SOUTH PADRE ISLAND

PHASE 1 STORM DRAINAGE MASTER PLAN

DECEMBER 2018 FINAL REPORT

PREPARED FOR THE CITY OF SOUTH PADRE ISLAND BY
KIMLEY-HORN AND ASSOCIATES, INC.

ACKNOWLEDGEMENTS

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CHAPTER 1: INTRODUCTION

Authority

On June 6, 2018, the City of South Padre Island, Texas (City), authorized Phase 1 of an update to the *Storm Drainage Master Plan* to evaluate the storm drainage needs within the study area identified by City staff. The *Storm Drainage Master Plan* may be referred to as the "study" or "plan" throughout this document.

Purpose of the *Storm Drainage Master Plan*

The purpose of this study is to update the City's 1983 *Storm Drainage Master Plan.* This study includes an Existing Conditions Assessment based on observations of the City's existing storm drainage systems within the study area. This study also includes drainage design information that could be applied to future drainage facility design within the City. General considerations, recommendations, and prioritizations for future drainage system improvements are also included in this study. This *Storm Drainage Master Plan* is intended to be a planning tool, and the recommendations provided herein shall be subject to additional engineering prior to design.

Scope of Study

The scope of this study is to provide Phase 1 of the *Storm Drainage Master Plan* update through an Existing Conditions Assessment and preliminary design recommendations. This study also describes the analysis needed to perform Phase 2 of this study which includes detailed hydraulic analysis and further prioritization of design recommendations for capital improvement projects. The scope of this study includes the following principal items:

Limits of Study

The study area for the scope of this study is from Haas Street to Sunset Drive between Laguna Madre and the Gulf of Mexico. Refer to **Figure 1**. The study area consists of approximately 335 acres of both residential and commercial developments. The Suites at Sunchase area was added to the study area after field work had been completed, and associated field reconnaissance was not performed.

Data Collection

Data collection included review of City Standards, Specifications, Ordinances, and Standard Details. Existing land use maps and inventory maps/sketches of the existing storm drain system were analyzed as a part of this study. Public involvement through a community survey and public meeting was included as part of the Data Collection. Field review and collected data provided a baseline for the Storm Drain Map and Existing Conditions Assessment. Rainfall data and tidal information were also collected.

Storm Drainage System

Based on the field review and data collected, the overall storm drainage system for the City was documented. A preliminary storm drain map was developed as well as an inventory of storm drain infrastructure. Drainage areas were delineated, and a drainage map for the study area was developed. Preliminary flows were calculated using the Rational Method. The preliminary hydrologic analysis for runoff peak flow determination in this study included design storm frequencies, rainfall intensities, and methodology for calculating runoff. The Rational Method was used for all drainage areas in the City and based on ultimate watershed conditions.

Existing Conditions Assessment

Phase 1 of this study provides the development of an Existing Conditions Assessment based on the data collected, field review, and community input. The Existing Conditions Assessment shall be used as a guideline for determining priority areas for future improvements and further analysis in Phase 2.

Design Recommendations

Phase 1 of this study includes preliminary design recommendations provided through the Existing Conditions Assessment and community feedback. These design recommendations shall be used as a planning tool for the City's consideration and shall be further analyzed prior to design. **Chapter 5** (Design Recommendations) also provides design alternatives to consider that may alleviate flooding

