.

8.0 LIST OF PREPARERS

The USACE Project Manager for the North Padre Island Storm Damage Reduction and Environmental Restoration Project is Carl Anderson.

PBS&J key personnel responsible for preparation of the DEIS are listed below:

Topic/Area of Responsibility	Name/Title	Experience
U.S. Army Corps of Engineers, Galveston District		
Project Coordination & Development	Carl M. Anderson Project Manager	25 Years, Construction and Project Management
Document Coordination & Review	Carolyn Murphy Environmental Section Chief	24 Years, Planning and Environmental Resources
Design Project Engineer, Technical Team Leader	David Brown Project Engineer	19 Years, Engineering
Water and Sediment Quality Review	Rob Hauch Physical Scientist	21 Years, Water and Sediment Quality Evaluations
Cultural Resources Coordination and Review	Janelle Stokes Archeologist	21 Years, Cultural Resources Coordination, Archeological Research and Surveys
Document Coordination & Review	Terrell W. Roberts, Ph.D. Wildlife Biologist	18 Years, Environmental, Threatened, and Endangered Species Impact Analysis
Document Coordination & Review	Sam Watson Environmental Specialist	9 Years, Regulatory, Environmental and Aquatic Resource Assessment
Air Quality; Water Quality; Hazardous, Toxic, and Radioactive Waste; Noise Impact Coordination & Review	David McLintock Environmental Protection Specialist	26 Years, Environmental Protection, Compliance, and Engineering
PBS&J:		
Project Manager, Water and Sediment Quality	Martin Arhelger Vice President, Project Director	27 Years, Environmental Assessment and Impact Analysis
Assistant Project Manager, Document Review, Cumulative Impacts	Patsy Turner Ecologist	17 Years, Environmental Assessment and Impact Analysis with Emphasis on Vegetation
Noise	Thomas Ademski Environmental Planner	3 Years, Environmental Planning and Noise Analysis
Historical/Cultural Resources	Clell Bond Vice President, Cultural Resources Director	35 Years, Archeology, Cultural Resources Management
Technical Support	Bob Bryant Lead Word Processor	13 Years, Word Processing

Topic/Area of Responsibility	Name/Title	Experience
PBS&J (cont'd):		
Vegetation; Endangered and Threatened Plant Species	Kathy Calnan Ecologist, Botanist	13 Years, Vegetation Analysis and Impacts
Historical/Cultural Resources – Marine	Bob Gearhart Archeologist; Magnetometer and Side-Scan Sonar Specialist	18 Years, Marine Archeology
Wildlife and Habitat; Endangered and Threatened Wildlife Species	Derek Green Biologist, Wildlife Specialist	20 Years, Environmental Assessment and Impact Analysis
Technical Support	David Kimmerling CAD/Graphics Specialist	18 Years, Graphics
Hazardous Materials	Steve McVey Geologist, HAZMAT Specialist	8 Years, Environmental Geology
Land Use; Environmental Justice; Socioeconomics	Chris Moore Environmental Planner	6 Years, Urban and Environmental Planning
Technical Support	Gray Rackley CAD/GIS Specialist	4 Years, CAD/GIS
Historical/Cultural Resources – Terrestrial	Robert Rogers Archeologist, Geoarcheologist	20 Years, Geomorphology
Air Quality	Ruben Velasquez, P.E. Senior Engineer, Air Quality Specialist	19 Years, Air Quality Analysis
Essential Fish Habitats	Lisa Vitale Marine\Aquatic Biologist	10 Years, Marine/Aquatic Biology

9.0 PUBLIC INVOLVEMENT, REVIEW, AND CONSULTATION

9.1 SCOPING PROCESS

Since the development of a feasibility study for reopening Packery Channel began in 1985, Federal, State and local agencies and the public have had numerous opportunities to identify issues regarding the Project. During the time leading up to preparation of an EIS, issues were raised by Federal, State, and local agencies; local officials; local and regional conservation groups; representatives of local business; and the public.

An information gathering session was held on 22 February 1999 to provide input on a proposed Scope of Work for studies to be utilized for the USACE expanded Project Study Plan (PSP, USACE, 1999). Agencies involved were TPWD, FWS, TNRCC, TWDB, GLO, NMFS, USGS, and the USACE. Representatives from Nueces County, the non-Federal sponsor until March 2000, and their consultants were also present, as was the Port of Corpus Christi Authority. A second informal session was held 1 April 1999 in conjunction with the Coastal Bend Bays Foundation (CBBF) board meeting. In addition to these two sessions, individual interviews were conducted with Dr. Scott Holt (University of Texas-Marine Science Institute (UTMSI)), Dr. Wes Tunnell (Texas A&M University-Corpus Christi Center for Coastal Studies) and Dr. Chris Onuf (USGS – Biological Resources Division). Comments and suggestions provided during these sessions and interviews were incorporated into the PSP to the extent possible.

On August 17, 2000, the USACE issued a Public Announcement (Appendix D) to provide Notice of Studies and Initial Public Scoping Meeting for the current Project. The Public Announcement also provided notice that the deadline for mailing comments to the USACE was September 29, 2000. The public meeting was held at the Bayfront Convention Center in Corpus Christi, Texas, on September 7, 2000, starting at 6:00 p.m. The purpose of the meeting was to inform the public of the ongoing study activities for the Packery Channel Project and to solicit public input regarding the study. A court reporter was present to transcribe comments made by the public during the scoping meeting, and each attendee had the option to either hand in or mail in a written comment or concern. The official transcript of the meeting is on file at the USACE, Galveston District office. Public comments received during the scoping process were incorporated into the work plan for the DEIS and are included in Appendix D.

9.2 OPTIONAL PUBLIC MEETINGS

As the former Project sponsor, Nueces County officials allowed the public to voice comments and concerns at hearings of the Nueces County Commissioners Court in January and February 1996. On April 1, 1999, a special presentation by USACE was conducted at a CBBF board meeting to provide information pertinent to the scope of work for the Packery Channel Project.

9.3 AGENCY COORDINATION

To address the complex issues associated with the proposed Project, the following Federal, State, and local agencies were formally invited by the USACE to provide technical advice during the meeting, noted in Section 9.1, before the PSP (USACE, 1999) was prepared: NMFS, FWS, USGS, EPA, TPWD, TNRCC, TWDB, GLO, Texas Department of Transportation (TxDOT), and PCCA.

The FWS and the TPWD were consulted before an 8-month piping plover survey (PBS&J, 2001b) was conducted. An August 2, 2001, meeting was attended by the USACE, GLO, TNRCC, TPWD, FWS, and City of Corpus Christi representatives. A list of agencies and interested persons and groups to whom the DEIS will be sent for formal review and comment is provided in Section 9.6.

Appendix A addresses the compliance of the proposed Project with the Texas Coastal Management Program and is presented for GLO review.

A letter report, providing a summary of the results of a cultural resources remote-sensing survey of the Packery Channel area, sent to the SHPO is provided in Appendix D. The concurrence stamp has been provided and signed by the SHPO in concurrence with a finding of No Historic Properties Affected.

9.4 PUBLIC VIEWS AND RESPONSES

The public views and concerns expressed during the various information gathering sessions and the public scoping meeting for this Project have been considered during the implementation of this DEIS. At the Public Hearing of September 7, 2000, concerns were expressed relative to (1) an inadequate project design and an underestimate of long-shore sand transport leading to dangers to boaters and increased frequency of maintenance dredging; (2) increased storm surge to Padre and Mustang Islands and the mainland; (3) increased development on the islands; (4) use of public funds for returns to private interests; (5) noise from frequent, if not continuous, channel dredging; the liability associated with accidents and any increased damage from hurricane surge. Proponents noted the beach protection and restoration aspects of the Project and the economic benefits.

9.5 EIS REVIEW PROCESS

The notice of availability of this DEIS in the Federal Register initiates a 45-day comment period during which comments are solicited from Federal, State, and local agencies, groups, and the public. A public hearing will be held after the DEIS has been available for review for a minimum of 15 days. After the public hearing and the end of the comment period, the USACE will respond to the comments received and prepare and distribute the FEIS. Comments on the FEIS will be received during a 30-day review period. A Record of Decision will then be issued which will document the end of the NEPA process.

9.6 LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES OF THE DRAFT STATEMENT WILL BE SENT

9.6.1.1 Federal Agencies

- U.S. Environmental Protection Agency
- National Marine Fisheries Service
- U.S. Fish and Wildlife Service
- U.S. Coast Guard

9.6.1.2 State Agencies

- Texas Department of Transportation
- Texas General Land Office
- Texas Historical Commission
- Texas Natural Resource Conservation Commission
- Texas Parks and Wildlife Department
- Texas Railroad Commission
- Texas Water Development Board

9.6.1.3 Elected Officials

- U. S. Senator, Kay Bailey Hutchison
- U.S. Senator Phil Gramm
- U.S. Representative Ruben Hinojosa
- U.S. Representative Solomon Ortiz
- Texas State Senator Carlos Truan
- Texas State Representative Gene Seaman
- Texas State Representative Vilma Luna
- Texas State Representative Jaime Capelo, Jr.
- Mayor Loyd Neal, City of Corpus Christi
- City Manager, City of Port Aransas
- Mayor Alfred Robbins, City of Ingleside
- Mayor Karen Gayle, City of Aransas Pass
- Mayor Joe Burke, City of Portland
- Nueces County Judge Richard Borchard

9.6.1.4 Organizations

- Port of Corpus Christi Authority
- Coastal Bend Bays and Estuaries Program
- Regional Director, Nueces River Authority
- Capt. Mike Kershaw, Pilots Association
- Texas Waterway Operators Association
- Douglas W. Svendson, Jr., Gulf Intracoastal Canal Association
- Padre Island Business Association
- Coastal Conservation Association
- Coastal Bend Environmental Coalition
- Common Cause

10.0 BIBLIOGRAPHY, ACRONYMS & ABBREVIATIONS

Adams, J. 2002. Personal communication to Kathy Calnan, PBS&J. Texas A&M University-Corpus Christi, Conrad Blucher Institute (TAMU-CBI). Corpus Christi, Texas. March 19.

Alexander, F., E. Cousins, K. Evans, S.J. Johnson, V.W. McKinney, P. Peckenpaugh, B. Roberts, L.H. Sparks, E.M. Tubbs, H.W. Ward, E.D. Williams, M.P. Wise, and D. Woods. 1950. Padre Island by Writers' Round Table. The Naylor Company, San Antonio, Texas.

American Ornithologist's Union (AOU). 1983. Committee on classification and nomenclature. Check-list of North American birds. 6th edition. American Ornithologists Union, Allen Press, Inc., Lawrence, Kansas.

