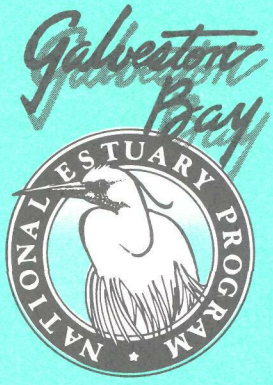
Shoreline Survey for Unpermitted Discharges to Galveston Bay



Galveston Bay
National Estuary Program
GBNEP-12
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Shoreline Survey for Unpermitted Discharges to Galveston Bay

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EXECUTIVE SUMMARY

The Shoreline Survey for Unpermitted Discharges is a study within the Galveston Bay National Estuary Program which identifies and maps permitted and unpermitted discharges in nine selected shoreline segments of the Galveston Bay system. These nine segments represent a cross section of typical shoreline segments which would be encountered in any estuarine environment. This study was designed to develop a standard methodology for future comprehensive shoreline surveys. A personal computer database program (ReflexPlus) was developed for this program.

The study was broken down into three basic parts: determination of permitted discharges within a segment, an aerial survey, and a shallow draft boat survey. Research was performed to determine the location, description and discharge type from the appropriate regulatory agencies. Permitted sites were plotted on seven and one half minute USGS topographical maps and the information entered into the database. Compilation of the initial data base was followed by an aerial photo-survey over each segment (still and video) to confirm the location of permitted sites, to document unpermitted discharges, to prioritize areas within the segment for the subsequent ground photo-survey, to plot the unpermitted sites on the same map for use in the ground survey. Aerial observations were also entered into the database. The final part was the shoreline photo-survey using shallow draft boats to verify the location (using LORAN C) of the plotted sites, to search for additional unpermitted discharges, to plot these on the same map, and enter these observations into the database. Some regions were better suited for aerial surveys (e.g., a shallow bayou) while others were better suited for ground surveys (e.g., a heavily foliated bayou or intensely developed shorelines). By combining both aerial and boat surveys efficient and complete coverage was achieved.

Based on our experience on this project a cost estimate, study design and methodology were developed to conduct a comprehensive survey of the entire Galveston Bay system. Numerous concerns in regard to logistics, methodology, and conceptual criteria have arisen and been identified through this study. These need to be addressed in the scope of work before such a comprehensive survey is undertaken.

All raw data developed in this project, including maps and charts, listings from the data base of permitted and unpermitted discharge locations, and photographs used in the documentation of sites are archived and available for inspection at the Galveston Bay Information Center. The Galveston Bay Information Center is located in the Jack K. Williams Library on the Texas A&M University at Galveston Campus on Pelican Island.

1.0 INTRODUCTION

The Galveston Bay National Estuary Program goals are to protect and improve water quality and to enhance living resources within the Galveston Bay Estuary. Various characterization studies have been contracted to better substantiate problems affecting the Galveston Bay estuary system, to evaluate their causes, and to recommend possible management solutions. The Shoreline Survey for Point Source Discharges is one such study.

Several water bodies along the Texas coast have been detrimentally impacted by various amounts of undocumented pollution from unpermitted discharges. Preliminary estimates suggest that the quantities of pollutants released from these sources may exceed amounts discharged from permitted sources. The management committee felt that in order to formulate successful environmental management plans for the Galveston Bay system, it would be necessary first to obtain background information on the distribution and sources of unpermitted discharges located along the shoreline of the bay. The information could then be used for further determination of the impacts of unpermitted discharges on water and sediment quality, and aquatic organisms. With little background information on the distribution of unpermitted discharges in the Galveston Bay system, the objectives of this study are to identify and map unpermitted point source discharges within selected shoreline segments of Galveston Bay and to develop a standard methodology and framework for future comprehensive shoreline surveys of the Galveston Bay system.

This pilot study utilized low altitude aerial surveys and shallow draft small boat surveys to determine the extent of and to document locations of unpermitted discharges along 159 miles of bayou and bay shoreline. Nine different shoreline types were surveyed. Positions of discharges, both permitted and unpermitted were logged on to a personal computer data base management system, and photographic documentation of both aerial and surface observations were catalogued. A data base for each shoreline segment was prepared along with topographic map depictions of the locations of permitted and discovered unpermitted discharges to the degree that identification and correlation is possible from field and agency records data. Documentation includes narrative description, photographs and positional data (latitude and longitude from LORAN C). The information was sorted to provide regulatory agencies management and enforcement information, and can be used for further determination of the impacts of unpermitted discharges on water and sediment quality and aquatic organisms. The methodologies, procedures and estimates of level of effort required (program cost estimates) were developed here with a view toward implementation of

comprehensive surveys throughout Galveston Bay and other coastal waters as well.

2.0 Study Objectives

The objectives of this study are to identify and map unpermitted point source discharges within selected shoreline segments of Galveston Bay and to develop a standard methodology and framework for possible future comprehensive shoreline surveys of the Galveston Bay system.

To accomplish these goals, the following activities were defined in the project scope of work:

1. Available discharge data on permitted discharges was obtained from:
   a. Railroad Commission (RRC) on pipeline permits and discharges of produced brines,
   b. Texas Water Commission (TWC) on permitted discharges,
   c. General Land Office (GLO) on pipeline permits,
   d. local governments (cities, counties, flood control districts) on stormwater discharges.
2. A plan to determine survey variability was implemented at the conclusion of all segment surveys. At least five randomly selected 1 mile transects within three survey segments were resampled as a check on survey variability and completeness.
3. Shallow draft boat surveys were conducted in bay and bayou segments to obtain a representative cross section of the various types of shoreline in the Galveston Bay system. The representative shoreline types selected for study are listed in Section 2.1.
4. A record was made of the location of all discharges, both permitted and unpermitted.
5. Responsible agencies were notified upon discovery of an unpermitted discharge. While storm sewers presently do not require permits, their presence and locations were recorded and catalogued separately.

2.1 Shoreline Types

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from the water and from land. Nine types of shoreline in the Galveston Bay system were surveyed for the presence of permitted and unpermitted discharges. These shoreline types represent a cross section of the types found throughout the bay system and are fairly inclusive of what may be found in any estuarine system. A total of 159 linear miles of shoreline/stream were designated for survey. The nine shoreline segments surveyed in this study are:

Cedar Bayou: Segment 0901, 19 river miles, industrialized/urban tributary.

Galveston Bay: Segment 2421, 22 shoreline miles, developed shoreline.

Double Bayou: Unclassified Segment in Chambers county, 22 river miles, agricultural/rural tributary with oil field activity.

East Bay: Segment 2423, 40 shoreline miles, marinas and agricultural/undeveloped open bay shoreline.

Chocolate Bayou: Tidal segment 1107, 14 river miles, moderately developed rural tributary.

Armand Bayou: Tidal segment 1113, 8 river miles, suburban tributary.

Dickinson Bayou: Tidal segment 1103, 15 river miles, moderately developed suburban/rural tributary.

Dickinson Bayou: Above tidal segment 1104, 7 river miles, rural non-tidal tributary.

Carancahua Lake and Bayou: Unclassified, 12 shoreline and river miles, rural secondary bay with oil field activity.

3.0 METHODOLOGY

3.1 Approach and Overview

By their very nature the locations of, or other data relative to, unpermitted discharges into coastal waters are not likely to be discernable from the records of regulatory governmental agencies. Identifying these unpermitted discharges in the Galveston Bay system is exacerbated by the number of permitted discharges whose physical locations are uncertain or unknown to the regulatory agencies, the large number of legally permitted discharges, and the wide variety and great length of shoreline types with limited accessibility. The limitations of the "water's edge perspective" and the lack of a definitive indicator of a discharge point other than the visual identification of a pipe, outfall, or discharge point with effluent also confound efforts to comprehensively survey an area in a single,

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reasonably short period of time. Thus, a survey undertaken by simply cruising along the shoreline by boat in search of discharge structures is an ineffective and inefficient means to meeting project objectives.

