

Document No 951183
EH&A Job No 15650-40

LAGUNA MADRE
REVIEW OF INFORMATION CONCERNING
WATER AND SEDIMENT QUALITY
AND TISSUE CHEMISTRY

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CONTRACT DACW64-94-D-0006

November 1995

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INTRODUCTION

In response to concerns about the Laguna Madre, an Interagency Coordination Team (ICT) was assembled to develop and analyze the information necessary to determine the present and projected health of the Laguna Madre ecosystem. The ICT is comprised of personnel from the Texas Department of Transportation (TXDOT), the Texas General Land Office (GLO), the Texas Natural Resource Conservation Commission (TNRCC), the U.S. Environmental Protection Agency (USEPA), the U.S. Army Corps of Engineers (USACE), the U.S. Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), the Texas Water Development Board (TWDB), and the Texas Parks and Wildlife Department (TPWD). The Corpus Christi Bay National Estuary Program (CCBNEP) serves in an advisory capacity to the ICT. An immediate problem faced by the ICT was to determine what water and sediment quality information was available so that data gaps could be identified and the need for additional studies could be determined. Under Contract DACW-94-D-0006, the USACE issued Delivery Order No. 0028 (DO28) to Espey, Huston & Associates, Inc. (EH&A) to provide a review information concerning sediment and water quality and tissue chemistry in the Laguna Madre.

DO28 required EH&A to "help the ICT narrow the scope of study to evaluate the impacts of dredging and disposal practices in the Laguna Madre by (1) identifying past, on-going, and foreseeable studies and data collections on sediment quality (including borings data), water quality, and tissue chemistry, (2) collecting copies of the data summaries and/or reports, and (3) preparing a brief description of each data set or report to catalog the various data for easy use by the ICT." EH&A is also to prepare an assessment of the gaps in the information needed by the ICT. This report presents the results of EH&A's efforts under Delivery Order No. 0028. A list of the data summaries and reports collected and retained on file by EH&A, under Item 2 above, is presented in Section 5.0.

STUDY AREA

The Laguna Madre is a long, narrow, hypersaline lagoon extending from Corpus Christi Bay to the southern end of South Bay near the Rio Grande. However, since the concerns of the ICT are with dredging and disposal practices in the Laguna Madre, the study area under DO28 is from the vicinity of the J. F. Kennedy Causeway to the Brownsville Ship Channel.

Two excellent bibliographies were supplied to EH&A Hockaday, Robinson, Salaiz (1995) and Tunnell and Alvarado (1994) In addition to the efforts described in Section 2, these bibliographies were used extensively in the pursuit of information

The earliest reference provided in Tunnell and Alvarado (1994) is entitled *Report on the military reconnaissance of the Laguna Madre* (Meade, 1846). In 1930, an article by J G Burr titled "Sail Down the Laguna" was published in the Texas Game, Fish, and Oyster Commission (TGFOC) yearbook. TGFOC personnel collected data in the Laguna Madre as early as the 1940s (Gunter, 1945, Anderson, 1949, Baker, 1949). Joseph Breuer, TGFOC and TPWD, reported on the Laguna Madre in three different decades (Breuer, 1957, 1959, 1960, 1962a,b; 1971; 1972) and others in the TPWD reported of numerous investigations beginning in the 1960s (Hawley, 1963, Martinez, 1963, 1965, 1967, 1968, 1972, 1974, Osborn, 1963, Childress, 1967, 1968, 1970, Bryan, 1971) The TWDB and USGS began reporting on the chemical and physical characteristics of the Laguna Madre as early as 1970 (Hahl and Ratzlaff, 1970, 1972, 1973, 1975) and the Marine Science Institute has publications going back into the 1950s (Collier and Hedgpeth, 1950, Hedgpeth, 1953, Breuer, 1957, Shepard and Ruznak, 1957, Simmons, 1957, Ruznak, 1960, Hellier, 1962, Copeland, 1967; Copeland and Hoese, 1966, Maurer and Parker, 1972)

2.0 METHODS AND MATERIALS

2.1 DATA COLLECTION

EH&A compiled a preliminary list of contacts who were then sent a letter explaining the project and a copy of the preliminary list. The letter asked that the recipients provide additional contacts and sources of information of which they were aware. EH&A then contacted individuals on the updated list to request information pertinent to the project. Information was collected from Federal and State agencies, universities, and volunteer and private organizations. A final list of contacts and organizations is presented in Table 1. Documents were obtained via mail, duplication, and document retrieval. Three databases were searched for information pertaining to the project. The first two are entitled Bibliography, Laguna Madre of Texas (January 1994) and Texas Coastal Ecology Bibliography (February 1995) by Dr. John W. Tunnell, Jr. and Sandra A. Alvarado at the Center for Coastal Studies, Texas A&M University - Corpus Christi. The third is entitled Water Related Natural Resources of the Lower Rio Grande Valley of Texas, An Annotated Bibliography (September 1995) by Dr. Don L. Hockaday, Gayle Curry Robinson, and Cheryl Salaz of the Coastal Studies Laboratory at the University of Texas - Pan American, South Padre Island, Texas. In addition, the Coastal Bend Monitoring and Research Workshop sponsored by the University of Texas Marine Science Institute (UTMSI) and the CCBNEP was attended in order to gather information and visit with professionals who conduct investigations within the Laguna Madre system.

2.2 DATA ANALYSIS

The information collected was compiled, reviewed and summarized by project and participating organization and is presented in Section 3.0. A review of the information was conducted and an assessment of the information gaps that still need to be filled is presented in Section 4.0.

TABLE 1

LAGUNA MADRE INFORMATION CONTACT LIST

ORGANIZATION	LOCATION	CONTACT
Conrad Blucher Institute	Corpus Christi, TX	Dr Nicholas Kraus
Corpus Christi Bay National Estuary Program	Corpus Christi, TX	Richard Volk
National Biological Survey	Corpus Christi, TX	Dr. Christopher Onuf
National Marine Fisheries Service	Galveston, TX	Dr. Pete Sheridan
National Marine Fisheries Service	Galveston, TX	Dr Roger Zimmerman
Texas A&M University	College Station, TX	Dr. B J Presley
Texas A&M University	College Station, TX	Dr John Morse
Texas A&M University - GERG	College Station, TX	Dr. Jim Brooks
Texas A&M University - GERG	College Station, TX	Dr Gary Wolff
Texas A&M University - CCS	Corpus Christi, TX	Dr. John Tunnell, Jr
Texas A&M University - CCS	Corpus Christi, TX	Dr Roy Lehman
Texas A&M University - TAES	Corpus Christi, TX	Dr Bobby Eddleman
Texas A&M University - TAES	Corpus Christi, TX	Dr Juan Landivar
Texas Department of Health	Austin, TX	Kirk Wiles
Texas Department of Health	Austin, TX	Mike Ordner
Texas General Land Office	Austin, TX	Kelly Hutchinson
Texas General Land Office	Aransas Pass, TX	Lloyd Mullins
Texas Natural Resource Conservation Commission	Austin, TX	Trey Murff
Texas Natural Resource Conservation Commission	Austin, TX	Christine Kolbe
Texas Natural Resource Conservation Commission	Austin, TX	Jack Davis
Texas Natural Resource Conservation Commission	Austin, TX	Barbara Landry
Texas Natural Resource Conservation Commission	Corpus Christi, TX	James Bowman
Texas Parks and Wildlife Department	Austin, TX	Don Pitts
Texas Parks and Wildlife Department	Corpus Christi, TX	Dick Harrington
Texas Parks and Wildlife Department	Rockport, TX	Larry McEachron
Texas Watch Citizen Water Quality Monitoring	Austin, TX	Chris Pinero
Texas Watch Citizen Water Quality Monitoring	Corpus Christi, TX	John Giles
Texas Water Development Board	Austin, TX	Dr Gary Powell
Texas Water Development Board	Austin, TX	Dr. Ruben Solis
Texas Water Development Board	Austin, TX	David Brock

TABLE 1 (Concluded)

LAGUNA MADRE INFORMATION CONTACT LIST

ORGANIZATION	LOCATION	CONTACT
U.S Army Corps of Engineers	Galveston, TX	Denise Sloan
U S Army Corps of Engineers	Galveston, TX	Tim Baumer
U S Army Corps of Engineers	Galveston, TX	Dr. Terry Roberts
U S Army Corps of Engineers	Galveston, TX	June Keller
U S Army Corps of Engineers	Galveston, TX	David Campbell
U S Environmental Protection Agency	Dallas, TX	Phillip Crocker
U.S Environmental Protection Agency	Dallas, TX	Doug Jacobsen
U.S Environmental Protection Agency	Dallas, TX	Charlie Howell
U.S Environmental Protection Agency	Gulf Breeze, FL	John Macauley
U.S Environmental Protection Agency	Gulf Breeze, FL	J. Kevin Summers
U.S Fish and Wildlife Service	Corpus Christi, TX	Johnny French
U S Fish and Wildlife Service	Corpus Christi, TX	Thomas Schultz
U S. Fish and Wildlife Service	Corpus Christi, TX	Robyn Cobb
U S. Fish and Wildlife Service	Corpus Christi, TX	Tom Serota
U S Geological Survey	Austin, TX	Betty Hines
U S Geological Survey	Austin, TX	Evan Hornig
U S Geological Survey	San Antonio, TX	Darwin Ockerman
University of Texas - Center for Research & Water Resources	Austin, TX	Dr. George Ward
University of Texas - Marine Science Institute	Port Aransas, TX	Dr Tony Amos
University of Texas - Marine Science Institute	Port Aransas, TX	Dr Ed Busky
University of Texas - Marine Science Institute	Port Aransas, TX	Dr. Ken Dunton
University of Texas - Marine Science Institute	Port Aransas, TX	Dr Paul Montagna
University of Texas - Marine Science Institute	Port Aransas, TX	Dr. Terry Whittledge
University of Texas - Pan American	Edinburg, TX	Dr Terry Ellison
University of Texas - Pan American	Edinburg, TX	Dr Frank Judd
University of Texas - Pan American	South Padre Island, TX	Dr Don Hockaday

3 0 RESULTS AND DISCUSSION

The major past, ongoing, and foreseeable water, sediment, and tissue quality studies in the Laguna Madre and adjacent areas are summarized in Table 2. The parameters are grouped into three main categories including conventional parameters (i.e. personal observations, temperature, dissolved oxygen, salinity, nutrients, etc.); trace metals, and organics which are further broken down into volatiles, semivolatiles, and pesticides. For most studies, specific parameters are selected within each of these categories. When possible, a representative list of parameters is presented in tabular form or described in the text. When not feasible, as for the numerous special studies performed by the TNRCC, group classifications are presented. Figures for various studies are also provided to present the approximate station locations in the Laguna Madre and surrounding areas. However, more accurate figures with specific station descriptions are presented in each study's respective document. The project summaries from these various activities are discussed below.

During the course of this project, several studies were encountered that did not (1) pertain to the particular project area but were nearby or (2) did not pertain to the precise scope of the project, i.e., studies concerned with seagrasses in the Laguna Madre but not sediment chemistry. Rather than lose this information, which is probably of value to the ICT, these studies are included in Section 3.2.