———. 1998. Check-list of North American birds. 7th edition. Allen Press, Lawrence, Kansas. 829 pp.

Audubon Outdoor Club of Corpus Christi (AOCCC). 1994. Checklist of the birds within a 40-mile radius of Corpus Christi, Texas. 6th edition. Audubon Outdoor Club of Corpus Christi, Corpus Christi, Texas.

Bailey, G.L. 1987. Archeological Bibliography of the Southern Coastal Corridor Region of Texas. Special Report 29. Office of the State Archeologist, Texas Historical Commission, Austin.

Barrera, T.A., Gamble, L.R., Jackson, G. Maurer, T. Robertson, S.M. and M.C. Lee. 1995. Contaminants assessment of the Corpus Christi Bay complex, Texas 1988-1989. U.S. Fish and Wildlife Service, Ecological Services, Corpus Christi, Texas, Region 2. September 1995. 61 pp. + appendices.

Bartlett, R.D. and P.P. Bartlett. 1999. A field guide to Texas reptiles and amphibians. Gulf Publishing Company, Houston, Texas.

Beasley, P.W. 1998. Texas Agricultural Experiment Station, Texas A&M University System, Port Aransas, Texas. Personal communication to F. Davis, EH&A, October 29.

Beaver, C. 2001. Center for Coastal Studies, Texas A&M University at Corpus Christi. Personal communication with Sam Copeland, PBS&J, 24 September.

Black, S.L. 1989. South Texas Plains. In: From the Gulf to the Rio Grande: Human Adaptation in Central, South, and Lower Pecos, Texas. Arkansas Archeological Survey Research Series No. 33.

Blair, W.F. 1950. The Biotic Provinces of Texas. Tex. J. Sci. 2:93-117.

Board of Engineers. 1846. Chart of Aransas and Corpus Christi Bays, report of Board of Engineers, July 9, 1846. La Retama Public Library. Corpus Christi, Texas.

Bond, C.L. and S. Kotter. 1989. Cultural resources survey of proposed Corps of Engineers disposal areas 182A and 187A, Corpus Christi Bay to Baffin Bay, Padre Island, Kleberg County, Texas. EH&A document no. 890257. Austin, Texas.

Bond, C.L. and R.R. Rogers. 2001. A cultural resources survey of Packery Channel, Nueces County, Texas. Prepared for U.S. Army Corps of Engineers, Galveston District. PBS&J document no. 010265. August.

Bond, C., R. Gearhart, J. Enright, and D.L. Sherman. 2002. Additional Cultural Resources Survey of the Packery Channel Project, Nueces County, Texas. Prepared for the U.S. Army Corps of Engineers, Galveston District. February 2002.

Bowles, W.F., Jr. 1983. Intensive survey of thee Brownsville Ship Channel (Segment 2494). Field measurements, water chemistry, sediment chemistry and biological indices. IS-55. Texas Department of Water Resources, Austin, Texas. 49 pp.

Brannon, J.M., R.H. Plumb, and I. Smith. 1978. Long-term release of contaminants from dredged material. DMRP. USAEWES. Technical Report D-78-49.

Breuer, J.P. 1962. An ecological survey of the lower Laguna Madre of Texas, 1953-1959. Publications of Institute of Marine Sciences, University of Texas 8: 153-183.

———. 1972. Ecological survey of the Brownsville Ship Channel, 1971-1972. Coastal Fisheries Project, TPWD. Mimeo.

Briggs, A.K. 1971. Archeological resources in the Texas coastal lowlands and littoral. Office of the State Archeologist Special Report 5. Texas Historical Commission, Austin, Texas.

Britton, J.C. and B. Morton. 1989. Shore ecology of the Gulf of Mexico. University of Texas Press, Austin, Texas, 387 pp.

Brown, C.L. and R. Clark. 1968. Observations on dredging and dissolved oxygen in a tidal waterway. Water Resour. Res. 4(6): 1381-1384.

Brown, D. 2001. Project Engineer, USACE, Galveston District. Electronic mail to Trap Puckette (URS). July.

Brown, L.F. Jr., J.H. McGowen, T.J. Evans, C.G. Groat and W.L. Fisher. 1977. Environmental geologic atlas of the Texas coastal zone-Kingsville area. Bureau of Economic Geology, University of Texas, Austin, Texas. 131 pp.

Brown, L.F. Jr., J.L. Brewton, J.H. McGowen, T.J. Evans, W.L. Fisher, and C.G. Groat. 1976. Environmental geologic atlas of the Texas coastal zone: Corpus Christi area. Bureau of Economic Geology, University of Texas, Austin, Texas. 123 pp.

Burd, A.B. and K.H. Dunton. 2001. Field verification of a light-driven model of biomass changes in the seagrass *Halodule wrightii*. Marine Ecology Progress Series (MEPS) 209:85-98 (abstract). Jan. 5. Inter-Research, Oldendorf/Luhe.

Buschang, S. 2002. Personal communication with Kathy Calnan, PBS&J, Austin, Texas. Texas General Land Office, Corpus Christi, Texas. April 11.

Buskey, E.J., S. Stewart, J. Peterson, and C. Collumb. 1996. Current status and historical trends of Brown Tide and Red Tide phytoplankton blooms in the Corpus Christi Bay National Estuary Program Study Area. 1-173 pp. In T.E. Whitledge and J. W. Tunnell Jr. (eds.), Corpus Christi Bay National Estuary Program – Living Resources. Vol: CCBNEP-07. Texas Natural Resource Conservation Commission, Austin, Texas.

Calhoun, C.A. 1964. A polychrome vessel from the Texas Coastal Bend. Bulletin of the Texas Archeological Society 35:205-212.

Calnan, T.R., R.S. Kimble, and T.G. Littleton. 1986. Benthic macroinvertebrates, Pp. 45-66 in: W.A. White et al. 1986, Submerged lands of Texas, Brownsville-Harlingen area: sediments, geochemistry, benthic macroinvertebrates, and associated wetlands. Bureau of Economic Geology, The University of Texas at Austin. 138 pp. +maps.

Campbell, L. 1995. Endangered and threatened animals of Texas, their life history and management. Texas Parks and Wildlife Department, Resource Protection Division, Endangered Resources Branch. Austin, Texas. 130 pp.

Campbell, T.N. 1956. Archeological material from Five Islands in the Laguna Madre, Texas coast. Bulletin of the Texas Archeological Society, Volume 27.

———. 1958. Archeological remains from the Live Oak Point site, Aransas County. The Texas Journal of Science 10(4):423-442.

———. 1964. Appraisal of the Archeological Resources of Padre Island, Texas. Report submitted to the National Park Service by the Anthropology Department, The University of Texas at Austin.

Carlson, D.L. 1983. Archeological survey of the Hilltop Nature Area, Nueces County, Texas. Archeological Research Laboratory, Texas A&M University, College Station, Texas.

Carlson, D.L., D.G. Steele, and H.L. Bruno. 1982. Archeological Investigations at the Allison Site (41NU185), Nueces County, Texas. Reports of Investigations No. 1. Archeological Research Laboratory, Texas A&M University, College Station, Texas.

Center for Coastal Studies (CCS). 1996. Project summary for current status and historical trends of the estuarine living resources within the Corpus Christi Bay National Estuary Program study area. Volume 3. CCBNEP-06C. Texas Natural Resource Conservation Commission, Austin, Texas.

Cisneros, Tony. 2002. Telephone communication between Chris Moore (PBS&J), and Tony Cisneros (Director) of the City of Corpus Christi – Parks and Recreation Department. March 11, 2002.

Coastal Bend Bays Plan (CBBP). 1998. Published by Texas Natural Resource Conservation Commission, Austin, TX. SFR-59/CBBEP-1.

Coastal Impact Monitoring Program (CIMP). 1995. Report of literature review on discharges from the Rio Grande and Arroyo Colorado and their impacts. Texas General Land Office, Austin, Texas. GLO-9/95.

Collins, H.C., H.S. Douglas, and W.H. Hoffman. 1878. To accompany report on survey of Corpus Christi and Aransas passes and bays and their connections. Texas Historical Commission, map file of the State Nautical Archaeologist. Austin. Texas.

Collins, J.T. 1990. Standard common and current scientific names for North American amphibians and reptiles. Third ed. Society for the Study of Amphibians and Reptiles, miscellaneous publications, Herpetological Circular No. 19. 41 pp.

Compagno, L.J.V. 1984. Sharks of the world. An annotated and illustrated catalogue of sharks species known to date. Part 1. Hexanchiformes to Lamniformes. FAO Fish Synop. 125:1-249.

Copeland, B.J. 1965. Fauna of the Aransas Pass (Texas) inlet. Part 1. Larval and post-larval fish. Publication of the Marine Science Institute of the University of Texas. Volume 10.

Copeland, B.J. and W. Truitt. 1966. Fauna of the Aransas Pass (Texas) inlet. Part 2. Post larval penaeid shrimp. Texas Journal of Science. March 1966.

Corbin, J.E. 1963. Archeological materials from the northern shore of Corpus Christi Bay, Texas. Bulletin of the Texas Archeological society 34:5-30.

Corpus Christi Caller Times. 1972. 3 September edition. Corpus Christi public library. Corpus Christi, Texas.

———. 2000. "A Matter of Location - Island Setting Brings Steady Flow of New Development to Port Aransas, North Padre Island." November 4. Available on the internet: <www.caller2.com/2000/november/04/today/local_ne/8344.html> Accessed on March 28, 2002.

Corpus Christi Chamber of Commerce. 2002. Economic Overview. Available on the Internet at: <http://www.corpuschristichamber. org/relocation_info/overview_contents.htm> Accessed on March 22, 2002.

Corpus Christi, City of. 2002a. North Padre Island Storm Damage Reduction of Environmental Restoration Project (Packery Channel), Dune Protection Permit Application. Prepared for the Texas General Land Office. March 18.

———. 2002b. Packery Channel/TIF Information Sheet. Available on the internet at: http://www.ci.corpus-christi.tx.us/images/packery.PDF> Accessed on April 12, 2002.

Corpus Christi Convention and Visitor's Bureau. 2002. Area Attractions. Available on the Internet at: <http://www.corpuschristi-tx-cvb.org/attractions.html> Accessed on March 21, 2002.

Correll, D.S. and M.C. Johnston. 1970. Manual of the vascular plants of Texas. The University of Texas at Dallas, Richardson, Texas. 1881 pp.

Dankers, N. and D. R. Zuidema. 1995. The role of the mussel (*Mytilus edulis* L.) and mussel culture in the Dutch Waden Sea. Estuaries 18:71-80.

