# KLEBERG COUNTY STORMWATER MANAGEMENT MASTER PLAN

## SOUTH TEXAS WATER AUTHORITY

## OCTOBER 1986

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A Centerra Company

NAISMITH ENGINEERS, INC.
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KLEBERG COUNTY

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# EXECUTIVE SUMMARY

Kleberg County is susceptible to flooding because some of its defined drainageways and creeks are constricted by inadequate channel capacities and man-made barriers such as road and railroad embankments, and because its flat topography and low soil permeability create poor drainage and ponding. Two feasible solutions to flooding problems in the County are (1) to identify areas of inadequate drainage and limit development in these areas, and (2) to upgrade drainage channels and replace constrictive barriers in existing developed areas.

There are eleven drainage basins that must be analyzed in order to develop a stormwater masterplan for the unincorporated areas of Kleberg County. These analyses should include development plans and causes of specific area flooding. Maintenance program requirements, environmental impacts, and cost estimates are other critical factors in the viability of the masterplan.

Hydrology studies for the area are based on determining the instantaneous peak discharge values at key points along the eleven drainageways in the County. Peak discharge is a function of precipitation magnitude and intensity, drainage area, topography, soil type, soil-moisture conditions, channel conveyance and other factors. Because the streams of Kleberg County lack sufficient historical storm event records, a method selected as best applicable to the County is the Cypress Creek Method from the Agricultural Research Service. The hydraulics were then determined using the Corps of Engineers HEC-2 Model, which computes and plots the water surface profiles for all flow conditions, including the effects of bridges, culverts, weirs, embankments and dams. The program can determine water surface profiles for various frequency floods for both natural and modified conditions.

The masterplan provides for reduced flood damages through both structural and non-structural measures. Possible non-structural measures include floodplain regulation, floodproofing, flood forecasting, on-site detention of stormwaters, clearing and snagging existing streams, and buyout and relocation of structures in the existing floodplain. Possible structural measures include storing flood waters in reservoirs, enlarging and straightening the channels, enlarging the bridge openings, and constructing flood protection levees.

The flooding potentials and recommended alternative solutions for each of the eleven drainageways are outlined in the following list. In all cases, development in the areas should be carefully controlled within the 100-year flood boundaries to insure adequate flood protection and to meet FEMA requirements.

| BASIN DESCRIPTION | NEEDED IMPROVEMENTS |
|---|---|
| 1. San Fernando Creek - Inadequate channel capacity in upper portion of watershed. | (a) Replace and raise bridge on FM 2045<br>(b) Widen channel from Station 572+53 to Station 1060+00. Lower channel invert elevation.<br>(c) Replace bridge at FM 1355.<br><br>Note: Bridge replacement at FM 1355 and channelization are partly within Nueces County. |
| 2. Carreta Creek - Catches overflow from San Fernando Creek. | (a) None proposed. |
| 3. Tranquitas Creek - Limited development; no public roads in watershed. | (a) None proposed.<br>(b) Study safety measures for dam at Tranquitas Lake (outside the scope of this study). |
| 4. Santa Gertrudis Creek - Limited development. | (a) Replace culverts at FM 1717 with bridge. |

| | |
|---|---|
| 5. Escondido Creek - Limited development; no public roads upstream of Co. Rd. 1030N. | (a) Replace culverts at Co. Rd. 1030N with bridge.<br>(b) Study safety measures for dam at Escondido Lake (outside scope of this study.) |
| 6. Jaboncillos Creek - Extensive overbank flooding both upstream and downstream of US 77, due to inadequate channel capacity and constrictions at US 77 and Missouri-Pacific RR bridges. Some culverts are not functioning. | (a) Widen channel from Station 245+55 to Station 422+25. Lower channel invert elevation.<br>(b) Replace two bridges at US 77.<br>(c) Replace bridge at Mo.-Pac. RR.<br>(d) Replace culvert at Co. Rd. 2170W with three 18-in. culverts.<br>(e) Replace culvert at Co. Rd. 1020 with 18-in. culverts.<br>(f) Replace bridge at FM 772. |
| 7. Ebanito Creek - FM 772 overtopped at structures in four locations, inadequate channel capacity and obstructions at US 77 and Missouri-Pacific RR bridges. Culverts at Co. Rd. 1030S plugged. | (a) Widen channel from Station 130+00 to Station 195+00. Lower channel invert elevations.<br>(b) Replace culverts at four FM 772 locations with bridges.<br>(c) Replace both Southbound and Northbound bridges at US 77.<br>(d) Replace bridge at Mo.-Pac. RR.<br>(e) Replace culvert at Co. Rd. 1030S with three 24-in. culverts. |
| 8. Radicha Creek - Limited development. | (a) None proposed. |
| 9. Arania Creek - Little slope or channel capacity. All roads are overtopped during flood events. | (a) Replace five culverts at FM 628 with bridges.<br>(b) Replace culvert at Co. Rd. 1090S with three 18-inch culverts.<br>(c) Widen channel from Station 65+76 to Station 120+76. Lower invert channel elevation. |
| 10. Salado Creek - Limited development. | (a) None proposed. |
| 11. Los Olmos Creek - Limited development now and in foreseeable future. | (a) No analysis was made. |

A sensitivity analysis of the channel roughness parameters (n-values) indicate that maintenance of stream channels is critical to helping solve local flooding problems.

Estimated capital costs for the recommended improvements are itemized in the Masterplan Report. The total estimated costs for all the improvements are $45,393,000 with $12,151,400 for structures and $33,241,600 for channelization efforts. It should be noted that channelization of the San Fernando Creek is a major portion of the total sum, nearly $27,000,000, and that such efforts will extend over into Nueces County.

Priority for implementing the recommended improvements is based on these criteria: severity of flooding problem, development potential of the area, capital costs, maintenance costs, ease of implementation, environmental impacts and socio-economic benefits. Weighting factors were then applied to these criteria, and the following order ranks the priority of the improvements.

| Rank | Basin | Activity | Amount ($1000) |
|---|---|---|---|
| 1 | Arania | Bridge at FM 628 (Sec. 2.01) | 328.8 |
| 2 | Arania | Bridge at FM 628 (Sec. 2.05) | 328.6 |
| 3 | Arania | Culverts at Co. Rd. 1090S | 4.0 |
| 4 | Escondido | Bridge at Co. Rd. 1030N | 509.1 |
| 5 | Ebanito | Bridge at FM 772 (Sec. 4.60) | 394.8 |
| 6 | Ebanito | Bridge at FM 772 (Sec. 4.00) | 529.2 |
| 7 | Santa Gertrudis | Bridge at FM 1717 | 1,029.6 |
| 8 | Arania | Bridge at FM 628 (Sec. 2.21) | 327.8 |
| 9 | Arania | Bridge at FM 628 (Sec. 2.25) | 327.8 |
| 10 | Arania | Bridge at FM 628 (Sec. 2.30) | 328.1 |
| 11 | Jaboncillos | Bridge at Mo-Pac RR | 1,032.0 |
| 12 | Ebanito | Bridges at US 77 | 907.2 |
| 13 | Ebanito | Bridge at Mo-Pac R.R. | 786.0 |
| 14 | Jaboncillos | Culverts at Co. Rd. 2170W | 4.5 |
| 15 | Ebanito | Culverts at Co. Rd. 1030S | 4.5 |
| 16 | Ebanito | Bridge at FM 772 (Sec. 4.93) | 401.0 |
| 17 | Jaboncillos | Bridge at FM 772 | 703.2 |
| 18 | Jaboncillos | Bridges at US 77 | 1,696.8 |
| 19 | Jaboncillos | Culverts at Co. Rd. 1020 | 4.0 |
| 20 | Arania | Channel Improvement | 263.8 |
| 21 | Ebanito | Channel Improvement | 869.5 |

| | | | |
|---|---|---|---|
| 22 | San Fernando | Bridge at FM 2045 | 1,458.0 |
| 23 | San Fernando | Bridge at FM 1355 | 1,046.4 |
| 24 | Jaboncillos | Channel Improvements | 5,175.5 |
| 25 | San Fernando | Channel Improvements | 26,932.8 |

An environmental impact assessment was performed by an independent specialist to determine potential effects on downstream estuarine systems, given the improvements noted above. The conclusion reached is that there are not expected to be any significant impacts.

Financial plans to fund the floodway drainage improvements in Kleberg County must project a necessary tax rate to support $40 million worth of bonds issued over a ten-year period. Proper application can slow the level of tax needed for debt service. By issuing short (ten year) maturities, low interest rate (7.5%) costs can reasonably be projected. Kleberg County could issue serial issues for a maximum projected tax rate of 7 cents per $100 valuation. The County has a 30 cent taxing authority for flood control projects.

The legal orders required to implement the drainage requirements are already in place through the County's subdivision regulations. A modification to the existing subdivision order is proposed in the Masterplan. Separate deliverables that are part of the Masterplan Report are: Drainage Criteria and Design Manual, maps and profiles.

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# SECTION 1 - INTRODUCTION

Kleberg County is susceptible to three primary sources of flooding. One source is from the defined drainageways and creeks, wherein flooding occurs due to inadequate channel capacity, restrictions within the channels, and the construction of man-made barriers with inadequate capacity to pass the stormwater flows, such as roads and railroad embankments. During times of flooding, these man-made barriers act as small dams that retard the flow. The second major source of flooding is from poor drainage due to the flat topography within the County. During storm events, water tends to pond and then drain off or evaporate very slowly. Therefore, a large area can have water slowly moving across it in a sheet flow pattern rather than in defined drainageways. This problem is aggravated by the fact that the soils have a very low permeability rate and little water percolates into the ground. The third cause of flooding is from tidal sources, but the evaluation of flooding in tidal areas is beyond the scope of this study.

It is recognized that due to the topography of the land and the expense of providing adequate drainage, not all areas of Kleberg County are suitable for development. One purpose of this study is to identify these areas and limit development in them, in recognition that the least expensive solution is to prevent drainage problems in the first place and this is best done by not allowing development in floodplain or flood prone areas. These areas can then be maintained in their present land use and provide a beneficial service to the County by providing natural storage and areas for passage of flood waters. Some existing developed areas are located where frequent flooding occurs. If possible, alternatives were evaluated to provide relief to these areas. In some cases, improvements to maintenance of existing drainage ditches have been recommended.

Kleberg County is impacted by eleven major drainageways, or creeks:

San Fernando Creek

Carreta Creek

Tranquitas Creek

Santa Gertrudis Creek

Escondido Creek

Jaboncillos Creek

Ebanito Creek

Radicha Creek

Arania Creek

Salado Creek

Los Olmos Creek

These streams and creeks are analyzed in this study to determine the causes of flooding and to find alternatives that will alleviate or minimize this flooding in developed or developing areas.

Ponding, or sheet flow, is analyzed here as a separate problem. If the ponding is due to man-made barriers, relief through construction of drainageways or culverts can be examined and existing channels and structures enlarged. If the problem is caused solely by flat topography, solutions such as specifying that floor slabs and roads be constructed above the anticipated flood levels can be looked at. Other solutions include storage or detention ponds in the upper part of the basins, and flood plain zoning.

In addition to the engineering aspects of the proposed improvements, the effects of the improvements on freshwater inflows to the affected bays and estuaries are important considerations. These factors include the change of timing of the inflows, variations expected in salinity and changes in sedimentation, pesticide, and nutrient loading and their effects on the sensitive habitat in the bays and estuaries.

Other non-engineering aspects are the consideration of local orders governing the drainage jurisdictions and platting requirements for developing areas. This report will draft a modification to the existing order to be considered by the Commissioners Court, and also provide and recommend financing options available to the County.

The present report provides for all phases in the development of a stormwater master plan for Kleberg County. The following section will discuss the general purposes and goals for stormwater master plans, including FEMA flood control guidelines. Section 3 will describe the study area, along with the principal flooding and drainage problems of the area. The methodology used for basin analyses and hydrology studies as applied to Kleberg County is defined in Section 4. After this preliminary information is presented, the specific master plan recommendations for Kleberg County and its associated cost estimates are given in Sections 5 and 6, respectively. These recommendations, applicable to the unincorporated areas of Kleberg County, will cover:

- Development plans for the eleven basins
- Causes of specific area flooding
- Drainage system needs for improved flood control
- Master drainage plan, along with prepared maps and profiles showing the plan
- Maintenance program requirements for the plan

The environmental impact and its effects on bays and estuaries are described in Section 7. The priority system for the proposed improvements is outlined in Section 8, and a draft of modified drainage orders for consideration by the County is given in the final section.

## SECTION 2 - PURPOSE OF THE MASTER PLAN

Development of a stormwater master plan for the County should adhere to the following criteria:

1. Technically sound. Use proven hydrologic and hydraulic procedures that are consistent with the County's objectives.

2. Community input. Input from local communities should be obtained at all levels of master plan development. A series of preliminary and follow-up meetings can identify problem areas and discuss alternatives. This allows community officials and the public to participate in development of the master plan.

3. Compatible. The masterplan must be compatible and coordinated with planned drainage improvements of the communities, developers and other governmental agencies or private groups planning drainage improvements.

4. Comprehensive. The master plan must integrate the solution of drainage problems with other development issues, including water quality, land use, salt water intrusion into the groundwater, tidal surges, and maintenance of environmentally sensitive areas.

5. Flexible. Kleberg County is experiencing pressure for development. The master plan must be flexible enough to assure adequate drainage for planned land development, yet be capable of modification if development does not occur as planned.

6. Implementable. Consideration must be given to the ease of implementing the master plan, including acquisition of right-of-way, designation of effective floodways, ease of maintenance, permitting, and the use of conventional construction techniques.

7. Cost effective. The final master plan must be an economical solution to the drainage problems and still meet the above requirements. In some instances, the least costly alternative can not be chosen because of problems with the other criteria.

Conventional stormwater drainage master plans usually provide both a solution to existing flood problems and adequate drainage for anticipated future development in a watershed. The evolution and selection of drainage improvements are partially based on future development plans, as envisioned at the present time. Any changes in the future development plans of a drainage basin or revision of the recommended master plan in the basin can render the traditional stormwater drainage master plan inadequate or obsolete..

A dynamic stormwater management program can be significantly impacted by the utilization of computer programs that analyze large amounts of data in a uniform manner and optimize solutions readily. Currently, hydrology is developed using computer programs such as the Corps of Engineers HEC-1 or the Soil Conservation Services TR-20, or through regionalized or standard procedures. The hydraulic analysis is done with programs such as the Corps of Engineers HEC-2 or the Soil Conservation Services WSP-2. Computers have become a key element in the development of dynamic stormwater management programs.

Standard hydrologic procedures were utilized to determine peak flow values for this study. Hydraulic models of the streams were developed. The strength of a dynamic master plan lies in its flexibility after the first master plan is submitted. The County is provided with the computer models used and copies of all input files. As development patterns change, the master plan can be updated and checked to see if the master plan alternatives or other proposed improvements are adequate. If the alternatives prove inadequate or other changes are proposed, they can be quickly evaluated and incorporated into the revised master plan. In this way, the County always has a current master plan that can be an effective tool for use in urban planning. The advantages of dynamic stormwater master plans include:

1. The ability to quickly evaluate proposed changes to the master plan at a specific location.
2. The ability to quickly evaluate downstream responses to changes in the master plan.

## Initial and Major Drainage Systems

All local and regional planning must take into consideration both the initial and the major stormwater drainage systems. The initial drainage system will transport the runoff from various frequency design storms. The design frequency will vary according to type and use of facility. This system is necessary to reduce street maintenance costs, provide protection against regularly recurring damage from stormwater runoff, and provide convenience to the residents. Storm sewer systems consisting of swales, ditches, and underground pipes are a part of the initial storm drainage system, and offer protection, for purposes of this report, from storms with a frequency of occurrence of once in twenty-five years. The initial system must assure a minimum of future drainage problems within the ability of the community to afford drainage facilities.

The major drainage system necessary to transport flow from extreme events, which is normally established as the runoff that can be expected to have a 1% chance of occurrence in any single year, or expected to be equalled or exceeded on the average of once every 100 years. The major drainage system may not carry this load, but must be designed to prevent loss of life and major damage to property and public facilities.

Every developed area needs these two distinct drainage systems, and both systems should be planned and properly engineered to insure adequate drainage. Development proposals should receive full site planning and engineering analyses, and should protect downstream property as well as the property being developed. In this regard, uniform professional consideration must be applied to each site, which are defined by the area's drainage criteria manual.

Drainage Criteria Manual

In "Drainage Criteria and Design Manual, Kleberg County, Texas," (Ref. 43), a separate document, a storm drainage design is presented in order to achieve a uniform method of assuring adequate storm drainage as the County develops. The manual lists the reference information used and gives design factors and graphs for use as engineering guides in the planning and design of drainage facilities for the initial and major storm systems.

The manual can not be expected to cover extraordinary situations but should be adequate for most applications. It is not intended as a replacement for sound engineering judgment, but as a guide to providing adequate drainage. It is kept in loose-leaf form and should be reviewed and modified periodically in order to achieve a reliable and consistent design method for the analysis of storm drainage practices.

FEMA Flood Plain Management Program

The Federal Emergency Management Agency (FEMA) encourages state and local governments to adopt sound floodplain management programs, and this is partly accomplished through the National Flood Insurance Program. Each Flood Insurance Study includes a flood boundary and floodway map (FBFM) designed to assist communities in developing sound floodplain management measures. Such a map was prepared for Kleberg County and is unaffected by the present study results. The salient features of the maps are:

- Flood boundaries. In order to provide a national standard, the 100-year flood has been adopted by FEMA as the base flood for purposes of floodplain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100- and the 500-year floods have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:24,000 with a contour interval of 5 feet. In cases where the 100-year and the 500-year boundaries are close together, only the 100-year boundary is shown. For inland flooding, FEMA uses three flood zone designations: A or A numbered zones indicate areas inundated by the 100-year flood, B zones are areas between the 100-year and 500-year flood boundaries, and C zones are areas outside the 500-year flood boundary. Other map details involve coastline determinations and other boundaries designating special flood layouts or areas not subject to flooding.

- Floodways. Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity and increases the flood heights of streams and the flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment in order that the 100-year flood may be carried without substantial increases in flood heights. Minimum standards of FEMA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. These floodways are presented to local agencies as minimum standards that can be adopted or used as a basis for additional studies. Floodways are not delineated in coastal high hazard areas.

- Base Flood Elevations. Base flood elevations have been established in areas of special hazards (A and V zones) by detailed engineering methods. In coastal areas affected by wave action, base flood elevations are generally maximum at the normal open shoreline. These elevations generally decrease in a landward direction at a rate dependent on the presence of obstructions capable of dissipating the wave energy. Where possible, changes in base flood elevations have been shown in 1-foot increments on the Flood Insurance Rate Maps. Base flood elevations shown in the wave action areas represent the average elevation within the zone. Current program regulations generally require that all new construction be elevated such that the first floor, including basement, is above the base flood elevation in A and V Zones.

- Velocity Zones. The U.S. Army Corps of Engineers has established the 3-foot wave as the criterion for identifying coastal high hazard zones, and this has been adopted by FEMA for the determination of V Zones. Because of the additional hazards associated with high-energy waves, the National Flood Insurance Program requires much more stringent floodplain management measures in these areas, such as elevating structures on piles or piers.

## SECTION 3 - DESCRIPTION OF THE AREA

### Field Reconnaissance and Surveying

The study area consisted of the unincorporated areas of Kleberg County, excluding areas subject to flooding from tidal sources. During the initial coordination meetings it was decided to limit the study area to west of Baffin Bay and areas outside the anticipated growth corridor of U. S. Highway 77. The remaining portion of the county is owned by the King Ranch, and they indicated they had no plans for development of this land at this time. A field reconnaissance survey was conducted within the study area in order to determine the condition of the channels and structures on the streams, identify roughness factors (Manning's "n" values) for the channels and overbanks, identify channel constrictions and constraints, and determine basin boundaries. A photo log of a majority of the structures in the study area was compiled to assist in the development of the hydraulic models for the study. FEMA survey data, when available, were used in the study.

In areas where FEMA survey data were not available, cross sections were determined from USGS quad maps. In addition, survey data on the location and elevation (both top of road and channel invert) were obtained for structures included in the hydraulic models. As part of this process, a tabulation of benchmarks found and set was made. This tabulation of benchmarks is included as Appendix A and the locations are shown on the Stormwater Master Plan Maps.

Description

Kleberg County is located along the Texas Gulf Coast. The county is bordered by Nueces County to the north, Jim Wells County to the west, and Kenedy County to the south. Kleberg County extends about 20 miles from north to south and about 48 miles from the western boundary to the eastern shore of Padre Island, and encompasses approximately 544,600 acres (581 sq. mi.) Kingsville is the county seat and the largest town in the county.

Kleberg County is one of several counties that form an almost uniform curve on the western coast of the Gulf of Mexico. This curve is known locally as the Coastal Bend of Texas. Kleberg County is located right below the center of this curve. Its mainland consists of flat to undulating or gently rolling terrain, with elevations ranging from sea level along the coast and Baffin Bay to elevation 165 feet mean sea level (MSL) in the northwest portion of the county. The county can generally be divided into two distinct soil types. West of San Fernando Creek and the Cayo del Grullo the soil is predominantly a sandy loam. The soil is generally poorly to moderately well drained. East of San Fernando Creek and the Cayo del Grullo the soil is predominantly clays and clayey loams. These soils are generally in a poorly drained condition.

The climate of the county is semi-arid, which results in long summers and mild winters. Rainfall averages about 26.5 inches per year and the average maximum July temperature is 96 degrees F, and the average minimum January temperature is 48 degrees F.

Severe tropical storms occur about once in every 10 years, and less severe storms occur about once in 5 years. When storms strike the coast 100 miles to the east or south, Kleberg County receives beneficial rains and there is little wind. Hurricanes strike chiefly in August and

September, though tropical storms have occurred as early as June and as late as October. Several tropical storms and hurricanes have been encountered in and near Kleberg County (see Refs. 28-31).

## Development Standards

Several unplatted subdivisions have been developed in Kleberg County. These developments were built prior to platting and subdivision controls being implemented within the County. They would not meet minimal standards if they were to be submitted for platting now. At the time these subdivisions were started, the County was powerless to force developers to comply with the County's platting requirements since the County had no enforcement authority. Through its subdivision requirements, the County now has the authority to require adequate drainage be provided. For further details on the County's subdivision requirements, see Section 9.

## Existing Flood Protection Measures

Some channels have been constructed or improved throughout the county in an attempt to alleviate flooding problems and to drain low-lying areas in a reasonable amount of time. These ditches and channel improvements are primarily for agricultural drainage and flow improvements through the City of Kingsville. Kingsville has plans to do additional drainage work within its corporate boundaries in the near future.

Existing hurricane flood protection is limited to evacuation plans in the City of Kingsville and the unincorporated communities within the county.

# SECTION 4 - BASIN ANALYSIS METHODOLOGIES

In analyzing solutions to the flooding and drainage problems, principles of hydrology, hydraulics, and economics are employed. This section discusses the methodologies applicable for a basin analysis of Kleberg County and neighboring Nueces County. These methods are then used in Section 5 for providing the master plan recommendations for Kleberg County.

## HYDROLOGY

A significant component of the drainage studies performed for Kleberg and Nueces Counties involves the determination of instantaneous peak discharge values for key points located along each of the 15 defined drainage-ways (excluding the Nueces River) considered. Peak discharge values at each key point are determined for return periods ranging from 2 to 100 years. For example, the estimated 50-year peak discharge is likely to be equalled or exceeded only once in a typical fifty-year period, that is, a 2 percent chance of occurrence in any given year. Peak discharge values are used in the computation of water surface profiles which, in turn, delineate the floodplain or inundated region surrounding the primary drainage-way during a flood event.

Peak discharge at any given point in a watershed may be a function of precipitation magnitude and intensity, drainage area, topography, general soil type, antecedent soil-moisture conditions, channel conveyance, and numerous other factors. Due to the diversity of factors whose interrelationships determine the maximum runoff for a particular storm event, a number of methods have been developed to estimate instantaneous peak discharge. One method for estimating peak discharge for storm events associated with various return periods is based on frequency analysis of measured historical peak streamflows in the watershed of interest. Unfortunately, none of the streams passing through Kleberg and Nueces Counties have records of sufficient length to facilitate this procedure. Therefore, alternative hydrologic methods were required for the selected watersheds of this study.

Several Flood Insurance Studies (Refs. 5, 6, 7, 8, and 9) of the Kleberg and Nueces County area sponsored by the Federal Emergency Management Agency have utilized hydrologic methods developed by the U.S. Geological Survey (USGS Method, Ref. 16) and the Agricultural Research Service (Cypress Creek Method, Ref. 20) in the determination of 10-, 50-, 100-, and 500-year flood flows. The District 16 office of the Texas Highway Department, located in Corpus Christi, generally uses the USGS Method for rural watersheds and the Rational Method for smaller urban watersheds in the hydrologic design of bridges and highway drainage. The Texas Department of Water Resources (now the Texas Water Development Board), on the other hand, applied hydrologic methods developed by the Soil Conservation Service (SCS Method, Ref. 17) in the performance of their bay and estuary studies, which included the Laguna Madre estuary (Ref. 22) and the Nueces and Mission-Aransas estuaries (Ref. 23). Of the four hydrologic methods named above, three methods for the estimation of peak discharge were considered applicable to the current study: the SCS, USGS, and Cypress Creek Methods.

Methods for Peak Discharge Estimation

1. Soil Conservation Service Method

The first peak flow estimation method considered was the Soil Conservation Service (SCS) Method, which is described at length in the SCS National Engineering Handbook, Section 4, "Hydrology" (Ref. 17). To summarize briefly, peak discharge for typical applications is estimated by the SCS method based on the following equation:

$$q_p = \frac{484\ AQ}{T_p} \qquad (1)$$

where: $q_p$ = Peak discharge in cubic feet per second (cfs)

$A$ = Watershed area, sq. mi.

$Q$ = Depth of effective precipitation, in.

$T_p$ = Time to peak discharge, hr.

The depth of effective precipitation or direct runoff, Q, is a function of total depth of precipitation, watershed curve number, and the initial rainfall abstraction. The initial abstraction is the sum of rainfall before runoff begins and is comprised of interception by trees and vegetation, evaporation, and soil water storage. It is normally assumed to be two-tenths of the potential maximum retention, S, which is a function of the curve number, CN.

$$S = \frac{1000}{CN} - 10 \qquad (2)$$

The potential maximum retention, S, is the maximum amount of rainfall that can be retained and/or infiltrated into the soil. The watershed curve number, CN, is an indicator of runoff potential and is based on hydrologic soil groups and land use classes defined by the SCS. The watershed curve number varies with the soil type, land use, the hydrologic condition of the cover, and the antecedent moisture conditions. Soils with a low curve number will have less total runoff from the same storm event as soils with a higher curve number. Note that the initial abstraction as well as the potential maximum retention is a particularly difficult quantity to estimate without intensive field studies. Time to peak discharge, $T_p$, is generally approximated by the sum of six-tenths of the time of concentration plus one-half of the duration of precipitation excess, with the time of concentration being the time it takes a particle of water from the most hydrologically distant point in the watershed to reach the point where the peak flow rate is being estimated.

One problem expected to arise in the use of the SCS Method for the estimation of peak discharge involves the value of the constant, 484, in equation (1), which is based on a time of recession to time to peak ratio of 1.67 to 1.00 using a triangular hydrograph approximation. The SCS Handbook (p. 16.7) states: "This constant has been known to vary from about 600 in steep terrain to 300 in very flat swampy country." As the terrain in Kleberg, Nueces, and surrounding counties is generally very flat, it is probable that a constant value less than 484 will prove appropriate.

2. U.S. Geological Survey Method

The second method considered for applicability to the Kleberg and Nueces County area was developed by the U.S. Geological Survey (USGS) in: "Technique for Estimating the Magnitude and Frequency of Floods in Texas" (Ref. 16). This study incorporated annual peak discharge data from 289 sites throughout the state using procedures outlined by the Hydrology Committee of the U.S. Water Resources Council in 1976. Multiple regression techniques were used to develop equations for predicting the peak discharge for various return periods. Independent variables considered in the multiple regression analyses included drainage area, slope, channel length, elevation, mean annual precipitation, evaporation, and the 24-hour rainfall intensity with a 2-year recurrence interval. The state was subsequently divided into six regions on the basis of the distribution of the residuals from a single statewide regression of the 10-year flood.

The present study covers a region of the state in which flood-frequency relationships were considered by the USGS to be undefined. Nueces County, however, is immediately adjacent to Flood-Frequency Region 1 as delineated by the USGS in the referenced report. In Region 1, the only independent variables found to be significant at the 95 percent confidence level were slope and drainage area. Equations and nomographs are provided from which the 2-, 5-, 10-, 25-, 50-, and 100-year peak discharge values can be determined given watershed slope and drainage area.

3. Cypress Creek Method

The Cypress Creek Method as applied by Stephens and Mills (Ref. 20) of the Agricultural Research Service (ARS) is the third alternative method of peak discharge estimation to be considered for the South Texas study area. Stephens and Mills applied the method to three rural watersheds in the Southern Florida Flatwoods major land resource area. The experimental watersheds range in size from 15.6 to 98.6 square miles and typically have sandy soils and slopes in the 0 to 2 percent class. According to the referenced report (p. 3), the three watersheds are "judged to be representative in many ways of the Gulf Coast and Atlantic Coast Flatwoods, and of level, sandy parts of the Southern Coastal Plain." Given the similarities in watershed size, topography, coastal proximity and meteorological influence, and soil type between the experimental watersheds and those in Kleberg and Nueces Counties, applicability of the Cypress Creek Method was considered for the present study.

The general governing equation defining the peak 24-hour average runoff rate in the Cypress Creek Method is as follows:

$$Q_a = CM^x \tag{3}$$

where: $Q_a$ = Peak 24-hour average runoff rate, cfs

$C$ = Coefficient related to rainfall excess

$M$ = Drainage area, sq. mi.

$x$ = Exponent defining the impact of drainage area on discharge

Once the peak 24-hour average runoff rate, $Q_a$, is determined, it is multiplied by a ratio that varies with drainage area to compute instantaneous peak discharge. Analysis of the data for this study showed a defined relationship between the average runoff rate of a watershed and the true instantaneous peak flow generated, based on the drainage area of the basin. Based on a graphical analysis of annual maximum 24-hour average runoff plotted versus watershed area for a total of 20 events affecting the three experimental watersheds, Stephens and Mills found the best estimate of the exponent, x, to be 0.83. The coefficient, C, is assumed to be linearly related to rainfall excess, $R_e$, by the equation:

$$C = 16.39 + 14.75R_e \tag{4}$$

This equation was derived by least squares regression based on 20 runoff events, and the coefficient of determination, $r^2$, associated with the equation was found to be 0.823. Once the peak 24-hour average runoff rate has been determined by equations (3) and (4), it must be multiplied by a ratio that varies with drainage area to obtain instantaneous peak discharge.

## Application of Peak Discharge Estimation Methods

Each of the three methods for estimating peak discharge discussed in the preceding sections was applied to the Oso Creek and Los Olmos Creek watersheds in Kleberg and Nueces Counties, respectively. These were the only two watersheds in the area for which an adequately lengthy sequence of unregulated historical gaged streamflow and annual peak discharge measurements could be obtained from the U.S. Geological Survey (USGS) to confirm the applicability of a particular method. In addition, these two watersheds more or less typify the geographic and soil type extremes to be found in the study area. The Oso Creek watershed is located in northern Nueces County and has soil-cover complexes that are predominantly clay with low infiltration rates (Ref. 18). Los Olmos Creek, on the other hand, forms a portion of the southern boundary of Kleberg County, and the soil-cover complexes found within its watershed are predominantly sands with somewhat higher infiltration rates (Ref. 19).