3 1 PROJECT SUMMARIES

3 1.1 Conrad Blucher Institute (CBI)

The CBI operates all Texas Coastal Ocean Observation Network (TCOON) stations for water level, wind and air temperature and certain tide gauges in the Laguna Madre (Figure 1) (Kraus, 1995). The CBI also has several fixed platform monitoring stations and roving stations associated with special projects (Kraus, 1995). Typically, the fixed platforms electronically monitor the current, turbidity, light intensity near the bottom, salinity, pH, dissolved oxygen, chlorophyll-a, and water temperature. Additional parameters are monitored depending on the nature of the project. The roving stations generally take the same parameters as the fixed platform in addition to study-specific parameters. The CBI currently has fixed platform studies in conjunction with the U.S. Army Corps of Engineers (USACE), Texas General Land Office (GLO), and the University of Texas Marine

TABLE 2
LIST OF ORGANIZATIONS AND RELATED STUDIES
LAGUNA MADRE

ORGANIZATION	WATER, SEDIMENT, AND TISSUE QUALITY				
	CONVENTIONAL PARAMETERS	TRACE METALS	ORGANICS		
			Semivolatiles	Volatiles	Pesticides
Conrad Blucher Institute (CBI)					
TCOON	W				
Fixed Platform Studies	W				
Espey, Huston & Associates (EH&A)					
Intensive Inflow Study (1980)	W				
Texas A&M University System (TAMU)					
TAMU - Corpus Christi					
Center for Coastal Studies					
Dr Lehman	W				
Kurtis Rhudy	W				
Texas Agricultural Experiment Station - (TAES)					
King Ranch Study	W	W			W
TAMU - Main campus - College Station					
Geochemical and Environmental Research Group (GERG)	W, S	S, T	S, T	S, T	S, T
Texas Department of Health (TDH)	W				
Texas General Land Office (GLO)					
Biological Productivity Study - UTMSI	W				
Fixed Platform - Arroyo Colorado Cutoff	W				
Texas Natural Resource Conservation Commission (TNRCC) ¹					
Segment 2491 (Laguna Madre)	W	S, T	S, T	S, T	S, T
Special Study - Port Isabel Harbor	W, S	W, S	W, S	W,S	W,S

W = Water, S = Sediment, T = Tissue

¹ Information for TNRCC segment monitoring includes 1989-1992 data

² The studies contain all or a combination of the parameters marked. Numbers in parentheses refer to the number of studies

TABLE 2 (Continued)

LIST OF ORGANIZATIONS AND RELATED STUDIES
LAGUNA MADRE

ORGANIZATION	CONVENTIONAL PARAMETERS	TRACE METALS	WATER, SEDIMENT, AND TISSUE QUALITY		
			Semivolatiles	Volatiles	Pesticides
TNRCC (continued)					
Segment 2492 (Baffin Bay/Alazan Bay/etc.)	W	S, T	S, T	S, T	S, T
Special Study - San Fernando Creek	W, S	W, S	W, S	W, S	W, S
Segment 2201 (Arroyo Colorado Tidal)	W	S, T	S, T	S, T	S, T
Special Studies (6) ²	W	W, S, T	W, S, T	W, S, T	W, S, T
Lower Rio Grande/Lower Arroyo Colorado Survey	W	S, T	S, T	S, T	S, T
Texas Parks and Wildlife Department (TPWD)					
Routine Coastal Monitoring	W				
Texas Watch Citizen Water Quality Monitoring Program	W				
Texas Water Development Board (TWDB)					
Coastal Data System	W				
Intensive Three-day Studies	W				
TDWR (1983) - Freshwater Inflow Study	W	S			S
U S Army Corps of Engineers (USACE)					
Corpus Christi Bay to Mudflats	W	W, S, T	W, S, T	W, S	W, S, T
Channel to Harlingen	W	W, S	W, S	W, S	W, S
Channel to Port Mansfield	W	W, S	W, S	W, S	W, S
Port Isabel to the Mudflats	W	W, S	W, S	W, S	W, S
Port Isabel Small Boat Harbor	W	W, S	W, S	W, S	W, S
Brazos Island Entrance Channel	W	W, S, T	W, S	W, S	W, S, T

W = Water, S = Sediment, T = Tissue

¹ Information for TNRCC segment monitoring includes 1989-1992 data² The studies contain all or a combination of the parameters marked. Numbers in parentheses refer to the number of studies

TABLE 2 (Continued)

LIST OF ORGANIZATIONS AND RELATED STUDIES
LAGUNA MADRE

ORGANIZATION	WATER, SEDIMENT, AND TISSUE QUALITY				
	CONVENTIONAL PARAMETERS	TRACE METALS	ORGANICS		
			Semivolatiles	Volatiles	Pesticides
USACE (continued)					
Brownsville Channel	W	W, S	W, S	W, S	W, S
Fixed Platform Studies	W				
GIWW - EIS and EA	W	W, S	W, S	W, S	W, S
U S Environmental Protection Agency (EPA)					
EMAP-E	W	S, T	S, T	S, T	S, T
U S Fish and Wildlife Service (FWS)					
Corpus Christi Bay Complex Study	W	S, T	S, T	S, T	S, T
Lower Rio Grande Valley Study	W	S, T	S, T	S, T	S, T
U S Geological Survey (USGS)	W				
University of Texas System (UT)					
UT - Bureau of Economic Geology (UTBEG)	W	S			
UT - Marine Science Institute (UTMSI) - Port Aransas	W				
UT - Pan American - Edinburg	W				
 -RELATED PROJECTS					
Port of Corpus Christi Authority					
Dredged Material Study	W				
National Biological Survey (NBS)					
Seagrass Surveys	W				

W = Water, S = Sediment; T = Tissue

¹ Information for TNRCC segment monitoring includes 1989-1992 data² The studies contain all or a combination of the parameters marked. Numbers in parentheses refer to the number of studies

TABLE 2 (Continued)

LIST OF ORGANIZATIONS AND RELATED STUDIES
LAGUNA MADRE

ORGANIZATION	CONVENTIONAL PARAMETERS	TRACE METALS	WATER, SEDIMENT, AND TISSUE QUALITY		
			Semivolatiles	Volatiles	Pesticides
Texas A&M University System (TAMU)					
TAMU - Corpus Christi - Center for Coastal Studies					
Dr. Sharma	W, S	S	S	S	
Texas Agricultural Experiment Station - (TAES)					
Odem Ranch Study	W	W			W
Texas Natural Resource Conservation Commission (TNRCC) ¹					
Segment 2481 (Corpus Christi Bay)	W	W, S, T	W, S, T	W, S, T	W, S, T
Special Studies (2) ²		W	W, S, T	W, S, T	W, S, T
W, S, T					
Segment 2484 (Corpus Christi Inner Harbor)	W	S	S	S	S
Special Study (1) ²	W	W, S	W, S	W, S	W, S
Segment 2493 (South Bay)	W				
Segment 2494 (Brownsville Ship Channel)	W	S, T	S, T	S, T	S, T
Special Study (1) ²	W	S	S	S	S
Segment 2301 (Rio Grande Tidal)	W	W, S, T	W, S, T	W, S, T	W, S, T
Texas Parks and Wildlife Department (TPWD)					
Selected Bay Study	W	S, T	S, T	S, T	S, T

W = Water, S = Sediment; T = Tissue

¹ Information for TNRCC segment monitoring includes 1989-1992 data² The studies contain all or a combination of the parameters marked. Numbers in parentheses refer to the number of studies.



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Figure 1
CONRAD BLUCHER INSTITUTE
TCOON STATION LOCATIONS

Science Institute (UTMSI). Please refer to the USACE, GLO, and UTMSI sections for project descriptions.

3 1 2 Corpus Christi Bay National Estuary Program (CCBNEP)

The CCBNEP is currently in the planning/organization stage in an effort to develop a monitoring program suitable for their goals and objectives (Volk, 1995). The CCBNEP will focus on a monitoring plan which will identify trends in water quality and natural resources, clarify the relationship between loads and potential uses, identify areas of environmental concerns, and monitor the effectiveness of actions taken to address those concerns. The CCBNEP is starting to fund certain projects in order to aid in this planning stage with the majority of work to come upon implementation of the Comprehensive Conservation and Management Plan (CCMP). The surface runoff water assessments being conducted by the Texas Agricultural Experiment Station (TAES) is an example of the type of early projects sponsored by the CCBNEP (refer to TAES, Section 3 1 5 2, for project description).

3 1.3 Espey, Huston & Associates, Inc. (EH&A)

In July 1980, with the support and coordination of several agencies, the Texas Department of Water Resources (TDWR) conducted an Intensive Inflow Study of the Laguna Madre System of Texas (EH&A 1980a, b). The objective of this study was to obtain hydrographic and water-quality data in sufficient detail and over a sufficient period to characterize the hydrodynamics, transport processes and flux budgets of waterborne constituents in the Laguna Madre system of Texas. The geographical coverage of the field activities extended from Brazos Santiago Pass at the southern extreme of the Laguna Madre to the JFK Causeway near Flour Bluff, where the Laguna joins Corpus Christi Bay (Figure 2). The parameters involved were current measurements, salinity, conductivity, dissolved oxygen, and temperature. The EH&A (1980a) report documents that portion of the study concentrating upon the hydrographic behavior of the GIWW in the Upper Laguna (i.e., from the Landbridge to the JFK Causeway). The EH&A (1980b) report describes the procedures employed and the hydrometeorological conditions attending the Intensive Inflow Study.



3 1 4 National Marine Fisheries Service (NMFS)

The NMFS has not completed any research on water, sediment, or tissue quality in the Laguna Madre (Sheridan, 1995) However, NMFS is currently conducting research in two related areas The first project is a comparison of fauna, flora, and sediments of restored and natural seagrass beds for EPA's Gulf of Mexico Program The second project involves a comparison of dredged material disposal sites with adjoining undisturbed seagrass habitats for the ICT In both studies, the only sediment information is organic content and grain size The first project was initiated in April 1995 and the second in August 1995

3 1 5 Texas A&M University System (TAMU)

3 1 5 1 Texas A&M University - Corpus Christi

Dr Virender K Sharma at the Center for Coastal Studies, currently has projects involving Trace Metals and Organic Contaminants in the Corpus Christi Bay System, Trace Metal Species in Corpus Christi Bay, and Hydrocarbons in Laguna Madre Sediments Several attempts to contact Dr Sharma with regards to this project were made and no response was obtained

Rachael L. Brooks and Dr Roy L Lehman at the Center for Coastal Studies are conducting a project entitled "Nutrient Concentrations and Phytoplankton Populations Before, During, and After Maintenance Dredging of the Gulf Intracoastal Waterway in the Upper Laguna Madre" (Lehman, 1995) Sampling was initiated in October 1994 at four sites in the Upper Laguna Madre These sites include (1) the mouth of the Laguna Madre at Corpus Christi Bay, (2) halfway between the first site and Baffin Bay, (3) at the mouth of Baffin Bay, and (4) at the mouth of the land cut, south. Sampling was conducted before, during, and after dredging activities and then at six months and one year The final collections were made in October 1995 Water samples collected from the four sites in the Upper Laguna Madre are being analyzed for ammonia, nitrate, and phosphate concentrations Populations of phytoplankton, especially the brown tide organism, and bacteria are being evaluated along with correlation between meteorological, salinity, and pH conditions

Kurtis B Rhudy is currently involved in a project assessing physical and chemical water quality parameters in respect to the brown tide bloom in Baffin Bay (CBMRW, 1995) Mr. Rhudy's

study has a total of 10 sampling sites (GPS) along transects within Baffin Bay, Alazan Bay and Cayo del Grullo, each containing three sites. Due to its small size Laguna Salada has only one site. At each established site, orthophosphate, nitrate-nitrogen, ammonia, Brown Tide organisms, diatoms and zooplankton are monitored. Water quality parameters including temperature, salinity, pH, dissolved oxygen, specific conductivity, redox potential, and turbidity are also being monitored. All sampling is monthly for one year (initiated in April 1995) with additional sampling following heavy rainfall events.