Davis, W.B. and D.J. Schmidly. 1994. The mammals of Texas. Texas Parks and Wildlife Dept. Distributed by University of Texas Press. 338 pp. Austin, Texas.

Dempster, J.P. 1975. Animal Population Ecology. Academic Press, London. 155 pp.

DeYoe, H.R., D.A. Stockwell, R.R. Bidigare, M. Latasa, P.W. Johnson, P.E. Hargraves, and C.A Suttle. 1997. Description and characterization of the algal species *Aureoumbra lagunensis* gen. et. sp. nov. and referral of *Aureoumbra* and *Aureococcus* of the *Pelagophyceae*. J. Phycol. 33:1042-1048.

Dixon, J.R. 2000. Amphibians and reptiles of Texas. Second edition. Texas A&M University Press, College Station, Texas.

Drake, Kiel, K. Drake, and J. Thompson. 1999. The effects of dredge material on piping plovers and snowy plovers along the southern Laguna Madre of Texas. Final report 1997-1999. Ceasar Kleberg Wildlife Research Institute, Texas A&M University, Kingsville.

Dunn, G.E. and Miller, B.I. 1964. Atlantic hurricanes: Baton Rouge, Louisiana State University Press. 377 pp.

Dunton, K.H. 1994. Seasonal growth and biomass of the subtropical grass Halodule wrightii in relation to continuous measurements of underwater irradiance. Marine Biology 120:470-489.

———. (in press) Characterization of seagrasses, light and water column parameters. Chapter VI of SEIS for the Laguna Madre GIWW Dredged Material Management Plan. Prepared for the U.S. Army Corps of Engineers – Galveston District, Galveston, Texas.

Economic Research Associates (ERA). 2000. Forecast of Potential TIF Revenue Flows Generated by Future Development of North Padre Island, Final Report. Submitted to the City of Corpus Christi. June.

Ellicott International. 2002. Mud Cat™ Dredges, technical data and specifications. Available on the internet: <www.mudcat.com> Accessed April 11, 2002.

Espey, Huston & Associates (EH&A). 1978. The biological effects of turbidity. Prepared for Board of Trustees, Galveston Wharves and Northville Industries Corporation. EH&A Doc No. 78187.

———. 1980. Dredging impact study. Prep. for Brownsville Navigation District. EH&A Doc. No. 80221.

———. 1981. Proposed deepwater channel and multipurpose terminal construction and operation near Brownsville, Texas. EH&A Doc No. 80490.

———. 1987. Bioassay Testing of Wastewater Effluent Samples from Corpus Christi Bay Station Outfalls A, B, C, D and E. EH&A Doc No. 870713. June.

———. 1988. Terrestrial magnetic survey of Packery Channel, Padre Island, Corpus Christi, Texas. EH&A document no. 880147.

———. 1993a. Piping plover survey, Commodore's Cove, Unit II, Nueces County, Texas. EH&A document no. 930776. Austin, Texas.

———. 1993b. Piping plover and snowy plover survey of the proposed Packery Channel Marina site, Nueces County, Texas. Prepared for Robert Braubach, San Antonio, Document No. 930313, May 1993.

———. 1998. Benthic macroinfaunal analysis of dredged material placement areas in the Laguna Madre, Texas – Spring and fall surveys. EH&A document no. 970740: 90 pp. +Appendices. Austin, Texas.

Federal Emergency Management Agency (FEMA). 1985. National Flood Insurance Program, Flood Insurance Rate Maps. Nueces County, Texas (unincorporated areas; panels 563, 564, 705).

Fields, R.C. 1984. An Archeological Survey of Two Alternate Well Pad Locations in the Padre Island National Seashore, Kenedy County, Texas. Prewitt and Associates Letter Report No. 259, Austin, Texas.

Fitzpatrick, W.S., J. Fitzpatrick, and T.N. Campbell. 1964. A Rockport Black-on-Gray Bessel from the Vicinity of Corpus Christi, Texas. Bulletin of the Texas Archeological Society 35:193-204.

Flemer, D.A., W.L. Dovel, et al. 1968. Gross Physical and Biological Effects of Overboard Spoil Disposal in Upper Chesapeake Bay. J. Samit Eng. Div., Proc. Am., Soc. Civ. Engin. 94:683-706.

Fox, A.A. and T.R. Hester. 1976. An Archaeological Survey of Coleto Creek, Victoria and Goliad Counties, Texas. Archaeological Survey Report No. 18. Center for Archaeological Research, The University of Texas at San Antonio.

Fuls, B. and L.W. McEachron. 1997. Trends in relative abundance and size of selected finfishes and shellfishes along the Texas coast: November 1975-December 1995. Management Data Series No. 137. Texas Parks and Wildlife Department, Coastal Fisheries Division. Austin, Texas.

Garrett, J.M. and D.G. Barker. 1987. A field guide to reptiles and amphibians of Texas. Texas Monthly Field Guide Series. Texas Monthly Press. Austin, Texas. 225 pp.

Gibson and Hester. 1982. An Archeological Survey of a Pelto Oil Company Well Drilling Site on North Padre Island, Kleberg County, Texas. A report by the Center for Archeological Research, The University of Texas at San Antonio.

Gill, R.E. Jr.; P. Canevari; and E.H. Iversen. 1998. Eskimo curlew (*Numenicus borealis*). In: The Birds of North America, no. 347 (A. Poole and F. Gill, editors). The Birds of North America, Inc., Philadelphia, PA.

Gill, S.K., J.R. Hubbard, and G. Dingle. 1995. Tidal Characteristics and datums of Laguna Madre, Texas: National Oceanic and Atmospheric Administration Technical Memorandum NOS OES 008, 57 p.

Good, Carolyn. 1984. Letter report: Cultural resources assessment. Project area in Nueces County, Texas. USACE permit 17078, Galveston, Texas.

Goodwyn, F. 1970. Behavior, life history and present status of the jaguarundi, *Felis yagouaroundi* (Lacepede), in South Texas. M.S. thesis, Texas A&I University, Kingsville, Texas. 63 pp.

Gould, F.W. 1975. Texas plants – a checklist and ecological summary. MP-585/Rev. Texas A&M University, Texas Agricultural Experiment Station, College Station, Texas. 121 pp.

Green, N. 1985. The Bald Eagle. In: A.M. Enos and R.L. DiSilvestro (editors), Audubon wildlife report 1985. Pp. 508-531. National Audubon Society, New York.

Gulf Coast Association of Geological Societies (GCAGS). 1959. Transactions. Volume IX.

Gulf of Mexico Fishery Management Council (GMFMC). 1998. Generic Amendment for Addressing Essential Fish Habitat Requirements in the Following Fishery Management Plans of the Gulf of Mexico: Shrimp Fishery of the Gulf of Mexico, Red Drum Fishery of the Gulf of Mexico, Reef Fish Fishery of the Gulf of Mexico, Coastal Migratory Pelagic Resources (Mackerels) in the Gulf of Mexico and South Atlantic, Stone Crag Fishery of the Gulf of Mexico, Spiny Lobster in the Gulf of Mexico and South Atlantic, and Coral and Coral Reefs of the Gulf of Mexico. National Oceanic and Atmospheric Award No. NA87FC0003.

Guzman, H.M. and R.W. Schreiber. 1987. Distribution and status of brown pelicans in Venezuela in 1983. Wilson Bull. 99(2):275-279.

Haig, S.M. and L.W. Oring. 1985. Distribution and status of the piping plover throughout the annual cycle. J. Field Ornithol. 56(4):334-345.

———. 1987. The piping plover. In: 1987 Audubon Wildlife Report. National Audubon Society, Academic Press, New York, pp. 508-519.

Hall, E.R. 1981. The Mammals of North America. 2 vol. John Wiley & Sons, New York. 1180 pp.

Hall, G.D. 1987. A perspective on some prehistoric cemeteries in Texas: Loma Sandia in the regional setting. In Archaeological Investigations at the Loma Sandia Site (41LK28): A Prehistoric Cemetery and Campsite in Live Oak County, Texas (review draft), By A.J. Taylor and C.L. Highley. Texas Department of Transportation, Austin, Texas.

Hammer, Siler, George Associates (HSGA). 1997. Economic Impact Analysis – Packery Channel Project. Prepared for Nueces County, Texas. April.

Hatch, S.L., K.N. Gandhi, and L.E. Brown. 1990. Checklist of the vascular plants of Texas. TAES, Texas A&M University. College Station, Texas. 158 pp.

Headrick, P. 1993. The Archeology of 41NU11, The Kirchmeyer Site, Nueces County, Texas: Long Term Utilization of a Coastal Clay Dune. Studies in Archeology 15, Texas Archeological Research Laboratory, The University of Texas at Austin.

Hector, D.P. 1983. Status report on *Falco femoralis septentrionalis*. U.S. Fish and Wildlife Service, Office of Endangered Species, Albuquerque, New Mexico. 51 pp.

Hedgpeth, J.W. 1967. Ecological aspects of the Laguna Madre, a hypersaline estuary, p. 408-419. In G.H. Lauff (ed.), Estuaries. AAAS Publication 83, American Association for the Advancement of Science, Washington, D.C.

Hester, T.R. 1980. Digging Into South Texas Prehistory. Corona Publishing Company, San Antonio, Texas.

Hicks & Company Environmental/Archeological Consulting and Lockwood Andrews & Newman. (Hicks et al.) 1999. Environmental Assessment for Park Road 22 - JFK Causeway.

Highley, C.L, A. Gerstle, and T.R. Hester. 1977. An archaeological and historical assessment of the Tule Lake tract, Nueces County, Texas. CAR Survey Report 27. The University of Texas at San Antonio.

Hildebrand, H. 1983. Random notes on sea turtles in the western Gulf of Mexico. In: D. Owens et al. (editors) Proc. Western Gulf of Mexico Sea Turtle Workshop, Texas A&M University, College Station, Texas. Pp. 34-40. TAMU-SG-84-105. 74 pp.

———. 1986. Personal communication to Derek Green, EH&A, January 16, 1986. Corpus Christi, Texas.

———. 1987. A reconnaissance of beaches and coastal waters from the border of Belize to the Mississippi River as habitats for marine turtles. Report prepared for National Marine Fisheries Service, Southeast Fisheries Center, Panama City Laboratory, Panama City, Florida. Purchase Order No. NA-84-CF-A-134. 63 pp.

Hirsch, N. D., L. H. DiSalvo, and R. Peddicord. 1978. Effects of dredging and disposal on aquatic organisms. U.S. Army Corps of Engineers, Waterways Eper. Sta. Tech. Rep. DS-78-5.

Hoese, H.D. 1965. Spawning of marine fish in the Port Aransas, Texas, area as determined by the distribution of young and larvae. Doctoral dissertation, University of Texas. August 1965.