In order to apply the SCS Method, hourly flow rates from three independent historical storm events for Oso Creek at Corpus Christi (USGS Gage #08211520) and two independent historical storm events for Los Olmos Creek near Falfurrias (USGS Gage #08212400) were computed from stage records using rating curves provided by the USGS. Drainage areas above the gages are 90.3 and 480 square miles for Oso Creek and Los Olmos Creek, respectively. Precipitation measurements at the following locations were obtained for the selected storm events from National Weather Service records.

Oso Creek Watershed:

Hourly Rainfall Station: Corpus Christi Airport

Daily Rainfall Stations: Robstown, Chapman Ranch

Los Olmos Creek Watershed:

Hourly Rainfall Stations: Corpus Christi Airport, Hindes, Sarita 7E, Cotulla, Zapata

Daily Rainfall Stations: Benavides, Hebbronville, Falfurrias, Freer 18WNW

Analysis of precipitation data and runoff hydrographs yielded estimates of effective rainfall depth, Q, and total precipitation depth, P, for each storm event which, in turn, were used to estimate the appropriate SCS curve number for each of the two watersheds. The resulting curve numbers adjusted to antecedent soil moisture condition II, which is considered the average moisture condition of the soil, as defined by the SCS are presented in Table 4-1.

The data presented in Table 4-1 are by no means comprehensive; however, they do indicate that the rainfall-runoff characteristics of the two watersheds are quite different. This is apparent in the disparity of the average estimated curve number for each of the watersheds: approximately 74 for Oso Creek and 43 for Los Olmos Creek. A much smaller portion of the total storm rainfall contributes to basin runoff or becomes effective rainfall in the Los Olmos Creek watershed where sandy soils are more dominant than in the Oso Creek watershed where the soils contain more clays. It is also noted that these curve numbers are substantially lower than those determined solely on the basis of the soil type and land use guidelines published by the SCS. The Texas Department of Water Resources (now the Texas Water Development Board), however, has estimated curve numbers of 73 and 35 for the respective portions of the Oso Creek and Los Olmos Creek watersheds above the USGS gage locations (Refs. 22 and 23).

TABLE 4-1

SUMMARY OF SCS CURVE NUMBER ESTIMATION ANALYSES

| Stream | Event | Observed Peak Hourly Discharge (cfs) | Total Precip. (Inches) | Effective Rainfall (Inches) | SCS* Curve Number |
|---|---|---|---|---|---|
| Oso Creek | Apr. 1977 | 2,240 | 3.69 | 1.26 | 86 |
| | Aug. 1980 | 10,630 | 11.77 | 5.20 | 71 |
| | Feb. 1982 | 5,596 | 4.67 | 2.67 | 64 |
| Los Olmos Creek | Aug. 1980 | 1,342 | 7.73 | 0.15 | 45 |
| | May 1982 | 3,019 | 5.09 | 0.36 | 43 |

* Curve numbers are shown for antecedent soil moisture condition II.

Analysis of the observed storm runoff hydrographs using a triangular hydrograph approximation indicated time of recession to time of peak ratios somewhat greater than the 1.67 to 1.00 ratio generally assumed in the SCS Method. Analysis of the three storm hydrographs for Oso Creek yielded an average ratio 1.94 to 1.00, which implies that the constant in the peak discharge equation could equal 440 rather than 484. The corresponding average ratio for Los Olmos Creek was found to be 2.76 to 1.00, yielding a constant of approximately 343. These modified constants were used along with 24-hour precipitation estimates obtained from the "Rainfall Frequency Atlas of the United States, TP-40" (Ref. 14) in the computation of peak discharge for various return period events. Peak discharge estimates for Oso and Los Olmos Creeks for return periods of 2-, 5-, 10-, 25-, 50-, and 100-years computed using the SCS Method are presented in Table 4-2.

Required parameters for the computation of peak discharge estimates for various return periods using the USGS Method Region 1 equations included slope and drainage area. Slope in this method is defined as the average slope of the streambed between points 10 and 85 percent of the distance along the main-stream channel from the site to the basin divide. The resulting peak discharge estimates for Oso and Los Olmos Creeks are presented in Table 4-2.

The Cypress Creek Method was also applied to the Oso and Los Olmos Creek watersheds so that the results might be compared with those obtained by SCS and USGS peak discharge estimation techniques (Table 4-2). Total 24-hour precipitation for return periods ranging from 2 to 100 years was obtained from TP-40, and the effective precipitation, $R_e$, was computed by

TABLE 4-2

PEAK DISCHARGE ESTIMATES
COMPUTED BY ALTERNATIVE METHODS

Uso Creek at Corpus Christi (USGS #08211520):

| Method * | Return Period (Years) 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|
| SCS | 3,440 | 6,350 | 8,150 | 10,500 | 12,600 | 15,050 |
| USGS | 1,900 | 3,700 | 5,200 | 7,200 | 9,000 | 11,000 |
| CC | 2,110 | 3,220 | 3,900 | 4,800 | 5,590 | 6,530 |

Los Olmos Creek Near Falfurrias (USGS #08212400):

| Method * | Return Period (Years) 2 | 5 | 10 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|
| SCS | 1,330 | 5,260 | 8,840 | 13,900 | 18,750 | 26,050 |
| USGS | 6,000 | 15,000 | 23,000 | 36,000 | 48,000 | 62,000 |
| CC | 3,670 | 5,050 | 6,300 | 8,070 | 9,770 | 12,350 |

* SCS = Soil Conservation Service Method (Ref. 17)
USGS = U.S. Geological Survey Method (Ref. 16)
CC = Cypress Creek Method (Ref. 20)

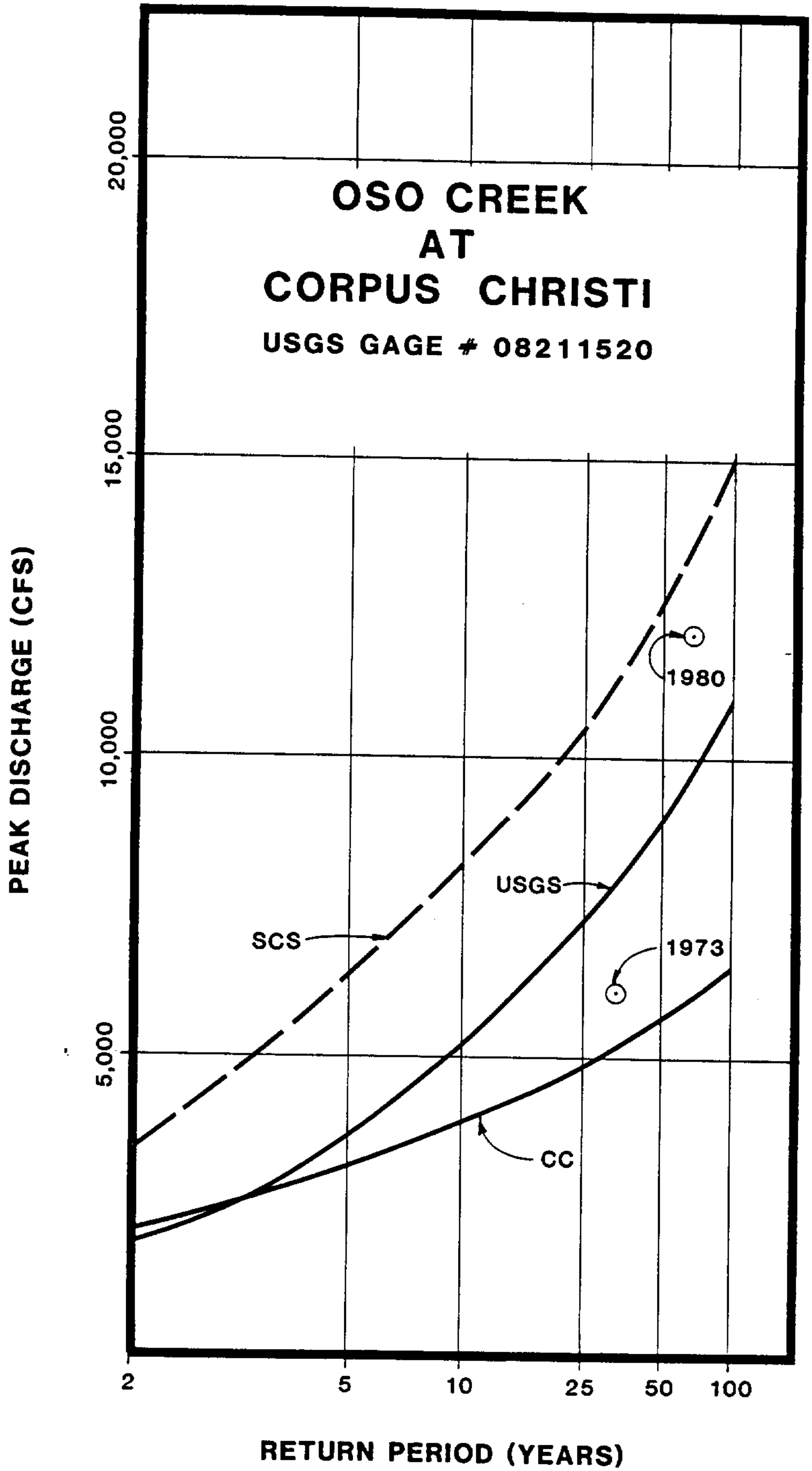
the SCS Method using the previously estimated average curve numbers of 74 and 43 for Oso and Los Olmos Creeks, respectively. The ratio of peak instantaneous discharge to peak 24-hour average discharge was assumed to be 1.145 to 1.00 for Oso Creek and 1.14 to 1.00 for Los Olmos Creek to account for watershed size.

Selection of Peak Discharge Estimation Method

The peak discharge estimates for the Oso and Los Olmos Creek watersheds presented in Table 4-2 are plotted versus return period in Figures 4-1 and 4-2. The individual points shown in Figure 4-1 correspond to observed historical annual maximum discharge values of 12,100 cubic feet per second (cfs) and 6,110 cfs occurring in 1980 and 1973, respectively, at the Oso Creek gage location. Discharge records prior to 1972 are nonexistent; however, USGS publications (Ref. 38) indicate that the instantaneous peak discharge of 6,110 cfs on October 12, 1973 was the maximum attained since 1919. The plotting position of these points with respect to return period or frequency is based on the Weibull plotting position relationship (Ref. 12). It is possible that the 1980 discharge (associated with Hurricane Allen) actually has a return period greater than the indicated plotting position, as the 2-day precipitation total recorded at the Corpus Christi Airport was 13.27 inches. This depth is in excess of the 100-year, 2-day precipitation depth of approximately 12.8 inches based on data from TP-49 (Ref. 42) and TP-40. Given these historical points of reference, it would appear that the USGS Method yields the most reasonable peak discharge estimates for the Oso Creek watershed.

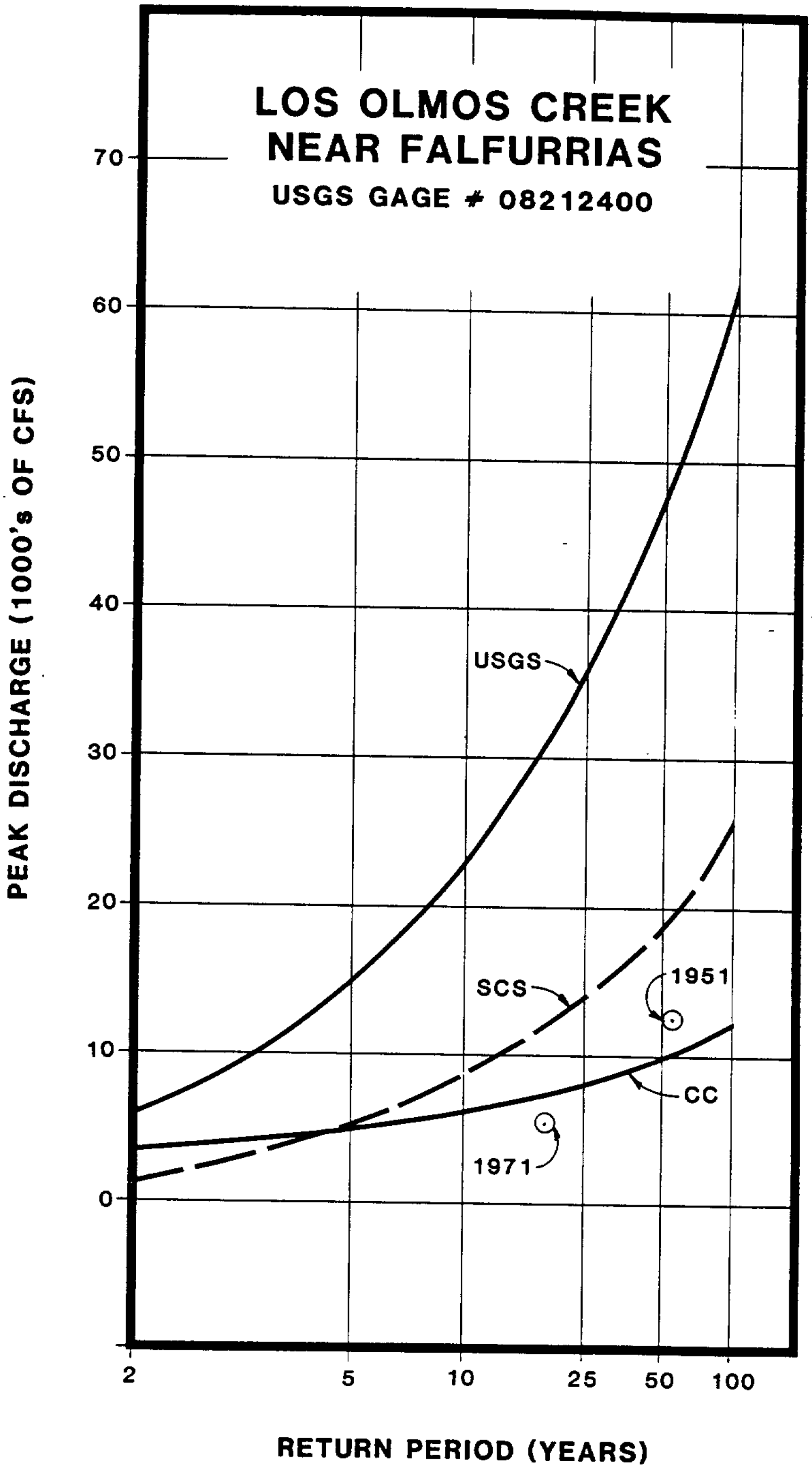
As in Figure 4-1, two observed historical annual maximum discharge values are plotted for reference in Figure 4-2 for the Los Olmos Creek

FIGURE 4-1



OSO CREEK
AT
CORPUS CHRISTI
USGS GAGE # 08211520
PEAK DISCHARGE (CFS)
20,000
15,000
10,000
5,000
SCS
USGS
1980
1973
CC
2
5
10
25
50
100
RETURN PERIOD (YEARS)

FIGURE 4-2



LOS OLMOS CREEK
NEAR FALFURRIAS
USGS GAGE # 08212400
PEAK DISCHARGE (1000's OF CFS)
70
60
50
40
30
20
10
0
USGS
SCS
1951
CC
1971
2
5
10
25
50
100
RETURN PERIOD (YEARS)

watershed. An estimated peak discharge of 12,500 cfs occurred on September 13, 1951 and the stage attained during this event is known to have been the highest since at least 1929. Precipitation on September 13, 1951 was measured at 13.21 inches at Alice, Texas. This depth of precipitation is, in fact, well in excess of the 100-year, 24-hour precipitation depth shown for the watershed in TP-40. The indicated peak discharge of 5,300 cfs that occurred in 1971 during Hurricane Fern is plotted as the maximum measured discharge that has occurred since installation of the USGS streamflow gage in 1966. Figure 4-2 indicates that the Cypress Creek Method yields suitable estimates of peak discharge for various return periods for the Los Olmos Creek watershed.

It is apparent in the two figures that peak discharge estimates for the Oso Creek and Los Olmos Creek watersheds could not be obtained by the same method. The SCS Method appears to generate values that are too high in both watersheds. While the peak discharge estimates based on the USGS study appear adequate for Oso Creek, they are much too high for Los Olmos Creek. The Cypress Creek Method, on the other hand, generates reasonable values for the Los Olmos Creek watershed, but appears to underestimate peak discharge for the Oso Creek watershed. Peak discharge estimates for various return periods were obtained by the USGS Method for streams in Nueces County, since the geologic and soil survey maps (Ref. 18) indicate that the clay soils found in the Oso Creek watershed are typical of both Nueces County and adjacent coastal areas assigned to Region 1 in the USGS study. The Cypress Creek Method was utilized for streams in Kleberg County because the soil map (Ref. 19) shows that the sandy soils found in the Los Olmos Creek watershed are common in the Kleberg County area. Each of the 15 streams selected for analysis in the current study is noted in Table 4-3 along with the adopted method of peak discharge estimation.

TABLE 4-3

RECOMMENDED METHODS OF PEAK DISCHARGE ESTIMATION

| Stream | Method * | County |
|---|---|---|
| Uso Creek | USGS | Nueces |
| Agua Dulce Creek | USGS | Nueces |
| Pintas Creek | USGS | Nueces |
| Petronila Creek | USGS | Nueces |
| Banquete Creek | USGS | Nueces |
| Quinta Creek | USGS | Nueces |
| Carreta Creek | CC | Nueces & Kleberg |
| San Fernando Creek | CC | Nueces & Kleberg |
| Tranquitas Creek | CC | Kleberg |
| Santa Gertrudis Creek | CC | Kleberg |
| Escondido Creek | CC | Kleberg |
| Jaboncillos Creek | CC | Kleberg |
| Ebanito Creek | CC | Kleberg |
| Velederos Creek | CC | Kleberg |
| Arania Creek | CC | Kleberg |
| Salado Creek | CC | Kleberg |
| Los Olmos Creek | CC | Kleberg |

* USGS = U.S. Geological Survey Method (Ref. 16)

CC = Cypress Creek Method (Ref. 20)

HYDRAULICS

HEC-2 Computer Program - Water surface profiles have often been determined using normal depth calculations or standard step backwater methods. The standard step backwater method is a common procedure for use in computer programs such as HEC-2 and WSP2 and should be used in flat terrain. The key input requirement for these computer programs is stream channel cross sections that adequately describe the hydraulic properties of the stream and bridge and culvert geometry. On streams where FEMA survey data were available, these were used as a part of this study. Where FEMA data were not available, cross sections were determined from USGS quad maps, county survey data of structures, and the field reconnaissance survey. Criteria for selection of the location of cross sections include

- Upstream and downstream face of hydraulic structures
- Typical section in channel 50 feet upstream and 50 feet downstream of hydraulic structures
- Centerline of hydraulic structures
- Changes in channel geometry and grade

Cross sections, channel reach, Manning "n" values and peak discharge rates are all coded for use in the backwater model. The use of a computer program to perform the backwater analysis has several advantages:

- Large volumes of field data can be easily handled.
- Multiple water surface profiles for varying frequencies can be computed at the same time.
- Subcritical, supercritical, and critical flow regimes can be calculated.
- Computer plotted cross sections and profiles may be obtained.
- Impacts of channel improvements and bridge replacements are easily assessed.

The Corps of Engineers HEC-2 Water Surface Profiles Model was selected for use in the storm drainage basin study. The program computes and plots (by printer) the water surface profile for either subcritical or supercritical flow conditions. The effects of various hydraulic structures such as bridges, culverts, weirs, embankments, and dams may be considered in the computation. The principal use of the program is for determining profiles for various frequency floods for both natural and modified conditions. The latter may include channel improvements, levees and floodways. Input may be in either English or metric units.

The one-dimensional computational procedures used by HEC-2 are similar to Method 1 in the Corps of Engineers Manual "Backwater Curves in River Channels" (Ref. 25). This method applies Bernoulli's theorem for the total energy at each cross section and Manning's formula for the friction head loss between cross sections. In the program, average friction slope for a reach between two cross sections is determined in terms of the average of the conveyances at the two ends of the reach. Other losses are computed using one of several methods. The critical water surface elevation corresponding to the minimum specific energy is computed using an iterative process.

Calibration of HEC-2 - The output of any computer model is dependent on the quality, application, and proper understanding of the level of input data. At the beginning of the study, a sensitivity analysis on water surface profiles was performed using typical stream channel characteristics which represented flat channel slopes, high Manning "n" values, defined channels with flat overbanks and a range of discharges. For the channel characteristics selected it was concluded that for flat channel slopes, the water surface elevation was most sensitive to a change in n-values and less sensitive to changes in channel geometry and discharge. In addition, it was determined that backwater effects from structures impact water surface elevations for long stretches of channel upstream from the structure. The results of the sensitivity analysis were used as guidelines in establishing existing channel conditions and recommending drainage improvements.

The sensitivity of n-values indicates that maintenance of stream channels is critical to solving local flooding problems. Also, it shows that channel improvements resulting in lower n-values would be a good alternative for increasing conveyance efficiency. The n-values for HEC-2 were established using information published in "Open Channel Hydraulics" (Ref. 2) and verifying these values with conditions observed during the field reconnaissance. Typical values that were used include:

| n | Channel Condition |
|---|---|
| .045 | Improved grass channel |
| .45-.10 | Natural channels |
| .06-.15 | Overbank areas |

The sensitivity of water surface elevations to discharge and channel geometry was low because of the flat overbank areas. As soon as the stormwater runoff exceeds bank capacity, the flow spills out into the flat overbank areas and establishes new flow patterns. In many instances the direction of overland flow is normal to the channel flow and would require more complex modeling procedures. In general, the capacity of overbank floodplain areas to store water is so unlimited that a large increase in discharge results in a small increase in flood elevations. When simulating these conditions in HEC-2, the effective flow area of a floodplain is determined and cross sections are extended at that point. When extended sections exceed one foot, the cross section and/or hydrology is modified. Channel geometry is fixed as per the field survey data. However, sections and overbank slopes are sometimes modified to provide for uniform flow regimes along a particular channel reach. In areas where it was difficult to obtain field survey data, upstream and downstream cross sections were used to interpolate the required section.

The backwater effects of undersized hydraulic structures are critical to the direction that recommended drainage improvements will take. Bridges and culverts are both difficult and costly to replace in most instances. The sensitivity analysis indicated that small backwater effects would be felt farther upstream. Application of the normal bridge routines contained in HEC-2 to structures throughout the County showed that outlet control governed the analysis.

Application of HEC-2 - The water surface profiles represent the bottom line of the hydraulic analysis. The water surface elevations computed by each cross section of the areas studied were drawn on enlargements (from 1" = 2000' to 1" = 900' to match aerial maps) of USGS 7-1/2 minute quad maps. The area between cross sections was interpolated based on the 5-foot contours on the enlarged quad maps to determine floodplain boundaries. In addition, water surface profiles, channel inverts and structures were plotted. From the floodplain mapping and profiles, areas of significant areal flooding, excess backwater at structures, and overtopping of roads were identified. Existing flood profiles were compared with available high water mark data to verify results and floodplain mapping.

Another level of hydraulic analysis was incorporated in the development of the drainage master plan. Alternatives were developed involving structural improvements, channel improvements, flood proofing, flood forecasting and warning, cleaning existing channels, relocation of structures within the floodplains, and floodway delineation. Impacts of these alternatives on the water surface elevation were determined using HEC-2. At each level of analysis, the model was further refined in order to more accurately simulate flow characteristics of the channels.

Shallow Flooding

Identification of areas subject to shallow flooding and ponding problems is a less quantifiable procedure than determining flood boundaries on defined drainageways. Several methods can be used to identify these areas, including review of topographic maps, soil survey maps and aerial photographs after severe rainfall events, and interviews with long-term residents. Topographic maps indicate areas that do not have defined drainageways or have depressions that would collect water. Soil survey maps show areas that have had standing water in them, which are identifiable by their undrained condition and by recent sedimentary type materials. The best ways to identify problem areas are to observe the area during severe rainfall events, which is normally not possible during the course of a study, or talk to people who have knowledge of the area. All these methods were used in identifying these areas within the unincorporated areas of Kleberg and Nueces Counties. By these procedures, areas identified as having shallow flooding or ponding problems were delineated and divided into two groups.

The locations identified on the masterplan maps as Zone 1 are comprised of areas subject to 12 inches or more of ponding or severe sheet flow. Due to the potential hazard, any development in these areas should provide adequate drainage and measures to protect roads and structures from damage. In the Zone 1 areas, an analysis of the flooding problems and corrective measures proposed should accompany drainage plans submitted to the County for approval. These requirements are outlined in the "Drainage Criteria and Design Manual" for the County (Ref. 43).

The locations identified as Zone 2 on the masterplan maps are comprised of areas subject to less than 12 inches of ponding or sheet flow. Development in these areas should account for this type of hazard by elevating roads and structures and by providing adequate drainage so that the flooding situation is not aggravated by development and the development itself is not ruined.

## Flood Control and Drainage Alternatives

Plan Components - Components of the master plan for the basins in the County were selected from a broad series of alternatives available for each basin. These alternatives propose various solutions to solving flood problems, including structural improvements, channelization, storage, floodway zoning and minimum building elevations. These are summarized below:

- Structural Improvements. The master plan is designed to retain the 100-year flood within the channel banks, prevent overtopping of major roads and bridges, and prevent houses from being inundated, where possible. Each of the drainage structures listed in the structure inventory (see Section 5) for each basin was evaluated for capacity, setting and structural condition. Structures in potential developing areas that could not pass the 100-year flood without causing significant backwater or overtopping were recommended for replacement. Emphasis was placed on keeping Farm to Market roads, State highways, and U.S. highways free from overtopping. Also, structures in poor condition, structures that are heavily silted from poor invert setting and structures that create erosion problems from high velocities were recommended for improvements. Structural improvements include replacing or modifying bridges and culverts and replacing low water crossings with bridges or culverts.

- Channelization. Many of the existing developments have encroached into floodplains, creating flooding problems along the stream. In these locations it was necessary to provide additional channel capacity in order to reduce flooding potential. Whenever possible, the natural stream channel courses were retained in the master plan. In addition, some areas are extremely flat and when the floodwaters overflow the streams, they can pass into adjacent drainage basins, aggravating the flood problems in these areas. Channelization alternatives generally consisted of widening existing channels, providing 4:1 sideslopes, and providing a maintenance easement on both sides of the channel.
- Storage. Various forms of storage including retention, detention and natural storage were investigated. The primary purpose of storage is to reduce the peak flow rate by capturing a portion of the flow during high runoff periods and slowly releasing it as floodwaters recede. When it is desirable to preserve the ecology of environmentally sensitive low-lying areas, natural storage areas are designated. These areas do not require any excavation, yet are effective in their natural state for improving stormwater quality, providing aquifer recharge and reducing downstream impacts of flooding.

- Floodplain Zoning. Floodplain and floodway zoning allow non-structural alternatives to solve drainage problems. Zoning regulations usually restrict development in the 100-year floodplain. In areas that are not currently developed, zoning is an effective way to prevent development in the floodplains to avoid future problems.
- Minimum Building Elevations. Some portions of the County have historically had flood problems due to flat topography or inadequate drainage. While these areas are not on defined drainageways, they do pond water. Development can occur in these areas if floor slabs are raised to minimum elevations and drainage in a reasonable time is provided. While yards and open areas may flood, houses and roads should remain above the anticipated flood levels.

Other alternatives that were looked at included floodproofing, flood forecasting and warning, clearing of channels, and a buyout of existing flood-prone buildings. Most of the basin master plans utilize a variety of solutions involving the integration of the structural, non-structural and storage solutions. The process used to select the best solution involves a set of criteria which could compare the various alternatives that were generated.

## Selection Criteria

The alternative solutions for each basin were evaluated and compared during the selection process. A set of criteria was established to evaluate the alternatives and provide guidance in selecting the final master plan. Throughout the course of the study, the priorities of each of the following criteria were established for each basin.

- Economics. Economic considerations include construction, land acquisition, right-of-way acquisition, and operation and maintenance costs. Less costly alternatives, taking into account maintenance costs, were given a higher priority.
- Hydrology. Reliability and performance of a drainage system vary, depending on the frequency of the selected design rainfall event. Typically, sound stormwater management accounts for initial drainage (25-year event) and for major drainage (100-year event). When analyzing alternatives to alleviate flood problems associated with a 25-year discharge, it is important to evaluate the performance of these alternatives subject to the 100-year flow.
- Environmental. Positive and negative impacts on water quality and the ecological balance of nature must be reviewed in master plan development. Typically, structural measures (channelization, structure replacement) may create adverse water quality effects and negative impacts on native wildlife and vegetation, while storage and non-structural measures imply positive water quality effects and preserve the natural environment of the area. Although this may be generally true, each situation was analyzed independently to determine the overall impacts of structural and non-structural measures on water quality and the natural environment of the area.
- Local Input and Coordination. Along with economics and costs, political and social acceptability are probably the most important criteria as to whether the master plan will be implemented. Thus, it is important that the recommended master plan reflect current attitudes. Input from local communities during the development of

the master plan helped insure coordination in development and eventual completion of the master plan. During the initial portions of the study, meetings were held with all communities, major landowners, developers and governmental agencies to solicit input for the study.

- Maintenance. Upkeep of structures, channels, and storage areas can be a jurisdictional headache and very time-consuming. Each alternative was analyzed as to its dependence on proper maintenance. A proper maintenance program for existing channels and structures would solve a great many of the existing flooding problems.

Types of alternatives that best meet all the previously discussed criteria include zoning the floodplain so there will be no development in flood-prone areas, and utilizing these same areas to generate more rapid conveyance of flood waters. Other alternatives that were considered in terms of the criteria include channelization, structure replacement, diversion, and inter-basin transfer.

## ALTERNATIVES CONSIDERED

A full range of alternative flood damage reduction measures has been evaluated, and several alternatives for resolving flooding problems have been identified. Flood damages could be reduced by structural or non-structural measures or by a combination of both. Possible non-structural measures include floodplain regulation, floodproofing, flood forecasting and warning, on-site detention of stormwaters, clearing and snagging the existing stream, and buyout and relocation of all or part of the structures in the existing floodplain. Possible structural measures include storage of all or part of the flood waters in a reservoir or system of reservoirs, enlarging and straightening the channels, enlarging the bridge openings, and constructing of flood protection levees.

Implementation of more stringent floodplain regulations by the County would be effective in controlling development in the area subject to flooding and would, as a consequence, minimize future flood losses. There may be some limited opportunity to floodproof some structures, but, because of the general type of structures in the area, such measures are not suitable. Buyout and permanent evacuation is not an acceptable solution.

During the course of the study it became apparent that the construction of levees and channelization would be very expensive alternatives due primarily to the flat topography, and would require the acquisition of large amounts of land throughout the County. In the existing condition, once the capacity of the channel is exceeded, the flow tends to spread out over large areas. Further increases in the flow do not significantly affect the water surface elevation because of the large flow-carrying capacity of the overbanks. Construction of levees to confine the flow to the channels would increase the water surface elevation within the levees and cause backwater problems great distances upstream. Construction of channel improvements would generally require extremely large channels to pass design storms due to the slow velocities and the large increase in capacity required to accommodate flow that was previously overbank flow. In most cases the channels are relatively shallow with slopes that are too flat to allow them to be deepened. In addition, constructing levees and improving channel capacity have the detrimental effect of deleting natural storage in the overbanks. Storage, in most cases, did not prove to be a viable alternative due to the prohibitive size and lack of adequate topography for structures.

The existing floodplains play a very important role in the passage of floodwaters in the County, both from a storage and flow capacity standpoint. They should be maintained in their present use as much as possible. In light of the cost of providing adequate flood protection in these areas and the availability of land suitable for development, development within the floodplains should be discouraged.

## Existing Flood Control Plans

During the initial coordination meetings with the communities, state and federal agencies, and others, no plans were indicated for major drainage improvements in the near future.