Our approach to designing the study plan was influenced by the following considerations. The expanse of geographic area in this study, and in subsequent applications of the techniques developed herein, is too large and diverse to simply cruise the shoreline and look. A step-wise approach to each area (river or shoreline segment) was needed so that proper resources could be directed where they would do the most good (that is, be most effective and efficient). Similarly, significant portions of the survey effort could be wasted in erroneous documentation of the presence of a permitted discharge or in tedious and unproductive searches of undefiled shoreline

The approach we adopted was to categorize each segment of river/shoreline with regard to the type and magnitude of discharges likely or known to be present in the area. These data were plotted on topographic maps and were augmented with data from visual observations made during low altitude overflights of each segment. The aerial surveys were conducted to (1) confirm known or permitted discharge points, (2) to look for visual evidence of others, (3) to designate areas within each segment as being of high interest, suspicion, or probability, (4) to eliminate some areas from further consideration, (5) to get an overview of how to approach the entire segment from the logistical perspective, and (6) to annotate the maps and data bases accordingly. From this data base, we developed a logistics plan to perform a shoreline survey by appropriate boat for each shoreline/river segment, selecting the best means, equipment, survey plan, and access for the specific segment.

A limitation to this method, as well as to all methods considered, is in the detection of underwater discharges. We are aware of which could be applied to the diversity of shoreline types on the scale of miles undertaken here. We acknowledged this shortcoming in our proposal and emphasize here that underwater discharges were not addressed, except where their structure was visible above the water line. There is no evidence either before or following our surveys to suggest that submerged (and hence concealed) unpermitted discharges constitute a significant contaminant input to the bay system.

3.1.1 Clearance and Priority Ranking Criteria

A set of criteria was developed for evaluating and ranking sections of the shoreline segments based on the presence of certain features observed from the air. The purpose of the clearance and ranking is two-fold. The presence of features or structures along or near the shoreline which might be associated with discharge activities would count toward high grading an area. Unless there were evidences to suggest a connection to the shoreline (buried pipeline scars, a pipe on

the surface, or a discharge ditch or canal) we limited the inshore boundary of the search area to approximately 500 meters from the shoreline. Such areas received close scrutiny during the boat survey. The absence of any such features (which would be required as a point of origin for the discharge) resulted in a section of the shoreline segment being low graded. Such a low graded area was eliminated from further boat survey if the survey effort required in that area was a difficult one, or received a fast cursory survey, if it could be done enroute to another section.

From the aerial survey and historical data base, each portion of a shoreline segment was categorized with respect to the need for subsequent boat survey. A particular shoreline portion was surveyed from the water (boat survey) if it was accessible by boat and one of the following qualifying criteria were met:

1) the visible presence of a known or suspected discharge structure (pipe, outfall, ditch, etc.)

2) the presence near the shoreline of a building structure or facility which is often associated with discharges (manufacturing plant, refinery, petroleum gathering, power generation)

3) the presence of man-made structures in close proximity to the shoreline in such concentration which makes resolution of possible discharges or sources impossible from the air

A portion of the shoreline was eliminated from boat survey if none of the above qualifying criteria characterized the particular shoreline portion.

In those instances where one of the qualifying criteria were met but the shoreline appeared inaccessible by boat, other means (on foot, via land, etc.) were used to investigate the features of interest.

Thus, all portions of the shoreline segments were classified into one of three categories:

1- requiring boat survey,

2- not requiring further boat survey,

3- requiring a confirmational up-close survey of the observed suspect features, but by a means other than by boat.

With this background information and plan, we dispatched field crews with survey objectives specific to each target segment. The boat surveys provided on-site confirmation of discharge points (both permitted and unpermitted, and actual, potential, or suspected).

Narrative and photographic documentation was obtained during the boat surveys, and location information (latitude and longitude of the discharge point) was provided by LORAN C. It was intended that GPS (Global Positioning System) be used in lieu of LORAN C for those times in which it was available. GPS is a satellite based radio navigation system which will include 18 satellites in 6 orbits providing positional accuracy on the order of meters when complete. However, subsequent to the development of the work plan the government reduced the accuracy of the GPS as part of their testing program. The resultant loss of accuracy combined with the intermittent availability of the GPS made the proposed use of GPS for positioning an impracticality for this pilot study. However, when the accuracy is reestablished it should be used as the positioning system of choice for this type of study.

3.2 Information Acquisition - Data Available

3.2.1 Maps and Charts

Commonly available nautical navigation charts and county road maps did not provide adequate detail or scale resolution to be of value in the study. Seven and a half minute quad sheets were obtained from the Texas Natural Resources Information System in Austin to encompass the entire study areas. These maps were used to develop the study design and were used in the field for data annotations as well as served as the base maps for the final reporting of data.

3.2.2 Permitted Discharge Data

We obtained a listing from the Texas Water Commission of the permitted discharges on each of the stream segments. Although these data do not include precise locations of the actual discharge points, this data base was the beginning basis for identification of permitted discharges. Visits were made to both the headquarters offices in Austin and the regional office in Deer Park to ensure we had an exhaustive listing of permittees for the segments to be surveyed.

Although stormwater discharge currently requires no permit (and hence there is no central regulatory agency), stormwater discharge points were identified and catalogued separately inasmuch as tentative identification would permit. Unlike permits from the TWC, we were unable to identify any municipal, city, or governmental agencies or offices which could speak to the issue of stormwater drainage in a thorough and comprehensive manner in regard to where the collection and discharge points into the stream segments are. Thus, we approached the stormwater discharge issue without any background information as to locations.

The Texas Railroad Commission (RRC) regulates and permits the discharge of produced waters from oil and gas production activities.

Similar to our contact with TWC, a listing of permitted produced water discharge permits was obtained either from their computer generated listings or from personal visits to their files.

Pipeline routes crossing navigable waters (and even most shallow bayous) were marked with appropriate identifying signs and warnings regarding anchoring and dredging. Even from the air, pipeline routes posed little problem in identification and recognition. Since these are not discharges, their locations were not logged in the data base nor were they documented in the field.

3.2.3 Permitted Discharges Data Base

The permit data was compiled using Reflex Plus software on an Apple Macintosh personal computer. The data base was designed to allow updating positional and descriptive information on the permitted discharges, and to also incorporate information on non-permitted discharges obtained from the field surveys. Data field entries included Permittee Name, Permit Number, Stream Segment Number, and a Description of the Location and Type of waste or process. As each permit was entered into the data base it was assigned a sequential GBNEP Number, a unique numerical identifier which was used on the maps and in cross referencing sightings in the field.

3.2.4 Mapping

Permitted and known discharge points obtained from the Railroad Commission and Texas Water Commission files were plotted on the topo maps in approximate position from the location descriptions given for verification in the field surveys, and as partial fulfillment of reporting requirements for the final report. The GBNEP Number was annotated on the map with an arrow pointing to the approximate location of the facility or discharge.

These draft maps with the annotated GBNEP numbers and the permitted discharge listings compiled by segment were used in both the aerial and boat surveys as the basis on which locations were confirmed and new sightings were recorded.

3.3 Observational Data and Documentation

3.3.1 Aerial Surveys

Aerial surveys were conducted over each stream or shoreline segment following compilation and plotting of the permitted discharges data. Multiple low altitude (500 to 1000 feet above ground level) circling passes were made in a Cessna 172 aircraft cruising in slow flight at about 70 knots. A two place Cessna 152 was proposed for the survey aircraft, but it was found to be too confining in the cockpit to attend to all the paperwork, photography, navigation, and flying requirements.

In all but one instance, the aerial survey crew consisted of the pilot (the project's principal investigator) and one observer. During the last survey the principal investigator was accompanied by two observers. Having a second observer, familiar with the project, on board made a significant improvement in the aerial survey from the standpoint of workload.