Hoese H.D. and R.H. Moore. 1998. The Fishes of the Gulf of Mexico Texas, Louisiana, and Adjacent Waters. Texas A&M University Press, College Station, Texas. 422 pp.

Holt, S. 1998. Potential effects of alternate design options for elevation of the JFK Causeway on migration and transport of fish and invertebrates in the Laguna Madre. Memorandum to Lockwood, Andrews and Newham, Inc., November 30, 1998. Appendix to Texas Department of Transportation draft environmental assessment - JFK Causeway. December.

Hopkins, T.S. 1972. The effects of physical alteration on water quality in Mulatto Bayou, Excambia Bay. Quarterly Journal Florida Academy of Sciences 35(1): 2 (Abstr.).

Howard, M., M.D. Freeman, E. Morley, L. McNatt, C.G. Ward and C. Beceiro. 1997. Archeological Survey and History of Mustang Island State Park, Nueces County, Texas. Texas Parks and Wildlife Department, Cultural Resources Program, Austin.

Howell, C.W. 1879. Annual report of the Chief of Engineers to the Secretary of War for the year 1879, Part 1. Washington.

Jones, C., R.S. Hoffmann, D.W. Rice, M.D. Engstrom, R.D. Bradley, D.J. Schmidly, C.A. Jones, and R.J. Baker. 1997. Revised checklist of North American mammals north of Mexico, 1997. Occ. Papers, Museum of Texas Tech University, Number 173. 19 pp.

Jones, F.B. 1977. Flora of the Texas Coastal Bend. Mission Press, Corpus Christi, Texas.

Koch, E. 2001. Beyond light: physical, geological, and geochemical parameters as possible submersed aquatic vegetation habitat requirements. Estuaries: 24(1): 1-17.

———. 2002. Impact of boat-generated waves on seagrass habitat. Journal of Coastal Research (in press). Fort Lauderdale (Florida), ISSN 0749-0208.

Kotter, S. 1993. Summary report: results of cultural resources investigation at Site 41NU219 within the proposed Packery Channel Marina, Nueces County, Texas. EH&A document no. 930282. Austin, Texas.

Kral, R. 1983. A report on some rare, threatened, or endangered forest-related vascular plants of the south. Vol. II. Technical publication R8-TP2, U.S. Department of Agriculture, Forest Service, Southern Region.

Kraus, N.C. and D.J. Heilman. 1997. Packery Channel feasibility study: inlet functional design and sand management. Report 1 of a two-part series. Final report. Prepared for Naismith Engineering, Inc., Corpus Christi, Texas.

Lee Wilson & Associates, Inc. (LW&A). 1998. Characterization of dredged material, Laguna Madre, Texas. LW&A document no. EP556014. Santa Fe, New Mexico.

Lonard, R. I. and F. W. Judd. 1985. Effects of a severe freeze on native woody plants in the lower Rio Grande Valley, Texas. The Southwestern Naturalist 30:397-403.

———. 1991. Comparison of the effects of the severe freezes of 1983 and 1989 on native woody plants in the lower Rio Grande Valley, Texas. Southwestern Naturalist, 36: 213- 217.

Mabie, D.W. 1990. Bald eagle nest survey and management. Performance report, Federal Aid Project No. W-125-R-1, Job NO. 30. Texas Parks and Wildlife, Austin, Texas. 1 November 1990. 12 pp.

Martin, G.D. and W.H. Potter. n.d. Preliminary Archaeological Survey of a Portion of the Texas Coast. Privately printed, ca 1931. Copy on file at the Texas Archeological Research Laboratory, J.J. Pickle Research Campus, The University of Texas at Austin.

May, E.B. 1973. Environmental effects of hydraulic dredging in estuaries. Alabama Marine Resources Bulletin 9:1-85.

McGowen, J.H. and R.A. Morton. 1979. Sediment distribution, bathymetry, faults and salt diapirs, submerged lands of Texas. Bureau of Economic Geology, The University of Texas at Austin. 31 pp.

McHugh, J.L. 1967. Estuarine nekton. Pages 581-620 in Lauff, G. H. (ed.), Estuaries. Amer. Assoc. Advanc. of Sci. Publication No. 83. Washington, D. C.

McMahan, C.A. 1965-1967. Survey, coastal waterfowl. Federal Aid Projects W-29-R-18 to 24, Completion Reports, Job No. 17, Texas Parks and Wildlife Department. Austin, Texas.

Mercado-Allinger, P.A and R.A. Ricklis. 1996. Regional Preservation Plan for Archeological Sites, Southern Coastal Corridor Archeological Region, Central & Southern Planning Region In Archeology in the Central and Southern Planning Region, Texas: A Planning Document. Office of the State Archeologist, Special Report 35 and the Department of Antiquities Protection, Cultural Resource Management Report 7. Austin, Texas.

Merkord, G.W. 1978. The distribution and abundance of sea grasses in Laguna Madre of Texas. M.S. Thesis, Texas A&I University, Kingsville, Texas. 56 pp.

Miles, D.W. 1950. The life histories of the spotted seatrout (*Cynoscion nebulosus*) and redfish (*Sciaenops ocellatus*). Texas Game, Fish and Oyster Comm., Marine Lab. Ann. Rpt. (1949-1950): 66-103.

Montagna, P.A., S.A. Holt, K.H. Dunton. 1998. Characterization of Anthropogenic and Natural Disturbance on Vegetated and Unvegetated Bay Bottom Habitats in the Corpus Christi Bay National Estuary Program Study Area. Final Project Report, Corpus Christi Bay National Estuary Program, Corpus Christi, Texas.

Moore, P.G. 1977. Inorganic particulate suspensions in the sea and their effects on marine animals. Ann. Rev. Oceanogr. Mar. Biol. 15:225-363.

Mortimer, J.A. 1982. Feeding ecology of sea turtles. In: K. Bjorndal (editor), Biology and Conservation of Sea Turtles. Pp. 103-109. Smithsonian Institution Press, Washington, D.C. 583 pp.

Morton, J.W. 1977. Ecological effects of dredging and dredge spoil disposal: a literature review. Technical Papers U.S. Fish and Wildlife Ser. #94.

Morton, R.A., W.A. White, and R.C. Nava. 1998. Sediment budget analysis for Laguna Madre, Texas: an examination of sediment characteristics, history, and recent transport.

Mounger, M.A. 1959. Mission Espiritu Santo of Coastal Texas: An example of historic site archeology. Unpublished master's thesis, Department of Anthropology, The University of Texas at Austin.

Musick, J.A., S. Branstetter, and J.A. Colvocoresses. 1993. Trends in shark abundance from 1974-1991 for the Chesapeake Bight region of the U.S. mid-Atlantic coast. Pp. 1-18. In: Conversation Biology of Elasmobranchs (Branstetter, S. ed.). NOAA Tech. Rep. NMFS 115.

National Fish and Wildlife Laboratory (NFWL). 1980. Selected vertebrate endangered species of the seacoast of the United States – Brown Pelican Eastern and California subspecies. U.S. Fish and Wildlife Service, Biological Services Program, Washington, D.C. FWS/OBS-80/01.40. 16 pp.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS and FWS). 1991a. Recovery plan for U.S. population of loggerhead turtle. National Marine Fisheries Service, Washington, D.C. 64 pp.

———. 1991b. Recovery plan for U.S. population of Atlantic green turtle. National Marine Fisheries Service, Washington, D.C. 52 pp.

———. 1992. Recovery plan for leatherback turtles in the U.S. Caribbean, Atlantic, and Gulf of Mexico. National Marine Fisheries Service, Washington, D.C. 65 pp.

National Marine Fisheries Service (NMFS). 2000. Leatherback sea turtle (*Dermochelys coriacea*) endangered species. Available on the Internet: http://www.nmfs.noaa.govt/prot-res/species/turtles/leatherback.html.

———. 2001. Office of Protected Resources – Candidate Species Information. Available on the internet: <http://www.nmfs.noaa.gov/prot_res/PR3/candidates/candidate.html>

National Oceanographic and Atmospheric Administration/U. S. Environmental Protection Agency. 1989. Strategic assessment of near coastal waters: susceptibility and status of Gulf of Mexico estuaries to nutrient discharges. NOAA/EPA Team on Near Coastal Waters, June 1989. 36 pp.

Natural Resources Conservation Services (NRCS). 1992. Land Use Estimates by county for Texas. Natural Resources Inventory Division. (Accessed at http://www.nhq.usda.gov/NRI/get_data.html)

Nature Serve: an online encyclopedia of life [web application]. 2000a. Version 1.0. Arlington (VA): Association for Biodiversity Information. Comprehensive report species *Charadrius montanus*. Available http://www.natureserve.org/. Accessed: October 16, 2000.

———. 2000b. Version 1.0. Arlington (VA): Association for Biodiversity Information. Comprehensive report species *Trichecus manatus*. Available http://www.natureserve.org/. Accessed: October 16, 2000.

New World Research (NWR). 1981a. Cultural Resources Survey of Proposed Seismic Test Lines in the Vicinity of the Port Mansfield Channel, Padre Island, Texas. New World Research Report of Investigations, No. 54.

———. 1981b. Cultural Resources Survey of Twelve Proposed Seismic Lines within the Padre Island National Seashore, Kenedy County, Texas. New World Research Report of Investigations, No. 55.

Newcomb, W.W. Jr. 1993. Indians of Texas. University of Texas Press. Austin, Texas.

Oberholser, H.C. 1974. The Bird Life of Texas. 2 vol. University of Texas Press, Austin, Texas. 1,069 pp.

Odum, H.T. and R.F. Wilson. 1962. Further studies on reaeration and metabolism of Texas Bays, 1958-1960. Publ. Inst. Mar. Sci., Univ. of Tex. (8):23-25.

Ortego, B. 2001. Bald eagle nest survey and management. Performance Report, Federal Aid Grant No. W-125-R-12, Project No. 10. Texas Parks and Wildlife Department, Austin, Texas. 30 September 2001.

O'Shea, T.J., and M.E. Ludlow. 1992. Florida manatee (*Trichechus manatus tatirostris*). Pp. 190-200 in S.R. Humphrey (editor). Rare and endangered biota of Florida. Volume 1: Mammals. University Press of Florida, Gainesville, Florida.

Pacific International Engineering (PIE). 2001. Corpus Christi Channel Improvement Project Shoreline Erosion Study. Prepared for Port of Corpus Christi Authority. Corpus Christi, Texas.

Pardo, Terry. 2000. Gas Services Division of Pipeline Safety, Texas Railroad Commission. Personal communication with Steve McVey, PBS&J. Austin, Texas. August.