# SECTION 5 - KLEBERG COUNTY MASTER PLAN

The master plan for Kleberg County involves the delineation of floodway zones, channel improvements, and structural modifications and replacements. The plan is directed at each basin's unique problems.

The following pages describe each basin and its specific problem areas, present the method and results of the analysis used, and list the alternative improvements recommended. An area map showing the floodway boundaries for the watershed is given for each basin.

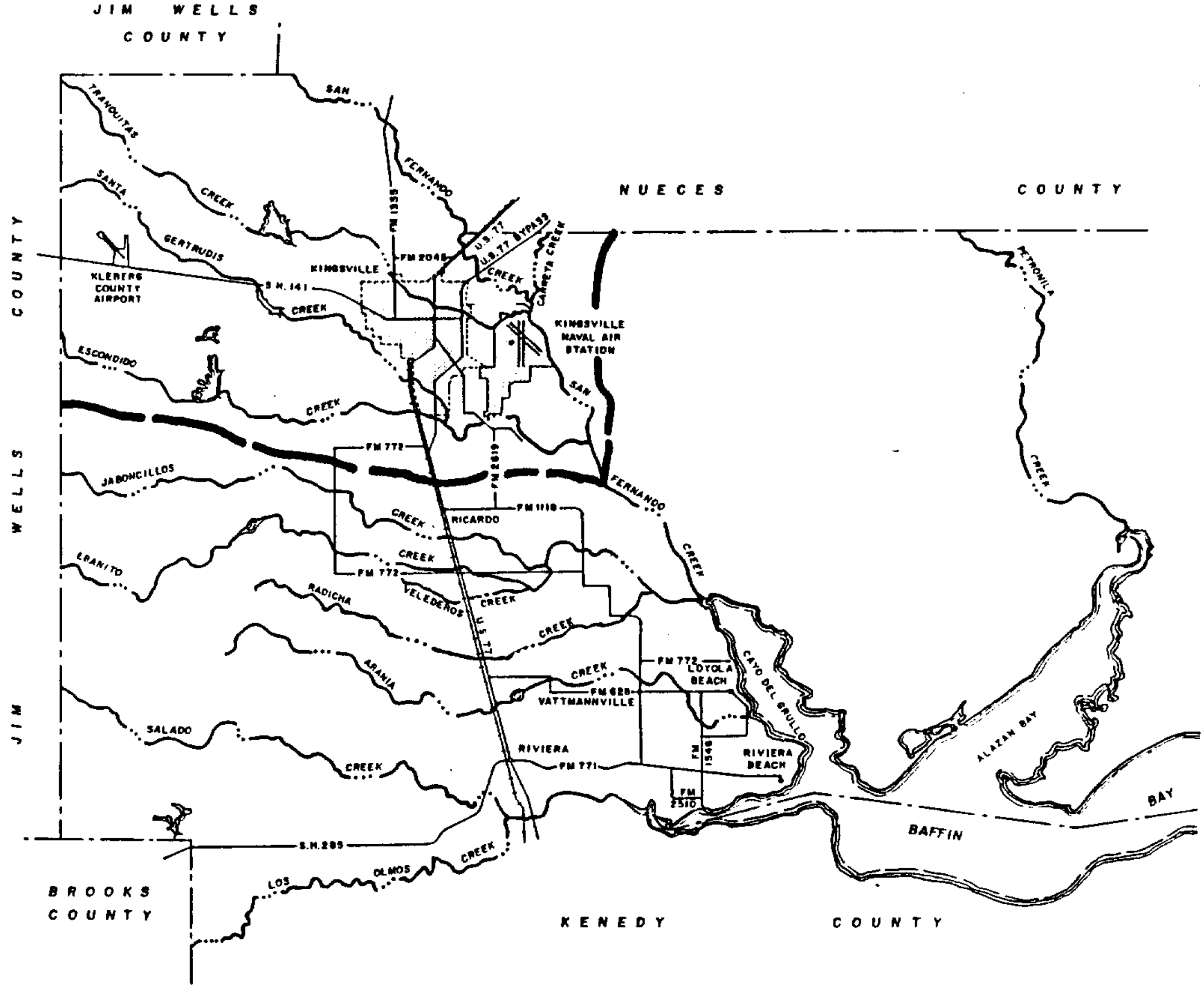
## Basin 1: San Fernando Creek

### Description

The San Fernando Creek watershed covers parts of four counties: Duval, Jim Wells, Nueces, and Kleberg. The Creek has its origin in the northern part of Duval County, passes through Jim Wells County into Nueces County where, for a distance, it forms the border with Kleberg County. It then passes into Kleberg County where it discharges into the Cayo del Grullo, an arm of Baffin Bay. San Fernando Creek has one tributary, Carreta Creek, that is partially in Kleberg County. Although San Fernando Creek drains only a small area in the north-central portion of Kleberg County, it has a total drainage area of approximately 1,260 square miles where it enters the Cayo del Grullo. At the point where it leaves Kleberg County and enters Nueces County, it has a drainage area of approximately 625 square miles. There are no incorporated areas within the watershed in Kleberg County. In Kleberg County, the general slope of the ground is from the northwest to the southeast at a rate of approximately 4.8 feet per mile.

FIGURE 5-1

## SAN FERNANDO – BASIN BOUNDARY




KLEBERG COUNTY
TEXAS

## Basin Analysis

During the initial coordination meetings, it was decided to study the San Fernando Creek through its entire reach through Kleberg County.

Hydrology for the San Fernando Creek watershed was performed using the Cypress Creek Method (Ref. 20). The basin was subdivided, and the required parameters of rainfall, curve number, and drainage area were determined. Table 5-1 shows the hydrologic parameters and peak discharge values used in the analysis.

Water surface profiles were calculated for the San Fernando Creek watershed using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. An inventory of existing structures is shown in Table 5-2. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

## Problem Areas

Direct flooding adjacent to the San Fernando Creek channel is not a severe problem due to the adequate channel capacity in the lower portion of the watershed. The bridge at FM 2045, east of Kingsville, is overtopped during flooding. The bridge has insufficient capacity to pass flood flows.

TABLE 5-1

SAN FERNANDO CREEK - PEAK DISCHARGE

| Location | Drainage Area (mi²) | 10-year Rainfall, in. | 10-year Q, cfs | 25-Year Rainfall, in. | 25-Year Q, cfs | 50-Year Rainfall, in. | 50-Year Q, cfs | 100-Year Rainfall, in. | 100-Year Q, cfs |
|---|---|---|---|---|---|---|---|---|---|
| At Naval Air Station | 687 | 7.00 | 9,130 | 8.25 | 11,590 | 9.35 | 14,015 | 10.75 | 17,390 |
| Above confluence with Tranquitas | 630 | 7.00 | 8,500 | 8.25 | 10,790 | 9.35 | 13,040 | 10.75 | 16,180 |
| At FM 1355 | 609 | 7.00 | 8,260 | 8.25 | 10,480 | 9.35 | 12,680 | 10.75 | 15,730 |

TABLE 5-2

SAN FERNANDO CREEK - STRUCTURE INVENTORY

| Section No. | Road | Structure Type | Structure Size, ft. |
|---|---|---|---|
| 8.01 | FM 2045 | 3-span bridge | 72 x 25 |
| 8.05 | US 77 Bypass (northbound) | 6-span bridge | 240 x 42 |
| 8.05 | US 77 Bypass (southbound) | 6-span bridge | 240 x 40 |
| 8.08 | US Bus. 77 | 6-span bridge | 174 x 58 |
| 8.083 | Mo-Pac RR | 13-span bridge | 208 x 15 |
| 8.15 | FM 1355 | 3-span bridge | 87 x 36 |

## Proposed Basin Improvements and Recommendations

1. Replace and raise the bridge on FM 2045 with a structure that has the hydraulic characteristics of a bridge with a 300-foot opening.

2. Widen the channel from Station 572+53 to Station 1,190+00 to a bottom width of 350 feet. Lower channel invert elevation to that shown on the Master Plan profiles.

3. Replace the bridge at FM 1355 with a structure that has the hydraulic characteristics of a bridge with a 200-foot opening.

4. Careflully control development in areas identified as being within the 100-year flood boundaries of San Fernando Creek.

Tables 5-3 and 5-4 summarize the structural and channelization improvements for San Fernando Creek.

TABLE 5-3

SUMMARY OF STRUCTURAL IMPROVEMENTS FOR SAN FERNANDO CREEK

| Location | Section | Station | Allowable Head Loss (ft) | Design Discharge (cfs) | Example Structure | Misc. |
|---|---|---|---|---|---|---|
| FM 2045 | 8.01 | 100+00 | 0.1 | 17,266 | Bridge with 300' span | Raise road 12.8' |
| FM 1355 | 8.15 | 841+50 | 0.7 | 15,727 | Bridge with 200' span | |

TABLE 5-4

SUMMARY OF CHANNEL IMPROVEMENTS FOR SAN FERNANDO CREEK

| Location | Station | Bottom Width (ft) | Design Discharge (cfs) |
|---|---|---|---|
| US 77 to county line | 572+53 to 1,190+00 | 350 | Varies - 16,082 to 14,311 |

## Basin 2: Carreta Creek

### Description

The Carreta Creek watershed covers a portion of the north-central part of Kleberg County. Carreta Creek has its origin in Nueces County near the Jim Wells County line, and travels in an easterly direction through the southern portion of the City of Bishop. Here it turns almost due south and crosses into Kleberg County where it joins San Fernando Creek. At its confluence with San Fernando Creek, it has a drainage area of approximately 37.4 square miles. At the Kleberg-Nueces county line, Carreta Creek has a drainage area of approximately 23.4 square miles. The general slope of the ground in the watershed is from the northwest to the southeast at a rate of about 6.3 feet per mile.

### Basin Analysis

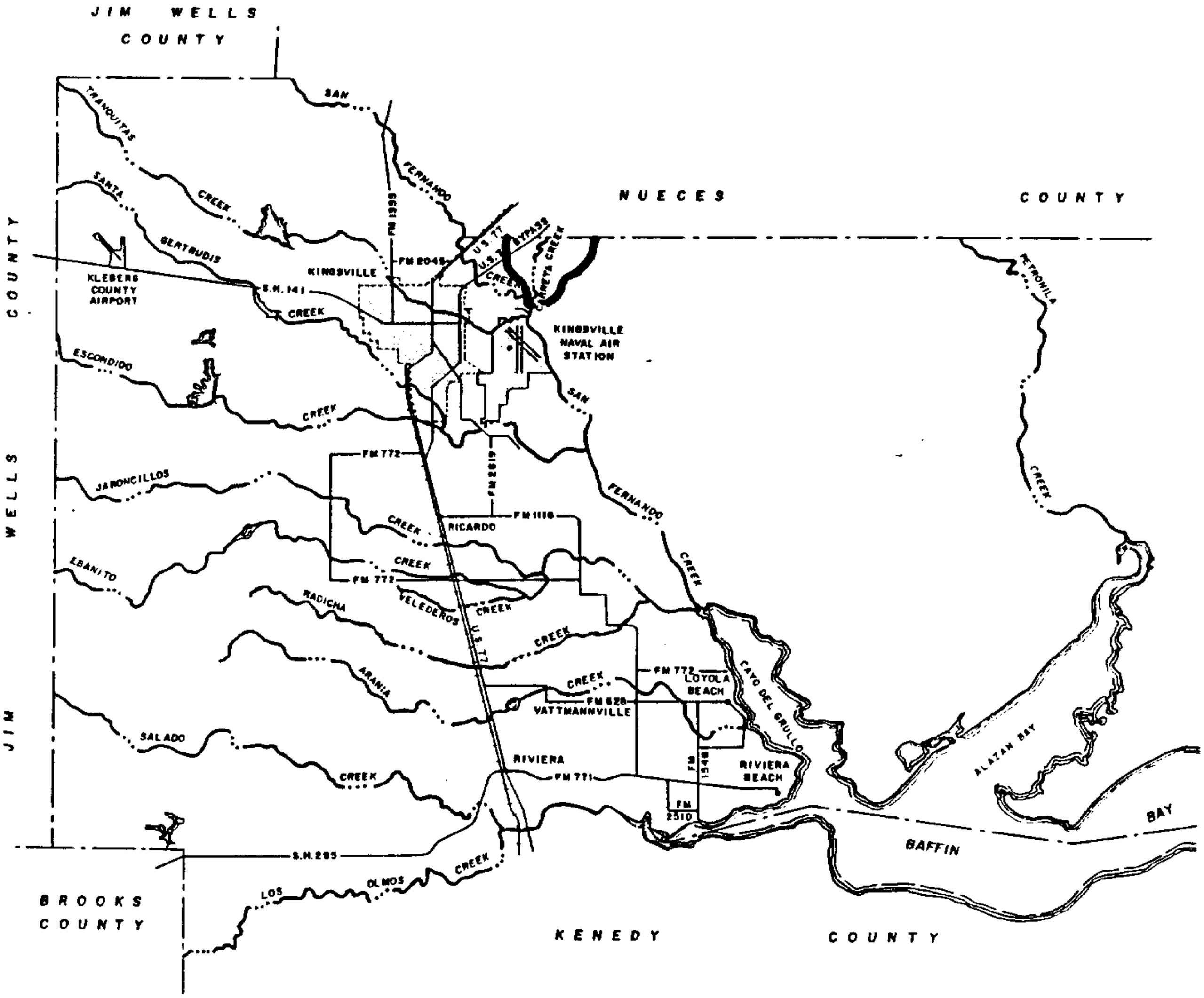
During the initial coordination meetings, it was decided to study Carreta Creek from its confluence with San Fernando Creek to the Kleberg-Nueces county line.

Hydrology for the Carreta Creek watershed was performed using the Cypress Creek Method (Ref. 20). The basin was subdivided, and the required parameters of rainfall, curve number, and drainage area were determined. Table 5-5 shows the hydrologic parameters and the peak discharge values used in the analysis.

Water surface profiles were calculated for Carreta Creek watershed using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. An inventory of existing structures is shown in Table 5-6. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

FIGURE 5-2

# CARRETA CREEK – BASIN BOUNDARY

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## Problem Areas

No specific problem areas were identified in the Carreta Creek watershed. Primary flooding problems are due to the flat topography limiting the rate stormwater can reach the channels of Carreta. Carreta Creek is subject to overflow from San Fernando Creek in Nueces County during periods of high water levels in San Fernando Creek.

## Proposed Basin Improvements and Recommendations

1. No improvements proposed.
2. Carefully control development in areas identified as being within the 100-year flood boundaries of Carreta Creek.

TABLE 5-5

CARRETA CREEK - PEAK DISCHARGE

| Location | Drainage Area ($mi^2$) | Peak Discharge | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 10-Year | | 25-Year | | 50-Year | | 100-Year | |
| | | Rainfall, in. | Q, cfs | Rainfall, in. | Q, cfs | Rainfall, in. | Q, cfs | Rainfall, in. | Q, cfs |
| At confluence with San Fernando | 37.4 | 7.25 | 971 | 8.60 | 1,250 | 9.80 | 1,525 | 11.20 | 1,875 |
| At Kleberg County Line | 23.4 | 7.25 | 702 | 8.60 | 903 | 9.80 | 1,100 | 11.20 | 1,360 |

TABLE 5-6

CARRETA CREEK - STRUCTURE INVENTORY

| Section No. | Road | Structure | |
|---|---|---|---|
| | | Type | Size |
| NO STRUCTURES WITHIN STUDY REACH | | | |

Basin 3: Tranquitas Creek

Description

The Tranquitas Creek watershed covers a portion of Kleberg and Jim Wells Counties. Tranquitas Creek travels in a southeasterly direction from its headwaters in Jim Wells County, south of the City of Alice, to the City of Kingsville. As with most of the watersheds in the western portion of the county, the watershed is long and relatively narrow, with a length of about 25 miles and a maximum width of about 4 miles. At its confluence with San Fernando Creek, it has a drainage area of about 49.1 square miles. The general slope of the ground in the watershed is from the northwest to the southeast at a rate of about 4.0 feet per mile. The creek passes through and drains the northern portion of the City of Kingsville.

Basin Analysis

During the initial coordination meetings, it was decided to study Tranquitas Creek from its confluence with San Fernando Creek to downstream of Tranquitas Lake.

Hydrology for the Tranquitas Creek watershed was performed using the Cypress Creek Method (Ref. 20). The basin was subdivided, and the required parameters of rainfall, curve number, and drainage area were determined. Table 5-7 shows the hydrologic parameters and the peak discharge values used in the analysis.

Water surface profiles were calculated for Tranquitas Creek watershed using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. An inventory of existing structures is shown in Table 5-8. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

FIGURE 5-3

## TRANQUITAS CREEK – BASIN BOUNDARY

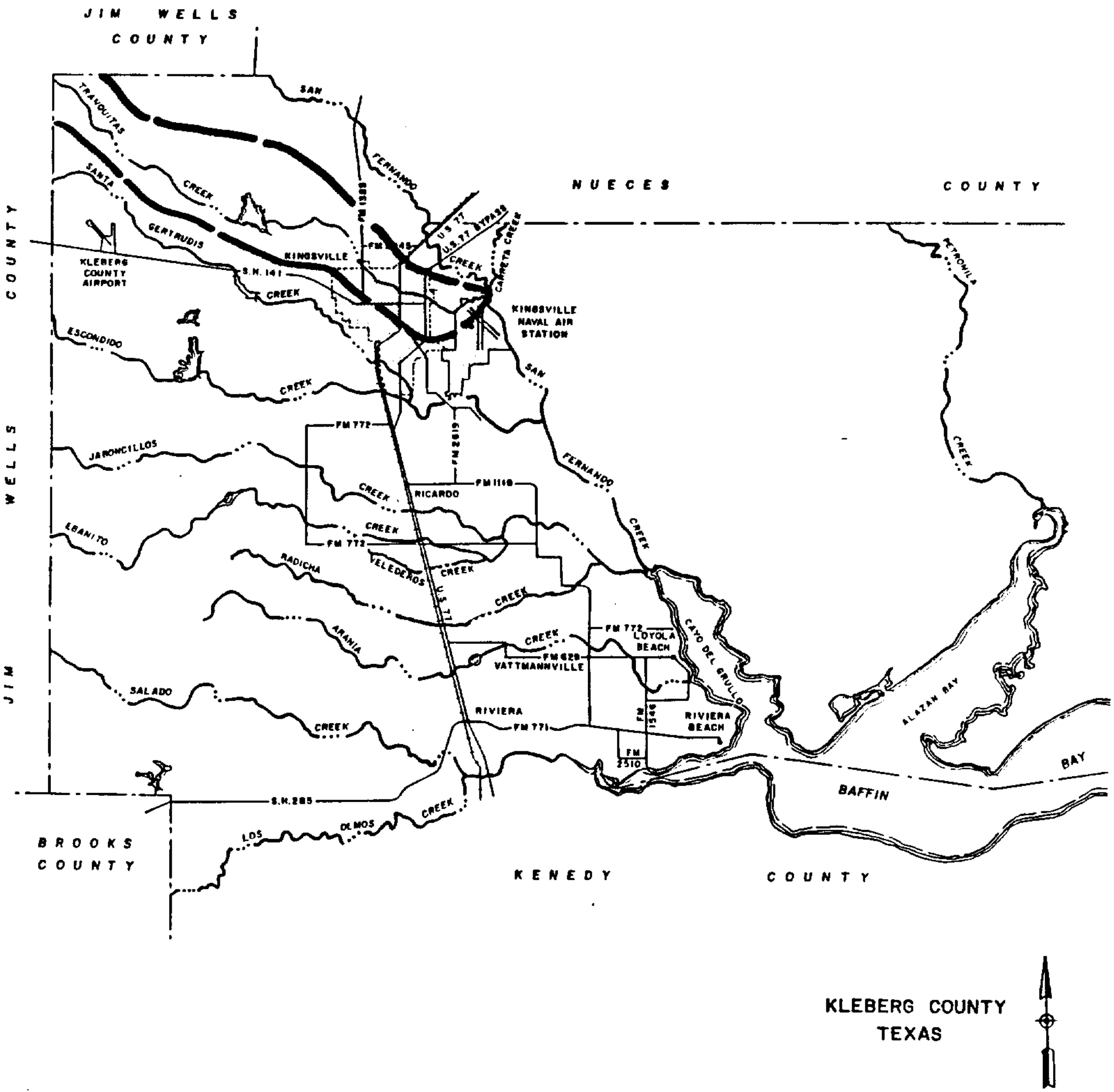


TABLE 5-7

TRANQUITAS CREEK - PEAK DISCHARGE

| Location | Drainage Area (mi²) | Peak Discharge | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 10-year | | 25-Year | | 50-Year | | 100-Year | |
| | | Rainfall, in. | Q, cfs | Rainfall, in. | Q, cfs | Rainfall, in. | Q, cfs | Rainfall, in. | Q, cfs |
| At confluence with San Fernando | 49.1 | 7.20 | 1,150 | 8.50 | 1,470 | 9.70 | 1,795 | 11.10 | 2,210 |
| At FM 1898 | 40.9 | 7.20 | 1,020 | 8.50 | 1,300 | 9.70 | 1,590 | 11.10 | 1,960 |
| At Section 9.14 | 29.5 | 7.20 | 817 | 8.50 | 1,040 | 9.70 | 1,275 | 11.10 | 1,575 |

TABLE 5-8

TRANQUITAS CREEK - STRUCTURE INVENTORY

| Section No. | Road | Structure | |
|---|---|---|---|
| | | Type | Size |
| NO STRUCTURES WITHIN STUDY REACH | | | |

## Problem Areas

Direct flooding adjacent to the Tranquitas Creek channel within the unincorporated areas of the county has not been identified as a problem due to the limited development in the area. Potential for development is limited by the fact that there are no public roads within the watershed.

Though outside the scope of this study, there is the potential of severe flooding within the watershed if a problem should occur with the dam forming Tranquitas Lake. Neither the hydrologic or physical condition of the dam was evaluated as a part of this study.

## Proposed Basin Improvements and Recommendations

1. No improvements proposed.
2. Carefully control development in areas identified as being within the 100-year flood boundaries of Tranquitas Creek.
3. Determine safety of the dam forming Tranquitas Lake and if appropriate develop a flood warning system for the basin in the event of severe rainfall. This could consist of an inspection of the dam during heavy rainfall events and a method of warning downstream residents (possibly through the Sheriff's office) in the event of problems.

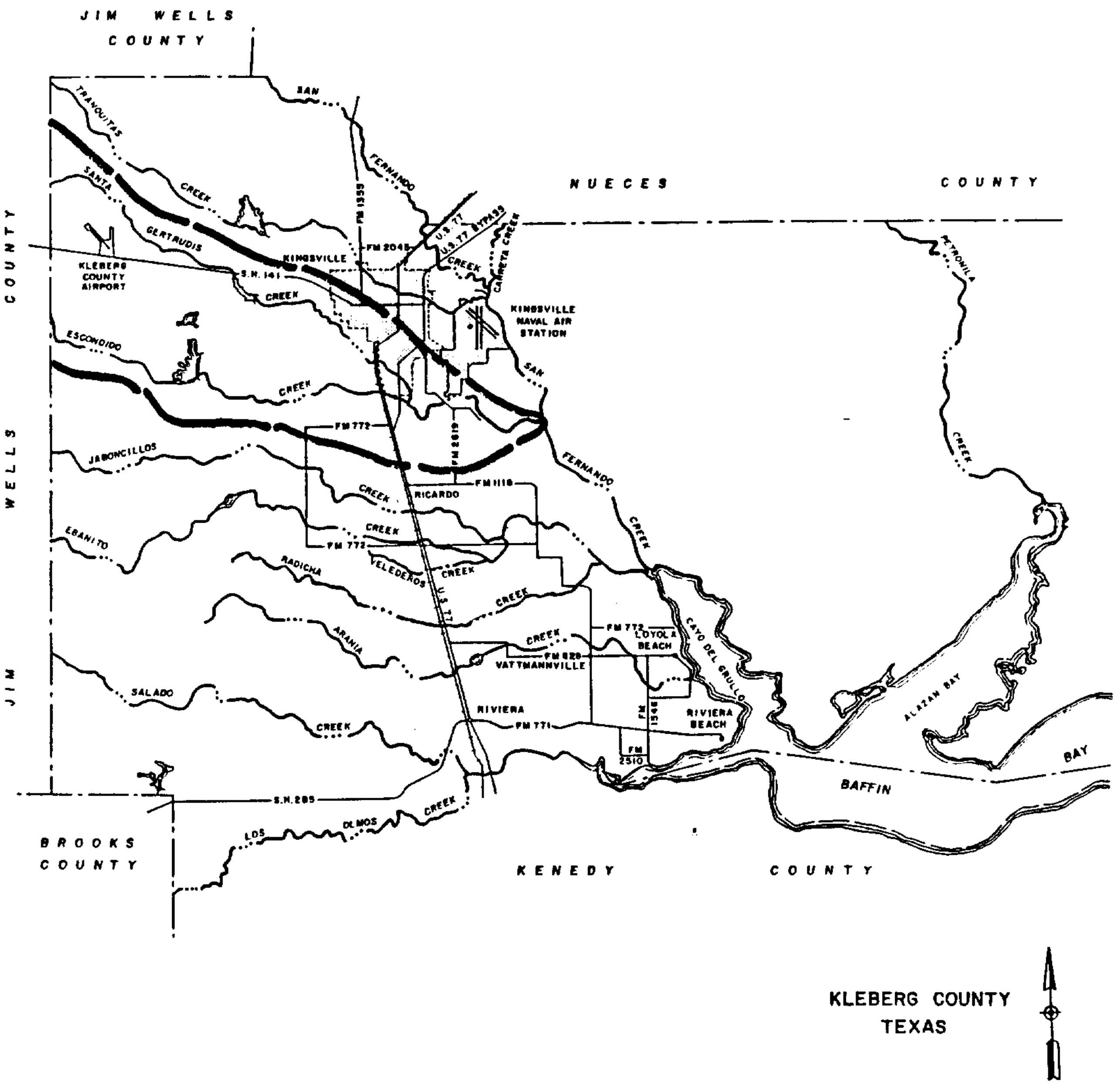
## Basin 4: Santa Gertrudis Creek

### Description

The Santa Gertrudis Creek watershed covers a portion of Kleberg, Jim Wells, and Duval Counties. Santa Gertrudis Creek travels in a southeasterly direction from its headwaters in Duval County, through Jim Wells County, and into Kleberg County to its confluence with San Fernando Creek. Within Kleberg County, Santa Gertrudis Creek has one major tributary, Escondido Creek. At its confluence with San Fernando Creek, it has a drainage area of about 557 square miles. The general slope of the

FIGURE 5-4

## SANTA GERTRUDIS CREEK - BASIN BOUNDARY



ground in the watershed is from the northwest to the southeast at a rate of about 6.7 feet per mile. The creek passes through and drains the southern portion of the City of Kingsville.

Basin Analysis

During the initial coordination meetings, it was decided to study Santa Gertrudis Creek from its confluence with San Fernando Creek to about two miles southwest of the City of Kingsville.

Hydrology for the Santa Gertrudis watershed was performed using the Cypress Creek Method (Ref. 20). The basin was subdivided, and the required parameters of rainfall, curve number, and drainage area were determined. Table 5-9 shows the hydrologic parameters and the peak discharge values used in the analysis.

Water surface profiles were calculated for Santa Gertrudis Creek watershed using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. An inventory of existing structures is shown in Table 5-10. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

TABLE 5-9

SANTA GERTRUDIS CREEK - PEAK DISCHARGE

| Location | Drainage Area (mi²) | Peak Discharge | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 10-year | | 25-Year | | 50-Year | | 100-Year | |
| | | Rainfall, in. | Q, cfs | Rainfall, in. | Q, cfs | Rainfall, in. | Q, cfs | Rainfall, in. | Q, cfs |
| At confluence with San Fernando | 557.1 | 7.00 | 7,670 | 8.25 | 9,735 | 9.35 | 11,770 | 10.75 | 14,600 |
| At US 77 Bypass | 439.1 | 7.00 | 6,290 | 8.25 | 7,980 | 9.35 | 9,650 | 10.75 | 11,980 |
| At Section 6.11 | 442.9 | 7.00 | 6,095 | 8.25 | 7,740 | 9.35 | 9,355 | 10.75 | 11,610 |

TABLE 5-10

SANTA GERTRUDIS CREEK - STRUCTURE INVENTORY

| Section No. | Road | Structure | |
|---|---|---|---|
| | | Type | Size, ft. |
| 6.05 | Co. Rd. 1070N | 2-span bridge | 59 x 26 |
| 6.35 | FM 1717 | 5-barrel box culvert | 6 x 6 x 41 |

## Problem Areas

Direct flooding adjacent to the Santa Gertrudis Creek channel within the unincorporated areas of the county has not been identified as a problem due to the limited development in the watershed. One problem identified during the analysis was the bridge at FM 1717. The bridge has inadequate capacity to pass the design storm without overtopping.

## Proposed Basin Improvements and Recommendations

1. Replace the culverts at FM 1717 with a structure that has the hydraulic characteristics of a bridge with a 300-foot span.
2. Carefully control development in areas identified as being within the 100-year flood boundaries of Santa Gertrudis Creek.

Table 5-11 summarizes the structural improvements for Santa Gertrudis Creek.

TABLE 5-11

SUMMARY OF STRUCTURAL IMPROVEMENTS FOR SANTA GERTRUDIS CREEK

| Location | Section | Station | Allowable Head Loss (ft) | Design Discharge (cfs) | Example Structure | Misc. |
|---|---|---|---|---|---|---|
| FM 1717 | 6.35 | 198+00 | 0.2 | 14,603 | Bridge with 300' span | Raise road 8.6' |

## Basin 5: Escondido Creek

### Description

The Escondido Creek watershed covers a portion of Kleberg and Jim Wells Counties. Escondido Creek travels in an easterly direction from its headwaters in Jim Wells County, through Kleberg County where it joins Santa Gertrudis Creek southeast of Kingsville. As with most watersheds in the western portion of the county, the watershed is long and relatively narrow, with a length of about 24 miles and a maximum width of about 6.5 miles. At its confluence with Santa Gertrudis Creek, it has a drainage area of about 111 square miles. The general slope of the ground in the watershed is from the northwest to the southeast at a rate of about 6.6 feet per mile.

### Basin Analysis

During the initial coordination meetings, it was decided to study Escondido Creek from County Road 1030N to an area downstream of Escondido Lake.

Hydrology for the Escondido Creek watershed was performed using the Cypress Creek Method (Ref. 20). The basin was subdivided, and the required parameters of rainfall, curve number, and drainage area were determined. Table 5-12 shows the hydrologic parameters and the peak discharge values used in the analysis.