Equipment necessary for the aerial survey included an aircraft with VHF radio, Mode C transponder, noise cancelling voice activated headsets and intercom for pilot and crew, a pocket dictation tape recorder and an auto focus/auto wind 35 mm camera with date/time annotation. We obtained excellent results with a Nikon Zoom-Touch 500, which has a 30 to 80 mm zoom and allows one hand operation for all functions. The proximity of some of the survey segments to airport traffic areas, and the Houston Terminal Control Area demand radio communication with the appropriate air traffic controllers, and the altitude reporting transponder is required by the FAR's (Federal Aviation Regulations). In fact, the busyness of the airspace in the vicinity of Ellington Field, Houston Gulf, and LaPorte airports was such that an observational crew of two should be required, as the pilot has his hands full just flying the plane. The intercom and headset allow meaningful communication even with the windows open and help alleviate fatigue in both the pilot and observer. These equipment requirements are noted as a precaution against attempting to accomplish subsequent surveys with inadequate aircraft or insufficient crew. Attempting to accomplish an equivalent survey with an ultralite aircraft or even with a no-radio/no-transponder aircraft would not be safe or prudent (and in some places it would be illegal).

Aerial observation log sheets (Figure 3-1) were compiled from the data base so that all observations from the aerial survey would be identifiable through an A/O (aerial observation) number. Each aerial observation file entry included a field for the segment number, the date, the time which was annotated on each picture taken, a description of the observation and its location, and a likely GBNEP cross reference number (i.e., A/O 47 is probably GBNEP # 119) or a new GBNEP number for unpermitted sites. The location of each observation was plotted on the maps using landmarks to estimate the location, and these locations were checked against aerial photos when processed the next day. Topo maps were marked directly in the air, not only with A/O numbers but with notes relating to logistical considerations. These latter would include such things as boat launching points, impasses to boat navigation on the water, areas of shoreline to be skipped in the boat survey, and particular areas or features to investigate in great detail.

As each permitted facility or suspected discharge was overflown, oblique photographs were taken from the open window of the aircraft as it circled the observed feature. Data was recorded for each A/O on the log sheets and similarly annotated on the map. VHS video

Figure 3-1

Galveston Bay National Estuary Program

Aerial Observations Log

A/O no. segment date time 1 time 2 no of photos

186

location:

---

description:

A/O no. segment date time 1 time 2 no of photos

187

location:

---

description:

A/O no. segment date time 1 time 2 no of photos

188

location:

---

description:

A/O no. segment date time 1 time 2 no of photos

189

location:

---

description:

A/O no. segment date time 1 time 2 no of photos

190

location:

---

description:

recording was made during much of the aerial survey, not as part of the documentation, but rather to facilitate locating some of the features by the boat crew during their subsequent survey. Upon completion of the aerial survey, the film was developed with two prints made from each frame, and the negatives remaining uncut. At the beginning of each roll was an identification picture naming the segment and date of survey. Thus, with this roll identification and each picture annotated with the hour and minute, each A/O photographed could be positively identified. One copy of each picture was placed in a manual with the appropriate A/O designator and GBNEP number written on the overlay. The other picture was archived for use in the final report. Suspected unpermitted discharges detected during the aerial survey were identifiable from the field logs through the A/O number and identifiable in the data base through their unique GBNEP number. Such discharges were high-graded for subsequent confirmation and documentation during the boat surveys.

While performing the aerial survey, it was possible in most cases to positively identify permitted discharges from the descriptions in the permits. Exceptions to this were when the permittee was a very small facility that couldn't be found from the description given, and when there were multiple permitted facilities on adjoining property (such as on Cedar Bayou). If the aircraft were to be equipped with LORAN C, it would be possible through the aerial surveys alone, to document most of the permitted discharges with photographs and positional information sufficient for this type survey.

3.3.2 Boat Surveys

It was our intent as proposed to complete all aerial surveys prior to the boat surveys. Completion of the first aerial survey on two segments changed our thinking on this concept. The amount of data and the variability and uniqueness of the environments to be surveyed was more than anticipated. To retain a "feel" for the segment developed during the aerial survey, we felt it imperative to process the photographs and data as quickly as possible and perform the boat survey soon after the aerial survey, and before proceeding with another aerial survey. There were exceptions to this. For example, our aerial survey of the western shore of Galveston Bay discerned only the permitted discharges and that the entire shoreline would need to be scrutinized by boat due to the density of residential dwellings. Therefore, we proceeded with other segments before returning to this difficult and tedious segment.

Two boats were used for this aspect of the survey. The boats were trailered to each segment. The primary vessel was a 17' Boston Whaler with a 90 hp outboard engine, capable of cruising at approximately 50 mph enroute to and from survey areas. The boat was equipped with power tilt trim (which permitted operation in shallow waters, less than 2'), a Northstar 800 Loran receiver, Hummingbird depth finder, compass, VHF marine radio, and 24 gallons of fuel. The secondary boat was a 12' flat bottom aluminum John boat with a 9 hp outboard and an electric trolling motor. This boat was required in most of Armand Bayou, where gasoline outboard motors are prohibited. The Northstar Loran and a handheld VHF radio were installed for this one survey. The boat survey crew was comprised of two individuals, one having been on the aerial survey.

A shore observation log was generated from the data base program (Figure 3-2). The log had fields for the date, segment number and area, latitude, longitude, Loran C time delays, number of photos taken, time interval on photographs, description and comments. The key entry on the shore observation log was the Shore observation number (S/O #). Each observation of a permitted, unpermitted, or suspected discharge was identified with an S/O #.

Figure 3-2

GALVESTON BAY NATIONAL ESTUARY PROGRAM
SHORE OBSERVATION LOG

DATE:_____ SEGMENT:_____ AREA:_____

SHORE OBS # 289 A/O #:_____ PHOTO TIME: _____

LAT:_____ TD:_____ # OF PHOTOS:_____

LONG:_____ TD:_____

DESCRIPTION/COMMENTS:

SHORE OBS # 290 A/O #:_____ PHOTO TIME: _____

LAT:_____ TD:_____ # OF PHOTOS:_____

LONG:_____ TD:_____

DESCRIPTION/COMMENTS:

SHORE OBS # 291 A/O #:_____ PHOTO TIME: _____

LAT:_____ TD:_____ # OF PHOTOS:_____

LONG:_____ TD:_____

DESCRIPTION/COMMENTS:

Both the maps (annotated with the permitted information and the aerial observations) and the photographs from the aerial surveys accompanied the boat crew. Thus, it was possible to correlate sites through their GBNEP number and the aerial observations (through their A/O #) with the S/O number in the field. Photographs were taken of all actual or suspected discharges. Thus, photographs depicting the aerial view and the view from the water surface were obtained. Exceptions to this were permitted sites which were never located or any type site which was not accessible by boat or from land. For the latter, the aerial photographs provide the only documentation.

As with the aerial photographs, duplicate prints were made, and the uncut negatives provided a title and date print for identification. One set of the photographs was correlated with the aerial photographs, providing aerial and surface documentation for most of the discharges. Discharges discovered during the boat surveys have photodocumentation from the surface perspective only.

3.4 Survey Variability

As a measure of the efficiency of these survey methods in detecting unpermitted discharges, five randomly selected one mile transects within three surveyed segments were the object of a repeat boat survey. The efficiency or effectiveness we were testing was of two types. First, would simple boat surveys along an entire shoreline yeild results equal to or greater than those from the combined aerial/boat surveys as implemented? Secondly, the statement of work required an investigation into varibility of results between surveyors. Thus different personnel had to be employed on the resurvey efforts. Segments and portions of segments which were inaccessible by boat (and Armand Bayou because of the logistical problems of needing two different boats) were eliminated from the selection process. Repeat boat surveys were performed on portions of East Bay, Galveston Bay, and Dickinson Bayou. The boat crew in this instance was not same as the crews that conducted the initial boat surveys.