3.1.5.2 Texas Agricultural Experiment Station (TAES)

Dr. Bobby R. Eddleman at the Texas A&M University Agricultural Research and Extension Center in Corpus Christi, Texas is the principal investigator for two projects concerning water quality in the project area (Eddleman, 1995). The first project is an assessment of surface runoff water for sediment, nutrients and chemicals from King Ranch croplands. The project site involves a large watershed in the northern and eastern portion of Kleberg County with runoff being accumulated from croplands acreage planted to cotton and grain sorghum. The runoff proceeds into nearby wetlands, then into Baffin Bay, and eventually ends up in the Laguna Madre estuary system. Sampling water quality parameters, including nutrients, pesticides, sediment, oil and grease, and trace elements, will occur in the drainage area adjacent to the croplands. The second project is an assessment of surface runoff water for sediment, nutrients and chemicals pertaining to the Odem Ranch Watershed. Dr. Eddleman is again the principal investigator and this project involves a small watershed in the western portion of San Patricio County. The runoff from the croplands, including cotton and grain sorghum, will enter wetlands areas and eventually into the Nueces River and Corpus Christi Bay system. Water quality parameters are the same as the previous study. For continuity, this latter study was included here instead of Section 3.2.

3.1.5.3 Geochemical and Environmental Research Group (GERG)

Starting in 1984, GERG has had six sampling sites in the Laguna Madre, five of which are in the Project Area (Figure 3), in conjunction with the GLO and the National Oceanic and Atmospheric Administration (NOAA) National Status and Trends (NS&T) program (Wolff, 1995). GERG has annually sampled sediments and oyster tissues, when feasible, from these sites for trace



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Figure 3
GERG-NS&T
STATION LOCATIONS

metals, pesticides/PCBs, and hydrocarbons along with the standard parameters of temperature and salinity

3.1.6 Texas Department of Health (TDH)

The Division of Shellfish Sanitation has several water quality stations in Corpus Christi Bay, the Laguna Madre, Baffin Bay, South Bay, the Arroyo Colorado, and Brownsville Ship Channel (Figure 4) (TDH, 1993). However, the hypersaline conditions of the Laguna Madre make shellfish classification for the study area a low priority, and the only stations that continue to be sampled (5 to 6 times per year) by TDH personnel are south of Port Mansfield (Ordner, 1995). The following parameters are taken during routine sampling: Bay I.D., Station I.D., date of collection, time of collection, tidal movement, 24-hour rainfall, 4-day rainfall, 7-day rainfall, sky condition, wind direction; wind velocity, air and water temperature, salinity, fecal coliform result, classification; and status of area when the data was collected

3.1.7 Texas General Land Office (GLO)

The GLO has a contract with UTMSI involving a multidisciplinary study of the biological productivity in the Laguna Madre (Hutchinson, 1995). The work plan specifies that surveying and biological sampling in the Lower Laguna Madre will be conducted during one day each month to maintain consistency. Hydrographic samples will be collected at 21 locations for profiles of conductivity, temperature, and dissolved oxygen using a state-of-the-art Seabird model 19 SeaCat profiler (Figure 5). Station depth and secchi depth for light penetration will also be collected along with a GPS position at each site. Water samples will be collected near-surface and near-bottom with a special Van Dorn sampling bottle and analyzed for nutrient content (orthophosphate, dissolved silicon, nitrate, nitrite, and ammonium) and plant pigments (Chlorophyll and phaeopigments). The rates of primary production will be measured at nine of the sites using C-14 uptake of the phytoplankton as an estimate of growth rate (Figure 5). Additional sampling sites will be used if deemed necessary. A special effort concerning water quality will be continued in the Channel to Harlingen with respect to the influence of the freshwater inflows and shrimp mariculture facilities.

The GLO also has a contract with TNRCC and TPWD for a project focusing on conditions associated with low headwater flows in the Rio Grande and Arroyo Colorado (Hutchinson,





1995) There were eight targeted sampling sites for toxic chemicals in water, sediment and aquatic organism tissue. Refer to the TNRCC - Lower Rio Grande Valley study (Section 3.1.8)

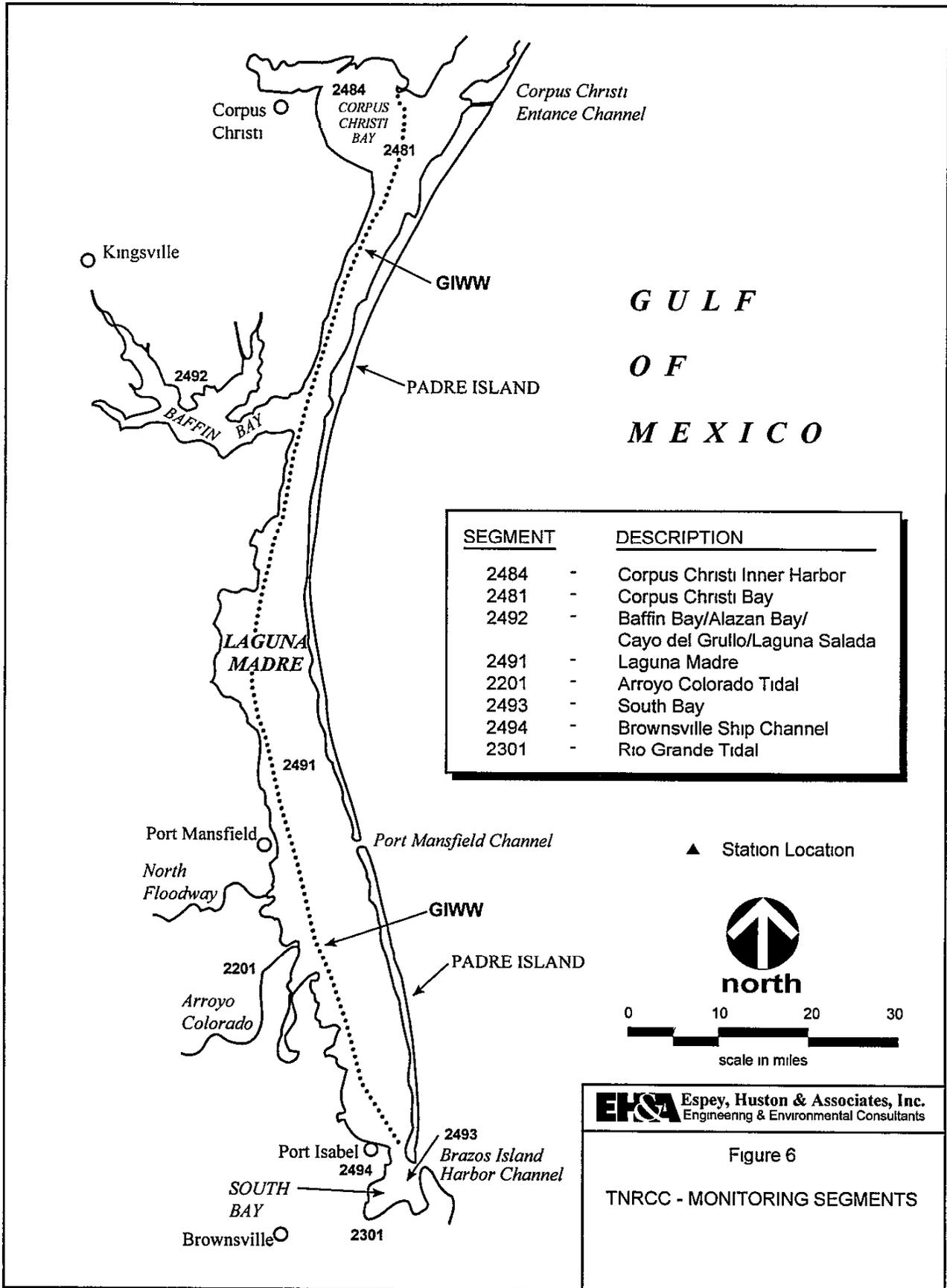
The GLO also has a contract with CBI for a data collection platform at the Arroyo Colorado Cutoff, 2-3 km upstream from the GIWW (Hutchinson, 1995). Continuous data on the following parameters were collected from July 1994 to August 1995: water velocity, temperature, salinity, conductivity; dissolved oxygen, turbidity, pH, total and dissolved nitrates, nitrites, ammonia, phosphates, and orthophosphate, total suspended solids, Chlorophyll a, total chlorophyll, and total organic carbon.

3.1.8 Texas Natural Resource Conservation Commission (TNRCC)

The majority of TNRCC's information comes from the Surface Water Quality Monitoring Team's fixed station monitoring effort (TNRCC, 1994) (Figure 6). The remainder of the information comes primarily from special studies or stations monitored by the International Boundary and Water Commission (IBWC), river authorities, cities, local governments, and Texas Watch Volunteers. The TNRCC has been involved in fixed station monitoring and/or special studies within the project area since 1969. Since that date, thirty on-segment and six off-segment stations have been monitored in Segment 2491 (Laguna Madre); fourteen on-segment and five off-segment stations have been monitored in Segment 2492 (Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada), and thirteen on-segment and four off-segment stations have been monitored in Segment 2201 (Arroyo Colorado Tidal). For individual stations, different parameters were sampled at different frequencies. The 12th edition of the State of Texas Water Quality Inventory (TNRCC, 1994) was reviewed and the following fixed station monitoring and special study information was provided:

Seven stations have been monitored in Segment 2491 (Laguna Madre) over the last four years. A special study was conducted December 11, 1984 involving Port Isabel harbor which included field and chemical measurements, metals and organics in water and sediment, bacteriological, and benthic macroinvertebrate sampling. There are no ambient toxicity monitoring stations in this segment.

Two on-segment and one off-segment stations have been monitored in Segment 2492 (Baffin Bay/Alazan Bay/Cayo del Grullo/Laguna Salada) over the past four years. A special study



was conducted May 16, 1988 on San Fernando Creek which included field and chemical measurements, metals and organics in water and sediment, bacteriological, benthic macroinvertebrate, plankton, and nekton sampling. There are no ambient toxicity monitoring stations on this segment.

Six on-segment and one off-segment stations have been monitored in Segment 2201 (Arroyo Colorado Tidal) over the last four years. There have been six special studies, conducted between August 1976 to December 1987, with published results. These studies have included all or some of the following parameters: field and chemical measurements, metals and organics in water, sediment, and tissue; bacteriological; benthic macroinvertebrate and nekton sampling, flow measurements, dye studies, and stream width measurements. There is one ambient toxicity monitoring station for this segment.

The TNRCC conducted a sampling effort in conjunction with several agencies in February 1994 entitled *Toxic Contaminants Survey of the Lower Rio Grande, Lower Arroyo Colorado, and Associated Coastal Waters*, which is currently in press. The agencies in conjunction with the TNRCC were the TPWD, GLO, USEPA, USFWS, and IBWC. A total of eight sites were sampled from streams which contribute inflow to the lower Laguna Madre and/or Gulf of Mexico (Figure 7, from (Davis *et al.*, 1995)). The sampling sites were subjected to measurements of conventional parameters in water, toxic chemical concentrations in water, sediment, and fish tissue; toxicity testing of water and sediment; and biological surveys of fish and benthic macroinvertebrate communities. In addition to trace elements and priority pollutants, water samples were analyzed for dissolved oxygen, pH, temperature, specific conductance, chloride, sulfate, total dissolved solids, total hardness, ammonia nitrogen, nitrate nitrogen, nitrite nitrogen, total Kjeldahl nitrogen, orthophosphorus, total phosphorus, chlorophyll a, total organic carbon, total suspended solids, turbidity, and residual chlorine, sediment for particle size composition, total organic carbon, and acid volatile sulfide, and fish tissue for percent lipid content (Davis *et al.*, 1995).