Water surface profiles were calculated for Escondido Creek watershed using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. An inventory of existing structures is shown in Table 5-13. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

FIGURE 5-5

## ESCONDIDO CREEK - BASIN BOUNDARY

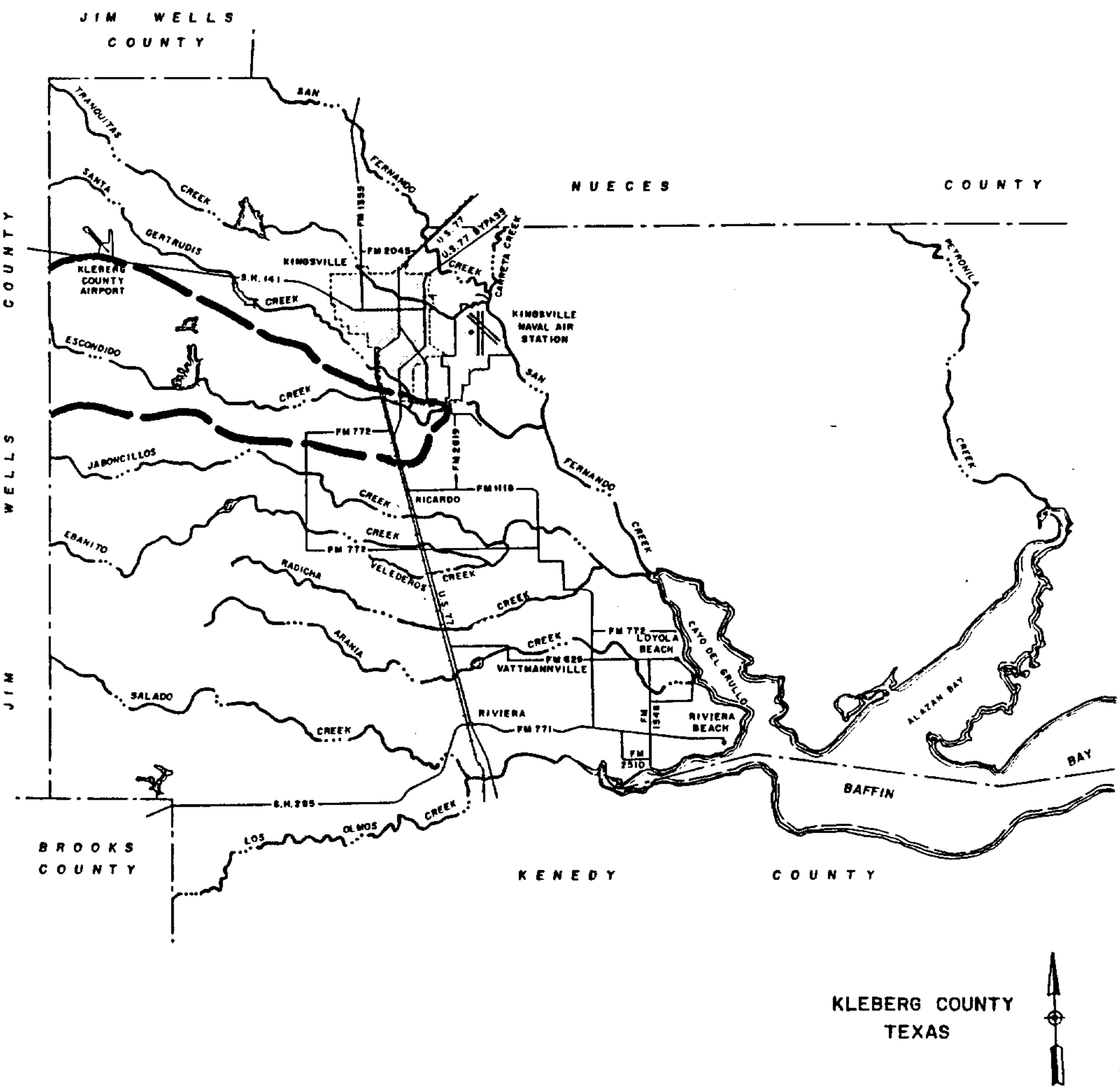


TABLE 5-12

ESCONDIDO CREEK - PEAK DISCHARGE

| Location | Drainage Area (mi²) | Peak Discharge | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 10-Year | | 25-Year | | 50-Year | | 100-Year | |
| | | Rainfall, in. | Q, cfs | Rainfall, in. | Q, cfs | Rainfall, in | Q, cfs | Rainfall, in. | Q, cfs |
| At confluence with Santa Gertrudis | 111.4 | 7.15 | 2,070 | 8.45 | 2,640 | 9.65 | 3,230 | 11.05 | 3,985 |
| At Section 7.40 | 93.4 | 7.15 | 1,790 | 8.45 | 2,280 | 9.65 | 2,795 | 11.05 | 3,450 |
| At Section 7.11 | 86.7 | 7.15 | 1,690 | 8.45 | 2,155 | 9.65 | 2,640 | 11.05 | 3,255 |

TABLE 5-13

ESCONDIDO CREEK - STRUCTURE INVENTORY

| Section No. | Road | Structure | |
|---|---|---|---|
| | | Type | Size |
| 7.00 | Co. Rd. 1030N | 4-CMP | 36" x 40' |

## Problem Areas

Direct flooding adjacent to the Escondido Creek channel within the unincorporated areas of the county has not been identified as a problem due to the limited development in the area. Potential for development is limited by the fact there are no public roads within the watershed upstream of County Road 1030N. County Road 1030N is overtopped during the design storm due to inadequate capacity of the existing culverts. This causes extensive backwater upstream and makes the road impassable during flooding.

Though outside the scope of this study, there is the potential of severe flooding within the watershed if a problem should occur with the dam forming Escondido Lake. Neither the hydrologic nor physical condition of the dam was evaluated as a part of this study.

## Proposed Basin Improvements and Recommendations

1. Replace the culverts at County Road 1030N with a structure having the hydraulic characteristics of a bridge with a 150-foot span.
2. Carefully control development in areas identified as being within the 100-year flood boundaries of Escondido Creek.
3. Determine safety of the dam forming Escondido Lake and if appropriate develop a flood warning system for the basin in the event of severe rainfall. This could consist of an inspection of the dam during heavy rainfall events and a method of warning downstream residents (possibly through the Sheriff's office) in the event of problems.

Table 5-14 summarizes the structural improvements for Escondido Creek.

TABLE 5-14

SUMMARY OF STRUCTURAL IMPROVEMENTS FOR ESCONDIDO CREEK

| Location | Section | Station | Allowable Head Loss (ft) | Design Discharge (cfs) | Example Structure | Misc. |
|---|---|---|---|---|---|---|
| Co. Rd. 1030N | 7.00 | 1+00 | 0.3 | 3,986 | Bridge with 150' span | Raise road 7.5' |

## Basin 6: Jaboncillos Creek

### Description

The Jaboncillos Creek watershed covers a portion of Kleberg, Duval, and Jim Wells Counties. Jaboncillos Creek travels in a southeasterly direction from its headwaters in Duval County, south of Benavides, through Jim Wells County into Kleberg County where it discharges into the Cayo del Grullo. As with most of the watersheds in the western portion of the county, the watershed is long and relatively narrow, with a length of about 50 miles and a maximum width of about 16 miles. At its confluence with Cayo del Grullo, it has a drainage area of about 261 square miles. The general slope of the ground in the watershed is from the northwest to the southeast at a rate of about 6.0 feet per mile.

### Basin Analysis

During the initial coordination meetings, it was decided to study Jaboncillos Creek from FM 1118 to about one mile west of FM 772.

Hydrology for the Jaboncillos Creek watershed was performed using the Cypress Creek Method (Ref. 20). The basin was subdivided, and the required parameters of rainfall, curve number, and drainage area were determined. Table 5-15 shows the hydrologic parameters and the peak discharge values used in the analysis.

Water surface profiles were calculated for Jaboncillos Creek watershed using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. An inventory of existing structures is shown in Table 5-16. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

FIGURE 5-6

# JABONCILLOS CREEK – BASIN BOUNDARY

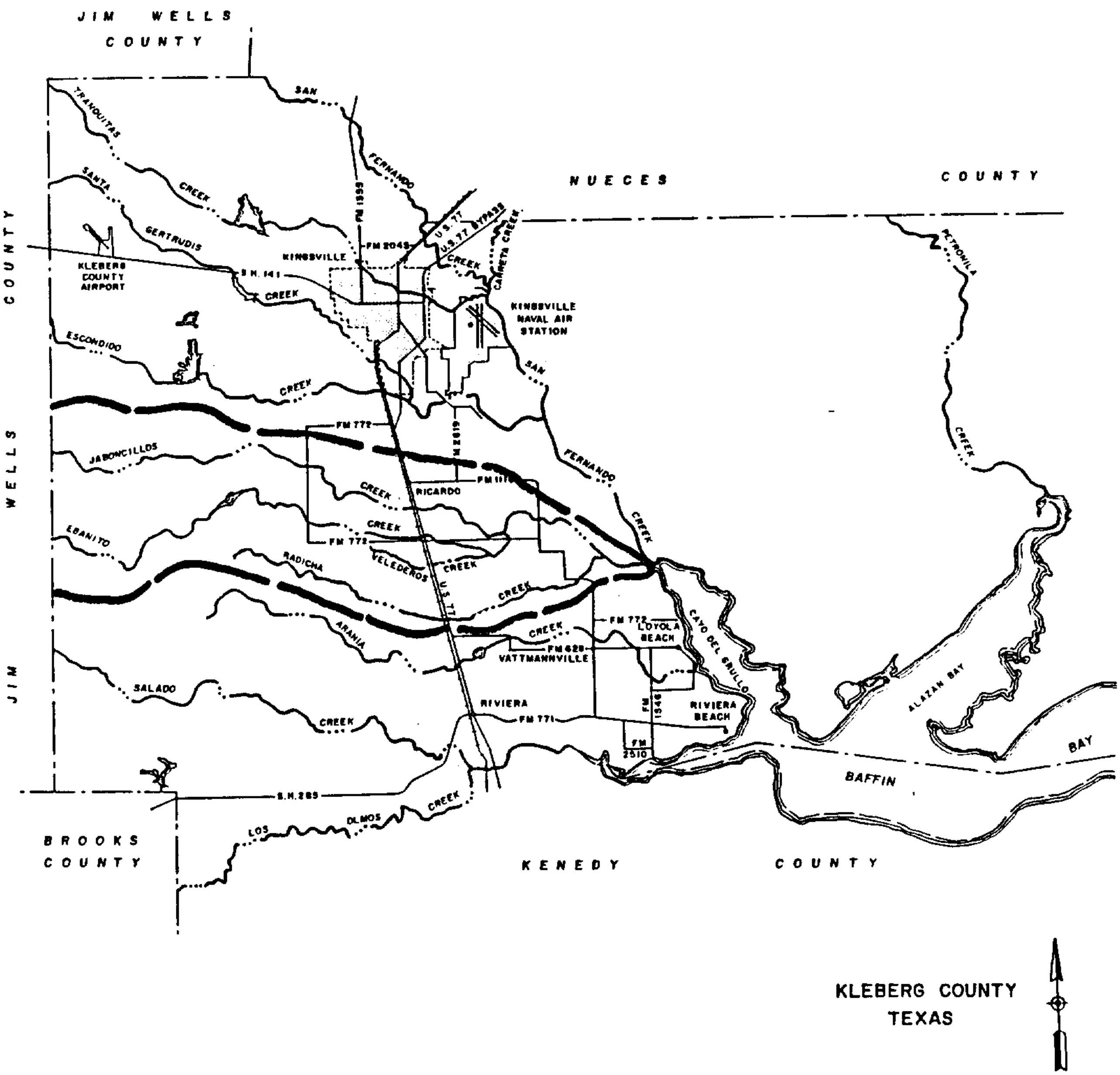


TABLE 5-15

JABONCILLOS CREEK - PEAK DISCHARGE

| Location | Drainage Area ($mi^2$) | Peak Discharge | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 10-Year Rainfall, in. | Q, cfs | 25-Year Rainfall, in. | Q, cfs | 50-Year Rainfall, in. | Q, cfs | 100-Year Rainfall, in. | Q, cfs |
| At FM 1118 | 261.3 | 7.05 | 4,121 | 8.32 | 5,245 | 9.50 | 6,420 | 10.90 | 7,940 |
| At Section 5.15 | 193.7 | 7.05 | 3,210 | 8.32 | 4,090 | 9.50 | 5,000 | 10.90 | 6,185 |
| At Section 5.41 | 179.1 | 7.05 | 3 010 | 8.32 | 3,830 | 9.50 | 4,690 | 10.90 | 5,800 |

TABLE 5-16

JABONCILLOS CREEK - STRUCTURE INVENTORY

| Section No. | Road | Structure Type | Structure Size |
|---|---|---|---|
| 5.00 | FM 1118 | 4-span bridge | 96' x 26' |
| 5.10 | Co. Rd. 1060N | 6-RCP | 24" x 40' |
| 5.17 | US 77 (northbound) | 2-span bridge | 118' x 45' |
| 5.17 | US 77 (southbound) | 6-span bridge | 120' x 42.5' |
| 5.17 | Mo-Pac RR | 10-span bridge | 140' x 15' |
| 5.22 | Co. Rd. 2170W | 4-RCP | 18" x 25' |
| 5.26 | Co. Rd. 2170W | 1-RCP | 18" x 24' |
| 5.30 | Co. Rd. 1020 | 1-RCP | 15" x 32' |
| 5.35 | FM 772 | 1-span bridge | 25' x 22' |

## Problem Areas

Jaboncillos Creek experiences extensive overbank flooding in an area upstream and downstream of U.S. 77. The cause of the flooding is a combination of inadequate channel capacity and constrictions at the U.S. 77 and Missouri-Pacific RR bridges. The overbank areas are very flat at these locations, and once the water rises above the channel banks, it spreads out over large areas. The flow tends to cross the basin boundary to the south into Ebanito Creek. In addition, the southern portion of Ricardo is affected by the backwater of Jaboncillos Creek.

The culverts at County Roads 2170W (second crossing) and 1020 are buried and do not appear to be functioning. The floodwaters trapped behind these roads have no way to drain as the floodwaters recede.

The structure at FM 772 has inadequate capacity to pass the design storm. The road is overtopped during flood events, making it impassable.

## Proposed Basin Improvements and Recommendations

1. Widen the channel from Station 245+55 to Station 422+25 to a bottom width of 300 feet. Lower the channel invert elevation to that shown on the Master Plan profiles.

2. Replace the structures at U.S. 77 with structures having the hydraulic characteristics of a bridge with a 240-foot span.

3. Replace the structure at the Missouri-Pacific RR with a structure having the hydraulic characteristics of a bridge with a 240-foot span.

4. Replace the existing structure at Co. Rd. 2170W (section 5.22) with three 18-inch RCP to provide drainage.

5. Replace the existing structure at Co. Rd. 1020 with three 18-inch RCP to provide drainage.

6. Replace the structure at FM 772 with a structure having the hydraulic characteristics of a bridge with a 200-foot span.

7. Carefully control development in areas identified as being within the 100-year flood boundaries of Jaboncillos Creek.

Tables 5-17 and 5-18 summarize the structural and channel improvements for Jaboncillos Creek.

TABLE 5-17

SUMMARY OF STRUCTURAL IMPROVEMENTS FOR JABONCILLOS CREEK

| Location | Section | Station | Allowable Head Loss (ft) | Design Discharge (cfs) | Example Structure | Misc. |
|---|---|---|---|---|---|---|
| US 77 | 5.17 | 317+00 | 0.4 | 6,185 | Bridge with 240' span | |
| Mo-Pac RR | 5.17 | 318+50 | 0.4 | 6,185 | Bridge with 240' span | |
| Co. Rd. 2170W | 5.22 | 423+30 | - | - | 3-18" RCP | |
| Co. Rd. 1020 | 5.30 | 489+00 | - | - | 3-18" RCP | |
| FM 772 | 5.35 | 601+50 | 0.5 | 6,185 | Bridge with 200' span | Raise road 2.3' |

TABLE 5-18

SUMMARY OF CHANNEL IMPROVEMENTS FOR JABONCILLOS CREEK

| Location | Station | Bottom Width (ft) | Design Discharge (cfs) |
|---|---|---|---|
| Co. Rd. 1060N to Co. Rd. 2170W | 245+55 to 422+25 | 300 | Varies - 7,939 to 6,185 |

Basin 7: Ebanito Creek

Description

The Ebanito Creek watershed covers portions of Kleberg and Jim Wells Counties. The creek has its origin in Jim Wells County northwest of Premont. From there it travels in an easterly direction into Kleberg County to its confluence with Jaboncillos Creek upstream of FM 1118. As with most of the watersheds in the western portion of the county, the watershed is long and relatively narrow, with a length of about 24 miles and a maximum width of about 3 miles. At its confluence with Jaboncillos Creek, it has a drainage area of about 55.1 square miles. The general slope of the ground in the watershed is from the northwest to the southeast at a rate of about 8.33 feet per mile.

Basin Analysis

During the initial coordination meetings, it was decided to study Ebanito Creek from its confluence with Jaboncillos Creek to upstream of FM 772.

Hydrology for the Ebanito Creek watershed was performed using the Cypress Creek Method (Ref. 20). The basin was subdivided, and the required parameters of rainfall, curve number, and drainage area were determined. Table 5-19 shows the hydrologic parameters and the peak discharge values used in the analysis.

Water surface profiles were calculated for Ebanito Creek watershed using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. An inventory of existing structures is shown in Table 5-20. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

FIGURE 5-7

## EBANITO CREEK – BASIN BOUNDARY

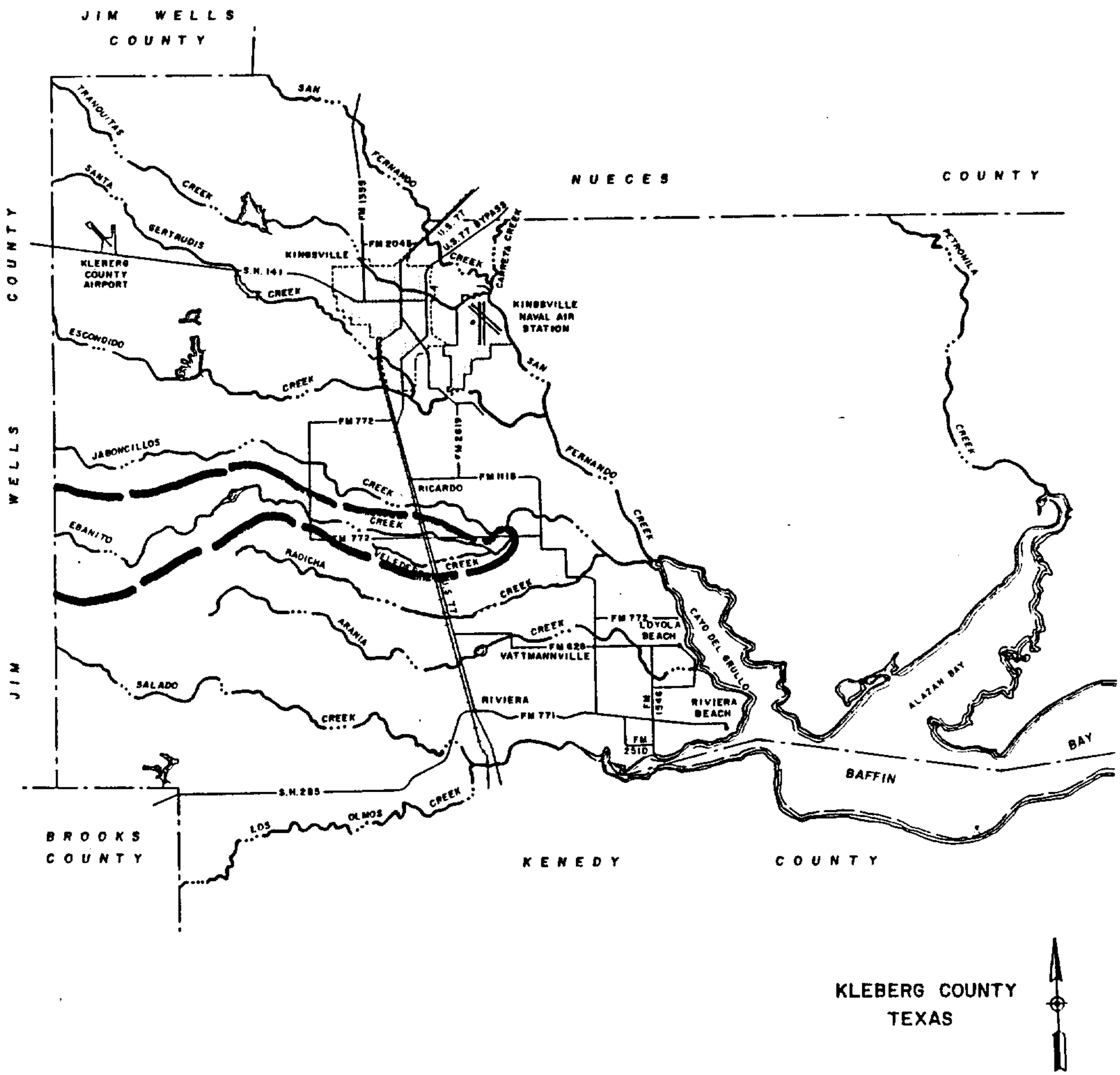



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TABLE 5-19

EBANITO CREEK - PEAK DISCHARGE

| Location | Drainage Area ($mi^2$) | Peak Discharge | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 10-Year Rainfall, in. | Q, cfs | 25-Year Rainfall, in. | Q, cfs | 50-Year Rainfall, in. | Q, cfs | 100-Year Rainfall, in. | Q, cfs |
| At confluence with Jaboncillos | 55.1 | 7.20 | 1,240 | 8.50 | 1,583 | 9.70 | 1,936 | 11.10 | 2,386 |
| At Co. Rd 1030 | 49.1 | 7.20 | 1,150 | 8.50 | 1,467 | 9.70 | 1,795 | 11.10 | 2,212 |
| At Co. Rd 1000 | 42.3 | 7.20 | 1,043 | 8.50 | 1,331 | 9.70 | 1,630 | 11.10 | 2,007 |

TABLE 5-20

EBANITO CREEK - STRUCTURE INVENTORY

| Section No. | Road | Structure Type | Structure Size |
|---|---|---|---|
| 4.00 | FM 772 | 3-barrel box culvert | 6' x 6' x 27' |
| 4.20 | Co. Rd. 1075S | 2-CM arch pipe | 39" x 57" x 34' |
| 4.40 | Co. Rd. 1065S | 2-RCP<br>1-RCP relief pipe | 2.8' x 2.0' x 26'<br>18" x 27' |
| 4.45 | Co. Rd. 1060S | 4-RCP | (2) 15" x 37'<br>(2) 24" x 37' |
| 4.55 | Co. Rd. 1055S | 2-RCP | 18" x 22' |
| 4.60 | FM 772 | 4-RCP | 36" x 39' |
| 4.65 | US 77 (northbound) | 1-span bridge | 58' x 45' |
| 4.65 | US 77 (southbound) | 3-span bridge | 55' x 43' |
| 4.65 | Mo-Pac RR | 5-span bridge | 63' x 15' |
| 4.70 | FM 772 | 2-RCP | 48" x 36" x 42' |
| 4.75 | FM 772 | 2-RCP | 48" x 30" x 42' |
| 4.85 | Co. Rd. 1030S | 2-RCP | 18" x 37' |
| 4.93 | FM 772 | 4-RCP | 18" x 40' |

## Problem Areas

Ebanito Creek crosses FM 772 in two locations downstream of U.S. 77. Both of these crossings have inadequate capacity to pass the design storm, causing overtopping of the road and making them impassable during flood events.

Ebanito Creek experiences extensive overbank flooding in an area upstream and downstream of U.S. 77. The cause of the flooding is a combination of inadequate channel capacity and constrictions at the U.S. 77 and Missouri-Pacific RR bridges. The overbank areas are very flat at these locations, and once water rises above the channel banks, it spreads out over a large area. The flow tends to cross the basin boundary to the north and flow into Jaboncillos Creek.

Immediately upstream of U.S. 77, the creek again crosses FM 772 at two locations. The structures at these locations are inadequate to pass the design storm and the road is overtopped.

Further upstream the creek crosses County Road 1030S. The existing culverts at this location are completely plugged, causing floodwaters to overtop the road and not drain after the floodwaters recede.

Upstream of County Road 1030S, the creek again crosses FM 772. The structure at this location is inadequate to pass the design storm and the road is overtopped, making it impassable.

## Proposed Basin Improvements and Recommendations

1. Replace the structure at FM 772 (section 4.00) with a structure having the hydraulic characteristics of a bridge with a 120-foot span.
2. Widen the channel from Station 130+00 to Station 195+00 to a bottom width of 120 feet. Lower the channel invert elevation to that shown on the Master Plan profiles.

3. Replace the structure at FM 772 (section 4.60) with a structure having the hydraulic characteristics of a bridge with a 120-foot span.

4. Replace the structures at U.S. 77 with structures having the hydraulic characteristics of a bridge with a 120-foot span.

5. Replace the structure at Mo-Pac RR with a structure having the hydraulic characteristics of a bridge with a 120-foot span.

6. Replace the existing structure at Co. Rd. 1030S with three 24-inch RCP to provide drainage.

7. Replace the structure at FM 772 (section 4.93) with a structure having the hydraulic characteristics of a bridge with a 120-foot span.

8. Carefully control development in areas identified as being within the 100-year flood boundaries of Ebanito Creek.

Tables 5-21 and 5-22 summarize the structural and channel improvements for Ebanito Creek.

TABLE 5-21

SUMMARY OF STRUCTURAL IMPROVEMENTS FOR EBANITO CREEK

| Location | Section | Station | Allowable Head Loss (ft) | Design Discharge (cfs) | Example Structure | Misc. |
|---|---|---|---|---|---|---|
| FM 772 | 4.00 | 1+00 | 1.5 | 2,386 | Bridge with 120' span | Raise road 5.0' |
| FM 772 | 4.60 | 168+50 | 0.45 | 2,386 | Bridge with 120' span | |
| US 77 | 4.65 | 189+00 | 0.55 | 2,386 | Bridge with 120' span | |
| Mo-Pac RR | 4.65 | 191+00 | 0.55 | 2,386 | Bridge with 120' span | |
| Co. Rd. 1030S | 4.85 | 323+00 | - | - | 3-24" RCP | |
| FM 772 | 4.93 | 442+50 | 0.2 | 2,212 | Bridge with 120' span | |

TABLE 5-22

SUMMARY OF CHANNEL IMPROVEMENTS FOR EBANITO CREEK

| Location | Station | Bottom Width (ft) | Design Discharge (cfs) |
|---|---|---|---|
| Co. Rd. 1060S to US 77 | 130+00 to 195+00 | 120 | 2,386 |

## Basin 8: Radicha Creek

### Description

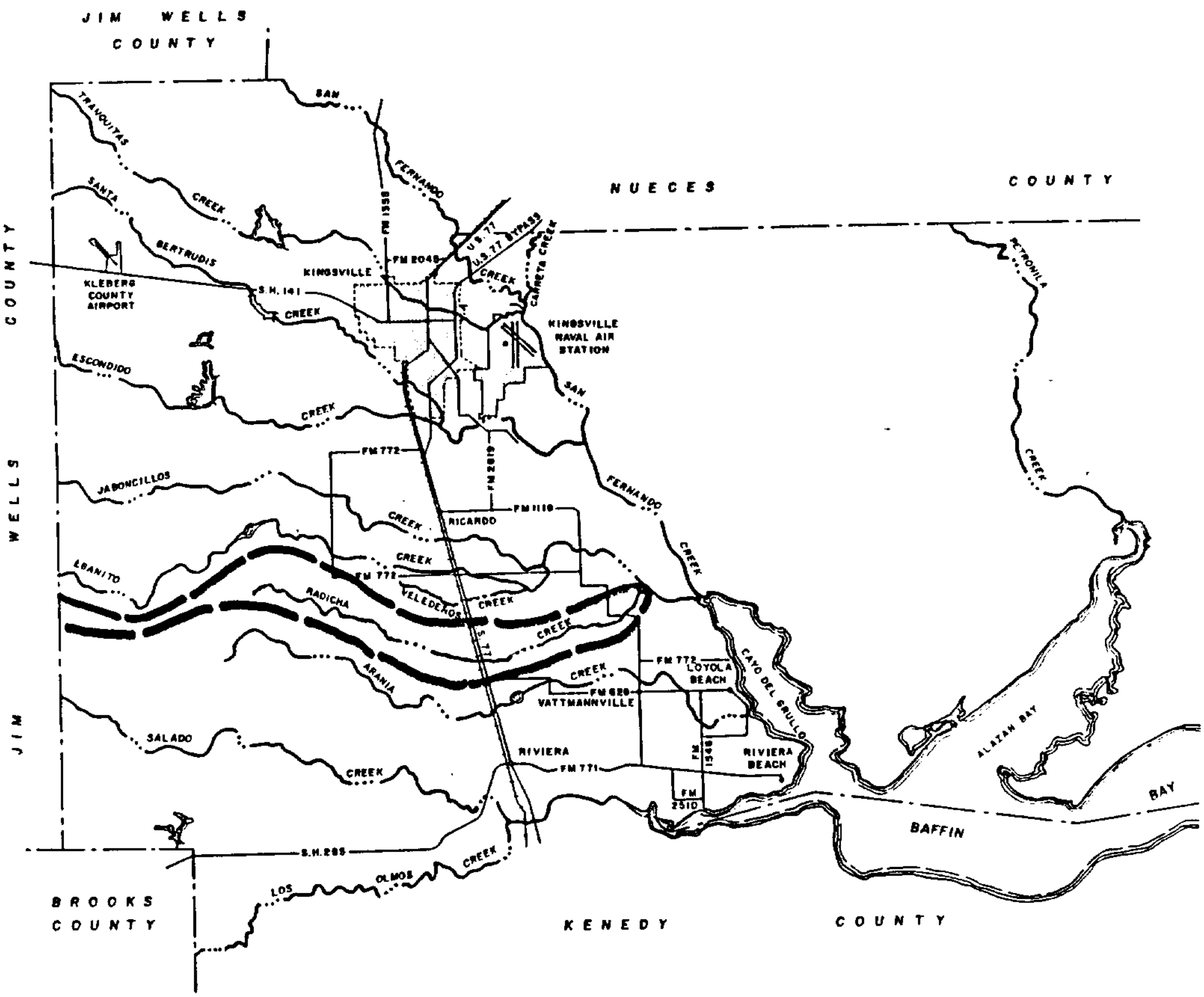
The Radicha Creek watershed covers portions of Kleberg and Jim Wells Counties. Radicha Creek travels in a southeasterly direction from its headwaters in Jim Wells County, northeast of Premont, to its confluence with the Cayo del Grullo, an arm of Baffin Bay. Radicha Creek has no major tributaries in Kleberg County. As with most of the watersheds in the western portion of the county, the watershed is long and relatively narrow, with a length of about 23 miles and a maximum width of about 2.5 miles. At its confluence with Cayo del Grullo, it has a drainage area of about 27.5 square miles. The general slope of the ground in the watershed is from the northwest to the southeast at a rate of about 5.9 feet per mile.

### Basin Analysis

During the initial coordination meetings, it was decided to study Radicha Creek from its confluence with Cayo del Grullo to about two miles west of U.S. 77.

FIGURE 5-8

# RADICHA CREEK - BASIN BOUNDARY




KLEBERG COUNTY
TEXAS

Hydrology for the Radicha Creek watershed was performed using the Cypress Creek Method (Ref. 20). The basin was subdivided, and the required parameters of rainfall, curve number, and drainage area were determined. Table 5-23 shows the hydrologic parameters and the peak discharge values used in the analysis.

Water surface profiles were calculated for Radicha Creek watershed using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. An inventory of existing structures is shown in Table 5-24. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

TABLE 5-23

RADICHA CREEK - PEAK DISCHARGE

| Location | Drainage Area ($mi^2$) | Peak Discharge | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 10-Year Rainfall, in. | Q, cfs | 25-Year Rainfall, in. | Q, cfs | 50-Year Rainfall, in. | Q, cfs | 100-Year Rainfall, in. | Q, cfs |
| At confluence with Cayo del Grullo | 27.5 | 7.25 | 786 | 8.60 | 1,010 | 9.80 | 1,235 | 11.20 | 1,520 |
| At Section 3.90 | 8.7 | 7.25 | 344 | 8.60 | 442 | 9.80 | 540 | 11.20 | 664 |

TABLE 5-24

RADICHA CREEK - STRUCTURE INVENTORY

| Section No. | Road | Structure Type | Structure Size |
|---|---|---|---|
| 3.50 | Co. Rd. 1070S | 2-RCP | 18" x 22' |
| 3.65 | US 77 (northbound) | 1-span bridge | 57' x 45' |
| 3.65 | US 77 (southbound) | 1-span bridge | 57' x 45' |
| 3.65 | Mo-Pac RR | 5-span bridge | 65' x 15' |

## Problem Areas

Direct flooding adjacent to the Radicha Creek channel within the unincorporated areas of the county has not been identified as a problem due to the limited development in the area.