These surveys were performed "blind". That is, the crew was not provided any information or pictures as to what may be expected in the areas. New topo maps, lacking any annotation, were the only data provided. The boat cruised as close to the shoreline as depth would permit, as both observers scanned for evidences of discharges of any kind. Binoculars were employed for all of East Bay and Galveston Bay because shallow water in the former and pier extensions in the latter kept the boat 50 to 200 meters from shore, except when a particular feature was to be investigated and photographed. At these times, boat progress was extremely slow with the motor in the tilt up position. It would be quite impractical to conduct the entire surveys at the speed and in this configuration required for these closer looks.

Those portions of segments re-surveyed were:

East Bay beginning at Shirley's Blue Beacon Bait Camp on Bolivar Island, 29°25.75', 94°42.56', and proceeding east along the south shore of East Bay to longitude 94°38.36'. From that point we proceeded across the bay to 29°32.58',94°38.54' to resume the survey westerly along the north shore to 29°31.55', 94°43.59'.

Galveston Bay beginning at the marina at 29°28.00', 94°55.33' and proceeding north along the shore to latitude 29°29.76'. From that point we proceeded north of Eagle Point Marina to begin re-survey toward the north at 29°30.58' on the western shore of Galveston Bay. This section was terminated at 29°30.89', 94°59.45'.

Dickinson Bayou beginning at the highway 146 bridge (29°27'49', 94°58.23') and proceeding upstream to 29°27.62', 95°00.68'

As evidence of actual or potential discharges was discovered, positions and descriptions were noted, photographs were taken, and positions annotated on the new maps. These data were compared with results from the aerial/boat survey investigations to determine the efficacy of the method employed. The efficiency of our method of survey is best illustrated by comparison of our blind confirmation survey result with those of the original survey for East Bay. During the confirmation survey we found the same and only discharge on the north shore that we had observed from the air. This was a permitted site but had its origin approximately 1 mile away and inland from the point of discharge on the shore. Had we only observed this from the shoreline, it is very unlikely that we could have made the connection between this discharge site and the permit. However, the pipe lying on the ground (and overgrown by brush along parts of its length) was visible from the air and trackable to its source. Another measure of the efficiency is the time required to survey these distances on this type of shoreline. The blind boat survey took about 4 hours from the time the boat was launched until our return to the marina. The same distance could be covered by air in less than 20 minutes over the shorelines investigated, and a total time of 30 minutes from the nearest airport. During this survey, we discovered the presence of an unpermitted discharge from under the building at the marina (Shirley's Blue Beacon Bait Camp). The 4" PVC pipe (no flow at the time of observation) was discovered by chance when we left the marina. While the original survey was limited to the bay portion of Segment 2423 and did not include the intracoastal waterway, the area in which the bait camp was located was not part of the areal extent of the survey design, but we noted the pipe's presence and its absence from the first survey report. It was well hidden beneath the marina structure, and would be very

easily missed on a routine survey of the area, and it certainly would not be indicated from the air.

The resurvey of the Galveston Bay shoreline showed the greatest disparity between the original and confirmation surveys. From the air, the large permitted sites were visible and noted. From the shoreline they were not, and were easily overlooked. The number of street and storm drains appeared to be potentially quite large and not plotable from the air. There were too many, their presence was obscured by the density of housing, trees, brush, etc. Thus, on this type of shoreline a shoreline survey by boat of essentially the entire length, preceded by an aerial survey to note the major permittees which are usually some distance from the shoreline and easily missed by boat, is the only feasible approach. In our re-survey utilizing two observers (one with binoculars) in addition to the boat driver, we reported significantly more potential discharges. However, these were all likely storm drains which were mere culverts under the road which paralleled the shoreline or bulkhead and lawn drains from residential properties. This difference is attributable to the lack of a good definition or criteria as to what constitutes an unpermitted discharge. None of the observed structures were discharging effluents at the time of observation, and some of the "discharge" structures we reported were as small as 1" pipes.

The re-survey of the Dickinson Bayou segment illustrates the greatest need for the combined aerial/boat survey approach. During both the original and confirmation boat surveys we did not observe five of the permitted or aerial observation sites which were either off the shoreline a short distance, or inaccessible by boat due to the extensive mud flats and shallows. These were only discernible from the air. In the original survey a discharge was observed at the marina at highway 146. In the resurvey no discharge or pipes were seen at this same area. Our inability to detect it was probably due to its being concealed by the congestion of boats (stacked two and three deep) at the docks. In contrast one permitted pipe was missed in the original boat survey and detected in the re-survey. Also two storm drains and two other unidentified pipes were noted coming from shoreline residences in the resurvey. Their omission in the original survey could be accounted for either by tide stage or concealment by boats at the docks during the initial survey.

Overall the confirmation surveys indicate that the aerial/boat survey method will provide the most efficient and complete coverage. However, there are likely to be omissions even with this double coverage, especially in areas of high residential and waterfront/marina type development.

4.0 DISCHARGE LISTINGS

The results of the aerial and boat surveys are summarized by segment number and presented in the appendicies. The data listings and site documentations are from the combined data bases of permitted sites, aerial observations, and surface observations. Permitted discharges are listed first in each segment and the unpermitted discharges discovered during these surveys follow. Photographs of the unpermitted discharge sites (both aerial and shoreline perspectives where possible) follow the unpermitted listings. Photographs are identifiable to the respective unpermitted site by the GBNEP number and the S/O or A/O number shown on each photograph and listed in the data files.

Photographs were taken and catalogued for each permitted site as part of the investigation but are not included as part of this report. Approximately 575 photographs were recorded and filed in the working documents used in performance of this study. These photographs are identifiable to the respective permitted sites by the GBNEP number and A/O number associated with each file entry and photograph.

The number and type of Permitted and Unpermitted Discharges annotated in this study are summarized in Table 4.1 and 4.2. The percentage of discharge structures located by the aerial, boat, and both type surveys are listed by segment (and hence shoreline type) in Table 4.3.

Table 4.3 shows the percentage of discharge structures located solely by the aerial survey, solely by the boat survey, and by both survey methods for both permitted and unpermitted discharges. Some permitted discharges were not located (due to being outside study area, e.g. offshore sites, etc.), these sites were excluded from inclusion in Table 1.

The percentage of both aerial and boat survey locating a permitted discharge ranges from 0 to 100%. At one end of the spectrum is Carancahua Bayou which was only accessible by the air, while four other segments showed complete confirmation. For Galveston Bay, segment 2421, the boat survey was critical for identifying discharge sites due to the high degree of development.

The proportion of unpermitted discharges located by both methods ranged from 0 to 73%. As with the permitted sites, highly developed areas (e.g. segment 2421) are highly dependent on boat surveys.

Table 4.1. Types of Permitted Discharges

Segment Description	Oil Related	Chemical Plant	Sewage Discharge	Power Plant	Unknown & Misc.
901	6	4	4	1	1
2421	2 (18)	2	6	1	0
Double Bayou	0	0	2	0	1
2423	5 (4)	0	1	0	0
1107	3 (1)	2	2 (3)	0	1
1113	2	2 (1)	1 (2)	0	2 (2)
1103	9	1	3	0	2
Carancahua Bayou	3	0	0	0	0
Total	30 (23)	11 (1)	19 (5)	2	7 (2)

Values in parentheses are sites outside study area but within segment.

Table 4.2. Types of Unpermitted Discharges

Segment Description	Storm Drains	Dredge Spoils	Oil Related	Lawn Drainage	Sewage Discharge	Unknown & Misc.
901	8	3	1	0	1	6
2421	8	0	0	14	1	8
Double Bayou	1	0	1	0	3	4
2423	2	0	0	0	0	5
1107	3	3	0	0	2	6
1113	7	0	2	0	0	1
1103	11	0	1	1	1	10
Carancahua Bayou	0	0	3	0	0	0
Total	40	6	8	15	8	40

Table 4.3. Percentage of Discharge Structures located by Aerial, Boat, and Both Survey Methods.