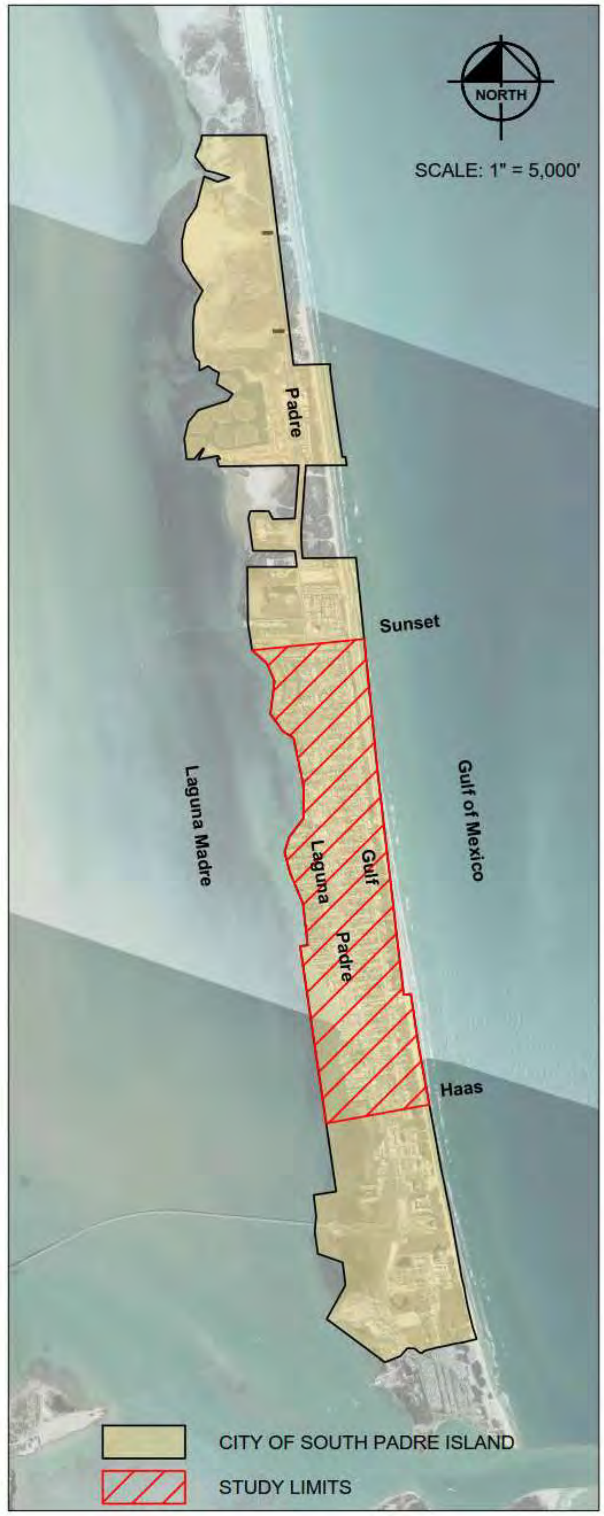

Figure 1. Vicinity Map

and provide needed storage in the City. These design alternatives shall be further considered in Phase 2 of this study. This chapter also outlines the general scope and process of the hydraulic analysis needed for the detailed design of storm drainage system capital improvements and cost estimates in Phase 2.

Phase 2 Storm Drainage Master Plan

Chapter 6 (*Phase 2 Storm Drainage Master Plan*) is reserved for the future Phase 2 of the *Storm Drainage Master Plan*. Phase 2 will likely include detailed analysis and engineering design of the recommendations provided herein.

CHAPTER 2: DATA COLLECTION

General

Various field data sets and available plan sets were utilized to determine the locations and attributes of the existing storm drain system. The data collected included the City's storm drain inventory sketches, available construction files, and record drawings for completed roadway and drainage projects. These data were used to develop the Existing Conditions Assessment and the Preliminary Storm Drain Map as shown in **Appendix A** (Preliminary Storm Drain Map). The Preliminary Storm Drain Map is a schematic to be used as a base map of the existing storm drain system and will serve as a basis for future system improvements. Topographic survey was not performed for this study. Thus, surveyed elevations of key infrastructure are not currently shown on the map.

The following data was collected from the City, field review, and applicable agencies:

- Inventory Map/Sketches of Existing Storm Drain System (Inlets, Manholes, and Outfalls);
- Tailwater/Tidal Information;
- Rainfall Data;
- City Ordinances, Regulations, and Guidelines for Stormwater Management;
- Soil Maps;
- Land Use Maps;
- Record Drawings for Completed Stormwater Management/Drainage Projects;
- Previous Studies, Reports, and/or Construction Plans;
- 2006 LiDAR; and,
- Aerial Images.

In addition to the development of the Storm Drain Map, existing drainage problem areas were gathered as a part of this study. Community input was gathered and documented through discussions and comment sheets at a community forum, an online survey, and through various meetings with the City staff. The local knowledge and first-hand experiences supplemented the field observations and served as the basis of priority areas for drainage improvement recommendations. The survey that was provided to the community is located in **Appendix B** (Community Drainage Survey), and a record of community drainage complaints is included in **Appendix C** (Drainage Complaints). An exhibit of these noted drainage problem areas is included in **Appendix D** (Drainage Problem Areas Map).

Figure 2. Field Review, August 2018

Field Review and Analysis

As part of this study, available data on the existing storm drain system within the City of South Padre Island was collected and analyzed. Several field visits were performed to verify the locations and conditions of the existing systems. City staff also performed several field visits to help identify pipe connections and flow directions throughout the existing system. These field visits also identified storm drain structures that were not previously identified on the City's storm drain inventory sketches and Google Earth KMZ files. Google Earth was utilized to identify, validate, and supplement the City's storm drain inventory sketches. The available data and the collected data from the various field visits were utilized to create a Storm Drain Map as shown in **Appendix A** (Preliminary Storm Drain Map). Physical properties of storm drain infrastructure, including pipe size and geometry, were approximated based on field reconnaissance or City storm drain inventory maps/sketches when plan set data or survey were unavailable. A total of 203 structures were reviewed for this study, and elevation data will be added after field survey is performed. Detailed topographic survey will be required prior to final design for any proposed drainage improvements.