## Proposed Basin Improvements and Recommendations

1. No improvements proposed.
2. Carefully control development in areas identified as being within the 100-year flood boundaries of Radicha Creek.

## Basin 9: Arania Creek

### Description

The Arania Creek watershed is located entirely within Kleberg County and has its origin in the southwestern part of the county. From there it travels in an easterly direction to its confluence with Cayo del Grullo, an arm of Baffin Bay. Arania Creek has no major tributaries within the county. As with most of the watersheds in the western portion of the county, the watershed is long and relatively narrow, with a length of about 18 miles and a maximum width of about 1.5 miles. At its confluence with Cayo del Grullo, it has a drainage area of about 16.5 square miles. The general slope of the ground in the watershed is from the northwest to the southeast at a rate of about 4.2 feet per mile.

### Basin Analysis

During the initial coordination meetings, it was decided to study Arania Creek from near Vattmanville to about two miles west of U.S. 77.

Hydrology for the Arania Creek watershed was performed using the Cypress Creek Method (Ref. 20). The basin was subdivided, and the required parameters of rainfall, curve number, and drainage area were determined. Table 5-25 shows the hydrologic parameters and the peak discharge values used in the analysis.

Water surface profiles were calculated for the Arania Creek watershed using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. An inventory of existing structures is shown in Table 5-26. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

FIGURE 5-9

# ARANIA CREEK – BASIN BOUNDARY

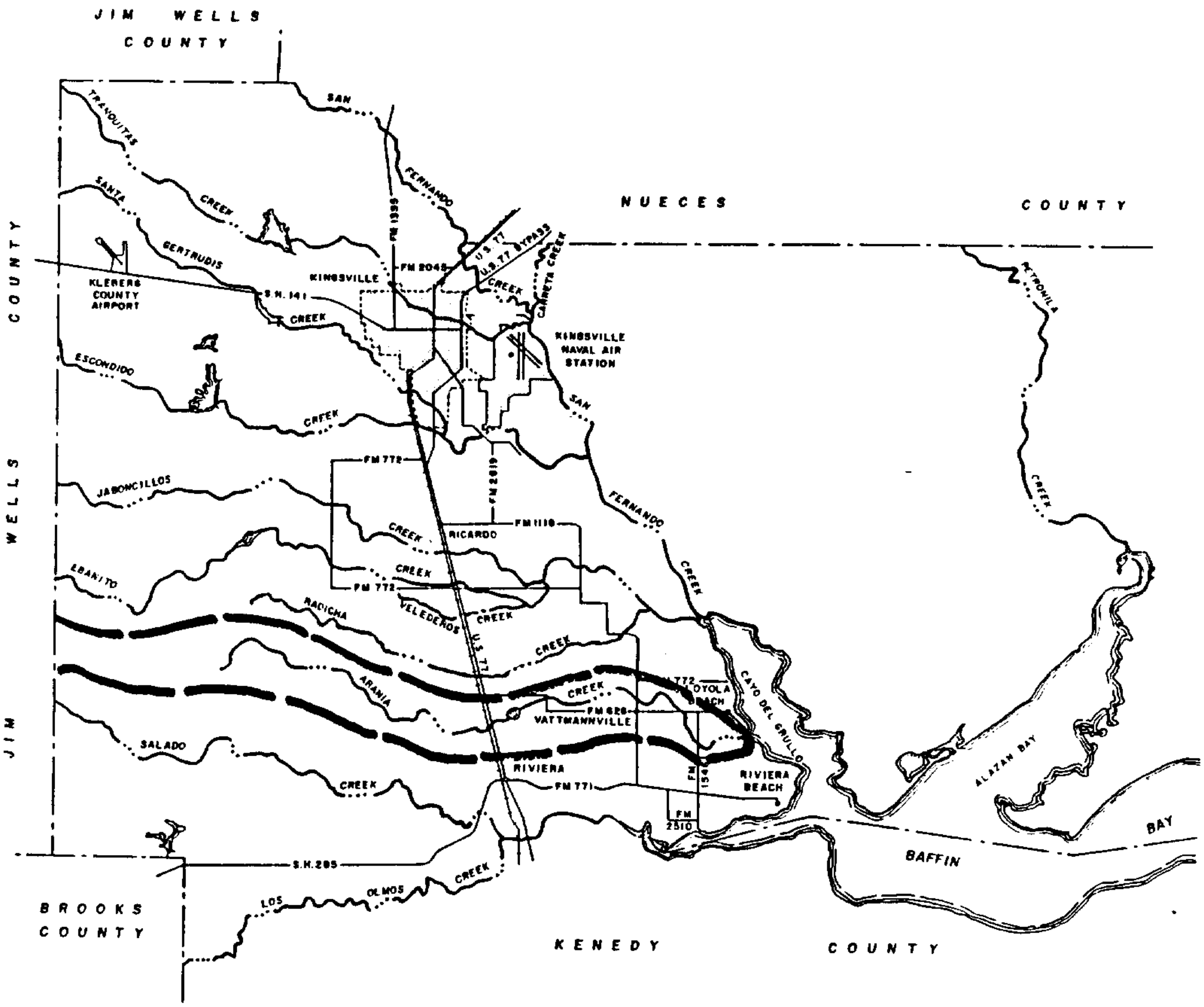



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TABLE 5-25

ARANIA CREEK - PEAK DISCHARGE

| Location | Drainage Area (mi²) | Peak Discharge | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 10-Year Rainfall, in. | Q, cfs | 25-Year Rainfall, in. | Q, cfs | 50-Year Rainfall, in. | Q, cfs | 100-Year Rainfall, in. | Q, cfs |
| At confluence with Cayo del Grullo | 16.5 | 7.25 | 546 | 8.60 | 702 | 9.80 | 857 | 11.20 | 1,055 |
| At Section 2.60 | 7.4 | 7.25 | 305 | 8.60 | 392 | 9.80 | 480 | 11.20 | 590 |

TABLE 5-26

ARANIA CREEK - STRUCTURE INVENTORY

| Section No. | Road | Structure Type | Structure Size |
|---|---|---|---|
| 2.01 | FM 628 | 5-RCP | 18" x 37' |
| 2.05 | FM 628 | 4-RCP | 18" x 39' |
| 2.10 | Co. Rd. 1090S | No structure found | |
| 2.21 | FM 628 | 1-RCP | 18" x 40' |
| 2.25 | FM 628 | 1-RCP | 18" x 40' |
| 2.30 | old FM 628 | 5-RCP | 36" x 45' |
| 2.30 | FM 628 | 5-RCP | 36" x 57' |
| 2.35 | US 77 (northbound) | 1-span bridge | 68' x 45' |
| 2.35 | US 77 (southbound) | 4-span bridge | 72' x 43' |
| 2.35 | Mo-Pac RR | 13-span bridge | 78' x 15' |

## Problem Areas

Downstream of U.S. 77, Arania Creek has little slope or channel capacity. All the roads have inadequate capacity to pass the design storm and are overtopped during flood events, making them impassable. Access to a large area of the county is completely cut off during severe storms.

## Proposed Basin Improvements and Recommendations

1. Replace the structure at FM 628 (section 2.01) with a structure having the hydraulic characteristics of a bridge with a 100-foot span.

2. Replace the structure at FM 628 (section 2.05) with a structure having the hydraulic characteristics of a bridge with a 100-foot span.

3. On Co. Rd. 1090S, add three 18-inch RCPs to provide drainage.

4. Deepen the channel from Station 65+76 to Station 120+76 to a bottom width of 30 feet. Lower the channel invert elevation to that shown on the Master Plan profiles.

5. Replace the structure at FM 628 (section 2.21) with a structure having the hydraulic characteristics of a bridge with a 100-foot span.

6. Replace the structure at FM 628 (section 2.25) with a structure having the hydraulic characteristics of a bridge with a 100-foot span.

7. Replace the structure at FM 628 (section 2.30) with a structure having the hydraulic characteristics of a bridge with a 100-foot span.

8. Carefully control development in areas identified as being within the 100-year flood boundaries of Arania Creek.

Tables 5-27 and 5-28 summarize the structural and channel improvements for Arania Creek.

## TABLE 5-27

## SUMMARY OF STRUCTURAL IMPROVEMENTS FOR ARANIA CREEK

| Location | Section | Station | Allowable Head Loss (ft) | Design Discharge (cfs) | Example Structure | Misc. |
|---|---|---|---|---|---|---|
| FM 628 | 2.01 | 27+00 | 1.0 | 1,055 | Bridge with 100' span | Raise road 2.3' |
| FM 628 | 2.05 | 55+00 | 0.5 | 1,055 | Bridge with 100' span | Raise road 2.8' |
| Co. Rd. 1090S | 2.10 | 66+80 | - | - | 3-18" RCP | |
| FM 628 | 2.21 | 122+20 | 0.5 | 1,055 | Bridge with 100' span | Raise road 3.2' |
| FM 628 | 2.25 | 150+00 | 0.7 | 1,055 | Bridge with 100' span | Raise road 3.4' |
| FM 628 | 2.30 | 183+10 | 0.5 | 1,055 | Bridge with 100' span | Raise road 1.9' |

---

## TABLE 5-28

## SUMMARY OF CHANNEL IMPROVEMENTS FOR ARANIA CREEK

| Location | Station | Bottom Width (ft) | Design Discharge (cfs) |
|---|---|---|---|
| Co. Rd. 1090S to FM 628 | 65+76 to 120+76 | 30 | 1,055 |

Basin 10: Salado Creek

Description

The Salado Creek watershed covers portions of Kleberg and Jim Wells Counties. Salado Creek travels in a southeasterly direction from its headwaters in Jim Wells County, near the town of Premont, to its confluence with Los Olmos Creek upstream of U.S. 77. Salado Creek has no major tributaries in Kleberg County. At its confluence with Los Olmos Creek, it has a drainage area of about 37.2 square miles. The general slope of the ground in the watershed is from the northwest to the southeast at a rate of about 6.6 feet per mile.

Basin Analysis

During the initial coordination meetings, it was decided to study Salado Creek from its confluence with Los Olmos Creek to downstream of Falcon Chiquita Dam.

Hydrology for the Salado Creek watershed was performed using the Cypress Creek Method (Ref. 20). The basin was subdivided, and the required parameters of rainfall, curve number, and drainage area were determined. Table 5-29 shows the hydrologic parameters and the peak discharge values used in the analysis.

Water surface profiles were calculated for the Salado Creek watershed using the Corps of Engineers Computer Backwater Model, HEC-2. Both natural cross sections and sections at structures were modelled. An inventory of existing structures is shown in Table 5-30. Section numbers correspond to the numbers found in the HEC-2 data, on the aerials, and on the profiles.

FIGURE 5-10

## SALADO CREEK – BASIN BOUNDARY

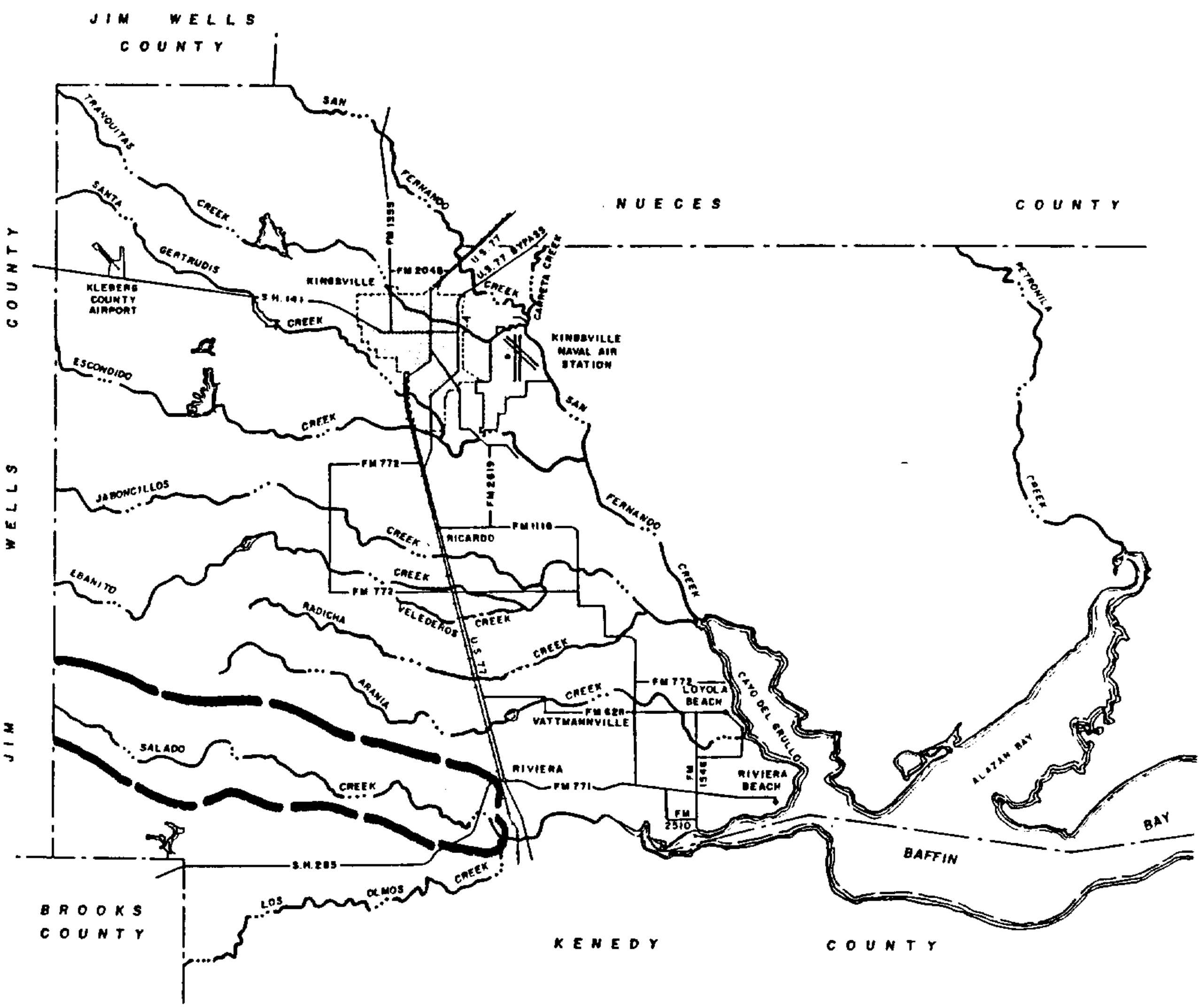


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TABLE 5-29

SALADO CREEK - PEAK DISCHARGE

| Location | Drainage Area (mi²) | Peak Discharge | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 10-year Rainfall, in. | Q, cfs | 25-Year Rainfall, in. | Q, cfs | 50-year Rainfall, in. | Q, cfs | 100-Year Rainfall, in. | Q, cfs |
| At confluence with Los Olmos | 37.3 | 7.20 | 959 | 8.50 | 1,223 | 9.70 | 1,496 | 11.10 | 1,840 |

TABLE 5-30

SALADO CREEK - STRUCTURE INVENTORY

| Section No. | Road | Structure Type | Structure Size, ft. |
|---|---|---|---|
| 1.20 | St. Hwy. 285 | 4-span Bridge | 120 x 30 |

Problem Areas

Direct flooding adjacent to the Salado Creek channel within the unincorporated areas of the county has not been identified as a problem due to the limited development in the area.

Proposed Basin Improvements and Recommendations

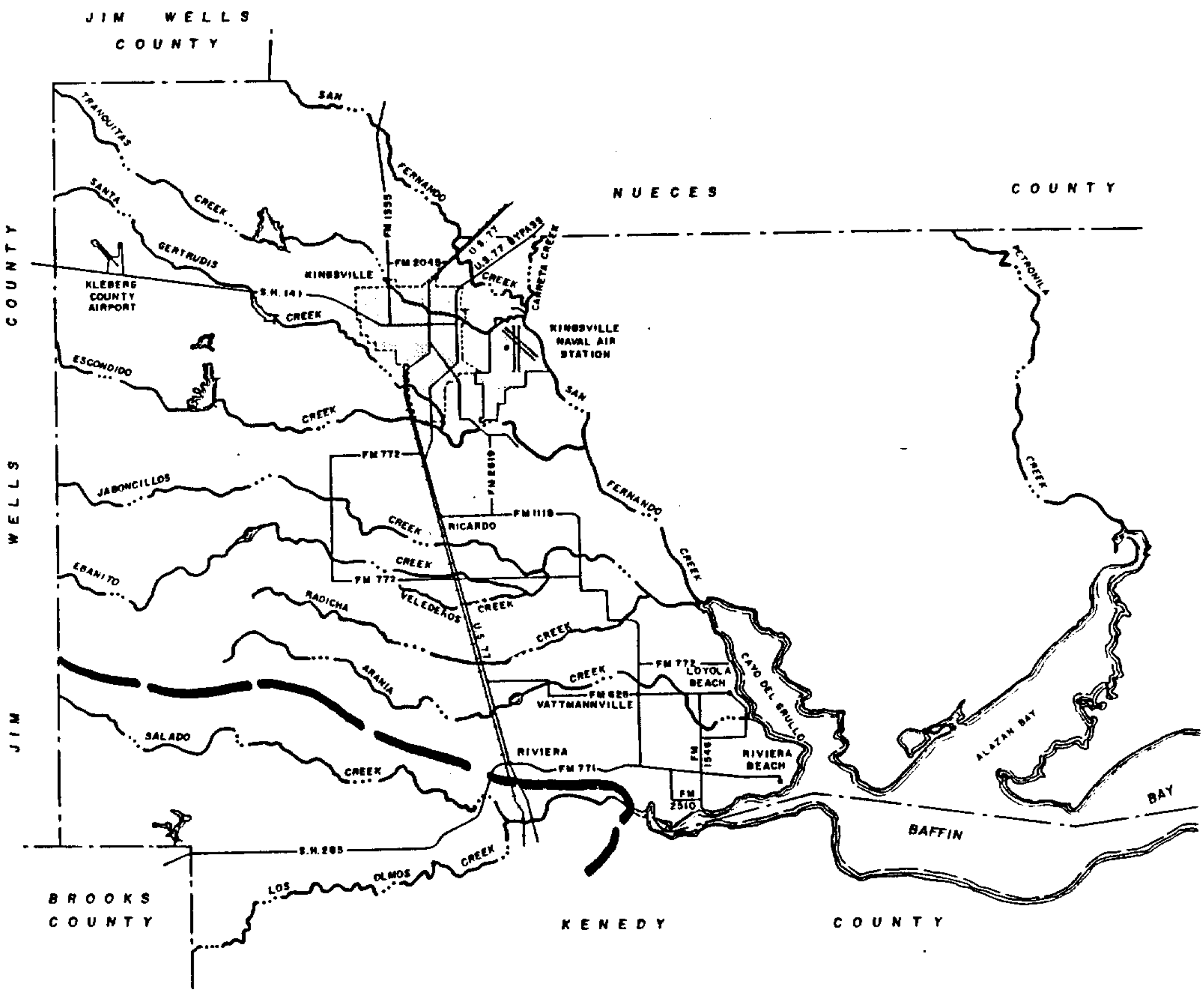
1. No improvements proposed.
2. Carefully control development in areas identified as being within the 100-year flood boundaries of Salado Creek.

Basin 11: Los Olmos Creek

Due to the limited development in the Los Olmos watershed and the low probability of any development occurring in the forseeable future, no analysis was made.

FIGURE 5-11

# LOS OLMOS CREEK – BASIN BOUNDARY




KLEBERG COUNTY
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## SECTION 6 - CAPITAL COSTS

Selection of the final master plan is dependent on the costs of implementing its solution, which in turn are a function of the level of protection provided. These costs include the capital costs to achieve the improvements and maintenance costs to sustain drainage capacity and repair damage when design storms are exceeded.

This report provides conceptual costs only. Consistent unit costs have been used throughout the County. These costs can be used as general guidelines in assessing improvement priorities and in budgeting long-range comprehensive stormwater management improvements.

Specific structure sizes and channel improvements are made here in order to define the hydraulic characteristics required to produce the water surface elevations of the master plan and to provide a basis for estimating the costs of the improvements. The final determination of these features and associated costs can not be made until a detailed engineering design has been completed.

The following summarizes the costs for the master plan improvements for the eleven basins in Kleberg County.

San Fernando Creek

1. 300-foot bridge at FM 2045

| | |
|---|---|
| Demolition of existing bridge | $ 18,000 |
| Construct new bridge | 819,000 |
| Earthwork | 378,000 |
| Subtotal Construction | $ 1,215,000 |
| Engineering and legal at 20% | $ 243,000 |
| Total | $ 1,458,000 |

2. Channelize from station 572+53 to 1,060+00 with 350-foot bottom width channel

| | |
|---|---|
| ROW (652 acres) | $ 1,304,000 |
| Clearing | 1,630,000 |
| Earthwork | 18,868,000 |
| Seeding | 642,000 |
| Subtotal Construction | $ 22,444,000 |
| Engineering and legal at 20% | $ 4,488,800 |
| Total | $ 26,932,800 |

3. 300-foot bridge at FM 1355

| | |
|---|---|
| Demolition of existing bridge | $ 18,000 |
| Construct new bridge | 819,000 |
| Earthwork | 35,000 |
| Subtotal Construction | $ 872,000 |
| Engineering and legal at 20% | $ 174,400 |
| Total | $ 1,046,400 |

TOTAL FOR SAN FERNANDO CREEK $ 29,437,200

Note: Bridge replacement at FM 1355 and channelization are partially within Nueces County.

Carreta Creek

No Improvements

Tranquitas Creek

No Improvements

Santa Gertrudis Creek

1. 300-foot bridge at FM 1717

| | |
|---|---|
| Remove existing culvert | $ 5,000 |
| Construct new bridge | 819,000 |
| Earthwork | 34,000 |
| Subtotal Construction | $ 858,000 |
| Engineering and legal at 20% | $ 171,600 |
| Total | $ 1,029,600 |

## Escondido Creek

1. 150-foot bridge at Co. Rd. 1030N

| | |
|---|---|
| Demolition of existing structure | $ 800 |
| Construct new bridge | 409,500 |
| Earthwork | 13,900 |
| Subtotal Construction | $ 424,200 |
| Engineering and legal at 20% | $ 84,900 |
| Total | $ 509,100 |

## Jaboncillos Creek

1. Channelize from station 245+55 to 422+25 with 300-foot bottom width channel

| | |
|---|---|
| ROW (157 acres) | $ 314,000 |
| Clearing | 392,500 |
| Earthwork | 3,606,400 |
| Subtotal Construction | $ 4,312,900 |
| Engineering and legal at 20% | $ 862,600 |
| Total | $ 5,175,500 |

2. 240-foot bridges at US 77

| | |
|---|---|
| Demolition of existing bridges | $ 104,000 |
| Construct new bridges | 1,310,000 |
| Subtotal Construction | $ 1,414,000 |
| Engineering and legal at 20% | $ 282,800 |
| Total | $ 1,696,800 |

3. 240-foot bridge at Mo-Pac RR

| | |
|---|---|
| Demolition of existing bridge | $ 14,000 |
| Construct new bridge | 396,000 |
| Construct Shoefly | 450,000 |
| Subtotal Construction | $ 860,000 |
| Engineering and legal at 20% | $ 172,000 |
| Total | $ 1,032,000 |

4. Add culverts at Co. Rd. 2170W, three 24-in. RCP — $ 4,500

5. Add culverts at Co. Rd. 1020, three 18-in. RCP — $ 4,000

6. 200-foot bridge at FM 772

| | | |
|---|---|---|
| Demolition of existing structure | $ | 6,000 |
| Construct new bridge | | 546,000 |
| Earthwork | | 34,000 |
| Subtotal Construction | $ | 586,000 |
| Engineering and legal at 20% | $ | 117,200 |
| Total | $ | 703,200 |
| TOTAL FOR JABONCILLOS CREEK | $ | 8,616,000 |

Ebanito Creek

1. 120-foot bridge at FM 772 (section 4.00)

| | | |
|---|---|---|
| Demolition of existing structure | $ | 6,000 |
| Construct new bridge | | 328,000 |
| Earthwork | | 107,000 |
| Subtotal Construction | $ | 441,000 |
| Engineering and legal at 20% | $ | 88,400 |
| Total | $ | 529,200 |

2. Channelize from station 130+00 to 195+00 with 120-foot bottom width channel

| | | |
|---|---|---|
| ROW (28.5 acres) | $ | 56,700 |
| Clearing | | 70,900 |
| Earthwork | | 597,000 |
| Subtotal Construction | $ | 724,600 |
| Engineering and legal at 20% | $ | 144,900 |
| Total | $ | 869,500 |

3. 120-foot bridge at FM 772 (section 4.60)

| | | |
|---|---|---|
| Demolition of existing structure | $ | 1,000 |
| Construct new bridge | | 328,000 |
| Subtotal Construction | $ | 329,000 |
| Engineering and legal at 20% | $ | 65,800 |
| Total | $ | 394,800 |

4. 120-foot bridges at US 77

| | | |
|---|---|---|
| Demolition of existing structures | $ | 50,000 |
| Construct new bridge | | 706,000 |
| Subtotal Construction | $ | 756,000 |
| Engineering and legal at 20% | $ | 151,200 |
| Total | $ | 907,200 |

5. 120-foot bridge at Mo.-Pac. RR

| | | |
|---|---|---|
| Demolition of existing structure | $ | 7,000 |
| Construct new bridge | | 198,000 |
| Construct shoefly | | 450,000 |
| Subtotal Construction | $ | 655,000 |
| Engineering and legal at 20% | $ | 131,000 |
| Total | $ | 786,000 |

6. Add culverts at Co. Rd. 1030S, three 24-in. RCP — $ 4,500

7. 120-foot bridge at FM 772 (section 4.93)

| | | |
|---|---|---|
| Demolition of existing structure | $ | 6,600 |
| Construct new bridge | | 327,600 |
| Subtotal Construction | $ | 334,200 |
| Engineering and legal at 20% | $ | 66,800 |
| Total | $ | 401,000 |

TOTAL FOR EBANITO CREEK — $ 3,892,200

Radicha Creek

No Improvements

Arania Creek

1. 100-foot bridge at FM 628 (section 2.01)

| | | |
|---|---|---|
| Demolition of existing structure | $ | 1,000 |
| Construct new bridge | | 273,000 |
| Subtotal Construction | $ | 274,000 |
| Engineering and legal at 20% | $ | 54,800 |
| Total | $ | 328,800 |

2. 100-foot bridge at FM 628 (section 2.05)

| | | |
|---|---|---|
| Demolition of existing structure | $ | 800 |
| Construct new bridge | | 273,000 |
| Subtotal Construction | $ | 273,800 |
| Engineering and legal at 20% | $ | 54,800 |
| Total | $ | 328,600 |

3. Add culverts at Co. Rd. 1090S, three 18-in. RCP — $ 4,000

4. Channelize from station 65+76 to 120+76 with 30-foot bottom width channel

| | | |
|---|---|---|
| ROW (12.6 acres) | $ | 25,200 |
| Clearing | | 31,600 |
| Earthwork | | 163,000 |
| Subtotal Construction | $ | 219,800 |
| Engineering and legal at 20% | $ | 44,000 |
| Total | $ | 263,800 |

5. 100-foot bridge at FM 628 (section 2.21)

| | | |
|---|---|---|
| Demolition of existing structure | $ | 200 |
| Construct new bridge | | 273,000 |
| Subtotal Construction | $ | 273,200 |
| Engineering and legal at 20% | $ | 54,600 |
| Total | $ | 327,800 |

6. 100-foot bridge at FM 628 (section 2.25)

| | | |
|---|---|---|
| Demolition of existing structure | $ | 200 |
| Construct new bridge | | 273,000 |
| Subtotal Construction | $ | 273,200 |
| Engineering and legal at 20% | $ | 54,600 |
| Total | $ | 327,800 |

7. 100-foot bridge at FM 628 (section 2.30)

| | | |
|---|---|---|
| Demolition of existing structure | $ | 400 |
| Construct new bridge | | 273,000 |
| Subtotal Construction | $ | 273,400 |
| Engineering and legal at 20% | $ | 54,700 |
| Total | $ | 328,100 |

TOTAL FOR ARANIA CREEK $ 1,908,900

Salado Creek

No Improvements

Los Olmos Creek

No Improvements

TOTAL IMPROVEMENTS FOR KLEBERG COUNTY = $45,393,000

Financial Plan

In order to implement the recommended masterplan improvements, Kleberg County will need to project the necessary tax rate to support the nearly $40 million worth of bonds required. By issuing short (ten year) maturities, the County would be able to complete the improvements in a reasonable amount of time with a maximum projected tax rate of $0.07 per $100 valuation. This is based on the presently available bond rate of 7.5%, available either through the Texas Water Development Board or on the open market. The County has the authority to tax at a maximum rate of $0.30 per $100 valuation for drainage improvements and road improvements and maintenance.

The following cash flow analysis and debt service schedules show how the improvements could be financed over a ten-year period. This assumes the County will issue equal issues every year over a ten-year period. The issues can be arranged in any order equalling an average of 10% per year (i.e., two issues of $20 million five years apart) and not significantly affect the debt service requirements.

Rotan Mosle Inc.