Patterson, P.E. and M.M. Ford. 1974. Oso Creek Flood Control Project Area, Nueces County, Texas: A Report on the Archeological and Historical Resources. Research Report No. 35. Texas Archeological Survey, The University of Texas at Austin.

PBS&J. 1999a. Seagrass Surveys of the Mustang Island Transmission Line Project, Nueces County, Texas. Prepared for Central Power and Light Co. Document No. 990913. June.

———. 1999b. Project study plan for Packery Channel. Prepared for the U.S. Army Corps of Engineers-Galveston District, Galveston, Texas.

———. 2000. Letter report to Michael Tatterson, Central and South West Services, Inc. Updated Seagrass surveys. March 17, 2000.

———. 2001a. Hazardous, Toxic, and Radioactive Waste Study, Packery Channel and Gulf Intracoastal Waterway Mile Station 552 to 576. Prepared for the U.S. Army Corps of Engineers, Galveston District. Document No. 000346, October.

———. 2001b. Piping plover and snowy plover survey, Corpus Christi Ship Channel-Channel Improvement Project, Nueces County, Texas, September 2000 – April 2001. Final Report. Prepared for U.S. Army Corps of Engineers, Galveston District, Document No. 010163, July 2001.

———. 2001c. Hydrodynamic and salinity modeling of opening Packery Channel to the Gulf of Mexico. Letter Report. Prepared for the U.S. Army Corps of Engineers, Galveston District.

Pearce, J.B. 1972. Biological survey of submerged refuse. Mar. Pollution Bull. 3(10): 157-158.

Perret, W.S., J.E. Weaver, R.C. Williams, F.L. Johanson, T.D. McIlwain, R.C., Raulerson, and W.M. Tatum. 1980. Fishery profiles of red drum and spotted seatrout. Gulf States Mar. Fish. Comm., Ocean Springs, MS. No. 6, 60 p.

Poole, J.M. 1985. Status report on *Anthericum chandleri* Greenm. and Thomps. Texas Natural Heritage Program. 4 Dec. Austin, Texas.

Poole, J.M. and D.H. Riskind. 1987. Endangered, threatened, or protected native plants of Texas. Texas Parks and Wildlife Department, Austin, Texas.

Poole, J.M., J. Singhurst, D. Hurlburt-Price, and W.R. Carr. 2000. A list of rare plants of Texas. Austin, Texas.

Port of Corpus Christi Authority. 1999. Final draft report, La Quinta baseline, environmental assessment. July.

Prewitt, E.R. (Editor). 1984. Archeological and historical Investigations in the proposed Baker's Port project and vicinity, southern Live Oak Peninsula, San Patricio County, Texas. Prewitt and Associates Report of Investigations 25.

Prewitt, E.R. 1981. Cultural Chronology in Central Texas. Bulletin of the Texas Archeological Society 52:65- 89.

Pulich, W.M. Jr. 1980. The ecology of a hypersaline lagoon: The Laguna Madre, p. 103-122. In P.L. Fore and R.D. Peterson (eds.), Proceedings of the Gulf of Mexico Coastal Ecosystems Workshop. U.S. Fish and Wildlife Service, Biological Report FWS/OBS-80/30, Albuquerque, New Mexico.

———. 1998. Seagrass conservation plan for Texas. Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas.

Pulich W.M., Jr., C. Blair, and W.A. White. 1997. Current status and historical trends of seagrass in the Corpus Christi Bay National Estuary Program Study Area. Report CCBNEP-20. Corpus Christi Bay National Estuary Program, National Resources Center, TAMU-CC, Corpus Christi, Texas. 131 pp.

Pulich, W.M. Jr.; T. Amos, L. Turnbull, S. Holt, and J. Wilds, compilers. 1985. Birds of Mustang Island. Texas Parks and Wildlife Department, Resources Management Section. Austin, Texas. TPWD Brochure 4000-432. June 1985.

Quammen, M.L. and C.P. Onuf. 1993. Laguna Madre: seagrass changes continue decades after salinity reduction. Estuaries 16, 303-311.

Raasch, M. 2002. Personal communication between Chris Moore (PBS&J) and Mic Raasch (Planner), City of Corpus Christi – Planning Department. April 11, 2002.

Ray, G. and D. Clarke. 1999. Environmental assessment of open-water placement of maintenance dredged material in Corpus Christi Bay, Texas. Waterways Experiment Station final report. Prepared for U.S. Army Corps of Engineers. January.

Rhoads, D.C., P.L. McCall and J.Y. Yingst. 1978. Disturbance and production on the estuarine seafloor. American Scientist 66:577-586.

Ricklis, R. A. 1986. Archaeological investigations at the McKinzie Site (41NU221), description and contextual interpretations. Unpublished Mater's thesis, Department of Anthropology, The University of Texas at Austin.

———. 1990. A Historical Cultural Ecology of the Karankawan Indians of the central Texas Coast: A Case Study in the Roots of Adaptive Change. Ph.D. dissertation, The University of Texas at Austin.

———. 1992. Aboriginal Karankawan adaptation and Colonial Period acculturation: Archeological and Ethnohistorical Evidence. Bulletin of the Texas Archeological Society 63:211-243.

———. 1993. A model of environmental and human adaptive change on the central Texas coast: geoarchaelogical investigations at White's Point, Nueces Bay, and surrounding area. Coastal Archaeological Studies, Inc., Corpus Christi.

———. 1995. Prehistoric occupation on the central and lower Texas coast: A regional overview. Bulletin of the Texas Archeological Society 66:265-300.

———. 1999. Archaeological Survey of Port of Corpus Christi Tracts 1 and 2, North Shore of Corpus Christi Bay, San Patricio County, Texas. TAS, Inc., and Coastal Archaeological Research, Inc.

Ricklis, R.A. and K.A. Cox. 1991. Toward a chronology of adaptive change during the Archaic of the Texas Coastal Bend area. La Tierra 18(2):13-31.

Ritchie, D.W. 1970. Fish. In: Gross physical and biological effects of overboard spoil disposal in upper Chesapeake Bay. L. E. Cronin (Ed.). Univ. Md., Nat. Res. Inst., Spec. Rpt. No. 3.

Robinson, L., P. Campbell, and L. Butler. 1998. Trends in Texas commercial fishery landings, 1972-1997. Management Data Series No. 158. Texas Parks and Wildlife Department, Coastal Fisheries Division. Austin, Texas.

Saldonia, M. 2002. Personal communication between Chris Moore (PBS&J) and Miguel Saldonia (Planner), City of Corpus Christi – Planning Department. April 11.

Sather, J.H. and R.D. Smith. 1984. An overview of major wetland functions and values. Prepared for Western Energy and Land Use Team Division of Biological Services Research and Development, U.S. Fish and Wildlife Service. FWS/OBS 84/18. 68 pp.

Sayles, E.B. 1935. An archaeological survey of Texas. Medallion Papers 17 (XVII). Gila Pueblo, Globe, Arizona.

Schmidly, J.D. 1991. The Bats of Texas. Texas A&M Univ. Press, College Station, Texas. 188 pp.

Science Applications, Inc. 1984. Characterization of the benthic environment at four existing and proposed dredged material disposal sites along the South Texas coast during October-November 1983. Draft final report. U.S. Environmental Protection Agency, Criteria and Standards Branch, Washington, D.C. 158 pp.

Scurlock, J.D., W.M. Lynn, and R.T. Ray. 1974. An assessment of the Archeological Resources of Padre Island National Seashore, Texas. Office of the State Archeologist Special Report 11, Austin, Texas.

Shafer, H.J. and C.L. Bond. 1983. An Archeological Review of the Central Texas Coast in Bulletin of the Texas. Texas Archeological Society 54 (1985 for 1983).

Shaver, D.J. 1984. The surf zone fish fauna of the Padre Island National Seashore. M.S. thesis, Texas A&I University, Kingsville, Texas. 231 pp.

———. 2000. Padre Island National Seashore, field station leader. Personal communication to Derek Green, PBS&J, 20 November 2000.

Sheridan, P. 1998. Colonization of dredged material placement areas by shoalgrass in Lower Laguna Madre, Texas, and the habitat value of these sites for fishery species. Final Report to the U.S. Army Corps of Engineers, Galveston District, Galveston, TX.

Sherk, J.A., Jr. 1971. The effects of suspended and deposited sediments on estuarine organisms. Natural Resources Institute of the Univ. of Maryland. Chesapeake Biological Lab. February 1971.

Sherman, K.M. and B.C. Coull. 1980. The response of meiofauna to sediment disturbance. Journal of Experimental Marine Biology and Ecology. 46, pp. 59-71.

Shiner, Moseley and Associates, Inc. 1987. Draft environmental assessment on reopening of Packery Channel. Prepared for Fish Trackers Inc., Reopen Packery Channel Association, Corpus Christi, Texas.

———. 1994. Piping plover roost site survey, Packery Channel. Prepared for the U.S. Army Corps of Engineers, Galveston. March 1994.

———. 1997. Re-opening Packery Channel Conceptual Phase: Jetties, Shoreline Stabilization and Dredging. Prepared for Naismith Engineering, Inc., Corpus Christi, Texas.

Shiner, Moseley and Associates, Inc., Carter and Burgess, Inc., Olivarri and Associates, Inc. 2001. Draft environmental assessment for the proposed Joe Fulton International Trade Corridor from IH 37 to US 181, Nueces County, Texas. April.

Simmons, E.G. undated. Biological aspects of passes. Texas Game and Fish Commission.

———. 1952. How fish use coastal passes. Part 1 (October) and Part 2 (November). Texas Game and Fish Commission.

———. 1953. How fish use coastal passes. Part 3 (January) and Part 4 (February). Texas Game and Fish Commission.

Simmons, E.G. and J.P. Brewer. 1962. A study of redfish (*Sciaenops ocellatus Linnaeus*) and black drum (*Pogonias cromis Linnaeus*). Pub. Of Inst. Mar. Sci., Univ. Texas. 8:184-211

Smith, H.A. 1988. Testing and evaluation of Site 41NU219 by the Corpus Christi Museum Archaeology Program. Corpus Christi Museum. Corpus Christi, Texas.

Snow, C. 1981. Southern Bald Eagle (*Haliaeetus leucocephalus leucocephalus*) and Northern Bald Eagle (*Haliaeetus leucocephalus alascanus*). Habitat management series for endangered species, Report No. 5. Bureau of Land Management, Denver, Colorado. T-N-171. 58 pp.

Southwest Parks and Monuments Association (SPMA). 1990. A checklist of the birds of Padre Island National Seashore. Southwest Parks and Monuments Association, Tucson, Arizona. 4M/SPMA/1990.