Public Involvement

Community involvement was an important part of this study. Input was requested from the community and City staff to help identify problem areas or areas of frequent flooding and drainage issues. This feedback was incorporated into **Appendix D** (Drainage Problem Areas Map) to demonstrate drainage problem areas throughout the City's existing storm drain system. The community feedback was also used as a basis for the design recommendations for the City's consideration presented in **Chapter 5** (Design Recommendations).

Community Drainage Survey

As part of the data collection process for this study, a Community Drainage Survey was distributed to residents and business owners in the City of South Padre Island, and community participation was collected to determine priority areas for further analysis. The Community Drainage Survey and responses, incorporated into **Appendix B** (Community Drainage Survey) and **Appendix C** (Drainage Complaints), respectively, were used to establish locations with drainage and flooding issues as well as locations with drainage improvements.

Public Meeting

A Public Meeting was held on August 1, 2018, at 4:00 PM at City Hall. The Public Meeting was held to gather data and inform the community of the *Storm Drainage Master Plan* update. At the Public Meeting, Comment Sheets, incorporated into **Appendix C** (Drainage Complaints), were collected to determine locations of drainage issues and further details regarding the flooding issues.

The Comment Sheet is presented in **Figure 5**. The information displayed and discussed at the meeting included project background and drainage considerations presented in **Figure 6** and **Figure 7**.

In addition to collecting Comment Sheets, a roll plot map of the City was utilized as a board for marking problem areas. Stakeholders were able to discuss areas of drainage concerns with City staff and the consultant team and were encouraged to mark the areas of concern on the roll plot map by areas of significant flooding, moderate flooding, and minor flooding. A suggestion board was also utilized at the Public Meeting to encourage stakeholders to provide input to alleviate drainage and flooding issues in the City.

Figure 3. Stakeholders at Public Meeting, August 2018

Figure 4. Roll Plot Map at Public Meeting, August 2018

South Padre Island Storm Drainage Master Plan Update

COMMENT SHEET

Storm Drainage Master Plan Open House Wednesday, August 1, 2018 City Hall, 4601 Padre Blvd. South Padre Island, TX 78597	**Comment Sheet Number** *(Staff only)*

Please provide us your contact information (optional).

Name: ______________________________ **Phone #:** ______________________________

E-mail: ______________________________ **Address:** ______________________________

Questions / Comments:

1. **Please provide the address or intersection of the drainage/flooding issue.**

2. **Please circle the frequency of flooding issues you have experienced.**

   Floods every time it rains *Floods often* *Floods sometime*

3. **Please circle the scale of flooding issues you have experienced.**

   Significant flooding issues *Moderate flooding issues* *Minor flooding issues*

4. **Please provide any additional comments.**

What interested you in attending tonight's public meeting?

For additional questions/comments, please contact:

Alex Sanchez	Darla Jones
956-761-8158	956-761-8107
CSanchez@MySPI.org	DJones@MySPI.org

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Figure 5. Public Meeting Comment Sheet

South Padre Island Storm Drainage Master Plan Update

PROJECT BACKGROUND

What is a Storm Drainage Master Plan?

A Storm Drainage Master Plan is a comprehensive planning document that investigates and analyzes existing drainage facilities to provide a summary of recommendations and prioritizations for adequate stormwater management.

The City of South Padre Island's Storm Drainage Master Plan update is needed to take the progress made, lessons learned, and information gathered since 1983, and update the Storm Drainage Master Plan to optimize drainage and flooding solutions for the future.

How is a Storm Drainage Master Plan used?

- ✓ As a guide for proposed improvements to the existing drainage system
- ✓ To focus on optimizing the use of existing resources
- ✓ To determine priority locations and alternatives
- ✓ To inform and promote stormwater management
- ✓ To provide a recommended implementation plan

Laguna Blvd Rain Event, June 2018

Padre Blvd Rain Event, June 2018

How can the public be involved in the Storm Drainage Master Plan update?

The public is encouraged to provide feedback concerning drainage issues to help in the development of the Existing Conditions Assessment. The feedback will be collected and incorporated in the Storm Drainage Master Plan update. Please visit http://www.myspi.org/ to respond to the **South Padre Island Community Drainage Survey**. Community participation is an important South Padre Island tradition, and we look forward to you being a part of this work to ensure continued preservation and enjoyment of South Padre Island.

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Figure 6. Public Meeting Project Background Exhibit

South Padre Island Storm Drainage Master Plan Update

DRAINAGE CONSIDERATIONS

What is Flooding?