# CASH FLOW ANALYSIS

KLEBERG COUNTY FLOOD CONTROL
SERIES 1986

| YEAR | BEGINNING BALANCE | INTEREST EARNINGS | PREV.YEAR ASSESSED VALUATION | TAX RATE | COLL. FACT. | TAX REVENUE | AVAILABLE BALANCE | DEBT SERVICE | ENDING BALANCE |
|---|---|---|---|---|---|---|---|---|---|
| 1987 | $0 | $0 | $0 | 0.000% | 95% | $0 | $0 | $0 | $0 |
| 1988 | $0 | $0 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $1,702,336 | $568,250 | $25,000,000 |
| 1989 | $25,000,000 | $1,250,000 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $27,952,336 | $1,163,250 | $20,000,000 |
| 1990 | $20,000,000 | $1,000,000 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $22,702,336 | $1,749,375 | $20,952,961 |
| 1991 | $20,952,961 | $1,047,648 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $23,702,945 | $2,330,750 | $21,372,195 |
| 1992 | $21,372,195 | $1,068,610 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $24,143,140 | $2,910,875 | $21,232,265 |
| 1993 | $21,232,265 | $1,061,613 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $23,996,214 | $3,497,875 | $20,498,339 |
| 1994 | $20,498,339 | $1,024,917 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $23,225,592 | $4,079,125 | $19,146,467 |
| 1995 | $19,146,467 | $957,323 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $21,806,126 | $4,662,750 | $17,143,376 |
| 1996 | $17,143,376 | $857,169 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $19,702,881 | $5,246,125 | $14,456,756 |
| 1997 | $14,456,756 | $722,838 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $16,881,930 | $5,831,625 | $11,050,305 |
| 1998 | $11,050,305 | $552,515 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $13,305,156 | $5,241,250 | $8,063,906 |
| 1999 | $8,063,906 | $403,195 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $10,169,437 | $4,657,625 | $5,511,812 |
| 2000 | $5,511,812 | $275,591 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $7,489,738 | $4,076,875 | $3,412,863 |
| 2001 | $3,412,863 | $170,643 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $5,285,842 | $3,495,500 | $1,790,342 |
| 2002 | $1,790,342 | $89,517 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $3,582,195 | $2,910,375 | $671,820 |
| 2003 | $671,820 | $33,591 | $2,559,903,485 | 7.000% | 95% | $1,702,336 | $2,407,747 | $2,328,750 | $78,997 |
| 2004 | $78,997 | $3,950 | $2,559,903,485 | 6.900% | 95% | $1,678,017 | $1,760,963 | $1,747,500 | $13,463 |
| 2005 | $13,463 | $673 | $2,559,903,485 | 6.000% | 95% | $1,459,145 | $1,473,281 | $1,163,875 | $309,406 |
| 2006 | $309,406 | $15,470 | $2,559,903,485 | 6.000% | 95% | $1,459,145 | $1,784,022 | $580,500 | $1,203,522 |
| 2007 | $1,203,522 | $60,176 | $2,559,903,485 | 5.750% | 95% | $1,398,347 | $2,662,045 | $2,641,975 | $20,070 |

KLEBERG COUNTY FLOOD CONTROL BONDS SERIES 1987
$4,000,000

## DEBT SERVICE SCHEDULE

| DATE | PRINCIPAL | COUPON | INTEREST | PERIOD TOTAL | FISCAL TOTAL | BONDS OUTSTANDING | BONDS PAID TO DATE |
|---|---|---|---|---|---|---|---|
| 7/ 1/87 | | | 150,000.00 | 150,000.00 | | 4,000,000.00 | |
| 1/ 1/88 | 285,000.00 | 7.500000 | 150,000.00 | 435,000.00 | 585,000.00 | 3,715,000.00 | 285,000.00 |
| 7/ 1/88 | | | 139,312.50 | 139,312.50 | | 3,715,000.00 | 285,000.00 |
| 1/ 1/89 | 305,000.00 | 7.500000 | 139,312.50 | 444,312.50 | 583,625.00 | 3,410,000.00 | 590,000.00 |
| 7/ 1/89 | | | 127,875.00 | 127,875.00 | | 3,410,000.00 | 590,000.00 |
| 1/ 1/90 | 325,000.00 | 7.500000 | 127,875.00 | 452,875.00 | 580,750.00 | 3,085,000.00 | 915,000.00 |
| 7/ 1/90 | | | 115,687.50 | 115,687.50 | | 3,085,000.00 | 915,000.00 |
| 1/ 1/91 | 350,000.00 | 7.500000 | 115,687.50 | 465,687.50 | 581,375.00 | 2,735,000.00 | 1,265,000.00 |
| 7/ 1/91 | | | 102,562.50 | 102,562.50 | | 2,735,000.00 | 1,265,000.00 |
| 1/ 1/92 | 380,000.00 | 7.500000 | 102,562.50 | 482,562.50 | 585,125.00 | 2,355,000.00 | 1,645,000.00 |
| 7/ 1/92 | | | 88,312.50 | 88,312.50 | | 2,355,000.00 | 1,645,000.00 |
| 1/ 1/93 | 405,000.00 | 7.500000 | 88,312.50 | 493,312.50 | 581,625.00 | 1,950,000.00 | 2,050,000.00 |
| 7/ 1/93 | | | 73,125.00 | 73,125.00 | | 1,950,000.00 | 2,050,000.00 |
| 1/ 1/94 | 435,000.00 | 7.500000 | 73,125.00 | 508,125.00 | 581,250.00 | 1,515,000.00 | 2,485,000.00 |
| 7/ 1/94 | | | 56,812.50 | 56,812.50 | | 1,515,000.00 | 2,485,000.00 |
| 1/ 1/95 | 470,000.00 | 7.500000 | 56,812.50 | 526,812.50 | 583,625.00 | 1,045,000.00 | 2,955,000.00 |
| 7/ 1/95 | | | 39,187.50 | 39,187.50 | | 1,045,000.00 | 2,955,000.00 |
| 1/ 1/96 | 505,000.00 | 7.500000 | 39,187.50 | 544,187.50 | 583,375.00 | 540,000.00 | 3,460,000.00 |
| 7/ 1/96 | | | 20,250.00 | 20,250.00 | | 540,000.00 | 3,460,000.00 |
| 1/ 1/97 | 540,000.00 | 7.500000 | 20,250.00 | 560,250.00 | 580,500.00 | | 4,000,000.00 |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |
| ACCRUED | | | | | | | |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |

DATED 1/ 1/87 WITH DELIVERY OF 1/ 1/87
BOND YEARS 24,350.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.088
N I C % 7.5000000 % WITH A BID OF 100.000

KLEBERG COUNTY FLOOD CONTROL BONDS SERIES 1988
$4,000,000

DEBT SERVICE SCHEDULE

| DATE | PRINCIPAL | COUPON | INTEREST | PERIOD TOTAL | FISCAL TOTAL | BONDS OUTSTANDING | BONDS PAID TO DATE |
|---|---|---|---|---|---|---|---|
| | | | | | | 4,000,000.00 | |
| 7/ 1/88 | | | 150,000.00 | 150,000.00 | | | |
| 1/ 1/89 | 285,000.00 | 7.500000 | 150,000.00 | 435,000.00 | 585,000.00 | 3,715,000.00 | 285,000.00 |
| 7/ 1/89 | | | 139,312.50 | 139,312.50 | | 3,715,000.00 | 285,000.00 |
| 1/ 1/90 | 305,000.00 | 7.500000 | 139,312.50 | 444,312.50 | 583,625.00 | 3,410,000.00 | 590,000.00 |
| 7/ 1/90 | | | 127,875.00 | 127,875.00 | | 3,410,000.00 | 590,000.00 |
| 1/ 1/91 | 325,000.00 | 7.500000 | 127,875.00 | 452,875.00 | 580,750.00 | 3,085,000.00 | 915,000.00 |
| 7/ 1/91 | | | 115,687.50 | 115,687.50 | | 3,085,000.00 | 915,000.00 |
| 1/ 1/92 | 350,000.00 | 7.500000 | 115,687.50 | 465,687.50 | 581,375.00 | 2,735,000.00 | 1,265,000.00 |
| 7/ 1/92 | | | 102,562.50 | 102,562.50 | | 2,735,000.00 | 1,265,000.00 |
| 1/ 1/93 | 380,000.00 | 7.500000 | 102,562.50 | 482,562.50 | 585,125.00 | 2,355,000.00 | 1,645,000.00 |
| 7/ 1/93 | | | 88,312.50 | 88,312.50 | | 2,355,000.00 | 1,645,000.00 |
| 1/ 1/94 | 405,000.00 | 7.500000 | 88,312.50 | 493,312.50 | 581,625.00 | 1,950,000.00 | 2,050,000.00 |
| 7/ 1/94 | | | 73,125.00 | 73,125.00 | | 1,950,000.00 | 2,050,000.00 |
| 1/ 1/95 | 435,000.00 | 7.500000 | 73,125.00 | 508,125.00 | 581,250.00 | 1,515,000.00 | 2,485,000.00 |
| 7/ 1/95 | | | 56,812.50 | 56,812.50 | | 1,515,000.00 | 2,485,000.00 |
| 1/ 1/96 | 470,000.00 | 7.500000 | 56,812.50 | 526,812.50 | 583,625.00 | 1,045,000.00 | 2,955,000.00 |
| 7/ 1/96 | | | 39,187.50 | 39,187.50 | | 1,045,000.00 | 2,955,000.00 |
| 1/ 1/97 | 505,000.00 | 7.500000 | 39,187.50 | 544,187.50 | 583,375.00 | 540,000.00 | 3,460,000.00 |
| 7/ 1/97 | | | 20,250.00 | 20,250.00 | | 540,000.00 | 3,460,000.00 |
| 1/ 1/98 | 540,000.00 | 7.500000 | 20,250.00 | 560,250.00 | 580,500.00 | | 4,000,000.00 |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |
| ACCRUED | | | | | | | |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |

DATED 1/ 1/88 WITH DELIVERY OF 1/ 1/88
BOND YEARS 24,350.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.088
N I C % 7.5000000 % WITH A BID OF 100.000

KLEBERG COUNTY FLOOD CONTROL BONDS SERIES 1989
$4,000,000

DEBT SERVICE SCHEDULE

| DATE | PRINCIPAL | COUPON | INTEREST | PERIOD TOTAL | FISCAL TOTAL | BONDS OUTSTANDING | BONDS PAID TO DATE |
|---|---|---|---|---|---|---|---|
| 7/ 1/89 | | | 150,000.00 | 150,000.00 | | 4,000,000.00 | |
| 1/ 1/90 | 285,000.00 | 7.500000 | 150,000.00 | 435,000.00 | 585,000.00 | 3,715,000.00 | 285,000.00 |
| 7/ 1/90 | | | 139,312.50 | 139,312.50 | | 3,715,000.00 | 285,000.00 |
| 1/ 1/91 | 305,000.00 | 7.500000 | 139,312.50 | 444,312.50 | 583,625.00 | 3,410,000.00 | 590,000.00 |
| 7/ 1/91 | | | 127,875.00 | 127,875.00 | | 3,410,000.00 | 590,000.00 |
| 1/ 1/92 | 325,000.00 | 7.500000 | 127,875.00 | 452,875.00 | 580,750.00 | 3,085,000.00 | 915,000.00 |
| 7/ 1/92 | | | 115,687.50 | 115,687.50 | | 3,085,000.00 | 915,000.00 |
| 1/ 1/93 | 350,000.00 | 7.500000 | 115,687.50 | 465,687.50 | 581,375.00 | 2,735,000.00 | 1,265,000.00 |
| 7/ 1/93 | | | 102,562.50 | 102,562.50 | | 2,735,000.00 | 1,265,000.00 |
| 1/ 1/94 | 380,000.00 | 7.500000 | 102,562.50 | 482,562.50 | 585,125.00 | 2,355,000.00 | 1,645,000.00 |
| 7/ 1/94 | | | 88,312.50 | 88,312.50 | | 2,355,000.00 | 1,645,000.00 |
| 1/ 1/95 | 405,000.00 | 7.500000 | 88,312.50 | 493,312.50 | 581,625.00 | 1,950,000.00 | 2,050,000.00 |
| 7/ 1/95 | | | 73,125.00 | 73,125.00 | | 1,950,000.00 | 2,050,000.00 |
| 1/ 1/96 | 435,000.00 | 7.500000 | 73,125.00 | 508,125.00 | 581,250.00 | 1,515,000.00 | 2,485,000.00 |
| 7/ 1/96 | | | 56,812.50 | 56,812.50 | | 1,515,000.00 | 2,485,000.00 |
| 1/ 1/97 | 470,000.00 | 7.500000 | 56,812.50 | 526,812.50 | 583,625.00 | 1,045,000.00 | 2,955,000.00 |
| 7/ 1/97 | | | 39,187.50 | 39,187.50 | | 1,045,000.00 | 2,955,000.00 |
| 1/ 1/98 | 505,000.00 | 7.500000 | 39,187.50 | 544,187.50 | 583,375.00 | 540,000.00 | 3,460,000.00 |
| 7/ 1/98 | | | 20,250.00 | 20,250.00 | | 540,000.00 | 3,460,000.00 |
| 1/ 1/99 | 540,000.00 | 7.500000 | 20,250.00 | 560,250.00 | 580,500.00 | | 4,000,000.00 |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |
| ACCRUED | | | | | | | |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |

DATED 1/ 1/89 WITH DELIVERY OF 1/ 1/89
BOND YEARS 24,350.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.088
N I C % 7.5000000 % WITH A BID OF 100.000

KLEBERG COUNTY FLOOD CONTROL BONDS SERIES 1990
$4,000,000

## DEBT SERVICE SCHEDULE

| DATE | PRINCIPAL | COUPON | INTEREST | PERIOD TOTAL | FISCAL TOTAL | BONDS OUTSTANDING | BONDS PAID TO DATE |
|---|---|---|---|---|---|---|---|
| 7/ 1/90 | | | 150,000.00 | 150,000.00 | | 4,000,000.00 | |
| 1/ 1/91 | 285,000.00 | 7.500000 | 150,000.00 | 435,000.00 | 585,000.00 | 3,715,000.00 | 285,000.00 |
| 7/ 1/91 | | | 139,312.50 | 139,312.50 | | 3,715,000.00 | 285,000.00 |
| 1/ 1/92 | 305,000.00 | 7.500000 | 139,312.50 | 444,312.50 | 583,625.00 | 3,410,000.00 | 590,000.00 |
| 7/ 1/92 | | | 127,875.00 | 127,875.00 | | 3,410,000.00 | 590,000.00 |
| 1/ 1/93 | 325,000.00 | 7.500000 | 127,875.00 | 452,875.00 | 580,750.00 | 3,085,000.00 | 915,000.00 |
| 7/ 1/93 | | | 115,687.50 | 115,687.50 | | 3,085,000.00 | 915,000.00 |
| 1/ 1/94 | 350,000.00 | 7.500000 | 115,687.50 | 465,687.50 | 581,375.00 | 2,735,000.00 | 1,265,000.00 |
| 7/ 1/94 | | | 102,562.50 | 102,562.50 | | 2,735,000.00 | 1,265,000.00 |
| 1/ 1/95 | 380,000.00 | 7.500000 | 102,562.50 | 482,562.50 | 585,125.00 | 2,355,000.00 | 1,645,000.00 |
| 7/ 1/95 | | | 88,312.50 | 88,312.50 | | 2,355,000.00 | 1,645,000.00 |
| 1/ 1/96 | 405,000.00 | 7.500000 | 88,312.50 | 493,312.50 | 581,625.00 | 1,950,000.00 | 2,050,000.00 |
| 7/ 1/96 | | | 73,125.00 | 73,125.00 | | 1,950,000.00 | 2,050,000.00 |
| 1/ 1/97 | 435,000.00 | 7.500000 | 73,125.00 | 508,125.00 | 581,250.00 | 1,515,000.00 | 2,485,000.00 |
| 7/ 1/97 | | | 56,812.50 | 56,812.50 | | 1,515,000.00 | 2,485,000.00 |
| 1/ 1/98 | 470,000.00 | 7.500000 | 56,812.50 | 526,812.50 | 583,625.00 | 1,045,000.00 | 2,955,000.00 |
| 7/ 1/98 | | | 39,187.50 | 39,187.50 | | 1,045,000.00 | 2,955,000.00 |
| 1/ 1/99 | 505,000.00 | 7.500000 | 39,187.50 | 544,187.50 | 583,375.00 | 540,000.00 | 3,460,000.00 |
| 7/ 1/99 | | | 20,250.00 | 20,250.00 | | 540,000.00 | 3,460,000.00 |
| 1/ 1/ 0 | 540,000.00 | 7.500000 | 20,250.00 | 560,250.00 | 580,500.00 | | 4,000,000.00 |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |
| ACCRUED | | | | | | | |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |

DATED 1/ 1/90 WITH DELIVERY OF 1/ 1/90
BOND YEARS 24,350.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.088
N I C % 7.5000000 % WITH A BID OF 100.000

KLEBERG COUNTY FLOOD CONTROL BONDS SERIES 1991
$4,000,000

DEBT SERVICE SCHEDULE

| DATE | PRINCIPAL | COUPON | INTEREST | PERIOD TOTAL | FISCAL TOTAL | BONDS OUTSTANDING | BONDS PAID TO DATE |
|---|---|---|---|---|---|---|---|
| 7/ 1/91 | | | 150,000.00 | 150,000.00 | | 4,000,000.00 | |
| 1/ 1/92 | 285,000.00 | 7.500000 | 150,000.00 | 435,000.00 | 585,000.00 | 3,715,000.00 | 285,000.00 |
| 7/ 1/92 | | | 139,312.50 | 139,312.50 | | 3,715,000.00 | 285,000.00 |
| 1/ 1/93 | 305,000.00 | 7.500000 | 139,312.50 | 444,312.50 | 583,625.00 | 3,410,000.00 | 590,000.00 |
| 7/ 1/93 | | | 127,875.00 | 127,875.00 | | 3,410,000.00 | 590,000.00 |
| 1/ 1/94 | 325,000.00 | 7.500000 | 127,875.00 | 452,875.00 | 580,750.00 | 3,085,000.00 | 915,000.00 |
| 7/ 1/94 | | | 115,687.50 | 115,687.50 | | 3,085,000.00 | 915,000.00 |
| 1/ 1/95 | 350,000.00 | 7.500000 | 115,687.50 | 465,687.50 | 581,375.00 | 2,735,000.00 | 1,265,000.00 |
| 7/ 1/95 | | | 102,562.50 | 102,562.50 | | 2,735,000.00 | 1,265,000.00 |
| 1/ 1/96 | 380,000.00 | 7.500000 | 102,562.50 | 482,562.50 | 585,125.00 | 2,355,000.00 | 1,645,000.00 |
| 7/ 1/96 | | | 88,312.50 | 88,312.50 | | 2,355,000.00 | 1,645,000.00 |
| 1/ 1/97 | 405,000.00 | 7.500000 | 88,312.50 | 493,312.50 | 581,625.00 | 1,950,000.00 | 2,050,000.00 |
| 7/ 1/97 | | | 73,125.00 | 73,125.00 | | 1,950,000.00 | 2,050,000.00 |
| 1/ 1/98 | 435,000.00 | 7.500000 | 73,125.00 | 508,125.00 | 581,250.00 | 1,515,000.00 | 2,485,000.00 |
| 7/ 1/98 | | | 56,812.50 | 56,812.50 | | 1,515,000.00 | 2,485,000.00 |
| 1/ 1/99 | 470,000.00 | 7.500000 | 56,812.50 | 526,812.50 | 583,625.00 | 1,045,000.00 | 2,955,000.00 |
| 7/ 1/99 | | | 39,187.50 | 39,187.50 | | 1,045,000.00 | 2,955,000.00 |
| 1/ 1/ 0 | 505,000.00 | 7.500000 | 39,187.50 | 544,187.50 | 583,375.00 | 540,000.00 | 3,460,000.00 |
| 7/ 1/ 0 | | | 20,250.00 | 20,250.00 | | 540,000.00 | 3,460,000.00 |
| 1/ 1/ 1 | 540,000.00 | 7.500000 | 20,250.00 | 560,250.00 | 580,500.00 | | 4,000,000.00 |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |
| ACCRUED | | | | | | | |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |

DATED 1/ 1/91 WITH DELIVERY OF 1/ 1/91
BOND YEARS 24,350.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.088
N I C % 7.5000000 % WITH A BID OF 100.000

KLEBERG COUNTY FLOOD CONTROL BONDS SERIES 1992
$4,000,000

DEBT SERVICE SCHEDULE

| DATE | PRINCIPAL | COUPON | INTEREST | PERIOD TOTAL | FISCAL TOTAL | BONDS OUTSTANDING | BONDS PAID TO DATE |
|---|---|---|---|---|---|---|---|
| 7/ 1/92 | | | 150,000.00 | 150,000.00 | | 4,000,000.00 | |
| 1/ 1/93 | 285,000.00 | 7.500000 | 150,000.00 | 435,000.00 | 585,000.00 | 3,715,000.00 | 285,000.00 |
| 7/ 1/93 | | | 139,312.50 | 139,312.50 | | 3,715,000.00 | 285,000.00 |
| 1/ 1/94 | 305,000.00 | 7.500000 | 139,312.50 | 444,312.50 | 583,625.00 | 3,410,000.00 | 590,000.00 |
| 7/ 1/94 | | | 127,875.00 | 127,875.00 | | 3,410,000.00 | 590,000.00 |
| 1/ 1/95 | 325,000.00 | 7.500000 | 127,875.00 | 452,875.00 | 580,750.00 | 3,085,000.00 | 915,000.00 |
| 7/ 1/95 | | | 115,687.50 | 115,687.50 | | 3,085,000.00 | 915,000.00 |
| 1/ 1/96 | 350,000.00 | 7.500000 | 115,687.50 | 465,687.50 | 581,375.00 | 2,735,000.00 | 1,265,000.00 |
| 7/ 1/96 | | | 102,562.50 | 102,562.50 | | 2,735,000.00 | 1,265,000.00 |
| 1/ 1/97 | 380,000.00 | 7.500000 | 102,562.50 | 482,562.50 | 585,125.00 | 2,355,000.00 | 1,645,000.00 |
| 7/ 1/97 | | | 88,312.50 | 88,312.50 | | 2,355,000.00 | 1,645,000.00 |
| 1/ 1/98 | 405,000.00 | 7.500000 | 88,312.50 | 493,312.50 | 581,625.00 | 1,950,000.00 | 2,050,000.00 |
| 7/ 1/98 | | | 73,125.00 | 73,125.00 | | 1,950,000.00 | 2,050,000.00 |
| 1/ 1/99 | 435,000.00 | 7.500000 | 73,125.00 | 508,125.00 | 581,250.00 | 1,515,000.00 | 2,485,000.00 |
| 7/ 1/99 | | | 56,812.50 | 56,812.50 | | 1,515,000.00 | 2,485,000.00 |
| 1/ 1/ 0 | 470,000.00 | 7.500000 | 56,812.50 | 526,812.50 | 583,625.00 | 1,045,000.00 | 2,955,000.00 |
| 7/ 1/ 0 | | | 39,187.50 | 39,187.50 | | 1,045,000.00 | 2,955,000.00 |
| 1/ 1/ 1 | 505,000.00 | 7.500000 | 39,187.50 | 544,187.50 | 583,375.00 | 540,000.00 | 3,460,000.00 |
| 7/ 1/ 1 | | | 20,250.00 | 20,250.00 | | 540,000.00 | 3,460,000.00 |
| 1/ 1/ 2 | 540,000.00 | 7.500000 | 20,250.00 | 560,250.00 | 580,500.00 | | 4,000,000.00 |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |
| ACCRUED | | | | | | | |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |

DATED 1/ 1/92 WITH DELIVERY OF 1/ 1/92
BOND YEARS 24,350.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.088
N I C % 7.5000000 % WITH A BID OF 100.000

KLEBERG COUNTY FLOOD CONTROL BONDS SERIES 1993
$4,000,000

## DEBT SERVICE SCHEDULE

| DATE | PRINCIPAL | COUPON | INTEREST | PERIOD TOTAL | FISCAL TOTAL | BONDS OUTSTANDING | BONDS PAID TO DATE |
|---|---|---|---|---|---|---|---|
| 7/ 1/93 | | | 150,000.00 | 150,000.00 | | 4,000,000.00 | |
| 1/ 1/94 | 285,000.00 | 7.500000 | 150,000.00 | 435,000.00 | 585,000.00 | 3,715,000.00 | 285,000.00 |
| 7/ 1/94 | | | 139,312.50 | 139,312.50 | | 3,715,000.00 | 285,000.00 |
| 1/ 1/95 | 305,000.00 | 7.500000 | 139,312.50 | 444,312.50 | 583,625.00 | 3,410,000.00 | 590,000.00 |
| 7/ 1/95 | | | 127,875.00 | 127,875.00 | | 3,410,000.00 | 590,000.00 |
| 1/ 1/96 | 325,000.00 | 7.500000 | 127,875.00 | 452,875.00 | 580,750.00 | 3,085,000.00 | 915,000.00 |
| 7/ 1/96 | | | 115,687.50 | 115,687.50 | | 3,085,000.00 | 915,000.00 |
| 1/ 1/97 | 350,000.00 | 7.500000 | 115,687.50 | 465,687.50 | 581,375.00 | 2,735,000.00 | 1,265,000.00 |
| 7/ 1/97 | | | 102,562.50 | 102,562.50 | | 2,735,000.00 | 1,265,000.00 |
| 1/ 1/98 | 380,000.00 | 7.500000 | 102,562.50 | 482,562.50 | 585,125.00 | 2,355,000.00 | 1,645,000.00 |
| 7/ 1/98 | | | 88,312.50 | 88,312.50 | | 2,355,000.00 | 1,645,000.00 |
| 1/ 1/99 | 405,000.00 | 7.500000 | 88,312.50 | 493,312.50 | 581,625.00 | 1,950,000.00 | 2,050,000.00 |
| 7/ 1/99 | | | 73,125.00 | 73,125.00 | | 1,950,000.00 | 2,050,000.00 |
| 1/ 1/ 0 | 435,000.00 | 7.500000 | 73,125.00 | 508,125.00 | 581,250.00 | 1,515,000.00 | 2,485,000.00 |
| 7/ 1/ 0 | | | 56,812.50 | 56,812.50 | | 1,515,000.00 | 2,485,000.00 |
| 1/ 1/ 1 | 470,000.00 | 7.500000 | 56,812.50 | 526,812.50 | 583,625.00 | 1,045,000.00 | 2,955,000.00 |
| 7/ 1/ 1 | | | 39,187.50 | 39,187.50 | | 1,045,000.00 | 2,955,000.00 |
| 1/ 1/ 2 | 505,000.00 | 7.500000 | 39,187.50 | 544,187.50 | 583,375.00 | 540,000.00 | 3,460,000.00 |
| 7/ 1/ 2 | | | 20,250.00 | 20,250.00 | | 540,000.00 | 3,460,000.00 |
| 1/ 1/ 3 | 540,000.00 | 7.500000 | 20,250.00 | 560,250.00 | 580,500.00 | | 4,000,000.00 |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |
| ACCRUED | | | | | | | |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |

DATED 1/ 1/93 WITH DELIVERY OF 1/ 1/93
BOND YEARS 24,350.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.088
N I C % 7.5000000 % WITH A BID OF 100.000

KLEBERG COUNTY FLOOD CONTROL BONDS SERIES 1994
$4,000,000

DEBT SERVICE SCHEDULE

| DATE | PRINCIPAL | COUPON | INTEREST | PERIOD TOTAL | FISCAL TOTAL | BONDS OUTSTANDING | BONDS PAID TO DATE |
|---|---|---|---|---|---|---|---|
| 7/ 1/94 | | | 150,000.00 | 150,000.00 | | 4,000,000.00 | |
| 1/ 1/95 | 285,000.00 | 7.500000 | 150,000.00 | 435,000.00 | 585,000.00 | 3,715,000.00 | 285,000.00 |
| 7/ 1/95 | | | 139,312.50 | 139,312.50 | | 3,715,000.00 | 285,000.00 |
| 1/ 1/96 | 305,000.00 | 7.500000 | 139,312.50 | 444,312.50 | 583,625.00 | 3,410,000.00 | 590,000.00 |
| 7/ 1/96 | | | 127,875.00 | 127,875.00 | | 3,410,000.00 | 590,000.00 |
| 1/ 1/97 | 325,000.00 | 7.500000 | 127,875.00 | 452,875.00 | 580,750.00 | 3,085,000.00 | 915,000.00 |
| 7/ 1/97 | | | 115,687.50 | 115,687.50 | | 3,085,000.00 | 915,000.00 |
| 1/ 1/98 | 350,000.00 | 7.500000 | 115,687.50 | 465,687.50 | 581,375.00 | 2,735,000.00 | 1,265,000.00 |
| 7/ 1/98 | | | 102,562.50 | 102,562.50 | | 2,735,000.00 | 1,265,000.00 |
| 1/ 1/99 | 380,000.00 | 7.500000 | 102,562.50 | 482,562.50 | 585,125.00 | 2,355,000.00 | 1,645,000.00 |
| 7/ 1/99 | | | 88,312.50 | 88,312.50 | | 2,355,000.00 | 1,645,000.00 |
| 1/ 1/ 0 | 405,000.00 | 7.500000 | 88,312.50 | 493,312.50 | 581,625.00 | 1,950,000.00 | 2,050,000.00 |
| 7/ 1/ 0 | | | 73,125.00 | 73,125.00 | | 1,950,000.00 | 2,050,000.00 |
| 1/ 1/ 1 | 435,000.00 | 7.500000 | 73,125.00 | 508,125.00 | 581,250.00 | 1,515,000.00 | 2,485,000.00 |
| 7/ 1/ 1 | | | 56,812.50 | 56,812.50 | | 1,515,000.00 | 2,485,000.00 |
| 1/ 1/ 2 | 470,000.00 | 7.500000 | 56,812.50 | 526,812.50 | 583,625.00 | 1,045,000.00 | 2,955,000.00 |
| 7/ 1/ 2 | | | 39,187.50 | 39,187.50 | | 1,045,000.00 | 2,955,000.00 |
| 1/ 1/ 3 | 505,000.00 | 7.500000 | 39,187.50 | 544,187.50 | 583,375.00 | 540,000.00 | 3,460,000.00 |
| 7/ 1/ 3 | | | 20,250.00 | 20,250.00 | | 540,000.00 | 3,460,000.00 |
| 1/ 1/ 4 | 540,000.00 | 7.500000 | 20,250.00 | 560,250.00 | 580,500.00 | | 4,000,000.00 |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |
| ACCRUED | | | | | | | |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |

DATED 1/ 1/94 WITH DELIVERY OF 1/ 1/94
BOND YEARS 24,350.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.088
N I C % 7.5000000 % WITH A BID OF 100.000

KLEBERG COUNTY FLOOD CONTROL BONDS SERIES 1995
$4,000,000

## DEBT SERVICE SCHEDULE

| DATE | PRINCIPAL | COUPON | INTEREST | PERIOD TOTAL | FISCAL TOTAL | BONDS OUTSTANDING | BONDS PAID TO DATE |
|---|---|---|---|---|---|---|---|
| 7/ 1/95 | | | 150,000.00 | 150,000.00 | | 4,000,000.00 | |
| 1/ 1/96 | 285,000.00 | 7.500000 | 150,000.00 | 435,000.00 | 585,000.00 | 3,715,000.00 | 285,000.00 |
| 7/ 1/96 | | | 139,312.50 | 139,312.50 | | 3,715,000.00 | 285,000.00 |
| 1/ 1/97 | 305,000.00 | 7.500000 | 139,312.50 | 444,312.50 | 583,625.00 | 3,410,000.00 | 590,000.00 |
| 7/ 1/97 | | | 127,875.00 | 127,875.00 | | 3,410,000.00 | 590,000.00 |
| 1/ 1/98 | 325,000.00 | 7.500000 | 127,875.00 | 452,875.00 | 580,750.00 | 3,085,000.00 | 915,000.00 |
| 7/ 1/98 | | | 115,687.50 | 115,687.50 | | 3,085,000.00 | 915,000.00 |
| 1/ 1/99 | 350,000.00 | 7.500000 | 115,687.50 | 465,687.50 | 581,375.00 | 2,735,000.00 | 1,265,000.00 |
| 7/ 1/99 | | | 102,562.50 | 102,562.50 | | 2,735,000.00 | 1,265,000.00 |
| 1/ 1/ 0 | 380,000.00 | 7.500000 | 102,562.50 | 482,562.50 | 585,125.00 | 2,355,000.00 | 1,645,000.00 |
| 7/ 1/ 0 | | | 88,312.50 | 88,312.50 | | 2,355,000.00 | 1,645,000.00 |
| 1/ 1/ 1 | 405,000.00 | 7.500000 | 88,312.50 | 493,312.50 | 581,625.00 | 1,950,000.00 | 2,050,000.00 |
| 7/ 1/ 1 | | | 73,125.00 | 73,125.00 | | 1,950,000.00 | 2,050,000.00 |
| 1/ 1/ 2 | 435,000.00 | 7.500000 | 73,125.00 | 508,125.00 | 581,250.00 | 1,515,000.00 | 2,485,000.00 |
| 7/ 1/ 2 | | | 56,812.50 | 56,812.50 | | 1,515,000.00 | 2,485,000.00 |
| 1/ 1/ 3 | 470,000.00 | 7.500000 | 56,812.50 | 526,812.50 | 583,625.00 | 1,045,000.00 | 2,955,000.00 |
| 7/ 1/ 3 | | | 39,187.50 | 39,187.50 | | 1,045,000.00 | 2,955,000.00 |
| 1/ 1/ 4 | 505,000.00 | 7.500000 | 39,187.50 | 544,187.50 | 583,375.00 | 540,000.00 | 3,460,000.00 |
| 7/ 1/ 4 | | | 20,250.00 | 20,250.00 | | 540,000.00 | 3,460,000.00 |
| 1/ 1/ 5 | 540,000.00 | 7.500000 | 20,250.00 | 560,250.00 | 580,500.00 | | 4,000,000.00 |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |
| ACCRUED | | | | | | | |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |

DATED 1/ 1/95 WITH DELIVERY OF 1/ 1/95
BOND YEARS 24,350.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.088
N I C % 7.5000000 % WITH A BID OF 100.000

KLEBERG COUNTY FLOOD CONTROL BONDS SERIES 1996
$4,000,000

DEBT SERVICE SCHEDULE

| DATE | PRINCIPAL | COUPON | INTEREST | PERIOD TOTAL | FISCAL TOTAL | BONDS OUTSTANDING | BONDS PAID TO DATE |
|---|---|---|---|---|---|---|---|
| 7/ 1/96 | | | 150,000.00 | 150,000.00 | | 4,000,000.00 | |
| 1/ 1/97 | 285,000.00 | 7.500000 | 150,000.00 | 435,000.00 | 585,000.00 | 3,715,000.00 | 285,000.00 |
| 7/ 1/97 | | | 139,312.50 | 139,312.50 | | 3,715,000.00 | 285,000.00 |
| 1/ 1/98 | 305,000.00 | 7.500000 | 139,312.50 | 444,312.50 | 583,625.00 | 3,410,000.00 | 590,000.00 |
| 7/ 1/98 | | | 127,875.00 | 127,875.00 | | 3,410,000.00 | 590,000.00 |
| 1/ 1/99 | 325,000.00 | 7.500000 | 127,875.00 | 452,875.00 | 580,750.00 | 3,085,000.00 | 915,000.00 |
| 7/ 1/99 | | | 115,687.50 | 115,687.50 | | 3,085,000.00 | 915,000.00 |
| 1/ 1/ 0 | 350,000.00 | 7.500000 | 115,687.50 | 465,687.50 | 581,375.00 | 2,735,000.00 | 1,265,000.00 |
| 7/ 1/ 0 | | | 102,562.50 | 102,562.50 | | 2,735,000.00 | 1,265,000.00 |
| 1/ 1/ 1 | 380,000.00 | 7.500000 | 102,562.50 | 482,562.50 | 585,125.00 | 2,355,000.00 | 1,645,000.00 |
| 7/ 1/ 1 | | | 88,312.50 | 88,312.50 | | 2,355,000.00 | 1,645,000.00 |
| 1/ 1/ 2 | 405,000.00 | 7.500000 | 88,312.50 | 493,312.50 | 581,625.00 | 1,950,000.00 | 2,050,000.00 |
| 7/ 1/ 2 | | | 73,125.00 | 73,125.00 | | 1,950,000.00 | 2,050,000.00 |
| 1/ 1/ 3 | 435,000.00 | 7.500000 | 73,125.00 | 508,125.00 | 581,250.00 | 1,515,000.00 | 2,485,000.00 |
| 7/ 1/ 3 | | | 56,812.50 | 56,812.50 | | 1,515,000.00 | 2,485,000.00 |
| 1/ 1/ 4 | 470,000.00 | 7.500000 | 56,812.50 | 526,812.50 | 583,625.00 | 1,045,000.00 | 2,955,000.00 |
| 7/ 1/ 4 | | | 39,187.50 | 39,187.50 | | 1,045,000.00 | 2,955,000.00 |
| 1/ 1/ 5 | 505,000.00 | 7.500000 | 39,187.50 | 544,187.50 | 583,375.00 | 540,000.00 | 3,460,000.00 |
| 7/ 1/ 5 | | | 20,250.00 | 20,250.00 | | 540,000.00 | 3,460,000.00 |
| 1/ 1/ 6 | 540,000.00 | 7.500000 | 20,250.00 | 560,250.00 | 580,500.00 | | 4,000,000.00 |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |
| ACCRUED | | | | | | | |
| | 4,000,000.00 | | 1,826,250.00 | 5,826,250.00 | | | |

DATED 1/ 1/96 WITH DELIVERY OF 1/ 1/96
BOND YEARS 24,350.000
AVERAGE COUPON 7.500
AVERAGE LIFE 6.088
N I C % 7.5000000 % WITH A BID OF 100.000

DEBT SERVICE SCHEDULE

| DATE | PRINCIPAL | COUPON | INTEREST | PERIOD TOTAL | FISCAL TOTAL | BONDS OUTSTANDING | BONDS PAID TO DATE |
|---|---|---|---|---|---|---|---|
| 7/ 1/87 | | | 139,125.00 | 139,125.00 | | 40,000,000.00 | |
| 1/ 1/88 | 290,000.00 | | 139,125.00 | 429,125.00 | 568,250.00 | 39,710,000.00 | 290,000.00 |
| 7/ 1/88 | | | 289,125.00 | 289,125.00 | | 39,710,000.00 | 290,000.00 |
| 1/ 1/89 | 585,000.00 | | 289,125.00 | 874,125.00 | 1,163,250.00 | 39,125,000.00 | 875,000.00 |
| 7/ 1/89 | | | 417,187.50 | 417,187.50 | | 39,125,000.00 | 875,000.00 |
| 1/ 1/90 | 915,000.00 | | 417,187.50 | 1,332,187.50 | 1,749,375.00 | 38,210,000.00 | 1,790,000.00 |
| 7/ 1/90 | | | 532,875.00 | 532,875.00 | | 38,210,000.00 | 1,790,000.00 |
| 1/ 1/91 | 1,265,000.00 | | 532,875.00 | 1,797,875.00 | 2,330,750.00 | 36,945,000.00 | 3,055,000.00 |
| 7/ 1/91 | | | 635,437.50 | 635,437.50 | | 36,945,000.00 | 3,055,000.00 |
| 1/ 1/92 | 1,640,000.00 | | 635,437.50 | 2,275,437.50 | 2,910,875.00 | 35,305,000.00 | 4,695,000.00 |
| 7/ 1/92 | | | 723,937.50 | 723,937.50 | | 35,305,000.00 | 4,695,000.00 |
| 1/ 1/93 | 2,050,000.00 | | 723,937.50 | 2,773,937.50 | 3,497,875.00 | 33,255,000.00 | 6,745,000.00 |
| 7/ 1/93 | | | 797,062.50 | 797,062.50 | | 33,255,000.00 | 6,745,000.00 |
| 1/ 1/94 | 2,485,000.00 | | 797,062.50 | 3,282,062.50 | 4,079,125.00 | 30,770,000.00 | 9,230,000.00 |
| 7/ 1/94 | | | 853,875.00 | 853,875.00 | | 30,770,000.00 | 9,230,000.00 |
| 1/ 1/95 | 2,955,000.00 | | 853,875.00 | 3,808,875.00 | 4,662,750.00 | 27,815,000.00 | 12,185,000.00 |
| 7/ 1/95 | | | 893,062.50 | 893,062.50 | | 27,815,000.00 | 12,185,000.00 |
| 1/ 1/96 | 3,460,000.00 | | 893,062.50 | 4,353,062.50 | 5,246,125.00 | 24,355,000.00 | 15,645,000.00 |
| 7/ 1/96 | | | 913,312.50 | 913,312.50 | | 24,355,000.00 | 15,645,000.00 |
| 1/ 1/97 | 4,005,000.00 | | 913,312.50 | 4,918,312.50 | 5,831,625.00 | 20,350,000.00 | 19,650,000.00 |
| 7/ 1/97 | | | 763,125.00 | 763,125.00 | | 20,350,000.00 | 19,650,000.00 |
| 1/ 1/98 | 3,715,000.00 | | 763,125.00 | 4,478,125.00 | 5,241,250.00 | 16,635,000.00 | 23,365,000.00 |
| 7/ 1/98 | | | 623,812.50 | 623,812.50 | | 16,635,000.00 | 23,365,000.00 |
| 1/ 1/99 | 3,410,000.00 | | 623,812.50 | 4,033,812.50 | 4,657,625.00 | 13,225,000.00 | 26,775,000.00 |
| 7/ 1/99 | | | 495,937.50 | 495,937.50 | | 13,225,000.00 | 26,775,000.00 |
| 1/ 1/ 0 | 3,085,000.00 | | 495,937.50 | 3,580,937.50 | 4,076,875.00 | 10,140,000.00 | 29,860,000.00 |
| 7/ 1/ 0 | | | 380,250.00 | 380,250.00 | | 10,140,000.00 | 29,860,000.00 |
| 1/ 1/ 1 | 2,735,000.00 | | 380,250.00 | 3,115,250.00 | 3,495,500.00 | 7,405,000.00 | 32,595,000.00 |
| 7/ 1/ 1 | | | 277,687.50 | 277,687.50 | | 7,405,000.00 | 32,595,000.00 |
| 1/ 1/ 2 | 2,355,000.00 | | 277,687.50 | 2,632,687.50 | 2,910,375.00 | 5,050,000.00 | 34,950,000.00 |
| 7/ 1/ 2 | | | 189,375.00 | 189,375.00 | | 5,050,000.00 | 34,950,000.00 |
| 1/ 1/ 3 | 1,950,000.00 | | 189,375.00 | 2,139,375.00 | 2,328,750.00 | 3,100,000.00 | 36,900,000.00 |
| 7/ 1/ 3 | | | 116,250.00 | 116,250.00 | | 3,100,000.00 | 36,900,000.00 |
| 1/ 1/ 4 | 1,515,000.00 | | 116,250.00 | 1,631,250.00 | 1,747,500.00 | 1,585,000.00 | 38,415,000.00 |
| 7/ 1/ 4 | | | 59,437.50 | 59,437.50 | | 1,585,000.00 | 38,415,000.00 |
| 1/ 1/ 5 | 1,045,000.00 | | 59,437.50 | 1,104,437.50 | 1,163,875.00 | 540,000.00 | 39,460,000.00 |
| 7/ 1/ 5 | | | 20,250.00 | 20,250.00 | | 540,000.00 | 39,460,000.00 |
| 1/ 1/ 6 | 540,000.00 | | 20,250.00 | 560,250.00 | 580,500.00 | | 40,000,000.00 |
| | 40,000,000.00 | | 18,242,250.00 | 58,242,250.00 | | | |
| ACCRUED | | | | | | | |
| | 40,000,000.00 | | 18,242,250.00 | 58,242,250.00 | | | |

DEBT SERVICE SCHEDULE

# SECTION 7 - ENVIRONMENTAL IMPACT

An important aspect of the process of evaluating drainage improvements in Kleberg County is to analyze the potential effects on downstream estuarine systems. This evaluation requires descriptions of potentially affected drainages and estuaries with regard to the proposed drainage improvements, and an estuarine impact assessment based on a literature review covering major data sources for the project area.

The principal improvements recommended in Section 5 involved enlarging channel sections, or reaches, that cause flooding due to inadequate capacity, and replacing drainage structures that presently retard flood flows or are overtopped during high water. The reaches recommended for improvement lie within the San Fernando, Jaboncillos, and Arania Creek basins in Kleberg County that discharge into the Cayo del Grullo. The extent and location of these improvements are shown on the Stormwater Master Plan profiles. This environmental section will also include impact assessments for the Oso Creek drainage area in Nueces County and the Petronila Creek drainage area in both Nueces County and Kleberg County.

For the following drainage basin discussions, hydrologic characteristics of the receiving streams and processes within the estuaries were defined from existing literature and from the hydrological engineering study. The end-results of these detailed descriptions are the environmental impact projections associated with the proposed drainage improvements in the study region.

## AFFECTED DRAINAGE AREAS

### Oso Creek

Oso Creek is an intermittent stream having a drainage area of about 600 $km^2$ (240 $mi^2$) located just to the south of Nueces and Corpus Christi Bays . Average discharge is 43,500 ac-ft, varying from about 17,000 ac-ft in dry years to 101,000 ac-ft in wet years (Hildebrand and King, 1978). Most of the area in the Oso Creek drainage is cropland, particularly in the southern part of the basin. However, urban areas, including Robstown in the upper watershed and southern Corpus Christi, appear to be expanding. Much of urban Corpus Christi is included in the watershed, but that 137 $km^2$ subbasin (53 $mi^2$) drains directly into Oso Bay and will not be affected by the proposed improvements. Hildebrand and King (1978) discuss the history of anthropomorphic changes in the basin, including drainage improvements, row cropping, urbanization, discharge of oil field brines, and the construction of sewage treatment facilities. Existing systems presently facilitate drainage over a substantial portion of the Oso Creek basin (Brown et al., 1976).

In addition to the extremely erratic runoff pattern in Oso Creek, the Texas Department of Water Resources (now the Texas Water Commission) presented data showing relatively high and quite variable levels of dissolved solids (TDWR, 1981). While total dissolved solids (TDS) averaged about 2350 mg/l, the range was from 500 to 5400 mg/l in runoff largely from cropland. Nutrient levels were also high with nitrate nitrogen and total phosphorus averaging about 3 and 2 mg/l, respectively, and exhibiting wide variations.

Baffin Bay Tributaries

The Petronila Creek system, including Agua Dulce, Pintas, Quinta, and Petronila Creeks, which empties into the extensive wind tidal flats of Cayo del Mazon and Cayo de Hinoso, at the head of Alazan Bay, drains an area of about 1768 $km^2$ (683 $mi^2$, HDR 1986; TDWR 1983 says 1320 $km^2$). This is an ungauged, intermittent drainage extending about 100 km to the northwest of Alazan Bay through western Nueces County into northern Jim Wells County. Using a water yield model, TDWR (1983) estimated that this basin contributed an average of about 36,000 ac-ft/yr to the Baffin Bay system during the 1941 through 1976 period of record. As is the case with Oso Creek and the tributaries of Baffin Bay, discharge in the Petronila Creek system is highly variable on both a monthly and an annual basis (TDWR, 1983).

Land use within the Petronila Creek basin is almost exclusively agricultural (both range and crop), except for oil and gas activities and some urban strip development in the vicinity of the highways U.S. 77 and State Hwy. 44 (Brown et al., 1976; 1977).

TDWR (1983) grouped the streams draining into the Upper Cayo del Grullo into the San Fernando Creek watershed. This 3313 $km^2$ (1610 $mi^2$) drainage is also intermittent and encompasses a lower, ungauged portion of 2,000 $km^2$ and a 1313 $km^2$ gauged area above Alice, Texas. Annual average inflow from this drainage was 60,991 ac-ft during the 1941-1976 period (TDWR, 1983). This drainage tends to provide a more constant inflow than do the other creek systems because of several upstream wastewater treatment facilities (Cornelius, 1984).

Land use in the San Fernando drainage basin is largely crop and range land with most of the cropland located between San Fernando Creek and

U.S. 77 (Brown et al., 1977). The cities of Kingsville and Alice are within the basin and undoubtedly influence downstream hydrology and water quality.

Arania, or Vattmann, Creek constitutes a small, intermittent drainage of 45 $km^2$ (16.5 $mi^2$) entering the Cayo del Grullo just south of Loyola Beach. The dominant basin land use is, again, crop and range. TDWR (1983) lumped this drainage with Los Olmos Creek.

The basin drained by Los Olmos and Salado Creeks extends through 103 km of ranchland to the west of its confluence with the Laguna Salada. The drainage includes a lower, ungauged 1080 $km^2$ area and a gauged 1240 $km^2$ basin northwest of Falfurrias (TDWR, 1983). Average annual inflow (1941-1976) to Baffin Bay was estimated to be 36,975 ac-ft/yr.

## PROPOSED DRAINAGE IMPROVEMENTS

### Oso Creek

The drainage improvements proposed for the Oso Creek basin are bridge replacements where FM 665 crosses West Oso Creek and at FM 763, State Hwy. 44, and the Texas-Mexican R.R. across Oso Creek, and the channelization of 10,947 ft of Oso Creek up and downstream of the FM 24 crossing. These actions are intended to relieve flooding along West Oso Creek and Oso Creek. Land use in both drainage basins above the proposed improvements is largely agricultural, greater than 75% (Brown et al., 1976). However, oil fields are present in both basins and urban areas have increased in importance, particularly north of Robstown in the Oso Creek drainage.

The proposed improvements will facilitate drainage of existing natural and artificial channels by increasing main channel capacity. A negligible net change in discharge and peak flow is expected to result from these improvements, while flow duration is expected to decrease somewhat. Total areas flooded by a given storm will decrease along the channelized reach, and drainage from surrounding areas will be more rapid due to the lowered water surface elevations in improved reaches.

Based on the projected maximum stream widths during a 100-year runoff event, improvements in Oso and West Oso Creeks will result in reducing overbank flooding by about 500 acres (see Section 5). For this same event, travel time from the upstream end of the Oso Creek channelized section to its confluence with West Oso Creek would be reduced about 12% from 12.44 hours to 10.9 hours. Considering both 25-year and 100-year events in West Oso Creek, travel time reduction after channel improvement is predicted to be from about 4 hours to 3 hours.

Baffin Bay Tributaries

Drainage improvements recommended for parts of the Petronila Creek system are limited to the channelization of single reaches on Pintas, Agua Dulce, and Petronila Creeks, and to replacement of the bridges at the FM 666 and 665 crossings. These streams are in many ways similar to Oso Creek, and the proposed improvements are predicted to have similar effects. No net change in discharge is expected to result, but peak flow travel times, presently on a scale of hours, would be reduced by 10 to 15% in the improved reaches of Petronila and Agua Dulce Creeks and up to about 40% through the Pintas Creek reach. Although substantial enhancements of average channel velocities are predicted to occur in the Pintas Creek reach (25-year event), the gentler slopes and greater channel widths in the other reaches will result in little or no velocity increase with the improvements. As in the case of Oso Creek, no substantial increase in sediment loading to estuarine areas is expected to result from the proposed drainage improvements, although the sediment load from Pintas Creek is expected to increase. As with the Oso Creek drainage, good design of the improvements will tend to minimize scour and erosion.

Data on nutrients and contaminents are not available for these streams, but since soil types, land use, and hydrology are similar to Oso Creek, it is very likely that they also exhibit relatively high and variable levels of nutrients and other dissolved materials.

Drainage improvements recommended for the intermittent streams draining into the Cayo del Grullo include both channelization and bridge replacements on Jaboncillos, Ebanito, San Fernando, and Arania Creeks and bridge replacements only on Escondido and Santa Gertrudis Creeks.

The nearly 62,000 ft channel improvement recommended on San Fernando Creek will result in substantially increased average channel velocities during peak flows through much of the improved reach (50-200% during a 25-year event). This, however, is the only major improvement recommended for this basin.

Relatively short reaches of Jaboncillos, Ebanito, and Arania Creeks would be channelized and numerous bridges replaced to relieve overbank flooding south of Kingsville.

## AFFECTED ESTUARINE SYSTEMS

Descriptions and comparisons of the major physical, chemical and biological characteristics of Texas Coastal Systems can be found in a few works of broad scope with varied viewpoints (Collier and Hedgepeth, 1950; Odum, 1967; Hackney, 1978). A large number of more narrowly focused works exist which provide detailed information on physical or chemical conditions, numbers and distribution of species or some index of production over broad geographic areas (e.g., Odum and Hoskin, 1958; Simmons and Breuer, 1962; Sorenson and Conover, 1962; Conover, 1964; Gunter et al., 1964; Copeland and Hoese, 1966; Texas Landings Series; Texas Colonial Waterbird Society, 1982). These and many other works are summarized in the Environmental Geologic Atlas Series of the University of Texas Bureau of Economic Geology (Brown et al., 1976; 1977) and in the Texas Department of Water Resources Series "Influence of Freshwater Inflows" (TDWR, 1979; 1983). Other publications reporting physical, chemical or biological data from the geographic areas potentially affected by this project include: (1) for Nueces-Corpus Christi: Holland et al, 1975; EH&A, 1977; Hildebrand and King, 1974, 1975, 1976, 1977, 1978; (2) for Laguna Madre: Simmons, 1957; Copeland et al, 1966; Merkord, 1978; Pulich, 1980; (3) for Baffin Bay-Alazan Bay: Breuer, 1957; Jensen, 1974; Suhm, 1974; Fuls, 1974; Tinnin, 1974; Suhm, 1976; Martin, 1979; and Cornelius, 1984, 1984b.

Many of the documents listed above address salinity and freshwater inflow characteristics with respect to biological impacts. A very large body of literature exists on the salinity tolerance of estuarine species (partially reviewed in TDWR, 1983) as well as works directly concerned with the effects of changes in freshwater inflow (Hoese, 1960; Copeland, 1966; Kinne, 1971; Holliday, 1971; TDWR, 1978, 1979, 1983). The extensive work on salinity relations of commercially important species is reviewed in Gunter et al., 1964, 1969, 1974.

## Nueces-Corpus Christi Bay

Oso Bay in the Nueces-Corpus Christi Bay system will receive the runoff from proposed drainage improvements in the watershed of Oso Creek.

Although Oso Creek and Oso Bay connect with Corpus Christi Bay, this relatively small system has more in common with the creeks emptying into the Baffin Bay-Laguna Madre system than with the Nueces River and its estuary. The Nueces System is distinguished from the others primarily by the amount and relatively constant presence of freshwater input, and is regarded as transitional between the low salinity bay systems to the northeast and the hypersaline lagoons to the south that receive only intermittent freshwater inflows.

In common with other Texas Coastal Systems, the Nueces-Corpus Christi system experiences relatively small excursions due to astronomical tides, with seasonal and meteorological effects generally much more important in determining circulation and water exchange with other systems.

Oso Bay and the Cayo del Oso (the tidally influenced portion of the creek), which extends upstream from the bayhead nearly 15 km, tend to be an extreme environment subject to periodic freshwater flooding on the one hand, and high salinities and water temperatures on the other because of restricted communication with Corpus Christi Bay during low flow periods. The estuary of Oso Creek is characterized by substantial areas of wind tidal flats that are sparsely vegetated and have historically been only temporarily covered by shallow, turbid water.

The inundated area of Oso Bay varies from about 2200 to 5700 acres. During the substantial periods when Oso Creek is not flowing, water levels in the Cayo del Oso have historically been governed by meteorological conditions. Wind tidal flats may be alternately exposed and inundated for days at a time. The fine silt and clay substrate here is easily resuspended, either by high winds when exposed surfaces dessicate, or by wind driven currents when inundated, resulting in characteristically turbid water over a soft, muddy bottom. The presence of a discharge from Central Power and Light's Davis Plant cooling pond appears to have ameliorated the environment in Oso Bay to some extent by reducing salinity fluctuations and improving circulation. Hildebrand and King (1978) estimated that the discharge of saltwater from the Laguna Madre into Oso Bay from this pond averages approximately 280 million gallons per day, or 311,000 ac-ft/yr, which is three times the wet-year flow of Oso Creek. This, together with the 20 million gallon per day (22,214 ac-ft/yr) freshwater discharge of two City of Corpus Christi sewage treatment plants, presently dominates the hydrology and water quality of Oso Bay.

Baffin Bay System

Freshwater inflows to the Baffin Bay-Laguna Madre system are quite small, and oceanic exchange is restricted since communication with the Gulf of Mexico is through the upper Laguna Madre whose only permanent openings are the Gulf Intracoastal Water Way (GIWW) to the south and Corpus Christi Bay in the north. Baffin Bay and the Laguna Madre are quite similar in water quality except when inflows from the creek systems north and west of Baffin Bay result in a salinity gradient from the bayheads out to the Laguna Madre. No other organized drainage system conveys freshwater to the upper Laguna Madre.

Laguna Madre waters tend to be relatively clear and shallow and support large stands of seagrasses. These account for much of that system's primary production and provide refuge and/or feeding areas for juvenile fin and shellfish. Baffin Bay waters are also shallow (average depth 0.9 m.) but tend to be more turbid, presumably because of the widespread silty clay substrates.

Numerous publications (e.g., Collier and Hedgepeth, 1950; TDWR, 1983; Cornelius, 1984, 1984b) discuss the large and essentially unpredictable changes in salinity and other water quality parameters characteristic of this system. Although the Baffin Bay-Laguna Madre complex is classified as a hypersaline lagoonal system, the frequency and severity of episodes of elevated salinity appear to have diminished since construction of the GIWW improved communication with Corpus Christi Bay and created a permanent opening through the land bridge to the Lower Laguna Madre.

A unique feature of Baffin Bay is the presence of calcareous reef structures built up of serpulid worm tubes. These reefs were thought to be extinct as recently as the early 1970's, but are now known to contain live worm populations. Likewise, seagrasses were also reported to be absent from the Baffin Bay system, but stands of shoalgrass (Halodule wrightii) and Widgeongrass (Ruppia maritima) are now present in appropriate habitat throughout the system. Although it is tempting to equate these apparent changes with the amelioration of hypersalinity mentioned above, the relationship is speculative.

The lower reaches of the drainages entering the Baffin Bay systems are dominated by extensive wind tidal flats which, in southern Texas, replace the bay head and creek mouth marshes common on the upper coast. The wind tidal flats are barren, featureless expanses of silts and clays that are irregularly flooded by meteorologically driven tides or (even more irregularly) by freshwater runoff. Wind tidal flat environments dominate the creek channels for many kilometers above the bay heads, being particularly well developed in the Cayo de Hinosa and Cayo del Mazon, and in the lower reaches of the San Fernando Creek drainage. The more frequently flooded portions of the flats support algal mat communities composed primarily of filimentous blue green algae and diatoms. These mat communities can be highly productive and appear to contribute considerable primary production to the bay system.

Permanently inundated areas may also occur on these flats, either as very shallow channels or as isolated pools. The channels may be associated with freshwater inflow or with saltwater drainage off the flats. In either case, these areas do not usually harbor algal mats because of the turbidity in waters over about 25 cm depth and because environmental conditions allow the development of herbivore populations capable of disrupting the mat community.

During periods of no freshwater inflow, creek channels may exhibit inverted salinity gradients, with salinities increasing upstream. This occurs when bay waters are isolated in stream channels by falling water levels. Salts become concentrated by evaporation and by solution of salts deposited in the substrata during previous cycles of inundation and evaporation. Numerous oilfield brine discharges also occur in these drainages, further contributing to hypersaline conditions in isolated pools. Large amounts of organic matter may accumulate in the hypersaline pools as the salt content, exotic ion ratios, and high water temperatures depress (or eliminate) grazer and decomposer populations.

Open water areas are dominated by benthic communities of polychaetes, molluscs, and small crustaceans. Large, mobile species important in the system include penaeid shrimp, black drum (Pogonais cromis), redfish (Sciaenops ocellata), mullet (Mugil cephalus) and others, all of which migrate into and out of these systems in response to changing environmental conditions.

IMPORTANT SPECIES AND HABITATS

Important species are defined as those which are (1) endangered or threatened, (2) commercially or recreationally important, or (3) essential to the maintenance of the ecosystem structure or function. Marine species and birds commonly associated with estuarine areas in category 1 regarded by the Texas Parks and Wildlife Department as actually or probably occurring in Kleberg and Nueces Counties are listed in Table 7-1.

Species listed by the U. S. Department of the Interior (USFWS, 1983, 1984) as endangered or threatened are protected under the provisions of the Endangered Species Act (1973, USC 1531 et seq.) amended in 1982 (PL 97-304), which enjoins the federal government from authorizing, participating in, or financing activities adversely affecting members of that species or its designated critical habitat (if any). State protected non-game species may not be taken, possessed, transported, exported, sold, or offered for sale, either directly or as part of a product (Rules 127.70.12.001-008 TPWD). This implies that all actions directly (provably) resulting in the death of members of protected non-game species would be a violation of these rules, absent the exceptions in 127.70.12.005-006, punishable as a misdemeanor. In addition, some of these protected non-game species correspond to federally listed threatened species (e.g., Atlantic Loggerhead, Atlantic Green Turtle) and are therefore also protected under federal regulations.

Of the federally listed species, there are four whales and three turtles which are marine forms, and the West Indian Manatee (Trichechus manatus) whose habitat includes large fresh and saltwater bodies that

Table 7-1

Endangered or Threatened Marine Species
Known, or Likely, to Occur in the Project Area

| Species | | Status[1] | Occurrence[2] |
|---|---|---|---|
| **Mammals** | | | |
| Dolphin, bridled | *Stenella frontalis* | P | Possible |
| Dolphin, rough-toothed | *Stena bredanensis* | P | Possible |
| Dolphin, spotted | *Stenella plagiodon* | P | Possible |
| Blue Whale | *Balaenoptera musculus* | P | Possible |
| Finback Whale | *B. physalis* | E | Possible |
| Right Whale | *Eubalana* spp. | E | Possible |
| Sperm Whale | *Physeter catadon* | E | Possible |
| Dwarf Sperm Whale | *Kogia simus* | P | Possible |
| False Killer Whale | *Pseudorca crassidens* | P | Possible |
| Goose-beaked Whale | *Ziphius cavirostris* | P | Possible |
| Killer Whale | *Orcinus orca* | P | Possible |
| Short-finned Pilot Whale | *Globicephala macrorhynca* | P | Possible |
| Pygmy Killer Whale | *Feresa attenuata* | P | Possible |
| Pyymy Sperm Whale | *Kogia breviceps* | P | Possible |
| Gulf Stream Beaked Whale | *Mesoplodon europaeus* | P | Possible |
| West Indian Manatee | *Trichecus manatus* | E | Possible |
| **Birds** | | | |
| Brown Pelican | *Pelecanus occidentalis* | E | Confirmed |

| | | | |
|---|---|---|---|
| Bald Eagle | <u>Haliaeetus leucocephalus</u> | E | Confirmed |
| Arctic Peregrine Falcon | <u>Falco peregrinus tundrius</u> | E | Confirmed |
| Whooping Crane | <u>Grus americana</u> | E | Possible |
| Interior Least Tern | <u>Sterna albifrons athalassos</u> | SE | Probable |
| Least Tern | <u>S. albifrons antillarum</u> | P | Confirmed |
| Reddish Egret | <u>Egreta rufescens</u> | P | Confirmed |
| White-Faced Ibis | <u>Plegadis chihi</u> | P | Confirmed |
| Osprey | <u>Pandion haliaetus carolinensis</u> | P | Confirmed |
| <u>Reptiles</u> | | | |
| Green Sea Turtle | <u>Chelonia mydas</u> | T | Confirmed |
| Hawksbill Turtle | <u>Eretmochelys imbracata</u> | E | Probable |
| Kemp's Ridley Turtle | <u>Lepidochlys kempii</u> | E | Probable |
| Leatherback Turtle | <u>Dermochelys coriacea</u> | E | Probable |
| Loggerhead Turtle | <u>Caretta caretta</u> | T | Confirmed |

1(Status) E - Endangered, listed by U.S. Fish and Wildlife Service (1983)
T - Threatened, listed by U.S. Fish and Wildlife Service (1983)
SE- Listed by State of Texas as Endangered (31T.A.C. 57.131-.136, 1984)
P - Listed by State of Texas as Protected Non-game species (127.70.12.001-.008)

2(Occurrence) Based on Texas Parks and Wildlife Information for Kleberg and Nueces Counties.

support substantial aquatic vegetation (Davis, 1974; Collins, 1981).

Among the endangered bird species listed in Table 7-1, the Brown Pelican and Bald Eagle are noted to have been actually observed ("confirmed") in Kleberg and Nueces Counties, while the Arctic Peregrine Falcon is "probable." The Brown Pelican (Pelicanus occidentalus) is strictly coastal, resting, feeding, and nesting in tropical and subtropical bay and estuary habitats on Atlantic and Gulf Coasts (Oberholzer, 1974).

Bald Eagles (Haliaeetus leucocephalus) are essentially non-migratory and along the Gulf Coast breed from late October through early May (Oberholzer, 1974). Bald Eagles typically inhabit margins of seacoasts, estuaries, and large freshwater bodies where suitable nest and lookout locations (tall trees or cliff ledges) are present. The Arctic Peregrine Falcon (Falco peregrinus tundrius), which is a winter migrant along the Texas Coast, likewise prefers isolated, elevated nesting areas, but non-nesting individuals may utilize a wide range of habitats (Oberholzer, 1974). Although suitable habitat is essentially non-existent around Oso Bay and contiguous areas of Corpus Christi Bay, the relatively isolated and undisturbed area of the King Ranch adjacent to Baffin Bay and the Laguna Madre contains appropriate habitat.