3 1.9 Texas Parks and Wildlife Department (TPWD)

TPWD coastal resource monitoring activities include several types of biological sampling for finfish and shellfish (McEachron, 1995). In association with each of these activities the following water quality parameters are collected: water temperature, salinity, dissolved oxygen, turbidity and weather conditions such as wind directions, air temperature, wind speed, and cloud cover. The sample



stations are randomly selected from TPWD's grid system. Coastal fisheries project reports containing this information are published by the TPWD. In the late 1960s, the Coastal Fisheries Branch conducted some investigations on levels of various pesticides in some species from selected Texas Bay areas including the Lower Laguna Madre (Childress, 1967, 1968). In 1971 a study on the lower portion of the Arroyo Colorado was conducted, again to investigate levels of pesticides in fish tissue (Bryan, 1971).

As previously mentioned, TPWD participated in a project with the TNRCC and GLO focusing on toxic conditions in the Rio Grande and Arroyo Colorado. There were eight targeted sampling sites for toxic chemicals in water, sediment and aquatic organism tissue. Refer to the TNRCC - Lower Rio Grande Valley study (Section 3.1.8).

3.1.10 Texas Watch Citizen Water Quality Monitoring Program

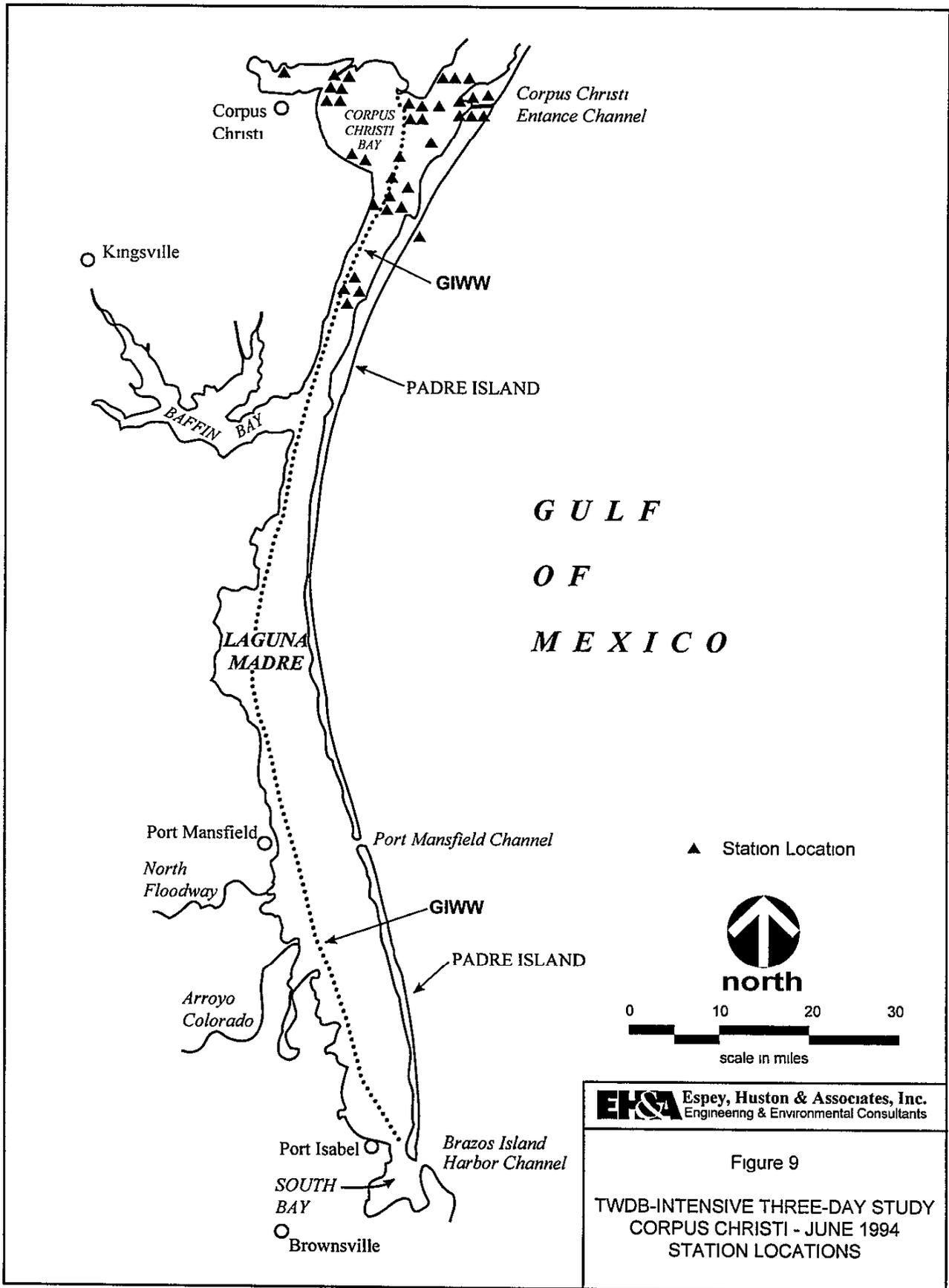
Texas Watch volunteers monitor ambient surface water quality parameters which include dissolved oxygen, pH, water and air temperature, salinity, conductivity, water clarity, and certain qualitative observations. These data add to the data collected by the TNRCC and other agencies. According to Chris Pinero (1995) (Texas Watch) in Austin, the only two monitoring stations in the Laguna Madre are near the GIWW at the JFK Causeway and along the west side of the Laguna Madre just south of the JFK Causeway. However, Texas Watch participants plan to assess the current monitoring sites and determine other important areas where sampling should be performed.

3.1.11 Texas Water Development Board (TWDB)

The TWDB conducts special three-day field studies to address various agency questions and data needs. The latest studies took place in 1991, 1994 and 1995. The 1991 study covered the entire extent of the Laguna Madre (Figure 8), while the 1994 and 1995 studies focused on the Corpus Christi Bay and Upper Laguna Madre (Figures 9 and 10, respectively) (Solis, 1995). The parameters typically collected during these studies include: station number, date, time, temperature, pH, conductivity, salinity, dissolved oxygen, wind velocity and tide elevations.

The TWDB Coastal Data System is a method of data collection using a datasonde for continuous measurements at routinely monitored stations ranging over the entire stretch of the Laguna







E&A Espey, Huston & Associates, Inc.
Engineering & Environmental Consultants

Figure 10

TWDB-INTENSIVE THREE-DAY STUDY
UPPER LAGUNA MADRE - JUNE 1995
STATION LOCATIONS

Madre including Baffin Bay and the Arroyo Colorado (Figure 11) (Brock, 1995) The Coastal Data System program was conducted between 1968 and 1989 The parameters routinely measured in the Laguna Madre include turbidity, conductivity, dissolved oxygen, transparency (secchi disk), pH, bicarbonate ion, salinity, ammonia, nitrite, nitrate, total Kjeldahl nitrogen, total phosphate, orthophosphate, total organic carbon, sulfate, chlorophyll-a, and total dissolved solids

The Texas Department of Water Resources, which was split into the TWDB and the Texas Water Commission (TWC, now TNRCC) published "Laguna Madre Estuary A Study of the Influence of Freshwater Inflows" (TDWR, 1983) This document compiles information from the USGS-TDWR and statewide monitoring network data stations for the period 1968-1977, unpublished records from the 1979-1980 Field Data Survey at USGS-TDWR line sites by the USGS, and unpublished records from a July, 1980, Laguna Madre Inflow Study by the TDWR (Refer to Section 3.1.3 for Laguna Madre Inflow Study). This report provides an extensive and comprehensive assessment of the influence of freshwater inflows to the Laguna Madre including information on physical characteristics, hydrology, circulation and salinity, nutrient processes, primary and secondary bay production, fisheries, and estimated freshwater inflow needs In 1994, "Freshwater Inflows to Texas Bays and Estuaries" was published by the TWDB (Longley, 1994). This project was a joint estuarine research study between the TWDB and the TPWD. TWDB information from the Coastal Data System and special studies were incorporated into this document along with other chemical and biological information collected by participating agencies and universities Unfortunately, since the study was concerned with freshwater inflows, there is very little data for the Laguna Madre

3.1.12 United States Army Corps of Engineers (USACE)

From 1974 to present, the USACE has conducted routine water, elutriate, and sediment sampling of the Laguna Madre system (Sloan, 1995) The areas of sampling are broken down into segments which include Corpus Christi Bay to the Mudflats (45 stations), Channel to Harlingen (17 stations), Channel to Port Mansfield (13 stations), Port Isabel to the Mudflats (50 stations), Port Isabel small boat harbor (1 station), Brazos Island Harbor Entrance Channel (7 stations) and Brownsville Ship Channel (12 stations) at 2-5 year intervals (Baumer, 1995). The sampling parameters are determined by contract and delivery order In the 1970s, mostly standard parameters and metals were determined but typically, present contracts include the parameters listed on Table 3. The data from these collections are entered into the Dredging History Database Management System maintained by the



TABLE 3
USACE PARAMETERS DETERMINED BY CHEMICAL ANALYSES

Metals		
Aluminum	Cobalt	Selenium
Antimony	Copper	Silver
Arsenic	Iron	Thallium
Barium	Lead	Vanadium
Beryllium	Manganese	Zinc
Cadmium	Mercury	
Chromium	Nickel	
Volatiles		
Acetone	2-Chloroethyl Vinyl Ether	Methylene Chloride
Acrolein	Chloroform	Styrene
Acrylonitrile	Chloromethane	1,1,2,2-Tetrachloroethane
Benzene	Cis-1,3-Dichloropropene	Tetrachloroethene
Bromo-dichloro-methane	Dibromochloromethane	Toluene
Bromoform	1,1-Dichloroethane	Trans-1,2-Dichloroethene
Bromomethane	1,1-Dichloroethene	Trans-1,3-Dichloropropene
2-Butanone	1,2-Dichloroethane	1,1,1-Trichloroethane
Carbon Tetrachloride	1,2,-Dichloropropane	1,1,2-Trichloroethane
Carbon Disulfide	Ethylbenzene	Trichloroethene
Chlorobenzene	2-Hexanone	Vinyl Acetate
Chloroethane	4-Methyl-2-Pentanone	Vinyl Chloride
		Xylene (total)
Semivolatiles		
Benzoic Acid	1,4-Dichlorobenzene	Isophorone
Benzyl Alcohol	2,4-Dichlorophenol	2-Methylnaphthalene
Bis(2-chloroethoxy)methane	Diethyl Phthalate	2-Methylphenol
Bis(2-chloroethyl)ether	2,4-Dimethylphenol	4-Methylphenol
Bis(2-chloroisopropyl)ether	Dimethyl Phthalate	2-Nitroaniline
Bis(2-Ethylhexyl)phthalate	Di-N-Butyl Phthalate	3-Nitroaniline
4-Bromophenylphenyl Ether	4,6-Dinitro-2-Methylphenol	4-Nitroaniline
Butylbenzyl Phthalate	2,4-Dinitrophenol	Nitrobenzene
4-Chloroaniline	2,4-Dinitrotoluene	N-Nitrosodiphenylamine
4-Chloro-3-cresol	2,6-Dinitrotoluene	N-Nitrosodiprophylamine
2-Chloronaphthalene	Di-n-octyl Phthalate	2-Nitrophenol
2-Chlorophenol	Diphenylamine	4-Nitrophenol
4-Chlorophenylphenyl Ether	Hexachlorobenzene	Pentachlorophenol
Dibenzofuran	Hexachlorobutadiene	Phenol
1,2-Dichlorobenzene	Hexachlorocyclopentadiene	1,2,4-Trichlorobenzene
1,3-Dichlorobenzene	Hexachloroethane	2,4,5-Trichlorophenol
		2,4,6-Trichlorophenol