	UNPERMITTED DISCHARGES			PERMITTED DISCHARGES		
SEGMENT	AERIAL OBS ONLY (%)	SHORE OBS ONLY (%)	BOTH AERIAL AND SHORE (%)	AERIAL OBS ONLY (%)	SHORE OBS ONLY (%)	BOTH AERIAL AND SHORE (%)
901	0	42	58	11	0	89
2421	0	97	3	13	38	59
DOUBLE BAYOU	0	60	40	0	0	100
2423	14	29	57	0	0	100
1107	7	20	73	17	0	83
1113	30	50	20	0	0	100
1103	33	54	13	45	0	55
CARANCAHUA BAYOU	100	0	0	100	0	0

4.1 Cedar Bayou: Segment 0901

This segment encompasses 19 river miles through an industrialized/urban tributary. The upper reaches of the Bayou are fairly inaccessible by boat, and there were no boat launch ramps except at the bay end. Numerous large permitted facilities discharge into this segment, and there is considerable dredging activity at the lower reaches. Permitted and unpermitted discharges documented in the survey for this segment are summarized in Table 4.4

Table 4.4. Summary of Discharges for Cedar Bayou: Segment 0901

GBNEP #	PERMIT	DISCHARGE TYPE
1	YES	UNKNOWN/MISC.
2	YES	OIL RELATED.
3	YES	OIL RELATED.
4	YES	OIL RELATED.
5	YES	OIL RELATED.
6	YES	OIL RELATED.
50	YES	SEWAGE.
51	YES	SEWAGE.
52	YES	OIL RELATED.
53	YES	CHEMICAL PLANT.
54	YES	CHEMICAL PLANT.
55	YES	POWER PLANT.
56	YES	CHEMICAL PLANT.
57	YES	CHEMICAL PLANT.
58	YES	SEWAGE.
59	YES	SEWAGE.
183	NO	DREDGE SPOILS.
184	NO	POSSIBLE STORM DRAIN.
185	NO	UNKNOWN/MISC.
186	NO	UNKNOWN/MISC.
187	NO	POSSIBLE STORM DRAIN.
192	NO	POSSIBLE STORM DRAIN.
200	NO	OIL RELATED.
201	NO	SEWAGE.
202	NO	POSSIBLE STORM DRAIN.
238	NO	DREDGE SPOILS.
239	NO	DREDGE SPOILS.
240	NO	UNKNOWN/MISC.
241	NO	POSSIBLE STORM DRAIN.
243	NO	POSSIBLE STORM DRAIN.
244	NO	UNKNOWN/MISC.
245	NO	POSSIBLE STORM DRAIN.
247	NO	POSSIBLE STORM DRAIN.
248	NO	UNKNOWN/MISC.
249	NO	UNKNOWN/MISC.

4.2 Galveston Bay: Segment 2421

This segment encompasses 22 shoreline miles of wide open bay. Extensive residential development is essentially continuous along the length of this developed shoreline. The great fetch of water across the bay to the east and south requires careful consideration for the weather and prevailing winds and seas during survey periods. The boat must be seaworthy to endure this open water, yet shallow draft in order to get near the shore is necessary. The hundreds of private piers extending hundreds of feet into the bay make an expedient survey from the water doubtful. The numerous lawn and bulkhead drains also tend to confuse the discovery and reporting of unpermitted discharges. Extensive embayments, containing yacht harbors and marinas along the shoreline, pose special problems. Permitted and unpermitted discharges documented in the survey for this segment are summarized in Table 4.5

Table 4.5. Summary of Discharges for Galveston Bay: Segment 2421

GBNEP #	PERMIT	DISCHARGE TYPE
7	YES	OIL RELATED.
8	YES	OIL RELATED.
10	YES	OIL RELATED.
11	YES	OIL RELATED.
12	YES	OIL RELATED.
13	YES	OIL RELATED.
14	YES	OIL RELATED.
15	YES	OIL RELATED.
16	YES	OIL RELATED.
17	YES	OIL RELATED.
18	YES	OIL RELATED.
19	YES	OIL RELATED.
20	YES	OIL RELATED.
21	YES	OIL RELATED.
22	YES	OIL RELATED.
23	YES	OIL RELATED.
24	YES	OIL RELATED.
25	YES	OIL RELATED.
26	YES	OIL RELATED.
61	YES	SEWAGE.
62	YES	SEWAGE.
63	YES	SEWAGE.
64	YES	POWER PLANT.
65	YES	CHEMICAL PLANT.
66	YES	CHEMICAL PLANT.
89	YES	SEWAGE.
98	YES	SEWAGE.
102	YES	SEWAGE.
204	NO	UNKNOWN/MISC.
154	YES	OIL RELATED.
155	NO	POSSIBLE STORM DRAIN.
203	NO	POSSIBLE STORM DRAIN.
213	NO	POSSIBLE STORM DRAIN.
217	NO	POSSIBLE STORM DRAIN.
221	NO	POSSIBLE STORM DRAIN.
225	NO	POSSIBLE STORM DRAIN.
226	NO	POSSIBLE STORM DRAIN.
252	NO	POSSIBLE STORM DRAIN.
173	NO	SEWAGE.
210	NO	UNKNOWN/MISC.
169	NO	YARD DRAINAGE.
170	NO	UNKNOWN/MISC.
171	NO	UNKNOWN/MISC.
172	NO	YARD DRAINAGE.
205	NO	YARD DRAINAGE.
206	NO	UNKNOWN/MISC.

Table 4.5. Summary of Discharge for Galveston: Segment 2421

GBNEP #	PERMIT	DISCHARGE TYPE
207	NO	UNKNOWN/MISC.
208	NO	YARD DRAINAGE.
209	NO	YARD DRAINAGE.
211	NO	YARD DRAINAGE.
212	NO	YARD DRAINAGE.
214	NO	YARD DRAINAGE.
215	NO	YARD DRAINAGE.
216	NO	YARD DRAINAGE.
218	NO	YARD DRAINAGE.
222	NO	UNKNOWN/MISC.
223	NO	UNKNOWN/MISC.
219	NO	YARD DRAINAGE.
220	NO	YARD DRAINAGE.
224	NO	YARD DRAINAGE.

4.3 Double Bayou: Unclassified Segment in Chambers County

The segment survey covered 22 river miles of this agricultural rural tributary with oil field activity at the upper end of the east fork. The tributary splits into two branches near the bay entrance. The western fork is smaller and not navigable for much distance due to its narrow width and depth. The eastern fork is larger but not navigable past the last house on the bayou, as a large sunken boat blocks the stream. Further on, a small dam prevents boat passage. The upper reach of the area surveyed is surrounded by oil activity and rice farming, but is inaccessible by boat. Much of the bayou is overgrown almost completely with trees. This and the isolation from any crossing roads makes air survey of this portion the only practical method for survey. Permitted and unpermitted discharges documented in the survey for this segment are summarized in Table 4.6

Table 4.6. Summary of Discharge for Double Bayou

GBNEP #	PERMIT	DISCHARGE TYPE
87	YES	UNKNOWN/MISC.
95	YES	SEWAGE.
96	YES	SEWAGE.
133	NO	UNKNOWN/MISC.
134	NO	SEWAGE.
135	NO	OIL RELATED.
136	NO	POSSIBLE STORM DRAIN.
232	NO	SEWAGE.
233	NO	UNKNOWN/MISC.
234	NO	SEWAGE.
235	NO	UNKNOWN/MISC.
236	NO	UNKNOWN/MISC.
237	NO	UNKNOWN/MISC.