Steidinger, K.A. 1979. Collection, enumeration and identification of free-living marine dinoflagellates, p. 435-442. In D.L Taylor and H.H. Seliger, [ed.], Proceedings of the Second International Conference on Toxic Dinoflagellate Blooms, Key Biscayne, Florida.

Stern, E.M. and W.B. Stickle. 1978. Effects of turbidity and suspended material in aquatic environments. Literature Review. Tech. Rep. D-78-21. USCE, Waterways Experiment Station, Vicksburg.

Stewart, R.M., D.G. McFarland, D.L. Ward, S.K. Martin, and J.W. Barko. 1997. Flume study investigation of the direct impacts of navigation-generated waves on submersed aquatic macrophytes in the Upper Mississippi River. Prepared for U.S. Army Engineer District, Rock Island, IL; for U.S. Army Engineer District St. Louis, MO; and for U.S. Army Engineer District St. Paul, MN. ENV Report 1. 62 pp.

Stickney, R.R. 1972. Effects of Intracoastal Waterway dredging on ichthyofauna and benthic macroinvertebrates. Skidaway Inst. Oceanogr., Savannah, Ga.

Stockwell, D.A. 1993. Studies on conditions conductive to the development and maintenance of a persistence brown tide in the Laguna Madre, Texas. Page 18 in Whitledge, T. E. and W. M. Pulich Jr. (eds.), Report Brown Tide Symposium Workshop, 15-16 July, 1991, UTMSI. Port Aransas, Texas.

Stutzenbaker, C.D. 1999. Aquatic and wetland plants of the western Gulf Coast. Texas Parks and Wildlife Department, Wildlife Division, Austin, Texas. 465 pp.

Suhm, D.A., A.D. Krieger, and E.B. Jelks. 1954. An introductory handbook of Texas archeology. Bulletin of the Texas Archeological Society 25.

Tanyeri-Abur, A. L. Jones and H. Jiang. 1998. The Estimation of the Economic Impacts of Industry, Services, Recreational Activities, Commercial Fishing and Tourism Associated with the Portion of the Gulf Intracoastal Waterway from Corpus Christi to Brownsville. Texas A&M University. Department of Agricultural Economics. College Station, Texas.

Teeter, A. 2000. Erosion and circulation of dredged material in Laguna Madre, Texas (in prep.).

Tennant, A. 1984. The snakes of Texas. Texas Monthly Press, Austin, Texas. 561 pp.

Tester, P.A. and P.K. Fowler. 1990. Brevotoxin contamination of *Mercenaria mercenaria* and *Crassostrea virginica*: a management issue, p. 499-503. In E. Graneli [ed.], Toxic marine phytoplankton. Elsevier Science.

Tewes, M. and D. Everett. 1987. Status and distribution of the endangered ocelot and jaguarundi in Texas. In: S.D. Miller and D.D. Everett (eds.), Cats of the world: biology, conservation, and management. Pp. 147-158. National Wildlife Federation, Washington, D.C. 501 pp.

Texas Biological and Conservation Data System (TXBCD). 1999. Special species list for Nueces and Kleberg counties. Texas Parks and Wildlife Department Austin, Texas.

———. 2001. Data files and information on USGS topographic maps. 11 September.

Texas Colonial Waterbird Nesting Census (TCWNC). 2000. Available on the internet: <ifw2es.fws.gov/clearlaketexas/texascoastalprogram/birddata.htm>

Texas Coastal Management Program (CMP). 1996. Texas Coastal Management Program, Final Environmental Impact Statement, August 1996. Texas General Land Office. Austin, Texas.

Texas Coastal Coordination Council. 1996. Waters under tidal influence. Texas Coastal Management Program: Final Environmental Impact Statement. Available on the internet: <www.glo.state.tx.us/gisdata/gisdata.html>. Published August 1996.

Texas Department of Economic Development (TDED). 2001. The Economic Impact of Travel on Texas. Available on the Internet at: <http://research.travel.state.tx.us/> Accessed on March 5, 2002.

Texas Department of Transportation (TxDOT). 1999. TxDOT Urban Files for Nueces County, Texas.

Texas Game and Fish Commission (TGFC). 1967. Possible biological effects of opening of Corpus Christi Pass and Demit Island Channel. Texas Game and Fish Commission. 1967.

Texas General Land Office (GLO). 2000. Texas Coastal Oil Spill Planning and Response. CD-ROM. September 2000.

———. 2001. Texas Wetland Information Network (WetNet). Available on the internet: <www.glo.state.tx.us/wetnet/>

Texas General Land Office and U.S. Fish and Wildlife Service (GLO & FWS). 1998. The Mollie Beattie Habitat Community, Nueces County, Texas.

Texas Natural Heritage Program (TNHP), Texas Parks and Wildlife Department. 1993. Plant communities of Texas. Austin, Texas.

Texas Natural Resource Conservation Commission (TNRCC). 1994. The state of Texas water quality inventory, 12th Edition: surface and ground water assessments and TNRCC water quality management programs. 283 pp.

———. 1998. Texas Clean Air Strategy. TNRCC New Texas Clean Air Strategy Page. Internet: http://www.tnrcc.state.tx.us.

———. 2000. Proposed Texas Surface Water Quality Standards, Chapter 307, Rule Amendment.

———. 2001a. Air Monitoring Site Details. Available on the internet: <http://163.234.20.128/air/monops/sitedetails.html> Accessed on June 20, 2001.

———. 2001b. Operation Clean Air, Natural Outlook, Spring 2001. Available on the internet: <http://163.234.20.128/admin/topdoc/pd/020/01-02/cleanair.html> Accessed on June 20, 2001.

Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened and watch lists of Texas plants. Pub. 9, Third Revision. August, 1993. Austin, Texas.

———. 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication No. 10. Austin, Texas. 22 pp.

Texas Ornithological Society (TOS). 1995. Checklist of the birds of Texas, 3rd Edition. 166 pp.

Texas Parks and Wildlife Department (TPWD). 1992. Coastal Wetlands Habitat. Developed from classified Landsat™ imagery. TPWD, Resource Protection, Aquatic Studies Branch, Austin, TX. GIS data available on the internet: <http://www.glo.state.tx.us/gisdata/gisdata.html> (under Land Use/Land Cover Imagery).

———. 1995. Compilation of digital data layer composed of wetland habitats and coastal land cover data, final report to Natural Resources Inventory Program, Appendix III: TPWD Land Cover Descriptions and Data Dictionary, Section 4.0, Water and Submerged Land, August 31, 1995. TPWD, Austin, Texas.

———. 2000. Nature; endangered and threatened species; leatherback sea turtle (*Dermochelys coriacea*). Available on the Internet: <http://www.tpwd.state.tx.us/nature/endang/animals/lethback.html>

Texas Water Commission (TWC). 1963. Reconnaissance Investigation of the Ground Water Resources of the Gulf Coast Region. Bulletin 6305.

Texas Water Development Board (TWDB). 1997. Effects of Structures and Practices on the Circulation and Salinity Patterns of the Corpus Christi Bay National Estuary Program Study Area.

———. 2001. Population and Water Demand Projections: Board Approved Regional Projections to be Used in the 2002 State Water Plan. Available on the Internet at: http://www.twdb.state.tx.us/data/popwaterdemand/popwaterdemandmain.htm#population> Accessed on March 6, 2002.

Texas Workforce Commission (TWC). 2001. Civilian labor force estimates for Texas Counties. Monthly publications from 1980-1999. Available on the internet: <http://twc.state.tx.us/siteindex/twcsite.html> Accessed on October 9, 2001.

Thomas, P.M. and C.S. Weed. 1980a. A Cultural Resources Survey of Houston Pipe Line Company's 12" Proposed Pipeline Padre Island, Texas. New World Research, Report of Investigations No. 30.

———. 1980b. Cultural Resources Survey of the Proposed Transcontinental Gas Pipeline Corporation's 24" North Padre Island Pipeline, Texas. New World Research, Report of Investigations No. 38.

Thompson, J.R. 1973. Ecological effects of offshore dredging and beach nourishment: A review. USCE, Coastal Engin. Res. Center, Miscellaneous Paper No. 1-73.

Tilden, J.W. and A.C. Smith. 1986. A field guide to western butterflies. The Peterson Field Guide Series. Houghton Mifflin Company, Boston, Massachusetts. 370 pp.

Trejo, J. 2002. Personal communication between Joe Trejo (Engineer), City of Corpus Christi, and Chris Moore (PBS&J). April 9.

Tunnell, J.W. Jr. and F.W. Judd. 2002. The Laguna Madre of Texas and Tamaulipas. Texas A&M University Press, College Station, Texas.

Tunnell, J.W. and S.A. Alvarado (eds.). 1996. Current status and historical trends of the estuarine living resources within the Corpus Christi Bay National Estuary Program Study Area. Volume 4. CCBNEP-06D, January 1996. Texas Natural Resource Conservation Commission, Austin, Texas.

Tunnell, J.W., Q.R. Dokken, E.H. Smith, and K. Withers. 1996. Current status and historical trends of the estuarine living resources within the Corpus Christi Bay National Estuary Program Study Area. Volume 1. CCBNEP-06A. Texas Natural Resource Conservation Commission, Austin, Texas.

Turner, B.L. 1983. Status report of *Ambrosia cheiranthifolia* Gray. Prepared for U.S. Fish and Wildlife Service.

Turner, R.E. 1977. Intertidal vegetation and commercial yields of Penaeid shrimp. Trans. of Am. Fisheries Society. 106(5):411-416.

Tyler, R. 1996. The New Handbook of Texas, Vol. 4 and Vol. 5. The Texas State Historical Association. Austin, Texas.

URS/Dames & Moore (URS). 2002. 100% Design Submittal, Design Documentation Report. Packery Channel - project design, Corpus Christi, Texas. Prepared for the U.S. Army Corps of Engineers, Galveston District, Galveston, Texas. March 1.

U.S. Army Corps of Engineers (USACE). 1975. Final environmental impact statement, maintenance dredging, Corpus Christi Ship Channel, Texas. November.

———. 1992a. Water Resource Policies and Authorities-Hazardous, Toxic, and Radioactive Waste (HTRW) Guidance for Civil Works Projects. USACE Document ER 1165-2-132.

———. 1992b. Letter from Don Nanninga, Acting Chief, South Evaluation Section, Galveston District Corps of Engineers to Robert Braubach representing South Texas Properties, Inc., dated July 16, 1992.

———. 1998. Oakland Harbor Navigation Improvement (–50 Foot) Project, FEIS. Available on the internet: <http://www.50ftdredge.com/> accessed 04/12/02> May.

———. 1999. Project Study Plan Packery Channel, Texas, Feasibility Study Phase, Version 3. August 1999.