TABLE 3 (Continued)

Pesticides	4,4'-DDD	Endrin
Aldrin	4,4'-DDE	Endrin Aldehyde
Alpha-BHC	4,4'-DDT	Heptachlor
Beta-BHC	Endosulfan I	Heptachlor Epoxide
Delta-BHC	Endosulfan II	Methoxychlor
Gamma-BHC	Endosulfan Sulfate	Toxaphene
Chlordane		
PCBs		
Aroclor-1016	Aroclor-1242	Aroclor-1260
Aroclor-1221	Aroclor-1248	Total PCBs
Aroclor-1232	Aroclor-1254	
PAHs		
Acenaphthylene	Benzo(gh)perylene	Indeno(1,2,3-cd)pyrene
Acenaphthene	Benzo(k)fluoranthene	Naphthalene
Anthracene	Chrysene	Phenanthrene
Benzo(a)anthracene	Dibenzo(a,h)anthracene	Pyrene
Benzo(a)pyrene	Fluoranthene	
Benzo(b)fluoranthene	Fluorene	
Total Organic Carbon		

USACE The USACE also maintains files of correspondence with USFWS and USEPA in which site visits or small sampling events took place. In addition, the USACE completed an Environmental Impact Statement (EIS) for Maintenance Dredging of the Gulf Intracoastal Waterway -Texas (USACE, 1975a), which was reprinted in 1984. The USACE also prepared an Environmental Assessment (USACE, 1990) which, while it pertains to upland disposal from Corpus Christi to the Mudflats, contained the 1988 water, elutriate, and sediment chemistry data for that reach of the GIWW. It also includes data on bioassays and bioaccumulation studies of three stations in that reach of the GIWW on samples collected in the summer of 1986 (EH&A, 1987). EISs have also been prepared for the Brownsville Ship Channel maintenance material (USACE, 1975b) and new work material (USACE, 1981, 1982, 1988).

The USACE has a contract with the CBI for environmental monitoring of dredging and processes in the Lower Laguna Madre between Port Isabel and the Arroyo Colorado (CBI, 1994a). The main issues of concern are encroachment of sediment onto seagrass beds and reduction of light within the water column, encroachment of sediment into wetlands, transport of dredged material back into the GIWW and loss of material from placement sites, and understanding cause-and-effect relations between hydrodynamic forcing and sediment movement. The first aspect of monitoring involved a fixed station that was emplaced before dredging and maintained for the duration of the project to make continuous measurements. Water samples were also taken during weekly maintenance of the fixed station. The second aspect of monitoring involved a roving station that would take measurements on designated transects or intensively at certain desired locations. The fixed station electronically monitors the current, turbidity, light intensity near the bottom, salinity, pH, dissolved oxygen, chlorophyll-a, and water temperature. A water sample was taken every week for direct measurement and instrument validation. The roving stations will measure the same parameters as the fixed platform. Bottom bathymetry surveys, seagrass inventories, and sediment sampling will also be conducted from the roving stations. Sediment type, layer thickness, and grain-size distribution will be analyzed from bottom core and grab samples.

The USACE has a similar contract with the CBI for environmental monitoring of dredging and processes in the vicinity of Baffin Bay (CBI, 1994b). The main issues of concern are the same as the above mentioned Lower Laguna Madre study. For the Baffin Bay study, three fixed stations will be emplaced before the dredging and maintained for the duration of the project and one

roving station will be utilized for a total of at least five surveys. The same parameters will be measured as for the Lower Laguna Madre study

3 1.13 United States Environmental Protection Agency (USEPA)

The Environmental Monitoring and Assessment Program (EMAP) is a national program initiated by EPA integrating the efforts of several federal agencies to evaluate the status and trends of the ecological resources of the United States (Macauley *et al* , 1994) EMAP-Estuarines (EMAP-E) is a part of EMAP organized to evaluate the status and trends of the estuarine resources of the United States. The Louisianan Province represents a single biogeographic area of the country corresponding to the Gulf of Mexico A series of indicators that are representative of the overall condition of estuarine resources are measured at each site These indicators were designed to address three major attributes of concern 1) estuarine biotic integrity, 2) societal values related to public use of estuarine resources, and 3) pollutant exposure of the environmental conditions under which biota live Table 4 lists the indicators used in the EMAP-E program There were two sites within the Laguna Madre system in 1991, none in 1992, one in 1993, and four in 1994 (Figure 12)

3 1.14 United States Fish and Wildlife Service (USFWS)

The USFWS conducted baseline contaminants assessments of the Corpus Christi Bay complex in 1988-89 (Barrera *et al.*, 1995) Sediment and biota was collected from a study area including Corpus Christi, Redfish, Nueces, Oso, and Baffin Bays, the Upper Laguna Madre, the Nueces River; and the Corpus Christi Inner Harbor Sediments were collected from May to July, 1988, while biota were collected from July to November, 1989 Seventy-three sediment samples and 15 biota samples were collected from the approximately 300 square kilometers of the Upper Laguna Madre and submitted for chemical analysis (Figure 13, from (Barrera *et al* , 1995)) Fifty-nine sediment samples and 15 biota samples were collected from the approximately 129 square kilometers of Baffin Bay and submitted for chemical analysis (Figure 14, from (Barrera *et al.*, 1995)). Biota consisted of composite samples of shoalgrass, eastern oysters, blue crabs, calico crabs, toadfish, and hardhead catfish Samples were analyzed for polycyclic aromatic hydrocarbons (PAHs), organochlorines (OCs), polychlorinated biphenyls (PCBs), and 23 trace elements Six biota samples were also analyzed for the dioxin, 2,3,7,8 TCDD

TABLE 4
USEPA EMAP-ESTUARIES LOUISIANIAN PROVINCE
LIST OF INDICATORS

BIOTIC INDICATORS

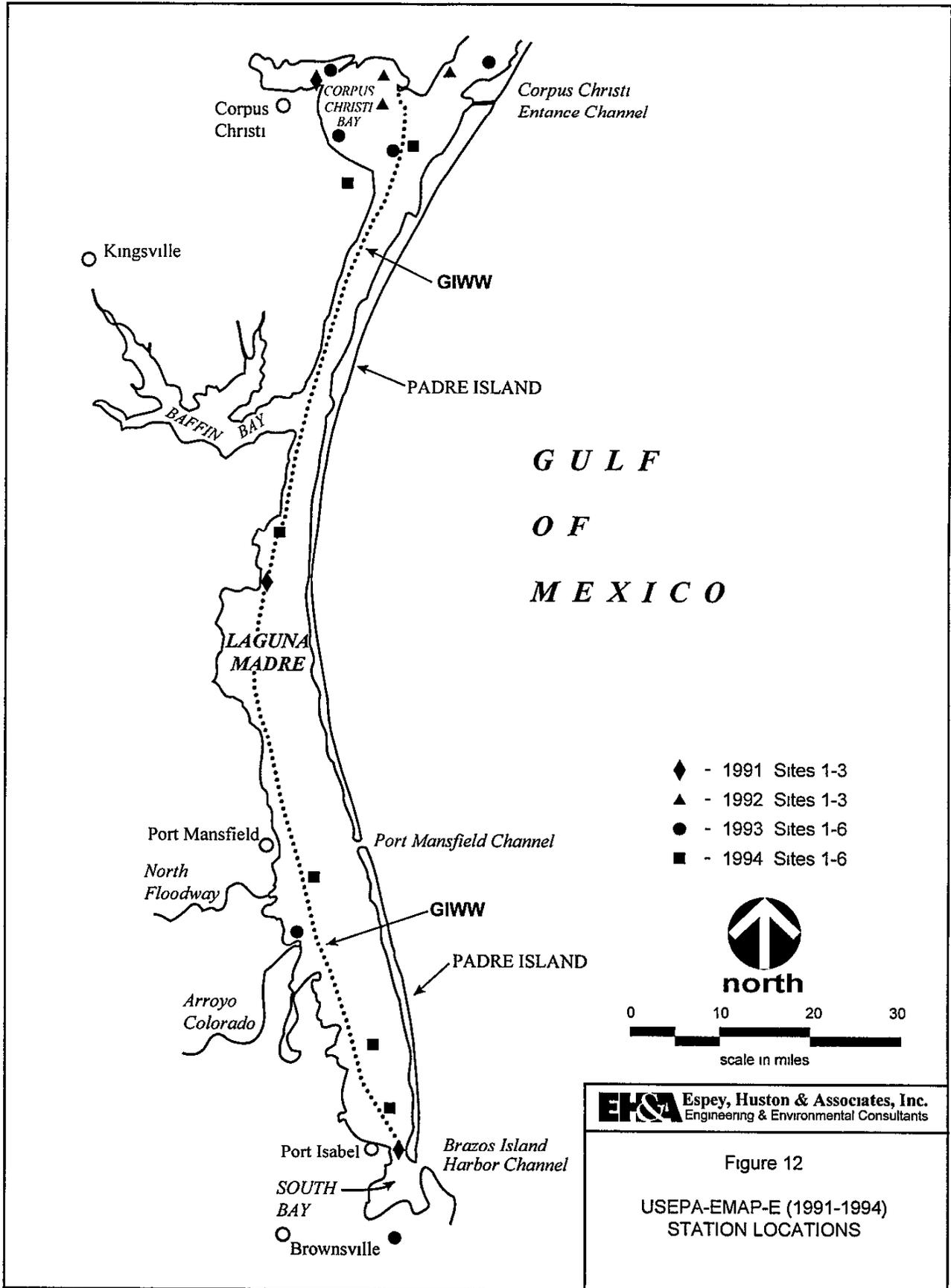
Number of Benthic Species
Total Benthic Abundance
Benthic Abundance by Taxa
Benthic Index
Number of Fish Species
Total Finfish Abundance
Gross Pathology
Macrophage Aggregates
Marine Debris
Water Clarity
Fish Tissue Contaminants