4.4 East Bay: Segment 2423

This segment includes 40 shoreline miles of wide open bay surrounded by agricultural and undeveloped open bay shoreline on the north and a few small marinas on the south, off the Intracoastal Waterway. Large expanses of shallow water and wetlands near the shoreline, and the wide open nature of the bay work against successful boat surveys for detecting discharges. The size, speed and seaworthiness of a boat required to cover the long distances (with no available shelter nearby) is not compatible with the shallow draft required to get near the shoreline. Also adding to the difficulty, is the expanse of wetlands on the south shore, with a myriad of channels, puddles, and streams which would hide most discharges from discovery except from above. Permitted and unpermitted discharges documented in the survey for this segment are summarized in Table 4.7

Table 4.7. Summary of Discharge for East Bay: Segment 2423

GBNEP #	PERMIT	DISCHARGE TYPE
27	YES	OIL RELATED.
28	YES	OIL RELATED.
32	YES	OIL RELATED.
33	YES	OIL RELATED.
34	YES	OIL RELATED.
35	YES	OIL RELATED.
36	YES	OIL RELATED.
37	YES	OIL RELATED.
93	YES	SEWAGE.
127	NO	POSSIBLE STORM DRAIN.
128	YES	OIL RELATED.
129	NO	POSSIBLE STORM DRAIN.
130	NO	UNKNOWN/MISC.
131	NO	UNKNOWN/MISC.
132	NO	UNKNOWN/MISC.
153	NO	UNKNOWN/MISC.
250	NO	UNKNOWN/MISC.

4.5 Chocolate Bayou: Tidal Segment 1107

This 14 mile segment of moderately developed rural tributary is the ideal setting for conducting a shoreline survey by boat. There are few significant tributaries which could contain hidden discharges. There are permitted facilities of major proportion, and smaller ones. There are not numerous storm drains to confuse the reporting, nor are the residential developments difficult to assess. Access is easy, almost in the middle of the segment, which is navigable through its length, and except for the bay at the south end, just about any small boat would suffice for surveying. Permitted and unpermitted discharges documented in the survey for this segment are summarized in Table 4.8.

Table 4.8. Summary of Discharge for Chocolate Bayou: Tidal Segment 1107

GBNEP #	PERMIT	DISCHARGE TYPE
47	YES	OIL RELATED.
48	YES	OIL RELATED.
67	YES	SEWAGE.
68	YES	SEWAGE.
69	YES	SEWAGE.
70	YES	SEWAGE.
71	YES	SEWAGE.
72	YES	CHEMICAL PLANT.
73	YES	CHEMICAL PLANT.
74	YES	UNKNOWN/MISC.
92	YES	OIL RELATED.
112	NO	SEWAGE.
113	NO	DREDGE SPOILS.
114	NO	DREDGE SPOILS.
115	NO	DREDGE SPOILS.
116	NO	UNKNOWN/MISC.
117	NO	SEWAGE.
118	NO	UNKNOWN/MISC.
119	NO	UNKNOWN/MISC.
120	NO	UNKNOWN/MISC.
121	YES	OIL RELATED.
122	NO	POSSIBLE STORM DRAIN.
123	NO	UNKNOWN/MISC.
124	NO	POSSIBLE STORM DRAIN.
125	NO	UNKNOWN/MISC.
126	NO	POSSIBLE STORM DRAIN.

4.6 Armand Bayou: Tidal Segment 1113

These 8 river miles, classified as a suburban tributary, are an enigma, as the shoreline and waterway itself are the most primitive or untouched areas of the entire study. The undeveloped bayou and shoreline are designated as a wildlife refuge and gasoline powered motors are prohibited for most of its length. Thus, two separate surveys, the second using the flat bottom boat and electric trolling motor, were required. Dense residential developments surround the bayou to the east and west. Discharges into the bayou were minimal, being mostly storm drains. Permitted and unpermitted discharges documented in the survey for this segment are summarized in Table 4.9

Table 4.9. Summary of Discharge for Armand Bayou: Segment 1113

GBNEP #	PERMIT	DISCHARGE TYPE
80	YES	UNKNOWN/MISC.
81	YES	CHEMICAL PLANT.
82	YES	CHEMICAL PLANT.
83	YES	UNKNOWN/MISC.
84	YES	SEWAGE.
85	YES	SEWAGE.
86	YES	SEWAGE.
90	YES	UNKNOWN/MISC.
91	YES	CHEMICAL PLANT.
94	YES	UNKNOWN/MISC.
176	NO	UNKNOWN/MISC.
177	NO	POSSIBLE STORM DRAIN.
178	NO	POSSIBLE STORM DRAIN.
179	NO	OIL RELATED.
180	YES	OIL RELATED.
181	YES	OIL RELATED.
182	NO	OIL RELATED.
227	NO	POSSIBLE STORM DRAIN.
228	NO	POSSIBLE STORM DRAIN.
229	NO	POSSIBLE STORM DRAIN.
231	NO	POSSIBLE STORM DRAIN.
246	NO	POSSIBLE STORM DRAIN.

4.7 Dickinson Bayou: Tidal Segment 1103 and Above Tidal Segment 1104

Tidal Segment 1103

This segment, extending 15 river miles west from its entrance into Galveston Bay, is described as a moderately developed suburban and rural tributary. At the bay end, the bayou is wide with large expanses of shallow water. Residential development is limited primarily to the north shore of the bayou. Oil field activity is primarily in the eastern portion and is not readily discernible from the shoreline. West of the highway 146 bridge there are large expanses of mud flats and shallow water which impede the boat surveys and limit access by water essentially to the main channel. The bayou narrows to a workable width two miles west of this bridge, and becomes increasingly narrow and shallower toward the non-tidal segment. The development along the shoreline and the trees overgrowing the bayou were sufficient that the entire bayou from 2 miles west of the highway 146 bridge to the highway 75 bridge required boat survey. Permitted and unpermitted discharges documented in the survey for this segment are summarized in Table 4.10

Above Tidal Segment 1104

Extending 7 river miles, this rural non-tidal tributary is only a very small stream which winds through agricultural fields with virtually no access to the stream bed. Few road bridges cross the bayou above the tidal segment, and from the air there appears nothing on the shoreline except a few drainage pipes which appear to drain rice fields. The stream is small enough to be jumped across in many places; thus, the only way to survey the shoreline from the ground would be to walk the entire length in the stream bed. Permitted and unpermitted discharges documented in the survey for this segment are summarized in Table 4.10

Table 4.10. Summary of Discharge for Dickinson Bayou: Tidal Segment 1103 and Above Tidal Segment 1104

GBNEP #	PERMIT	DISCHARGE TYPE
38	YES	OIL RELATED.
39	YES	OIL RELATED.
40	YES	OIL RELATED.
41	YES	OIL RELATED.
42	YES	OIL RELATED.
43	YES	OIL RELATED.
44	YES	OIL RELATED.
45	YES	OIL RELATED.
75	YES	CHEMICAL PLANT.
76	YES	OIL RELATED.
77	YES	UNKNOWN/MISC.
78	YES	SEWAGE.
79	YES	SEWAGE.
88	YES	UNKNOWN/MISC.
97	YES	SEWAGE.
138	NO	POSSIBLE STORM DRAIN.
139	NO	POSSIBLE STORM DRAIN.
140	NO	POSSIBLE STORM DRAIN.
141	NO	POSSIBLE STORM DRAIN.
142	NO	UNKNOWN/MISC.
143	NO	UNKNOWN/MISC.
144	NO	POSSIBLE STORM DRAIN.
145	NO	SEWAGE.
147	NO	OIL RELATED.
151	NO	POSSIBLE STORM DRAIN.
152	NO	UNKNOWN/MISC.
156	NO	UNKNOWN/MISC.
157	NO	POSSIBLE STORM DRAIN.
158	NO	POSSIBLE STORM DRAIN.
159	NO	POSSIBLE STORM DRAIN.
160	NO	UNKNOWN/MISC.
161	NO	YARD DRAINAGE.
162	NO	POSSIBLE STORM DRAIN.
163	NO	POSSIBLE STORM DRAIN.
164	NO	UNKNOWN/MISC.
165	NO	UNKNOWN/MISC.
166	NO	UNKNOWN/MISC.
167	NO	UNKNOWN/MISC.
168	NO	UNKNOWN/MISC.