The Interior Least Tern (Sterna albifrons athalassos), a geographic race of the Least Tern (Sterna albifrons antillarum), characteristically inhabits broad sandy bottomlands commonly associated with large rivers. No substantial habitat for this species is expected to occur in the estuarine receiving bodies (Oberholzer, 1974). The lower reaches of the creeks draining into Oso Bay, Alazan Bay, and the Cayo del Grullo, where extensive sand flats occur, are brackish to hypersaline. These areas would appear to be more attractive to the Least Tern than to the Interior Least Tern.

Commercially and recreationally important species comprise the second category of critical species inhabiting these bay systems, and they are discussed by a large number of authors with varying viewpoints. The requirements of these species, including the blue crab (*Callinectes sapidus*), white shrimp (*Penaeus setiferus*), croaker (*Micropogon undulatus*), black drum (*Pogonais cromis*), redfish (*Sciaenops ocellata*), and spotted seatrout (*Cynoscion nebulosus*), which are the most important species in the Baffin Bay-Upper Laguna Madre Fishery, are well known and can be considered in evaluating potential project impacts.

The third important species category, consisting of those essential to the ecosystem, is less well defined than the others, but in the context of the low diversity communities of the project area, this category includes the most abundant species present. Conditions resulting in the reduction or elimination of these populations would result in greatly altered communities. Examples include the mat-forming species of bluegreen algae discussed above and the sheepshead minnow (*Cyprinodon varigatus*), the only fish capable of inhabiting the shallow, hypersaline habitats in the area.

Habitats to be considered in project evaluation include those habitats critical to the well-being of important species. This is particularly important where the habitat may be particularly sensitive to the types of change associated with the project, or where the habitat is wholly or largely encompassed by the area of maximum impact. Freshwater marsh and swamp areas (largely confined to the Nueces River Valley) are considered of the highest value in the coastal bend region because of their importance to waterfowl and their limited extent. Seagrass beds and salty to brackish water marshes are also considered important, primarily because of their utility as nursery grounds for commercially and recreationally important species, but also because of the organic matter they contribute to bay food webs. Unique habitats, such as the serpulid reefs of Central Baffin Bay, are also considered to be important in impact evaluations.

## POTENTIAL IMPACTS

Potential effects on estuarine systems from the drainage improvements discussed above could result from changes in (1) the amount of freshwater input, (2) the timing of inflows, and (3) the amount and nature of dissolved and suspended material carried by the streamflow. Whether any effect could actually be detected in the estuary and whether that effect would be adverse depend on the magnitude of change in streamflow characteristics and on the nature of the receiving body.

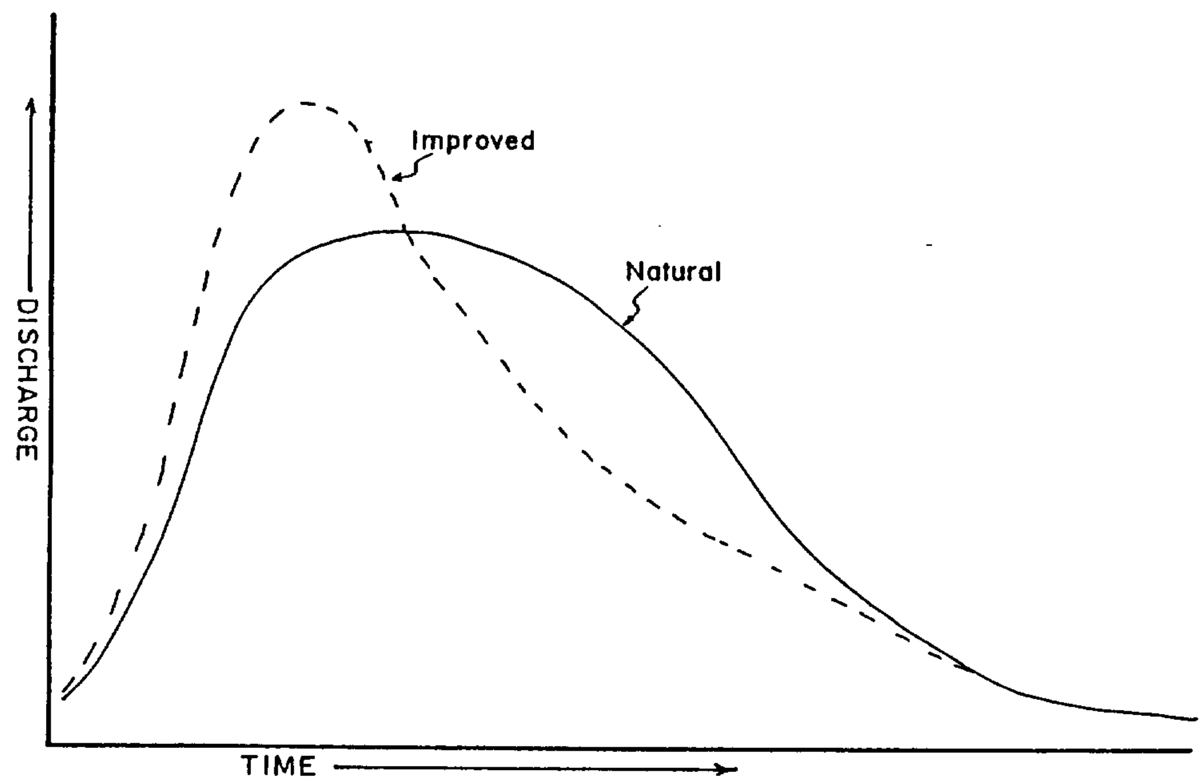
As already mentioned, the proposed bridge replacements and channelizations are not expected to result in any significant change in total discharge in any of the affected stream systems. However, some decrease in peak travel time during a storm event, together with higher current velocities, will occur in the improved sections. This will have the effect of reducing the amount of time after the flood peak during which large volume flows continue. The difference appears to amount only to hours or a few days since only main channel capacity will be increased and overbank flooding prevented. Drainage of ponded areas filled by upland runoff will be only incidentally affected and base flow from groundwater seepage will not be affected at all. Therefore, the longer term low flows that occur following sufficient rainfall should continue relatively unaltered after implementation of the recommended improvements.

Although more rapid drainage should result in shorter contact times for dissolution of nutrient or contaminant materials in flooded soils, the higher rates of flow will enhance transport of suspended materials. Water quality studies, primarily in urbanized areas (Austin, 1983, 1984a, 1984b), have shown that substantial proportions (e.g., 30-60%) of the nutrients, organic carbon, metals, and pesticides in runoff water can be associated with suspended solids. However, even in the extreme case of a 100-year runoff event in the Oso Creek channelized reach, water surface elevations were predicted to decrease by only about 1.5 to 2.5 feet from the natural to the improved condition. With the relatively flat topography typical of the region, no substantial increase in transport of upland soil material into the channels would occur. Although it is unlikely that there would be any substantial increase in sediment eroded from upland areas, some increase in competence and channel scour may occur as a result of increased velocities in and adjacent to improved reaches, as a result of higher current velocities. These velocities, however, will not reach a point that causes excessive scour or erosion. Properly designed channels and bridges will minimize this erosion potential. Channel velocities in the improved reaches are generally below 6 feet per second due to the flat slopes.

The short-term hydrologic changes (decrease in peak travel time, more rapid transport of water otherwise trapped in extensive overbank areas by channel constrictions) will tend to be attenuated during flow through the lower reaches of the streams. Increased current velocities are not expected to persist below the improved channel sections. This is indicated by the lack of significant changes in computed travel times and channel velocities in reaches below improved reaches.

Unfortunately, the type of modeling performed to evaluate the drainage improvements does not result in quantitative descriptions of the "before" and "after" hydrologic regimes. Figure 7-1 is a conceptual hydrograph (a plot of stream discharge over time at a given point) showing the type of change expected to result from removing channel restrictions. After improvement, peak discharge is somewhat greater, and discharge is initially reduced more rapidly since water is no longer retained in overbank storage by inadequate channel capacity. The area under the curve (total discharge) and the long-term tail-off to zero flow are unaffected by the proposed improvements.

FIGURE 7-1




TYPICAL HYDROGRAPH, SHOWING RUNOFF CHARACTERISTICS OF A CHANNEL REACH BEFORE AND AFTER IMPROVEMENT.

Oso Bay appears very unlikely to be affected by changes in the hydrologic regime of Oso Creek as a result of the drainage improvements discussed above. While the proposed improvements are limited in scope and located high in the basin, the primary reason for this conclusion is the present domination of Oso Bay hydrology and water quality by Central Power and Light's cooling pond discharge, which amounts to about three times the total wet year discharge of Oso Creek.

Alazan Bay and the Cayo del Grullo do not contain habitats that are dependent on a regular regime of freshwater input to maintain them. While the nutrients and other materials supplied by freshwater inflow are certainly important, maintenance of a particular salinity regime or relatively constant mixing zone, exemplified by the river delta and creek mouth brackish marshes characteristic of the upper coast, is not. Freshwater input and, in consequence, salinity can vary rapidly and unpredictably; Cornelius (1984), for example, reported Alazan Bay salinities ranging from below 10 to 50 ppt (parts per thousand).

The bayhead areas are not only devoid of macrophytes, but are largely flat, featureless expanses of silt and clay that do not provide sheltered nursery areas or food sources for important marine species. The important environmental factors in the biology of these areas are the relatively long periods of shallow inundation and dessication by meteorological tides, and the hypersaline conditions that result from successive episodes of inundation and evaporation (and oil field brine discharges). Salinities over 100 ppt are not uncommon in the Cayos surrounding Baffin Bay, including the large ones forming the mouths of Petronila and San Fernando Creeks.

The organisms characteristic of these areas -- blue-green algae mats, a few insect and crustacean species, sheepshead minnows, and the mullet -- are opportunistic, adapted to the rapid exploitation of disturbed and stressful habitats. These species are typically generalists, tolerant of a wider range of environmental conditions than are most species. As a consequence they are often widely distributed, but may show their largest population sizes in stressed areas where environmental conditions are unsuitable for competing species or predators.

Sessile species will typically be tolerant of wide ranges of salinity and dissolved oxygen concentrations, ionic ratios, temperature, and other unpredictably fluctuating factors. Mobile species often exhibit migratory behavior that is not simply programmed by season, but is strongly modified by changes in environmental conditions. Most of these species will exhibit high rates of growth and reproduction when conditions are favorable, will not be heavily dependent on the reproduction of a single year class, and will have several mechanisms for the dispersal of juveniles. The latter is a critical adaptation to recolonizing a disturbed habitat.

Events such as large inputs of freshwater, hypersaline episodes or dessication, and storm disturbance of sediments may produce tremendous local mortality, even among tolerant species. Exploitation of such areas following the return of more favorable conditions is an important component of estuarine production. It seems unlikely that the rather subtle changes in hydrology that appear to result from the proposed drainage improvements would have any substantial effect on such habitats and communities.

Arania Creek, unlike the other drainages, flows directly into the central Cayo del Grullo, and its discharge is therefore in much closer proximity to open water bay habitats. These include seagrass beds in some shallower areas and extensive benthic communities dominated by polychaete worms and molluscs (primarily Mulinia lateralis) in deeper bay waters. It is these areas that are important to the penaeid shrimp, black drum, and other economically important populations of the Baffin Bay system. However, these species also must be tolerant of the wide and unpredictable changes in environmental conditions that are characteristic of this system. Since the expected changes in freshwater inflow as a result of the recommended drainage improvements will amount to small differences in the pattern of input, it is not probable that effects of any biological consequences could be demonstrated, either on the wind tidal flats or in the bay community.

Because of increased current velocities in at least the improved reaches, an increased rate of sedimentation is a potential effect of drainage improvements. No quantitative data are available on scour and sediment transport increase. However, it can be expected that increased sediment loading from an improved reach would occur when channel velocities are increased over the present condition for a given runoff event. Based on 25-year events, average channel velocity changes are predicted over a range from -33% to over 200%. These increases are only at peak flows, which do not persist for long, and are not predicted to extend substantially below the improved reaches. Smaller events, with return intervals less than 25 years, will have lower current velocities and probably less difference between the improved and unimproved conditions and, consequently, should result in proportionately smaller sediment transport increase.

Since the estuarine receiving systems are characterized by extensive marginal flats, and bay bottoms of fine-grained, unconsolidated material are presently quite turbid and do not support large seagrass meadows except in the Laguna Madre, only a very large increase in sediment loading could result in evident effects. Siltation on seagrass beds and extant benthic communities would have to increase appreciably beyond the present level of disturbance due to flooding or to scour and burial by storm events. Considering the known resiliency of the estuarine community to disturbance of this type and the probable small increments in sediment loading, it does not seem likely that any impact would be noticeable in the estuary.

Among the endangered, threatened, and protected species potentially present in the project area, all the mammals, except for the West Indian Manatee, are primarily restricted to marine habitats outside the potential range of influence of the proposed drainage improvements. The Manatee typically inhabits tropical, heavily vegetated waters. While suitable habitat may be present in the Laguna Madre, it is not in either Oso or Baffin Bays, and the proposed drainage improvements are not considered of sufficient magnitude to affect aquatic macrophyte stands anywhere in the system.

The various sea turtle species listed in Table 7-1 are known to utilize inshore waters to varying extents, and might therefore be found in Baffin Bay waters. Among the birds, a small Least Tern nesting colony is known to have persisted on shell spits in Oso Bay at least through 1977, while the Reddish Egret and White Faced Ibis have been observed to nest on the GIWW spoil island located in the Laguna Madre at the mouth of Baffin Bay. The other listed birds would be much more likely to be found around Baffin Bay than Oso Bay.

No mechanism whereby the proposed drainage improvements could adversely impact any of these species is evident. Small changes in short-term flow patterns and sediment loading are likely to be detectable, if at all, only in the uppermost estuarine reaches of these systems. Certainly they will not result in any change in physical habitat or potential in estuarine areas. Changes in water quality parameters, particularly contaminants such as pesticides, are expected to be small. Contaminant loadings might be expected to increase in association with sediment loads, but both factors are probably much more sensitive to land use and agricultural practices within the basins than to channelization of stream courses and bridge replacements.

Increases in endangered bird populations, notably Bald Eagles, Ospreys, and Brown Pelicans, have been widely attributed to the elimination of the widespread use of chlorinated hydrocarbons. While some of this insecticide material (particularly the degradation products of DDT) persists in the soils and sediments of the project area, the proposed drainage improvements do not appear capable of substantially increasing the availability of this material in the downstream estuarine areas.

## Priority Ranking

Drainage improvement rating criteria provide a means to develop a priority list for construction of the recommended alternatives. In this procedure several items, or criteria, are used to evaluate the alternatives and compare them. The criteria used should represent the important County concerns in the decision-making process. All the criteria are not equally important, so weighting factors are applied to them, which will tend to make the alternatives that best meet the objectives of the County the higher priority items. Some of the criteria used to evaluate the alternatives are judgement values (such as socio-economic benefits) and some are more easily quantified (such as costs). For this study, seven criteria were used in evaluating the alternatives:

1. Severity of existing problem, which includes the flooding of homes, businesses, roads and utilities
2. Development potential
3. Environmental impacts, primarily on the bays and estuaries
4. Capital costs
5. Required maintenance
6. Ease of implementation
7. Socio-economic benefits, which include access during flooding, duration of flooding, public concern, etc.

The weighting factors used for the evaluation criteria are listed in Table 8-1.

TABLE 8-1

WEIGHTING FACTORS FOR EVALUATION CRITERIA

| Evaluation Criteria | Weighting Factor |
|---|---|
| 1. Severity of Existing Problem | 5 |
| 2. Development Potential | 4 |
| 3. Environmental Impacts | 3 |
| 4. Capital Costs | 5 |
| 5. Required Maintenance | 2 |
| 6. Ease of Implementation | 1 |
| 7. Socio-Economic Benefits | 3 |

Each of the alternatives was evaluated as having a range of impacts from desirable to undesirable effects. High impacts, assigned a value of 3, were given to alternatives that produced desirable effects, and low impacts, assigned a value of 1, were given to alternatives that produced undesirable, or negative, effects. Medium impacts were assigned a value of 2. Table 8-2 evaluates the alternatives according to weighting factors and impact values. Table 8-3 lists the improvements by rank.

TABLE 8-2

ALTERNATIVES RANKING TABLE

| Basin | Alternative | Evaluation Criteria[1] 1 WF=5 | 2 WF=4 | 3 WF=3 | 4 WF=5 | 5 WF=2 | 6 WF=1 | 7 WF=3 | Total Points |
|---|---|---|---|---|---|---|---|---|---|
| San Fernando | SR[2] @ FM 2045 | L-5 | M-8 | M-6 | M-10 | H-6 | M-2 | L-3 | 40 |
| | CI[3] | L-5 | L-4 | L-3 | L-5 | M-4 | L-1 | L-3 | 25 |
| | SR @ FM 1355 | L-5 | L-4 | H-9 | M-10 | H-6 | L-1 | L-3 | 38 |
| Santa Gertrudis | SR @ FM 1717 | M-10 | H-12 | H-9 | M-10 | H-6 | H-3 | H-9 | 59 |
| Escondido | SR @ CR 1030N | H-15 | M-8 | H-9 | H-15 | H-6 | H-3 | H-9 | 65 |
| Jaboncillos | CI | M-10 | M-8 | L-3 | L-5 | M-4 | L-1 | M-6 | 37 |
| | SR @ US 77 | H-15 | M-8 | M-6 | M-10 | H-6 | L-1 | M-6 | 52 |
| | SR @ Mo-Pac RR | H-15 | M-8 | M-6 | M-10 | H-6 | L-1 | H-9 | 55 |
| | SR @ CR 2170W | M-10 | L-4 | H-9 | H-15 | H-6 | H-3 | M-6 | 53 |
| | SR @ CR 1020 | M-10 | L-4 | H-9 | H-15 | H-6 | M-2 | M-6 | 52 |
| | SR @ FM 772 | M-10 | L-4 | H-9 | H-15 | H-6 | H-3 | M-6 | 53 |
| Ebanito | SR @ FM 772 | M-10 | H-12 | M-6 | H-15 | H-6 | M-2 | H-9 | 60 |
| | CI | H-15 | H-12 | L-3 | L-5 | M-4 | L-1 | M-6 | 46 |
| | SR @ FM 772 | H-15 | H-12 | M-6 | M-10 | H-6 | H-3 | H-9 | 61 |
| | SR @ US 77 | H-15 | H-12 | M-6 | H-5 | H-6 | M-2 | H-9 | 55 |
| | SR @ Mo-Pac RR | H-15 | H-12 | M-6 | L-5 | H-6 | L-1 | H-9 | 54 |
| | SR @ CR 1030S | M-10 | L-4 | H-9 | H-15 | H-6 | H-3 | M-6 | 53 |
| | SR @ FM 772 | M-10 | L-4 | H-9 | H-15 | H-6 | H-3 | M-6 | 53 |
| Arania | SR @ FM 628 | H-15 | H-12 | M-6 | H-15 | H-6 | H-3 | H-9 | 66 |
| | SR @ FM 628 | H-15 | H-12 | M-6 | H-15 | H-6 | H-3 | H-9 | 66 |
| | SR @ CR 1090S | H-15 | H-12 | M-6 | H-15 | H-6 | H-3 | H-9 | 66 |
| | CI | H-15 | H-12 | L-3 | M-10 | M-4 | L-1 | M-6 | 51 |
| | SR @ FM 628 | M-10 | M-8 | H-9 | H-15 | H-6 | H-3 | M-6 | 57 |
| | SR @ FM 628 | M-10 | M-8 | H-9 | H-15 | H-6 | H-3 | M-6 | 57 |
| | SR @ FM 628 | M-10 | M-8 | H-9 | H-15 | H-6 | H-3 | M-6 | 57 |

For example, H-15 in column 1 means the alternative is assigned a high impact at a point value of 3 (see page 8-2) and in Column 1 the weighting factor equals 5; hence, the point evaluation is 3 x 5, or 15. M (or medium) rates 2 points, and L (or low) rates 1 point.

1. Evaluation Criteria Numbers are shown in Table 8-1.
2. SR = Structure Replacement
3. CI = Channel Improvement

TABLE 8-3

PRIORITY RANKING

| Rank | Basin | Alternative | Points |
|---|---|---|---|
| 1 | Arania | Bridge at FM 628 (Sec. 2.01) | 66 |
| 2 | Arania | Bridge at FM 628 (Sec. 2.05) | 66 |
| 3 | Arania | Culverts at Co. Rd. 1090S | 66 |
| 4 | Escondido | Bridge at Co. Rd. 1030N | 65 |
| 5 | Ebanito | Bridge at FM 772 (Sec. 4.60) | 61 |
| 6 | Ebanito | Bridge at FM 772 (Sec. 4.01) | 60 |
| 7 | Santa Gertrudis | Bridge at FM 1717 | 59 |
| 8 | Arania | Bridge at FM 628 (Sec. 2.21) | 57 |
| 9 | Arania | Bridge at FM 628 (Sec. 2.25) | 57 |
| 10 | Arania | Bridge at FM 628 (Sec. 2.30) | 57 |
| 11 | Jaboncillos | Bridge at Mo-Pac RR | 55 |
| 12 | Ebanito | Bridge at US 77 | 55 |
| 13 | Ebanito | Bridge at Mo-Pac RR | 54 |
| 14 | Jaboncillos | Culverts at Co. Rd. 2170 W | 53 |
| 15 | Ebanito | Culverts at Co. Rd. 1030S | 53 |
| 16 | Ebanito | Bridge at FM 772 | 53 |
| 17 | Jaboncillos | Bridge at FM 772 | 53 |
| 18 | Jaboncillos | Bridge at US 77 | 52 |
| 19 | Jaboncillos | Culverts at Co. Rd. 1020 | 52 |
| 20 | Arania | Channel Improvement | 51 |
| 21 | Ebanito | Channel Improvement | 46 |
| 22 | San Fernando | Bridge at FM 2045 | 40 |
| 23 | San Fernando | Bridge at FM 1355 | 38 |
| 24 | Jaboncillos | Channel Improvement | 37 |
| 25 | San Fernando | Channel Improvement | 25 |

# SECTION 9 - LEGAL REQUIREMENTS

Texas counties are authorized to regulate development in flood areas by two statutes, both of which were passed to provide eligibility for flood insurance under the National Flood Insurance Act of 1968.

Art. 1581e-1 was enacted in 1969. It authorizes any county bordering on the Gulf of Mexico or the tidewater limits thereof to determine and describe the boundaries of flood, or rising water prone, areas.

This statute defines "flood, or rising water prone, area" to mean "an area that is subject to or exposed to flooding by the Gulf of Mexico or its tidal waters, including lakes, bays, inlets, and lagoons, which results in damage to land or property."

The commissioners court of any such county is authorized "to enact and enforce regulations which regulate, restrict, or control the management and use of land, structures, and other development in flood, or rising water prone, areas in such a manner as to reduce the danger or damage caused by flood losses. This power and authority may include, but not be limited to, requirements for flood-proofing of structures which are permitted to remain in, or be constructed in, flood, or rising water prone, areas; regulations concerning minimum elevation of any structure permitted to be erected in, or improved in, such areas; specifications for drainage; and any other action which is feasible to minimize flooding and rising water damage."

The Texas Flood Control and Insurance Act was first enacted in 1969, and was later amended in 1977. It appears in Section 16.311 et seq. of the Texas Water Code.

This Act authorizes counties (and all political subdivisions, including the South Texas Water Authority) to take all necessary and reasonable actions to comply with the requirements and criteria of the National Flood Insurance Program, including but not limited to:

"(1) making appropriate land use adjustments to constrict the development of land which is exposed to flood damage and minimize damage caused by flood losses;

(2) guiding the development of proposed future construction, where practicable, away from a location which is threatened by flood hazards;

(3) assisting in minimizing damage caused by floods;

(4) authorizing and engaging in continuing studies of flood hazards in order to facilitate a constant reappraisal of the flood insurance program and its effect on land use requirements;

(5) engaging in floodplain management and adopting enforcing permanent land use and control measures consistent with the criteria established under the National Flood Insurance Act;

(6) declaring property, when such is the case, to be in violation of local laws, regulations, or ordinances which are intended to discourage or otherwise restrict land development or occupancy in flood-prone areas and notifying the secretary, or whomever he designates, of such property;

(7) consulting with, giving information to, and entering into agreements with the Department of Housing and Urban Development for the purpose of:

(A) identifying and publishing information with respect to all flood areas, including coastal areas; and

(B) establishing flood-risk zones in all such areas and making estimates with respect to the rates of probable flood-caused loss for the various flood-risk zones for each of these areas;

(8) cooperating with the secretary's studies and investigations with respect to the adequacy of local measures in flood-prone areas as to land management and use, flood control, flood zoning, and flood damage prevention;

(9) taking steps to improve the long-range management and use of flood-prone areas;

(10) purchasing, leasing, and receiving property from the secretary when such property is owned by the federal government and lies within the boundaries of the political subdivision pursuant to agreements with the Department of Housing and Urban Development or other appropriate legal representative of the United States Government;

(11) requesting aid pursuant to the entire authorization from the commission;

(12) satisfying criteria adopted and promulgated by the commission pursuant to the National Flood Insurance Program; and

(13) adopting permanent land use and control measures with enforcement provisions which are consistent with the criteria for land management and use adopted by the secretary."

The jurisdiction of counties pursuant to these statutes has been defined by several Attorney General opinions.

Attorney General opinion No. H-978, dated April 12, 1977, concluded that counties can adopt only land use regulations that are required for compliance with the National Flood Insurance Program, and that these regulations can apply only in the areas designated by the Flood Insurance Administrator.

Attorney General opinion No. H-1024, dated July 18, 1977, concluded that Art. 1581e-1 limits the power of the commissioners court to enacting regulations applicable to areas subject to flooding by the Gulf of Mexico or its tidal waters, including lakes, bays, inlets, and lagoons.

However, the Attorney General pointed to Section 2 of Art. 1581e-1 which authorizes counties to determine and describe the boundaries of flood or rising water prone areas, and further providing that this determination "shall be conclusively established" when the commissioners court shall make a finding in a resolution passed by it that an area or areas located within the boundaries of such county or flood or rising water prone area.

The Attorney General concluded that the commissioners court may conclusively determine the geographical scope of its powers under Art. 1581e-1, and that such determination shall be final.

Kleberg County borders on the Gulf of Mexico and is therefore authorized by Art. 1581e-1 to enact land use regulations applicable only to areas subject to flooding by the Gulf of Mexico or its tidal waters, including lakes, bays, inlets, and lagoons. The commissioners court may conclusively establish the limits of these areas by making findings in a resolution.

Attorney General opinion MW-171, dated April 15, 1980, concluded that Sec. 16.311 et seq. of the Texas Water Code authorized Harris County to require building permits only in the areas designated by the Federal Flood Insurance Administrator. However, the opinion concluded that Art. 1581e-1 gives the Harris County Commissioners Court authority to require building permits in incorporated areas for structures constructed or placed in defined flood, or rising water prone, areas after these areas have been established by resolution of the commissioners court.

Attorney General opinion JM-123, dated December 30, 1983, concluded that Cameron County has no power to require utilities to deny service to individuals or entities not in compliance with the county flood control regulations.

Attorney General opinion JM-328, dated June 21, 1985, concluded that regulations enacted under Art. 1581e-1 and Sec 16.311 et seq. of the Texas Water Code do not constitute on their face a "taking" in violation of the federal or state constitutions.

In addition to the counties, the jurisdiction of political subdivisions pursuant to these statutes has been defined by several Attorney General opinions.

Attorney General opinion No. H-978, dated April 22, 1977, concluded that political subdivisions can adopt only land use regulations that are required for compliance with the National Flood Insurance Program, and that these regulations can only apply in the areas designated by the Flood

Insurance Administrator.

Attorney general opinion JM-123, dated December 30, 1983, concluded that Cameron County has no power to require utilities to deny service to individuals or entities not in compliance with the county flood control regulations. However, the Attorney General noted a rule of the Public Utility Commission permitting a utility to decline service to an applicant who has not complied with the utility's approved rules and regulations filed with the Commission or an applicant whose equipment is hazardous or of such character that satisfactory service cannot be given. The Attorney General concluded that a utility can voluntarily deny service to an applicant for the reasons set out in the Commission rules. The Attorney General also noted that a utility can seek an amendment to its regulations to deny service to buildings which lack permits required by law. Finally, he noted that if the county's regulations guard against the same conditions expressed in the utility's approved regulations on file with the Commission or if they prohibit utility hookups to applicants with equipment hazardous or unsatisfactory because of the danger of being located in a flood-prone area, the utility may voluntarily comply with them.

## CONCLUSION

The Commissioners Court of Nueces County has the following authority:

1. To adopt land use regulations having as their purpose and effect compliance with the requirements and criteria promulgated pursuant to the National Flood Insurance Program. These regulations apply only to areas designated by the Flood Insurance Administrator.

2. To define areas subject to flooding by the Gulf of Mexico or its tidal waters, including lakes, bays, inlets, and lagoons, and to adopt land use regulations for flood problems within these areas.

The provisions of the statute, and the Attorney General opinions, lead to the following conclusions concerning the authority of the South Texas

Water Authority to regulate development in flood hazard areas.

(1) South Texas Water Authority can adopt land use regulations which have as their purpose and effect compliance with requirements and criteria promulgated pursuant to the National Flood Insurance Program, provided these regulations apply only in areas designated by the Federal Flood Insurance Administrator as having special flood hazards.

(2) Utilities supplied with wholesale water by South Texas Water Authority can voluntarily agree with the Authority that they will deny service to structures in special flood hazard areas provided that the areas are identified by the utility as being ". . . of such character that satisfactory service cannot be given," or, that the utility places this provision in its regulations and has this provision approved by the Texas Water Commission.

In addition to the authority to regulate development in flood hazard areas, the Commissioners Court of Nueces County is authorized to regulate subdivisions by Art. 6702-1, Sec. 2.401. This statute requires the owner of any tract that is outside the corporate limits of any city who shall divide it into two or more parts for the purpose of laying out a subdivision to cause a plat to be filed in accordance with the requirements therein set forth.

At the request of the Commissioners Court the county attorney may file an action to enjoin a violation of any requirement established under the Commissioners Court subdivision order, and to recover damages to compensate the county in undertaking any construction or other activity necessary to bring about compliance with the subdivision order.

A person commits an offense if the person knowingly or intentionally violates a requirement of the subdivision order adopted by the Commissioners Court under this statute. The offense is a Class B misdemeanor.

Sec. 2.401 of Art. 6702-1 is the successor of the former Art. 6626a, which has been repealed.

Kleberg County has adopted a subdivision order under the authority of

Article 6626a. This subdivision order requires, in Section 19, that "roadway & drainage plans shall be prepared by a Registered Professional Engineer (Texas Registration)." This section may be amended to require that all drainage plans shall be in accordance with the Kleberg County "Drainage Criteria and Design Manual" adopted by the Commissioner's Court of Kleberg County, on _________, 198__, recorded in Volume _______, Page ___, as the Drainage Manual may be amended from time to time by order of the Commissioners Court.

The existing subdivision ordinance needs to be amended to reflect that it is adopted under the authority of Sec. 2.401 of Art. 6702-1, rather than the repealed 6626a.

It is therefore recommended that the following procedure be taken:

1. Adoption of the "Drainage Criteria and Design Manual" by the Commissioners Court.

2. Adoption of a new subdivision order containing the above-described addition to the existing order, and reflecting that it is adopted under the authority of Sec. 2.401 of Art. 6702-1.

Kleberg County also has authority to require development or building permits for construction in unincorporated areas that are floodplain areas designated by the Federal Insurance Administrator, and in areas designated by the Commissioners Court as being flood, or rising water prone, areas.

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