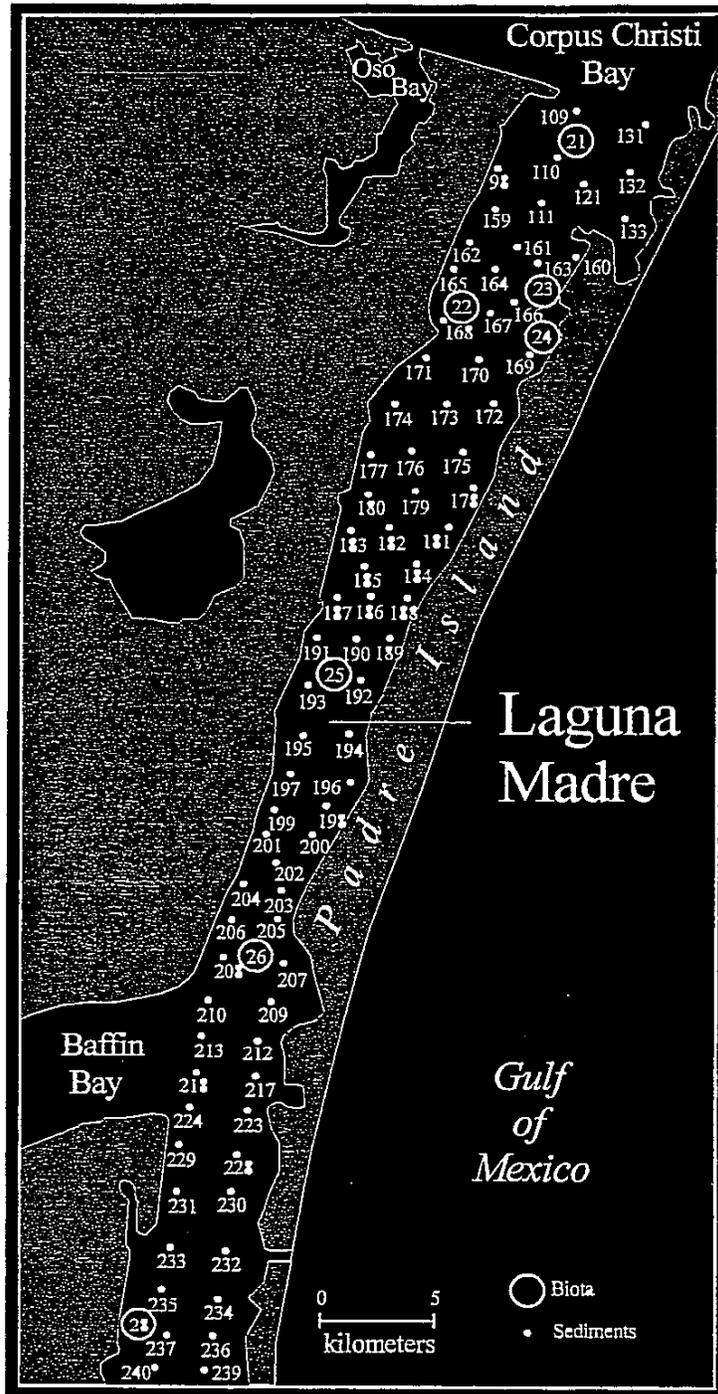
HABITAT INDICATORS

Water Depth
Water Temperature
Salinity
pH
Stratification
Percent Silt-Clay Content
Percent Total Organic Carbon
Acid Volatile Sulfides

EXPOSURE INDICATORS

Dissolved Oxygen (instantaneous)
Dissolved Oxygen (continuous)
Sediment Toxicity - *Ampelisca abdita*
Sediment Toxicity - *Mysidopsis bahia*
Sediment Contaminants - Alkanes and Isoprenoids
Sediment Contaminants - Polynuclear Aromatic Hydrocarbons
Sediment Contaminants - Polychlorinated Biphenyls
Sediment Contaminants - Pesticides
Sediment Contaminants - Heavy Metals
Sediment Contaminants - Butyltins



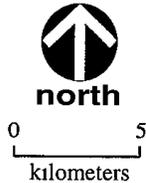
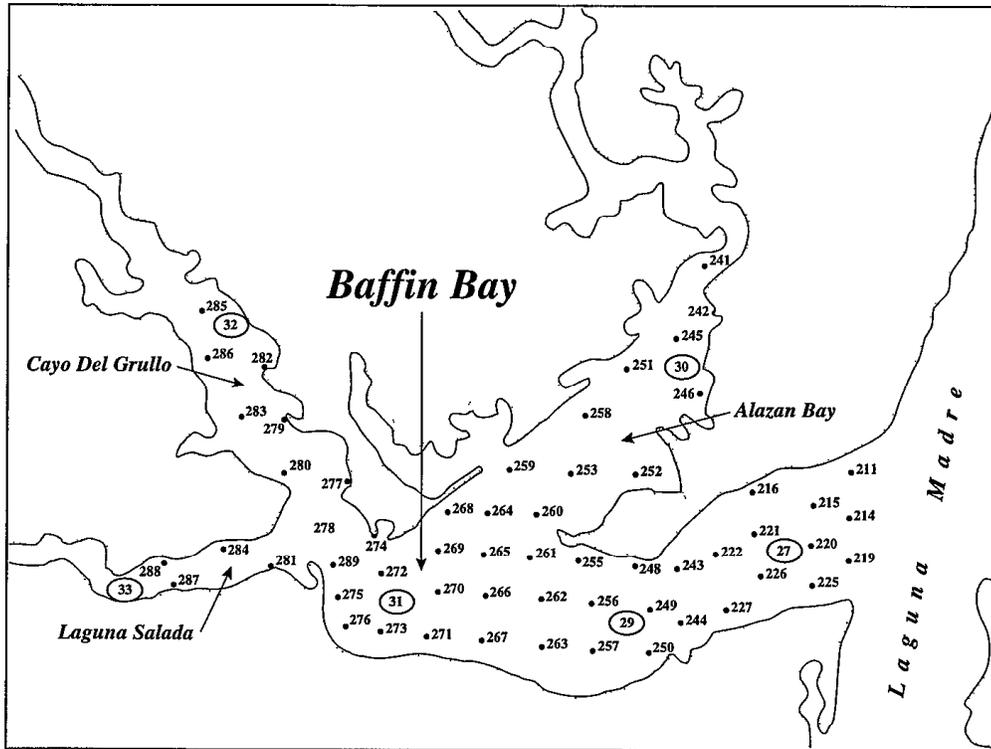


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Figure 13

USFWS-CORPUS CHRISTI BAY
COMPLEX STUDY
UPPER LAGUANA MADRE
STATION LOCATIONS

From Barrera et al 1995



- 33 Sediments
- Biota

EHS Espey, Huston & Associates, Inc.
Engineering & Environmental Consultants

Figure 14

USFWS-CORPUS CHRISTI BAY
COMPLEX STUDY
BAFFIN BAY
STATION LOCATIONS

From Barreera et al , 1995

The USFWS continues to monitor for contaminants in the Arroyo Colorado and Rio Grande (Schultz, 1995). Semi-permeable membrane devices (SPMDs), which are high-tech synthetic lipid surrogates that concentrate organic contaminants, are being experimented with in the Arroyo Colorado contaminant survey. Both surveys involve the collection of top predators for the evaluation of organics and metals.

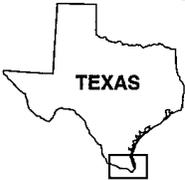
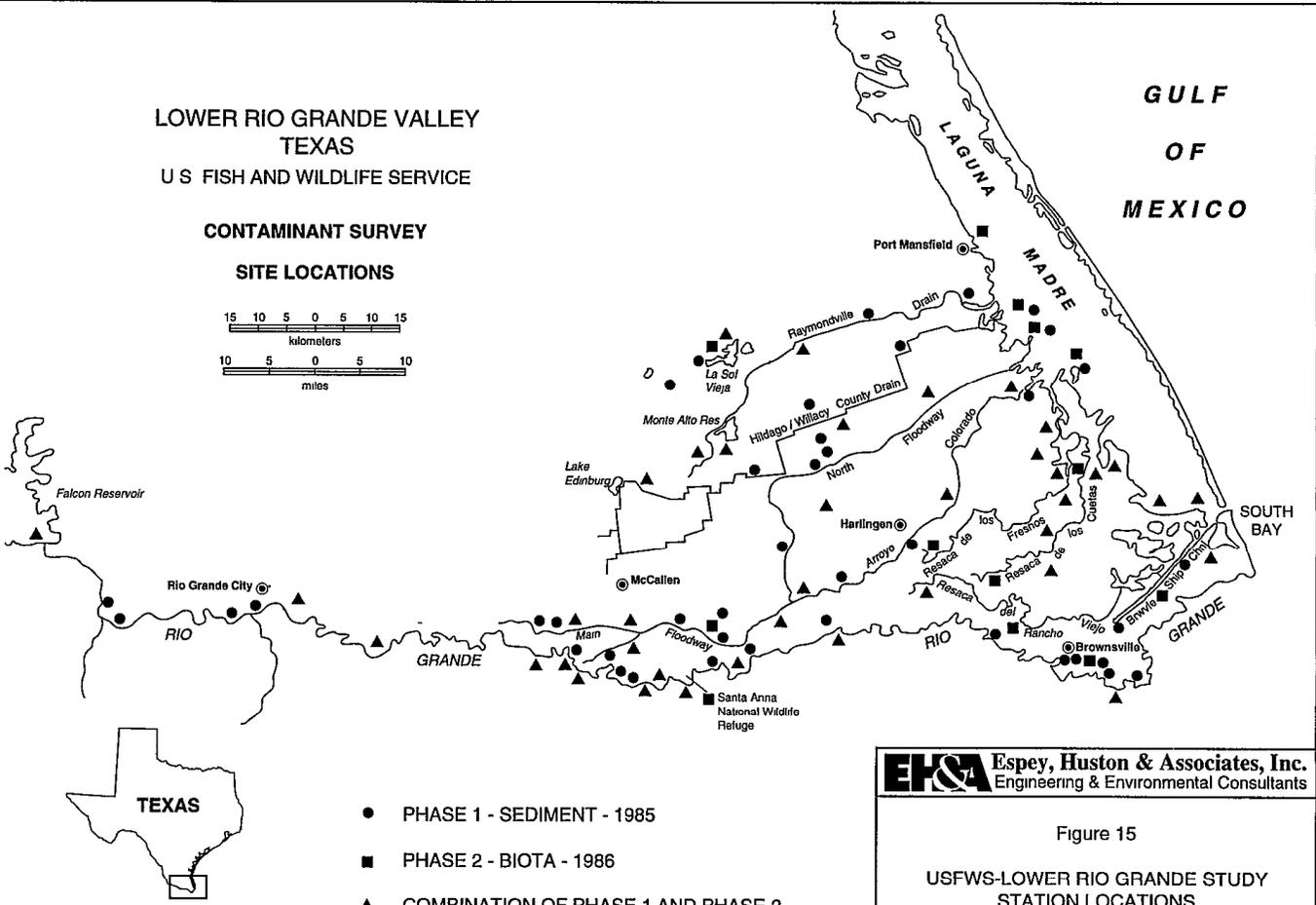
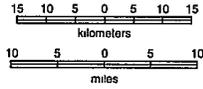
The USFWS Corpus Christi Ecological Services Field Office initiated a two-phase study to determine the extent of a contamination problem in the Lower Rio Grande Valley (Gamble *et al.*, 1988). The initial phase involved the collection of sediment samples throughout the Valley for analysis of trace elements, organochlorines, and polycyclic aromatic hydrocarbons. The second phase involved the collection of fish, birds, oysters, blue crabs and aquatic vegetation for similar analyses. Sediment was collected at 95 sites throughout the Lower Rio Grande Valley, a number of which were in the Laguna Madre or Laguna Madre watershed, in July and August 1985. Sediment was analyzed for 23 trace elements and organic compounds. Softshell turtles, fish, blue crab, oysters, seagrasses, cotton rats, and birds were collected at 64 sites throughout the Lower Rio Grande Valley in July and August, 1986. The stations along the Lower Laguna Madre in the project area ranged from Port Mansfield to Port Isabel (Figure 15, from (Gamble *et al.*, 1988))

3.1.15 United States Geological Survey (USGS)

The USGS under contract with the TWDB, is testing the applicability of the USGS Surface-Water, Integrated, Flow and Transport hydrodynamic model (SWIFT2D) to the Laguna Madre System (Ockerman, 1995). The SWIFT2D model is a two-dimensional, depth average, finite-difference model with the capability to simulate both flow and constituent transport. The SWIFT2D model will be calibrated primarily with data from an intensive survey of the Laguna Madre Estuary system performed by the TWDB from June 10-13, 1991. The TWDB data set contains tide, wind, flow velocity, salinity, pH, dissolved oxygen, and conductivity information for the four-day study period. Additional tide and wind data for the month of June, 1991, were obtained from the TCOON, which is operated by the CBI. The Laguna Madre will be split at the land cut and the upper and lower sections modeled independently. Calibration of the model on the upper portion of the Laguna Madre is currently underway (August 1995) and work on the lower portion will begin upon completion of calibration of the Upper Laguna Madre model.