4.9 Carancahua Lake and Bayou: Unclassified

This segment of 12 shoreline and river miles proved to be impossible to survey by boat within the scope of this study. A rural secondary bay with oil field activity, it was found through the aerial survey to be extremely shallow, swampy, and with a very circuitous route of the small bayou channel. The only access to the bayou and lake is through the lake entrance off the Intracoastal Waterway, northeast of Chocolate Bayou. The only vehicles observed in the area were all terrain swamp buggies being used by a seismic crew. A small flat bottom boat with oars and a small motor could likely be used in the lake, if it could be transited from its launching point miles down or across West Bay in any direction. Once in the lake, orientation and navigation would be extremely difficult as there are no features with which to reference one's position, and the land forms and true shorelines do not correspond to those shown on the map.

The aerial survey easily discovered the permitted discharges and other features identified as potential discharges. Confirmation on the ground with photographs and positional data proved impossible as access from the land would require transit across private property with locked gates. Almost all of the shoreline was devoid of any features which would draw interest as being a potential discharge. All of the discharges identified on the lake and bayou were related to oil field activity and were near described locations for existing permits. Without the aerial survey it is doubtful that even these permitted activities would have been discovered. A boat survey, if necessary, would require access across the private land and/or the use of two different type boats if it were to be approached from the lake. In either case, at least a day would be spent verifying essentially the absence of unpermitted discharges. Permitted and unpermitted discharges documented in the survey for this segment are summarized in Table 4.11

Table 4.11. Summary of Discharge for Carancahua Lake and Bayou

GBNEP #	PERMIT	DISCHARGE TYPE
46	YES	OIL RELATED.
60	YES	OIL RELATED.
105	YES	OIL RELATED.
106	NO	OIL RELATED.
107	NO	OIL RELATED.
108	NO	OIL RELATED.

5.0 Logistical and Methodological Problems

1. In this study, we found it difficult to determine precisely where to draw the limits of our investigation. Since the effort put into the investigation is really a function of how much area is to be covered, and not the point A to point B shoreline length, the estimation of areal coverage is critical to level of effort requirements. In the future, study area boundaries for a particular segment need to be more precisely defined. A number of permitted discharges on a particular stream or shoreline segment are quite distant from the actual shoreline and enter the segment via small intermittent stream beds. Another group of permitted discharges were on the segment but beyond the bounds designated for this study. In a comprehensive study of the entire bay system, it would be advantageous to define individual study areas by geographic bounds other than a segment number so that the inputs coming via "drainage ditches" or very small embayments off the main water body would be included. For this study our practical limits for investigating a known permitted site removed from the shoreline was on the order of a mile from the shoreline. In some instances where the discharge feature (pipe or ditch) was evident from the air, unpermitted sites were traced to their origins up to about a mile from the shoreline. Without such an obvious connection to the shoreline, the surveys were limited to approximately 500 meters from the shoreline in the aerial surveys, and basically at the shoreline for the boat surveys.

   On a similar vein, the issue of islands, waterways, and other extensions of the shoreline length need to be addressed prior to additional surveys. In this study, East Bay is paralleled by the Intracoastal Waterway. The input of discharges into East Bay via the ICW needs to be addressed; however, its inclusion as part of segment 2423 effectively doubles the length of shoreline to be surveyed.

2. Similar to the preceding, discharge inputs to the water bodies not arising from the shoreline, e.g., petroleum production structures in the bays, need to be more specifically addressed in the scope of work. The effort required to investigate each of these is substantial and not reflective of the shoreline length. In this study, permitted oil structures in the bays were noted but were not investigated or documented. Determining the existence of a discharge from these structures is also a problem, as most discharges would occur underwater and the discharge pipe would be indistinguishable from the supporting structure.

3. The boat surveys need to closely follow the aerial survey for each particular segment or area to be investigated. Much of the insight

gained from the aerial overview is lost if too much time passes or if other aerial surveys are conducted prior to the boat survey. The recommended procedure would be to follow each air survey with a boat survey the next day before proceeding with another aerial survey.

4. It is essential that at least one observer be present on both the aerial and boat surveys for each particular segment. It was found that a single person aerial survey is not a possibility. The preferred staffing would be a pilot/observer who is familiar with the project objectives and procedures and two observers/recorders who would photograph and annotate the charts and logs. Without a pilot versed in the project techniques, an observational crew of three is recommended.

5. The aerial survey proved to be the only way to survey some areas, and was found to be very advantageous in most of the segments surveyed. Some stream segments are too small and shallow to be accessed by boat, and in others, passage was blocked by dams, pipes, and fallen trees. Many shorelines and stream segments are surrounded by private land with no ready access available.

6. The use of Loran C as the positioning location system has some inherent limitations which become apparent when locations as measured in the field are transferred to the topo sheets. The time delays (TDs) are quite reliable in documenting a discharge position; however, the algorithms used to calculate latitude and longitude are not equally accurate throughout the geographic coverage areas. As a result, positional errors in the reported locations of the discharges will appear quite significant when the field recorded positions are plotted on the topo sheets. These errors will vary with the pair of time delays used in the calculation as well as the particular make of Loran unit (and the algorithm it uses). To resolve these apparent positional discrepancies, it is suggested that the TDs be used as the definitive measure of a discharge position until such time as GPS becomes sufficiently dependable and accurate to be the navigational method of choice.

7. Location and positions from the aerial survey were estimated visually with reference to the topo maps. With several areas being inaccessible by boat, we have no measured positional data. For future surveys, an aircraft Loran could be installed in the survey aircraft which would provide this needed information. Units are available which would allow automated data logging via RS232 output to a laptop computer in the aircraft. With this information and adequate aerial photography, more of the boat surveys (performed just to provide latitude and longitude and photographs) could be eliminated.

8. In areas of multiple discharge activity, there was no way to tell from the air or shoreline which discharge belonged to whom. It is recommended, as part of the permitting process and renewals, that discharges be marked at the point of discharge with a placard or sign, similar to those used to note the location and route of pipelines, which would identify by name and number the permit holder.

9. The learning curve both for utilization of the data base program and implementation of the aerial and boat surveys was much higher than expected, and was a greater effort than anticipated at the proposal. In fact, as of the time of preparation of this draft report, we are not as comfortable with handling data in the data base as we would hope to be. Should this project be expanded to encompass the entire Galveston Bay system and beyond, the time needed for familiarization and getting up to speed on techniques and data handling should be a significant factor in the level of effort proposed. For the sake of efficiency in such a comprehensive survey, we would recommend that the project be conducted in its entirety by a single contractor rather than divide it up into smaller segments where the costs of the learning curve will be reiterated with each change in contractor.

There needs to be a clear definition of what constitutes an unpermitted discharge before a comprehensive survey is undertaken. We have reported everything we observed which might be the source of some type of contamination into Galveston Bay. This conservative approach was taken because of a lack of specific criteria or direction in the scope of work to the contrary, and because of the type of reported unpermitted discharges which are reported to the Texas Water Commission. Things such as automotive antifreeze spilled into a roadside ditch, runoff from sawdust piles, and effluents from blocked restaurant drains are representative of the type of reports which are investigated by the Water Commission. Accordingly, we reported any suspect activity or structure. As a consequence of this conservative posture, we have reported numerous structures which may be no more than lawn drains which are to prevent bulkhead collapse on the shorelines. On the other end of that scale, we have reported large discharge pipes which appear to have (or continue to) drained dredged material disposal areas along Cedar and Chocolate Bayous. These may be regulated by Corps of Engineers or EPA permits or they may not fit the criteria for an unpermitted discharge. They are reported as unpermitted nevertheless. However, before a comprehensive survey is to be conducted, or even before these reported unpermitted discharges are investigated, a criteria of what constitutes unpermitted from a regulatory perspective should be established.