———. 2000. Final environmental assessment, Rincon Canal assumption of maintenance and beneficial uses of dredged material, Nueces County, Texas. August.

U.S. Bureau of the Census (USBOC). 1980. 1980 Census of Population – Summary Population and Housing Characteristics (Summary Tape Files 1 and 3).

———. 1990. 1990 Census of Population. Summary Population and Housing Characteristics (Summary Tape Files 1 and 3). Available on the Internet at: <http://factfinder.census.gov/servlet/ BasicFacts Servlet> Accessed on March 25, 2002.

———. 2000. 2000 Census of Population – Summary Population and Housing Characteristics (Summary Tape File 1). Available on the Internet at: <http://factfinder.census.gov/servlet/BasicFactsServlet> Accessed on March 25, 2002.

U.S. Coast Survey. 1869. Corpus Christi Pass, Texas. Texas Historical Commission, map file of the State Nautical Archaeologist. Austin, Texas.

U.S. Environmental Protection Agency (EPA). 1974. Information on levels of environmental noise requisite to protect public health and welfare with an adequate margin of safety. Office of Noise Abatement and Control.

———. 1978. Protective Noise Levels.: Condensed Version of EPA Levels Document. Office of Noise Abatement and Control.

———. 1986. Quality Criteria for Water, 1986. EPA 440/5-86-0001, as revised.

———. 1988. Corpus Christi Ship Channel ocean dredged material disposal site designation. EPA 906/09-88-003. Region VI.

———. 1998. Environmental Protection Agency Index of Watershed Indicators (IWI) Homepage. Available on the internet: <http://www.epa.gov/surf2/iwi>

———. 2001. Air Data Monitor Values Report. Office of Air Quality Planning & Standards. Available on the internet: <http://www.epa.gov/air/data/monvals.html> Accessed on June 20, 2001.

———. 2002. AIRData. Net tier report. Geographic Selection. Office of Air Quality Planning & Standards. Available on the internet: <http://www.epa.gov/air/data/nettier.html> Updated February 22, 2002.

U.S. Environmental Protection Agency/U.S. Army Corps of Engineers (EPA/USACE). 1991. Evaluation of Dredged Material Proposed for Ocean Disposal, Testing Manual. EPA-503/891/001. 205 pp + Appendices.

U.S. Fish and Wildlife Service (FWS), Department of the Interior. 1995. Threatened and endangered species of Texas. FWS Texas State Office, Austin, Texas.

———. 1997a. Federally and State Endangered Slender rush-pea *Hoffmannseggia tenella* information sheet. PWD LF W3000-019N. Austin, Texas.

———. 1997b. Identical letters from Jamie Rappaport Clark, Director, FWS, to Senators Phil Gramm and Kay Bailey Hutchison and Congressman Solomon P. Ortiz, dated 26 November 1997. (Included in Appendix D.)

———. 2001. Federally listed as threatened and endangered species of Texas. County by county list. October 31.

U.S. Navy. 1987. Environmental Impact Statement, Gulf Coast Strategic Homeporting, Corpus Christi/Ingleside, Texas. November.

Utter, T. 2002. Personal communication between Chris Moore (PBS&J) and Tom Utter, City of Corpus Christi. April 12, 2002.

Valdez, F., Jr. 1982. An Archeological Survey of a Proposed Drilling Site Located South of Baffin Bay on Padre Island National Seashore, Kenedy County, Texas. A report by the Center for Archeological Research, The University of Texas at San Antonio.

Van Siclen, D.C. undated. The Pleistocene Terraces and Sediments. Paper.

Villareal, T.A. and K. Dunton. 2000. UT-MSI, personal communication to Kathy Calnan, PBS&J; brown tide trends.

Voellinger, L.R., W. Hammon and M.W. Voellinger. 1991. A cultural resources survey to proposed disposal areas near the mouth of Baffin Bay, Kenedy and Kleberg counties, Texas. EH&A document no. 900479. Austin, Texas.

Wakeman, T.H. 1974. Release of trace constituents from sediments resuspended during dredging operations. In: American Chemical Society Conference, Atlantic City, NJ/COE San Francisco.

Ward, G.H. and N.E. Armstrong. 1997. Current Status and Historical Trends of Ambient Water, Sediment, Fish, and Shellfish Tissue Quality in the Corpus Christi Bay National Estuary Program Study Area. Publication CCBNEP-13. March 1997.

Ward, L. W. Kemp, and W. Boynton. 1984. The influence of waves and seagrass communities on suspended particulates in an estuarine embayment. *Marine Geology*, 59, pp. 85-103.

Warren, J.E. 1984. A cultural resources survey at Packery Point Development, Nueces County, Texas. J.E. Warren Report 114. George West, Texas.

———. 1985. An archaeological survey of a proposed drilling pad location on Padre Island National Seashore in Kenedy County, Texas. Submitted to Continental Shelf Associates Inc., Galveston, Texas by the Center for Archaeological Research, The University of Texas at San Antonio.

———. 1987. A cultural resources survey at Packery Point development, Nueces County, Texas. J.E. Warren Report 114. George West, Texas.

———. 1989. A field examination of archaeological Site 41NU219 on Padre Island, Nueces County, Texas. James E. Warren Report No. 207. George West, Texas.

Warren, T.A., L.M. Green, and K. W. Spillar. 1994. Trends in finfish landings of sport-boat anglers in Texas marine waters May 1974-May 1992. Management Data Series No. 109. Texas Parks and Wildlife Department, Coastal Fisheries Division. Austin, Texas.

Warshaw, S. 1975. Water quality segment report for Segment No. 2491, Laguna Madre. Report No. WQS-14. Texas Water Quality Board, Surveillance section, Field Operations Division. Austin, Texas.

Webb, W.P. (Editor). 1952. The Handbook of Texas, Vol. I and II. The Texas State Historical Association, Austin.

Webster, C.F. 1986. Port Isabel fishing harbor water quality survey. Physicochemistry, fecal coliform bacteria and benthos. LP 86-09. Texas Water Commission, Austin, Texas. 41 pp.

Werler, J.E. and J.R. Dixon. 2000. Texas snakes identification, distribution, and natural history. University of Texas Press, Austin, Texas.

White, W.A., T.R. Calnan, R.A. Morton, R.S. Kimble, T.G. Littleton, J.H. McGowen, and H.S. Nance. 1989. Submerged lands of Texas, Kingsville area: sediments, geochemistry, benthic macroinvertebrates, and associated wetlands. The University of Texas at Austin, Bureau of Economic Geology Special Publication, 137 pp.

White, W.A., T.A. Trembly, J. Hinson, D. Moulton, W. Pulich, E.H. Smith, and K.V. Jenkins. 1998. Current status and historical trends of selected estuarine and coastal habitats in the Corpus Christi national estuary program study area. Prepared for the Corpus Christi National Estuary Program, Corpus Christi, Texas. 161 pp.

Whitledge, T.E. 1993. The nutrient and hydrographic conditions prevailing in Laguna Madre, Texas before and during a brown tide bloom, pp. 711-716. In T.J. Smayda and Y. Shimizu (eds.), Toxic Phytoplankton Blooms in the Sea. Elsevier Science Publishers B.V., New York.

Windom, H.L. 1972. Environmental aspects of dredging in estuaries. J. Water. Har. and Coas. Eng. Div. ASCE, 98(WW4): 475-487.

Wright, T.D. 1978. Aquatic dredged material disposal impacts. U.S. Army Eng. Water Experiment Station Environmental Laboratory, Vicksburg, Miss. Technical Report DS-78-1.

Zonick, C. and M. Ryan. 1996. The ecology and conservation of piping plover (*Charadrius melodus*) wintering along the Texas Gulf Coast. 1995. Annual Report. Dept. of Fisheries and Wildlife, University of Missouri.

ACRONYMS & ABBREVIATIONS

AOU	American Ornithologists' Union
BA	Biological Assessment
BU	Beneficial Use
CAR	Center for Archeological Research
CBBF	Coastal Bend Bays Foundation
CBBP	Coastal Bend Bays Plan
CCBNEP	Corpus Christi Bay National Estuary Program
CSC	Center for Coastal Studies
CCSC	Corpus Christi Ship Channel
CERCLIS	Comprehensive Environmental Response Compensation and Liability Information System
CIMP	Coastal Impact Monitoring Program
CMP	Coastal Management Program
CO	carbon monoxide
CORRACT	Corrective Action List
cy	cubic yard(s)
dBA	decibel A-weighting
DCP	Dissolved Concentration Potential
DOQQ	digital ortho quarter quadrangle
E/SA	Endangered Due to Similarity of Appearance
EAD	Environmental Acceptability Document
EFH	Essential Fish Habitat
EH&A	Espey, Huston & Associates, Inc.
EIS	Environmental Impact Statement
EJ	Environmental Justice
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ERNS	Emergency Response Notification System
ESA	Endangered Species Act of 1973
FEMA	Federal Emergency Management Agency
FINDS	Facility Index System
FS	Feasibility Study
FWS	U.S. Fish and Wildlife Service
GIWW	Gulf Intracoastal Waterway

GLO Texas General Land Office

GMFMC Gulf of Mexico Fishery Management Council

HEP Habitat Evaluation Procedure

HSGA Hammer, Siler, George Associates

HTRW Hazardous, Toxic, Radioactive Waste

IH Interstate Highway

JFITC The Joe Fulton International Trade Corridor

JFK John F. Kennedy

Ldn average day-night noise level

LPC Limiting Permissible Concentration

LUST Leaking Underground Storage Tank

LWA Lee Wilson and Associates

MBHC Mollie Beattie Habitat Community

MCY million cubic yards

mg/kg milligrams per kilogram

mg/L milligrams per liter

MLLW mean lower low water

MLT mean low tide

MMPA maintenance material placement area

mph miles per hour

MSF Magnetic Silencing Facility

MSFCMA Magnuson-Stevens Fishery Conservation and Management Act

MSL mean sea level

NAAQS National Ambient Air Quality Standards

NAS Naval Air Station

NEPA National Environmental Policy Act

NMFS National Marine Fisheries Service

NO_2 nitrogen dioxide

NOAA National Oceanic and Atmospheric Administration

NO_x nitrogen oxides

NPDES National Pollutant Discharge Elimination System

NPL National Priority List

NRCS Natural Resources Conservation Service

NRHP National Register of Historic Places

NWR New World Research

O_3 ozone

PA	placement area
PAH	polycyclic aromatic hydrocarbons
Pb	lead
PCB	polychlorinated biphenyl
PCCA	Port of Corpus Christi Authority
PCRA	Packery Channel Reopening Area
PIE	Pacific International Engineering
PM_n	particulate matter (n = diameter [micrometers])
ppm	parts per million
ppt	parts per thousand
PSP	Project Study Plan
RCRA	Resource Conservation and Recovery Act
RCT	Railroad Commission of Texas
RIP	Rincon Industrial Park
RV	recreational vehicle
SAL	State Archeological Landmark
SAV	submerged aquatic vegetation
SCC	Southern Coastal Corridor
SH	State Highway
SO_2	sulfur dioxide
SOC	species of concern
SPILL	Spills Incident Information System
T/SA	Threatened due to similarity of appearance
TARL	Texas Archeological Research Laboratory
TCWNC	Texas Colonial Waterbird Nesting Census
TGFC	Texas Game and Fish Commission
THC	Texas Historical Commission
TNRCC	Texas Natural Resource Conservation Commission
TOC	total organic carbons
TOES	Texas Organization for Endangered Species
TOS	Texas Ornithological Society
TPH	total petroleum hydrocarbons
TPWD	Texas Parks and Wildlife Department
TRIS	Toxic Release Inventory System
TSDC	Texas State Data Center
TSS	Total Suspended Solids