LOWER RIO GRANDE VALLEY
TEXAS
U S FISH AND WILDLIFE SERVICE

CONTAMINANT SURVEY
SITE LOCATIONS



- PHASE 1 - SEDIMENT - 1985
- PHASE 2 - BIOTA - 1986
- ▲ COMBINATION OF PHASE 1 AND PHASE 2

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Figure 15
USFWS-LOWER RIO GRANDE STUDY
STATION LOCATIONS

From Gamble et al , 1968

Another project conducted by the USGS is a current status and historical trends in freshwater inflows to the CCBNEP study area (Ockerman, 1995). This project will build upon past work of the TWDB and ongoing work by the TWDB and TPWD. The objective of this project is to characterize the current status and historical trends (spatial and temporal variability) in freshwater inflows to the CCBNEP study area. Following a literature review of available reports on the subject of freshwater inflow data and analyses, all usable data on streamflow, rainfall, evaporation, ungaged historical flows, and wastewater return flows will be compiled. All drainage area and meteorological characteristics for rivers, streams, and saltwater bayous draining to the Mesquite, Copano, Aransas, Corpus Christi, Upper Laguna Madre, and Baffin Bay systems will be compiled.

A third effort will involve the characterization of nonpoint source loadings to the CCBNEP study area (Ockerman, 1995). This is a joint study between the USGS and the Natural Resources Conservation Service (NRCS). The study area consists of the 12-county area of the Texas Coastal Bend, including bays and estuaries along the 120 mile stretch of coastline. No data collection is intended for this study. Only available information and data will be analyzed and reported.

Other efforts by the USGS involve two joint projects with the TAES involving cropland runoff. These studies are described in Section 3.1.5.2.

3.1.16 University of Texas System (UT)

3.1.16.1 University of Texas - Bureau of Economic Geology

The Submerged Lands of Texas Project was initiated in 1975 and is based primarily on an intensive sampling program in which approximately 6,700 surficial bottom samples were collected mostly at one-mile intervals from bays and lagoons and from the continental shelf (White *et al.*, 1986). The sample-collection phase of the study was followed by an analytical phase that included detailed evaluation of surface sediment textures, sediment geochemistry, and benthic fauna. Many of the samples were analyzed to characterize the sediment distribution, selected trace and major element concentrations, and benthic macroinvertebrate populations from the Laguna Madre. The project was expanded to include wetlands due to the interconnection of submerged lands with adjacent marshes and associated wetlands. Of the seven area maps that cover the submerged coastal lands of Texas, the (1)

Corpus Christi area, (2) Kingsville area, and the (3) Brownsville-Harlingen area cover the study area of interest (Figure 16, from (White *et al* , 1986))

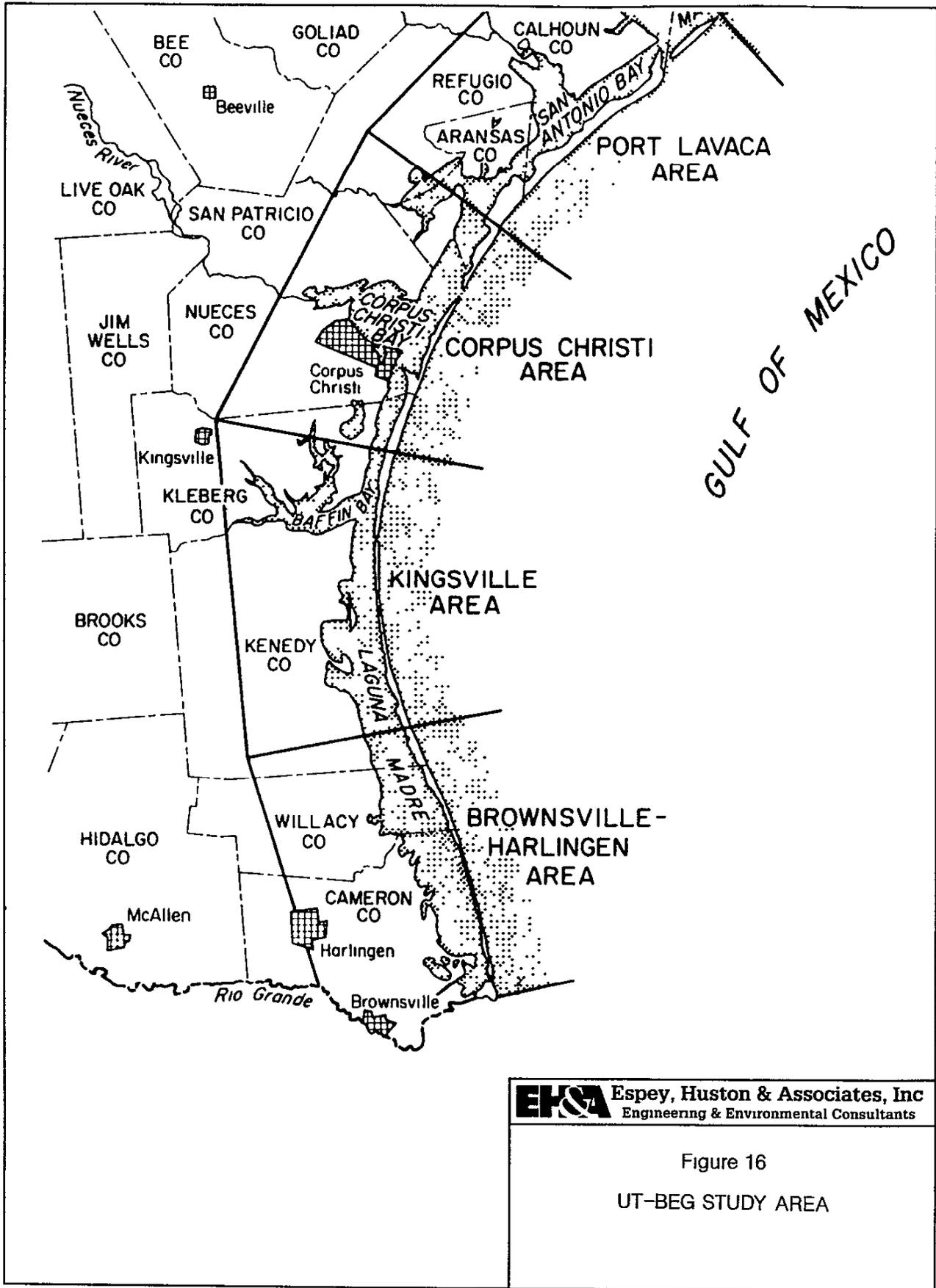
3 1 16 2 University of Texas Marine Science Institute

Dr Tony Amos at the Marine Science Institute has been involved in numerous surveys in the Laguna Madre and Corpus Christi Bay since October 1980 The surveys relevant to this project include sea temperature and salinity, weather, tides, and currents (CBMRW, 1995). From 1989 to 1992, at several locations in Nueces and Corpus Christi Bays and the Laguna Madre, Dr Amos measured sea temperature and salinity Dr. Amos has tidal data and current data from 1989 to 1992 at Baffin and Redfish Bays and current data for the same dates from Port Mansfield pass and since June 1994 at the Sun Oil Channel and the Gulf Intracoastal Waterway in the Laguna Madre. All current data are 10-minute interval, vector-averaged

The major area of study of Dr. Kenneth H Dunton involves seagrass biology and light requirements of seagrasses Dr Dunton has two stations in both the Upper and Lower Laguna Madre where he evaluates seagrass biomass/density and seagrass constituents (chlorophyll, CHN, carbohydrates) quarterly, water column chlorophyll, dissolved inorganic nitrogen, temperature and salinity, monthly, and photosynthetically active radiation (PAR) (underwater), PAR (surface for only the Lower Laguna Madre) and light attenuation (k) on a continuous basis (Dunton, 1995)

The major areas of study of Dr. Paul Montagna are benthic community ecology and trophic dynamics Dr. Montagna published "Effect of freshwater inflow on macrobenthos productivity and nitrogen losses in Texas estuaries, 1994-1995" Planned projects include modelling benthos biomass and productivity in Texas estuaries, oxygen depletion in Corpus Christi Bay, and effect of agricultural runoff in Baffin Bay (Montagna, 1995)

Dr. Terry E Whittedge and Dr Dean A Stockwell have several studies ongoing involving nutrients and brown tide Currently the Upper Laguna Madre/Baffin Bay is being monitored monthly with water samples at 12 locations and productivity at five of the locations to assess circulation patterns and the levels of nutrient enrichment and biological productivity (CBMRW, 1995) The Lower Laguna Madre/Arroyo Colorado is being monitored monthly with water samples at 22 sites and productivity at 10 sites to assess the distribution of brown tide and biological effects of freshwater



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Figure 16
 UT-BEG STUDY AREA

discharge of the Arroyo Colorado (CBMRW, 1995) Hydrography samples collected at each of the station sites include the following measurements at the surface and near bottom date, time, latitude, longitude, water depth, Secchi depth, temperature, salinity, conductivity, dissolved oxygen, percent oxygen saturation, pH, orthophosphate, silicate, nitrate, nitrite, ammonium, total suspended solids, chlorophyll-a, and phytoplankton species assessment Productivity samples include all hydrography parameters plus C-14 water-column primary productivity and alkalinity Selected stations are sampled for microphytobenthos primary productivity, and sediment chlorophyll Planned projects include a study of the gradient of nutrients and the brown tide organism in upper Laguna Madre and a study of ambient nutrient and brown tide concentrations adjacent to freshwater runoff sites in Alazan Bay and Cayo del Grullo

3.1.16.3 University of Texas - Pan American

Due to the lack of studies on the biology of *Halodule wrightii* in Lower Laguna Madre, especially as related to underwater light available for production, Dr Joseph L. Kowalski of the Department of Biology at the main campus in Edinburg, is measuring leaf production, chlorophyll a and b concentrations and seasonal biomass of *Halodule* in the Lower Laguna Madre at a site adjacent to the GIWW in about 1.3 m of water (CBMRW, 1995). Future projects include a plan to monitor seasonal concentrations of dissolved inorganic nitrogen in seagrass sediments and the surrounding water column in relation to underwater light levels and seasonal biomass in a bed of *Halodule*.

3.2 RELATED PROJECTS

3.2.1 Port of Corpus Christi Authority

The Port of Corpus Christi Authority in conjunction with the USACE is conducting a study to assess the environmental and physical effects of open water disposal of maintenance dredged material in Corpus Christi Bay (CBMRW, 1995) Dredging of the Corpus Christi Ship Channel open water reach (La Quinta Junction to Beacon 82) occurs approximately every three years. The study was initiated in August 1995 and is expected to be completed in approximately 15 months. One focus of the study is to investigate the effect of maintenance material placement on benthic communities The two major objectives include mapping the spatial scale of disturbance of dredged material placed

on bay bottom benthic habitats and determining the rate of benthic recovery following placement. In general, the spatial scale of disturbance will be mapped with sediment profiling imagery (SPI).