10. Consideration (either in method or cost) was not given in the scope of work or in our proposal as to reproduction of maps and photographs required for the documentation in the reports. Map reductions to the size which could be bound in a report would not show sufficient detail to be of value in locating the discharge points. The costs for color xerox to document the unpermitted discharges are approximately $1.20 per page with two sites per page. We have estimated for future projects that $100 per report copy be budgeted to cover color xerox of the photographs and reproduction of the maps.

11. The use of key maps (Key Maps, Inc., Houston) proved to be invaluable for pinpointing the location of many permitted discharges as described from the actual permits and also in locating unpermitted discharges where densities were too high and map resolution too low for latitude and longitude to be of value. As an example, street drains can be delineated by description such as "at the end of 10th Street at the intersection of H Avenue".

12. As an aid to locating positions on the myriad of storm and street drains and bulkhead or lawn drains along the western shore of Galveston Bay (or similar shorelines), it would be beneficial for a shorebased observation team to follow the boat survey crew from the highway paralleling the shoreline. Communicating by walkie talkie with the boat, the shore observation crew could document the location of these type discharges by house number or street intersection. They also would be in a better position in some cases to detect the presence of storm drains entering the bay.

6.0 Recommendations for Comprehensive Surveys

6.1 Design

The design of a comprehensive survey for unpermitted discharges should address entire areas surrounding Galveston Bay in order to eliminate the ambiguity and uncertainty of defining the study area. We recommend that such a survey be performed as a single project and not divided into smaller projects to be performed sequentially as funds or interest becomes available. Subsequent to submission of this report in draft form, it was learned that there are other regulatory agencies in the state of Texas which have need of similar information and pursue its acquisition in similar ways. The General Land Office utilizes aerial surveys in keeping track of new construction and the Texas Department of Health has used aerial surveys to locate aggregations of septic tanks which would influence their closure zones for shellfishing. With information and shared need, it would seem advantageous for any subsequent comprehensive survey design to incorporate this need and shared sponsorship.

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As a plan for conducting such surveys is formulated, it should be kept in mind that our study covered the broadest spectrum of shoreline types, and our estimate for performing further studies is based on that mix of shoreline types. A change in the mix of shoreline types would necessarily affect the cost and approach to conducting that survey. For example, to survey the Galveston and Houston ship channels and Clear Lake only, would be labor intensive on the boat survey aspects. Similarly, a survey of West Bay could be done quickly and efficiently by the method employed here. Thus, a comprehensive survey would encompass both ends of the difficulty spectrum and would tend to average out the costs. A select survey of particular segments may vary significantly in both directions from the estimated costs we have developed here.

6.2 Methodology

The methodology we recommend for performing a comprehensive survey of the Galveston Bay system is the same as we employed in this pilot study with the modifications as addressed in Section 5.0. Multiple boat surveys (and land surveys where the aerial survey indicates such a need) could be conducted simultaneously on the same or nearby shorelines or stream segments as the logistical plan and time constrains would require. Without having to redevelop methodology and techniques as was done in this study, a single comprehensive study could be done in a shorter period of time than our efforts in this study would indicate.

6.3 Cost

We have estimated the cost to perform a survey as described and performed in this study (Table 6-1). The task numbers are those identified and described in our study work plan. Our cost estimate does not include tasks which were part of this pilot project and would not be required to be repeated for a comprehensive study to be conducted. The estimate does not include labor or costs for Tasks 10 (developing clearance and priority ranking criteria), 11 (developing survey reporting forms), 17 (conducting calibration/efficiency surveys), or 20 (this section of this report), as these were part of the development process. Nor does the estimate allow any expense to become familiar with the project objectives, techniques, data base management system, or in general to "gear up" for such an undertaking. The estimates of time and materials are what we estimate it would take for us to repeat, based on what we have learned and done to date, an equivalent survey on a similar amount and makeup of shoreline miles. Two cost areas of our estimate which show significant costs that are reflected in our pilot study are costs for reproducing maps and color prints for the report, and accurate costs for aircraft charters for the aerial surveys to be performed by anyone. These are included in the costs estimates which follow.

Table 6-1. Estimated Survey Budget

	Senior Staff	Field Assistant	Staff	Travel	Supplies	Equipment Use
Data Acquisition & Processing						
Task 1			1		$360	$0
Task 2		4			$0	$0
Task 6	0	4		$75	$0	$52
Task 7	4	6		$300	$0	$156
Task 9	1	6	15		$0	$525
Task 13	2	14	3		$0	$425
Task 19	2	20	3		$0	$575
Man Days	9	54	22			
Subtotal Data Acquisition and Processing				$375	$360	$1,733
Field Surveys, Air & Boat						
Task 12	4	8		$2,100	$360	$60
Task 15		36		$800	$540	$3,168
Man Days	4	44				
Subtotal Field Surveys				$2,900	$900	$3,228
Reporting & Project Management						
Task 4	5		5		$0	$0
Task 8	1		1		$0	$0
Task 16		6		$150	$0	$0
Task 14	1	3			$0	$0
Task 18	2	8	15		$0	$200
Task 19	1	1	3		$1,000	$0
Task 22	2		1	$75	$0	$65
Task 24	5		10	$75	$0	$0
Man Days	17	18	35			
Subtotal Reporting & Project Management				$300	$1,000	$265
Category Total				$3,575	$2,260	$5,226
Salaries, Fringe, Indirect				$36,247		
Project Total				$47,308		

The cost estimates given here are based on nine different shorelines totaling approximately 160 linear miles of stream or shoreline. The estimates can be extended proportionally to arrive at an estimate for the entire bay once the number, location, and length of the streams and shorelines are defined.

7.0 Regulatory and Follow-up Action

A requirement of our project required notification of the appropriate state regulatory agencies immediately upon finding any unpermitted discharges. Because of the large number of apparent unpermitted discharges we waited until all segments were surveyed before notification was provided. Along with submittal of the draft report on August 20, 1991 we conveyed a listing and description of all unpermitted sites (approximately 126) to the Texas Railroad Commission and the Texas Water Commission for follow-up investigation.

By January 14, 1991 we received notification from the Railroad Commission that their investigation of all sites appearing to be related to oil and gas activities under their jurisdiction was complete. The Railroad Commission investigated 17 sites and found 12 to be within their jurisdiction. Of these, seven were permitted facilities and five did not require a permit under RRC rules. The changes of the status of these sites (permitted vs unpermitted) were noted in the revision to the data base included in the Appencicies to this report. Fifty-two man hours and 1300 highway miles driven were required for this enforcement action, and one site (inaccessible by land) remains to be inspected.

As of this revision of the draft report to final report (March 11, 1991) we had received no information from the Texas Water Commission regarding the status of the 100+ unpermitted discharge sites under their regulatory jurisdiction, and for which we had provided notification 7 months prior to this writing. Without information to the contrary from the Water Commission, the status of those unpermitted discharges remains at this time unchanged in the data base submitted with this report.

8.0 Study Participants

The following individuals of the Geochemical and Environmental Research Group, Texas A&M University, participated and contributed to this study:

Mr. David Bishop assisted in all of the boat surveys.

Ms. Suzanne Cardwell was the project administrator.

Dr. Roger R. Fay was the Principal Investigator, pilot on the aerial surveys, observer in the boat survey confirmation study, and the author of the report.

Ms. Joanna Fritz and Ms. Sherri Sanford were technical editors for the project.

Dr. Ian MacDonald acquired the historical permitted data and set up the Reflex data base.

Mr. Stephen Sweet was the project data manager and served as observer on some of the boat and aerial surveys.

Mr. R.J. Wilson performed the boat surveys and was observer on all of the aerial surveys.

In addition to the aforementioned GERG employees, Andrew Fay graciously volunteered his time to this project to serve as boat operator during the confirmation surveys.