TWC	Texas Workforce Commission
TWDB	Texas Water Development Board
TWQS	Texas Water Quality Standards
TXBCD	Texas Biological Conservation Data System
UCPA	Upland Confined Placement Areas
USACE	U.S. Army Corps of Engineers
USBOC	U.S. Bureau of the Census
USGS	U.S. Geological Survey
µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
VOC	volatile organic compound

11.0 GLOSSARY

The following definitions are for the convenience of those reading this Environmental Impact Statement and do not replace definitions in State, Federal, or local laws, regulations and ordinances.

anthropogenic – Relating to, or resulting from, the influence of humans on nature (e.g., anthropogenic pollution).

bathymetry – The measurement of depths of water in oceans, seas and lakes and the information derived from such measurements.

benthos – Aquatic bottom dwelling organisms which include worms, leeches, snails, flatworms, burrowing mayflies, clams.

bioaccumulation – The accumulation of contaminants in the tissues of organisms through any route, including respiration, ingestion, or direct contact with contaminated water, sediment, or dredged material.

biomass – The mass of living material in a given area or volume of habitat.

bivalve – Also known as pelecypods, bivalves include the familiar clams, oysters, and scallops. They are defined by the presence of two laterally-compressed shells, hinged together by an elastic ligament and shell teeth. The shells are closed by well-developed adductor muscles.

brackish water – A mixture of fresh and salt water.

coastal zone – Coastal waters and adjacent lands that exert a measurable influence on the uses of the sea and its ecology.

contaminant – A chemical or biological substance in a form that can be incorporated into, onto, or be ingested by and that harms aquatic organisms, consumers of aquatic organisms, or users of the aquatic environment.

crustacean – A group of aquatic animals characterized by jointed legs and a hard shell which is shed periodically, e.g., shrimp, crabs, crayfish, isopods, and amphipods.

deltaic – Of, or relating to, the alluvial deposits at the mouth of a river.

demersal – At or near the bottom.

detritivores – Detritivores are consumers of dead organic material (detritus). Detritus feeders recycle the carbon in this material by mechanically and chemically breaking it down. During decomposition, carbon is returned to the atmosphere to be reabsorbed by living plants.

diapir – A dome or anticlinal fold in which a mobile core (e.g., salt) has broken through the overlying sedimentary strata.

dinoflagellates – microscopic, (usually) unicellular, flagellated, often photosynthetic protists, commonly regarded as "algae."

dredged material – Material excavated from waters of the United States or ocean waters. The term dredged material refers to material which has been dredged from a water body, while the term sediment refers to material in a water body prior to the dredging process.

effluent – A discharge of pollutants into the environment, partially or completely treated or in its natural state. Generally used in regard to discharges into waters.

EIS – Environmental impact statement. A document prepared on the environmental impact of actions significantly affecting the quality of the human environment and used as a tool for decision-making.

estuary – Estuaries are bodies of water along our coasts that are formed when fresh water from rivers flows into and mixes with salt water from the ocean. In estuaries, the fresh river water is blocked from streaming into the open ocean by either surrounding mainland, peninsulas, barrier islands, or fringing salt marshes.

epiphyte – any plant that does not normally root in the soil but grows upon another living plant while remaining independent of it except for support.

eutrophication – When sediments, sewage, or fertilizers are introduced into a waterway, the concentration of available nutrients in that system will increase, resulting in a condition known as "eutrophication." Although wetlands are typically able to withstand substantial increases in the concentration of available nutrients, many deepwater habitats are not nearly so tolerant. Even relatively modest increases in the concentration of nitrogen or phosphorous may be sufficient to trigger an "algal bloom." Sometimes an algal bloom can kill all the fish in a lake or pond.

floodplain – The flat, low-lying portion of a stream valley subject to periodic inundation.

fluvial – Produced by the action of a stream.

gastropod – A member of the Class Gastropoda which includes snails and slugs. Most gastropods have a single, usually spirally coiled, shell into which the body can be withdrawn, although the shell is absent or reduced in some important groups.

genus – A category of biological classification ranking between the family and the species, comprising structurally or phylogenetically (evolutionary relationship) related species and being designated by a Latin or latinized capitalized singular noun.

groundwater – The supply of freshwater under the earth's surface in an aquifer or soil that forms the natural reservoir for man's use.

habitat – The specific area or environment in which a particular type of plant or animal lives. An organism's habitat provides all of the basic requirements for the maintenance of life. Typical coastal habitats include beaches, marshes, rocky shores, bottom sediments, mudflats, and the water itself.

hydrogen sulfide (H_2S) – A malodorous gas made up of hydrogen and sulfur with the characteristic of odor of rotten eggs. It is emitted in the natural decomposition of organic matter and is also the natural accompaniment of advanced stages of eutrophication. H_2S is also a byproduct of refinery activity and the combustion of oil during power plant operations. In heavy concentrations, it can cause illness.

infauna – Animals which live within the sediment of the sea bottom.

intertidal zone – The marine zone between the highest high tide point on a shoreline and the lowest tide point. The intertidal zone is sometimes subdivided into four separate habitats by height above tidal datum, typically numbered 1 to 4, land to sea.

lagoon – A shallow body of seawater generally isolated from the ocean by a barrier island. Also the body of water enclosed within an atoll, or the water within a reverse estuary.

larva (pl. **larvae)** – An embryo that differs markedly in appearance from its parents and becomes self-sustaining before assuming the physical characteristics of its parents.

lead – A heavy metal that may be hazardous to human health if breathed or ingested.

low tide – The lowest limit reached by a falling tide.

macroinvertebrate – An animal lacking a backbone and visible without the aid of magnification.

mean lower low water (MLLW) – The average height of all the lower low waters recorded over a 19-year period, or a computed equivalent period; usually associated with a tide exhibiting mixed characteristics.

mean low tide (MLT) – The average height of all low tides at a given place, usually over a period of 19 years.

mean sea level (MSL) – The mean surface water level determined by averaging heights at all stages of the tide over a 19-year period. MSL is usually determined from hourly height readings measured from a fixed predetermined reference level (chart datum).

mercury – A heavy metal, highly toxic of breathed or ingested. Mercury is residual in the environment, showing biological accumulation in all aquatic organisms, especially fish and shellfish. Chronic exposure to airborne mercury can have serious effects on the central nervous system.

nekton – Free-swimming aquatic animals essentially independent of wave and current action.

open-water disposal – Placement of dredged material in rivers, lakes, estuaries, or oceans via pipeline or surface release from hopper dredges or barges.

organism – Any living human, plant, or animal.

particulate matter – very fine solid or liquid particles in the air or in an emission, including dust, fog, fumes, mist, smoke, and spray, etc.

PCB – Polychlorinated biphenyls, a group of organic compounds used in the manufacture of plastics. In the environment, PCBs exhibit many of the same characteristics as DDT and may, therefore, be confused with that pesticide. PCBs are highly toxic to aquatic life, they persist in the environment for long periods of time and are biologically accumulative.

physiography – A landscape whose parts exhibit similar geologic structures and climate, and whose pattern of topographic relief differs significantly from that of adjacent landscapes, indicating a unified geomorphic history.

phytoplankton – Plantlike, usually single-celled members (generally microscopic) of the plankton community.

plankton – Drifting or weakly swimming organisms suspended in water. Their horizontal position is to a large extent dependent on the mass flow of water rather than on their own swimming efforts.

planktonic – Floating in the water column.

polychaetes – include such forms as sand worms, tube worms, and clam worms. Most have well developed, paired, paddle-like appendages (parapodia), well developed sense organs, and numerous setae (usually on the parapodia; "polychaete" means "many hairs").

runoff – The portion of rainfall, melted snow, or irrigation water that flows across ground surface and eventually is returned to streams. Runoff can pick up pollutants from the air or the land and carry them to receiving waters.

sediment – The layer of soil, sand, and minerals at the bottom of surface water that absorbs contaminants.

shoalgrass – Seagrass species (*Halodule beaudettei*); submerged perennial, restricted to shallow, saline coastal bays.

surface water – Water on the earth's surface exposed to the atmosphere as rivers, lakes, streams, and oceans.

swash – The rush of water onto the beach following the breaking of a wave.

terrigenous clastics – sandstones, conglomerates, breccias and mudrocks.

total petroleum hydrocarbons – a large family of several hundred chemical compounds that originally come from crude oil.

TNRCC – Texas Natural Resource Conservation Commission. On September 1, 1993, the Texas Air Control Board, Texas Water Commission, and parts of the Texas Department of Health merged and became the TNRCC.

toxic pollutant – Pollutants, or combinations of pollutants, including disease-causing agents, that after discharge and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will, on the basis of information available to the Administrator of the U.S. Environmental Protection Agency, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, or physical deformations in such organisms or their offspring.

turbidity – An optical measure of the amount of material suspended in the water. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. High levels of turbidity may be harmful to aquatic life.

wetlands – Areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support and that, under normal circumstances, do support a prevalence of vegetation typically adapted for life in saturated-soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (40 CFR Part 230), especially areas preserved for wildlife, zooplankton (planktonic animals that supply food for fish).

VOC – Volatile organic compounds. Secondary petrochemicals, including light alcohols, acetone, trichloroethylene, perchloroethylene, dichloroethylene, benzene, vinyl chloride, toluene, and methylene chloride, which are used as solvents, degreasers, paint thinners, and fuels. Because of their volatile nature, they readily evaporate into the air, increasing the potential exposure to humans. Due to their low water solubility, environmental persistence and widespread industrial use, they are commonly found in soil and groundwater.

zooplankton – Animal members of the plankton community.