A second focus of the study will be to monitor the short and long-term physical fate of dredged material placed in the authorized sites. Key aspects to be addressed include the influence of maintenance activities on ambient turbidity, material movement from the placement areas back into the channel, and acquisition of data sufficient to predict and verify formulas describing the causes and effects of hydrodynamic forcing on the transport and deposition for fine grained, cohesive, sediments. Meteorologic, wave, climate, hydrologic, and other physical measurements will be obtained from the entire water column by an array of instruments mounted on a fixed platform station located in a placement site on the western portion of Corpus Christi Bay. Fixed platform data will be augmented by data obtained from a roving station which will be deployed to achieve specific study objectives. This work for this second focus of study is being conducted by the CBI.

3.2.2 National Biological Survey (NBS)

Dr. Christopher P. Onuf has been conducting research on the seagrass meadows of the Laguna Madre. In particular, Dr. Onuf is examining the effects of dredging on underwater light in the Laguna Madre via an assessment of light vs. depth profiles associated with before, during, and after dredging conditions (Onuf, 1994).

3.2.3 TNRCC

Four stations have been monitored in Segment 2481 (Corpus Christi Bay) over the last four years. There was a special study conducted September 1, 1981, which included field measurements (dissolved oxygen, pH, temperature, conductivity, Secchi disk), chemical measurements (nutrients, BOD, solids, salts), and metals and organic substances in water, sediment, and animal tissue. There was also a special study conducted June 23, 1987, which included field and chemical measurements; metals and organics in water, sediment, and animal tissue, benthic macroinvertebrate sampling, and nekton sampling. There are no ambient toxicity monitoring stations in this segment (although the USACE has conducted water, elutriate, and sediment toxicity studies in conjunction with maintenance dredging).

Three stations have been monitored in Segment 2484 (Corpus Christi Inner Harbor) over the last four years. The two special studies conducted for Segment 2481 also apply to this segment. In addition, there was a special study conducted on August 8, 1982, which included field and chemical measurements, metals and organics in water and sediment, bacteriological, and benthic macroinvertebrate sampling. There are two ambient toxicity monitoring stations in this segment (and the USACE has conducted water, elutriate, and sediment toxicity studies in conjunction with maintenance dredging).

One station has been monitored in Segment 2493 (South Bay) in the last four years. There have been no special studies published and there are no ambient toxicity monitoring stations.

One on-segment and one off-segment stations have been monitored in Segment 2494 (Brownsville Ship Channel) over the last four years. A special study was conducted June 14, 1982, which included field and chemical measurements, metals and organics for sediment, bacteriological, and benthic macroinvertebrate sampling. There are no ambient toxicity monitoring stations for this segment (although the USACE has conducted water, elutriate, and sediment toxicity studies in conjunction with maintenance dredging).

One station has been monitored in Segment 2301 (Rio Grande Tidal) over the last four years. There have been no special studies published to date and there are no ambient toxicity monitoring stations for this segment.

3 2 4 TPWD

A cooperative study between the Gulf Coast Conservation Association (GCCA) and the TPWD was recently completed and entitled "An Assessment of Contaminant Concentrations in Estuarine Resources of Selected Reference Bays of Coastal Texas" (TPWD, 1995). The report was prepared by Dr. David R. Sager of TPWD, Austin, Texas. One selected reference bay was South Bay in the Lower Laguna Madre system. Collections were made for the South Bay site in October 1992. Eleven sediment samples were collected along with three composite samples of oysters from South Bay. Also, tissue samples were collected from blue crab, hardhead catfish, Atlantic croaker, red drum, spotted seatrout, and southern flounder. Samples were analyzed for nine trace elements and a suite of organic compounds: pesticides, polyaromatic hydrocarbons and polychlorinated biphenyls.

4.0 DATA GAPS

The concerns of the ICT, as indicated by the Scope of Work attached to Delivery Order 28, were primarily related to evaluating the impacts of dredging and disposal practices in the Laguna Madre. Therefore, the emphasis of this section will be toward data gaps that disallow determination of those impacts relative to water and sediment quality and tissue chemistry.

4.1 WATER

4.1.1 Quality

There is a wealth of data on standard parameters for water; i.e., temperature, pH, salinity, etc. Most of the studies discussed in the report include such data. However, other water quality data, such as trace metals and priority pollutant organic chemicals, are not found in most of the studies. Even so, the Influence of Freshwater Inflows Study conducted in the early 1980s (TWDR, 1983) contained good nutrient data and good coverage of the Laguna Madre. Also, the USACE has been collecting water quality data on a 2-5 year interval since 1974. These data have been collected at 95 stations along the GIWW, 13 stations on the Channel to Port Mansfield, and 17 stations on the Channel to Harlingen. These data and those from the TNRCC Segment samplings, special studies, and the Lower Rio Grande/Lower Arroyo Colorado Survey (LRG/LAC) can be used with the data from TDWR (1983) to get a good areal and temporal picture of the water quality in the Laguna Madre. One item should be noted. In all of the studies, trace metal concentrations were for total metals, not the dissolved metals which comprise the Texas Water Quality Standards (WQSS). However, while true comparison to the WQSS cannot be made with total metals concentrations, total metals do provide a worst-case scenario and methods are available to approximate some dissolved metals concentrations from total metals concentrations via total suspended solids concentrations.

4.1.2 Toxicity

There is one ambient toxicity monitoring station in TNRCC Segment 2201 (Arroyo Colorado Tidal). The LRG/LAC survey had water and elutriate toxicity studies at all eight stations with the two stations on the Arroyo Colorado and one on the North Floodway being within the Project Area. The USACE has elutriate bioassays for the Brownsville Ship Channel, the Port Mansfield Channel, and the Ship Channels in

Corpus Christi Bay, but none in the Laguna Madre proper, except for the liquid and suspended particulate phase bioassays on samples collected in the summer of 1986 (EH&A, 1987) from three stations in the GIWW, ranging from the mouth of Baffin Bay to six miles to the south.

4.2 SEDIMENT

4.2.1 Quality

The GERG study has five stations in the Lower Laguna Madre, with data collected annually since 1984. TNRCC data for Segment 2491 (Laguna Madre) include up to 14 samples over the last four years (different parameters were sampled at different frequencies) plus those collected in special studies and samples have been collected for the last twenty-two years. The USACE has sediment data collected at the same stations and times as those noted above for water chemistry. Additionally, the USACE data also include elutriate chemistry which indicates the chemical impact on the water column from dredging the sediments which were tested. The EMAP study contains some sediment data and the USFWS Corpus Christi Bay Complex Study (CCBCS) yielded data on 73 sediment samples in the Upper Laguna Madre and 59 samples in the Baffin Bay System. Some sediment data are available from the USFWS Lower Rio Grande Valley Study and UTBEG reported numerous analyses for trace metals in sediments throughout the Laguna Madre.

4.2.2 Toxicity

The USACE data base has sediment bioassays for the Brownsville Ship Channel, the Port Mansfield Channel, and the Ship Channels in Corpus Christi Bay, but none in the Laguna Madre proper, except for the solid phase bioassays on samples collected in the summer of 1986 (EH&A, 1987) from three stations in the GIWW, ranging from the mouth of Baffin Bay to six miles to the south.

4.2.3 Borings

The UTBEG study determined surficial sediment texture for numerous stations in the Laguna Madre but collected no borings data. The USACE and the Brownsville Navigation District have reported on borings data in relation to deepening the Brownsville Ship Channel and the USACE, the Nueces County Navigation District, and the U.S. Navy have reported on borings data in relation to deepening the Corpus

Christi Ship Channel and to Homeport. However, no response was received to EH&A's request for borings data in the Laguna Madre and none of the reports that were received included borings data.

4.3 TISSUE

4.3.1 Chemical Analyses

The GERG study reported on five stations in the Lower Laguna Madre, with annual data since 1984. The TNRCC data for Segment 2491 indicated as high as 10 samples, Segment 2201 as high as two samples, and Segment 2492 (Baffin Bay System) as high as one sample over the last four years. Additionally, there were special studies in Segment 2201 and the LRG/LAC included tissue chemistry. The EMAP data included oyster tissue data when oysters were found at the EMAP stations. The CCBCS included data from 15 biota samples (fauna and flora samples combined) in both the Upper Laguna Madre and the Baffin Bay System. The USFWS Lower Rio Grande Valley Study included seven tissue samples for chemical analysis.

4.3.2 Bioaccumulation

No bioaccumulation data were found during the course of this project for samples collected in the Laguna Madre, except for the bioaccumulation studies on samples collected in the summer of 1986 (EH&A, 1987) from three stations in the GIWW, ranging from the mouth of Baffin Bay to six miles to the south. Also, the USACE has conducted bioaccumulation studies in conjunction with maintenance dredging of the Brownsville Ship Channel, the Port Mansfield Channel, and the Corpus Christi Ship Channels.

4.4 CONCLUSIONS AND RECOMMENDATIONS

There appear to be sufficient data to analyze areal and temporal trends for water quality, including standard parameters, trace metals, and organics. There also appear to be sufficient sediment data for the same purposes. There may be too few tissue samples for trend analyses but, as noted below, additional tissue collections are not recommended. There is only one set of bioassays and bioaccumulation studies which have been conducted on water, elutriates, and sediments from the Laguna Madre.

It is recommended that a tiered approach be used, as is recommended in the "New Green Book", such that available information is examined to determine if there is a "cause for concern". To that end, it is recommended that the USACE and TNRCC water and sediment data sets, including that from the CCBCS, the GERG data, and the water data from TDWR (1983) be reduced and analyzed for temporal and areal trends. Other data could be included but these data sets provide the most extensive areal and temporal coverage. This reduction and analysis will allow the ICT to determine if there are areas of concern or if there are indications of contamination and, if so, whether they have been increasing with time. Additionally, the TNRCC, GERG, and EMAP tissue data should be examined to determine if they are sufficient for legitimate areal and temporal trend analysis.

If "causes of concern" are found, additional tiers of investigation could be used. For example, tissue analyses alone provide much less information, relative to the concerns with dredging and disposal, than do the bioaccumulation studies which have been developed over the years by the USEPA and USACE, with input from other concerned agencies and groups. Additionally, water and sediment chemical analyses alone provide less information concerning impacts to water column and benthic organisms, relative to concerns with dredging and disposal, than do suspended particulate and solid phase bioassays. Therefore, if "causes of concern" are found or if the ICT determines that the data sets need to be bolstered, it is recommended that a series of stations be selected along the GIWW through the Laguna Madre for the collection of maintenance material for suspended particulate phase and solid phase bioassays and bioaccumulation studies. Reference stations should be selected from the Laguna Madre in areas which are not influenced, or which are minimally influenced, by dredging and dredged material disposal. Water, elutriate, and sediment chemistry should be generated in conjunction with the bioassessment studies to provide synoptic information for comparison to the bioassessment data. It is recommended that only dissolved metals be included in the water and elutriate data to provide proper comparison with the WQSs. Information gained from these studies, along with the chemical data already generated, should allow an adequate characterization of the Laguna Madre relative to all but the physical impacts of dredging and dredged material disposal, areas not under the purview of Delivery Order

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