The **National Flood Insurance Program (NFIP)** defines a flood as: "A general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties (at least one of which is the policyholder's property) from:

- ✓ Overflow of inland or tidal waters;
- ✓ Unusual and rapid accumulation or runoff of surface waters from any source;
- ✓ Mudflow; or,

Collapse or subsidence of land along the shore of a lake or similar body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels that result in a flood as defined above."

Examples of Flooding/Drainage Issues:

- ✓ Dangerous intersections due to flooding
- ✓ Property flooding during storm events
- ✓ Flooded structures during storm events
- ✓ Ponding in sidewalks
- ✓ Ponding in driveways
- ✓ Ponding in yards
- ✓ Flooded storm drain inlets
- ✓ Debris collection in storm drain inlets

Scale of Flooding Examples:

Significant *flooding issues:*

- ✓ Extensive inundation of structures and roads
- ✓ Rain causes major roadway to shut-down for an extended period of time
- ✓ Deep ponding that does not drain within a day
- ✓ Evacuations of people and/or transfer of property to higher elevations

Moderate *flooding issues:*

- ✓ Some inundation of structures and roads
- ✓ Some public threat or inconvenience
- ✓ Vulnerable roadways during rain event

Minor *flooding issues:*

- ✓ Minimal or no property damage
- ✓ Nuisance flooding in low-lying areas
- ✓ Areas of poor drainage

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Figure 7. Public Meeting Drainage Considerations Exhibit

Data Collection for Hydrologic and Hydraulic Analyses

As part of this study, data for hydrologic and hydraulic analyses was gathered from existing City criteria and other federal, state, and governmental agencies.

Sources of Data

The sources of this data include City-provided resources, including the 1983 *Storm Drainage Master Plan*, as well as the below agencies:

- Federal Emergency Management Agency (FEMA);
- Texas Department of Transportation (TxDOT);
- United States Geological Survey (USGS);
- Texas Water Development Board (TWDB);
- Nation Oceanic and Atmospheric Administration (NOAA); and,
- City of South Padre Island.

Rainfall Data

The City receives an average annual rainfall of approximately 24 inches according to the TWDB's precipitation and gross lake evaporation data from 2010 to 2018. The City has previously used rainfall intensities from rainfall intensity duration frequency curves that were developed by TxDOT. NOAA has recently released updated precipitation estimates for Texas in *NOAA Atlas 14, Volume 11: Precipitation-Frequency Atlas of the United States.* The precipitation data from the 1983 *Storm Drainage Master Plan* and the updated precipitation data from the 2018 NOAA Atlas 14, Volume 11 release will be discussed with the Rational Method in **Chapter 3** (Storm Drainage System).

Tidal Elevation/Tailwater Elevation Data

Existing tailwater or tidal elevation data should be utilized for each storm event in hydraulic analyses for any proposed improvements to the storm drain system. Tidal impacts need to be considered for design recommendations to allow for proper sizing and storage during high tides. Tidal data was identified through the NOAA Tides and Currents, South Padre Island Station 8779748. The current maximum water level is 2.18 feet MHHW experienced on October 7, 2017. The current minimum water level is -0.87 feet MLLW experienced on January 23, 2016. The mean range is 1.18 feet. Refer to **Chapter 5** (Design Recommendations) for additional consideration and preliminary tailwater conditions.

Inundation Maps

Inundation maps were collected from the NOAA Sea Level Rise Viewer (2018) to help illustrate the effect the rise in sea level can have on the City. Refer to **Appendix E** (Sea Level Rise Inundation Maps) for current elevation conditions based on the NOAA data. The blue areas show areas of anticipated flooding, and the darker blue indicates greater depths. As the sea level rises, areas of Padre Boulevard are shown to be inundated.

CHAPTER 3: STORM DRAINAGE SYSTEM

General Drainage System

The existing storm drainage system consists primarily of reinforced concrete pipe culverts installed at street intersections, street low points, driveways, and enclosed storm drain. The stormwater runoff within the remaining limits of the study area is carried along the existing rights-of-way of city streets, natural drainage courses, and constructed open ditches and earth channels. Most of these existing culverts are circular pipe in sizes ranging from 18 inches to 30 inches in diameter. The enclosed storm drain systems are located under several east-west streets. Most of the enclosed storm drain systems are 24-inch diameter reinforced concrete pipe. They begin at Padre Boulevard and continue westward, crossing Laguna Boulevard, to the Laguna Madre. Most systems include an inlet on the east and west sides of Padre Boulevard as well as on the east and west sides of Laguna Boulevard. In general, the east side of the City sheet flows to Padre Boulevard and the west side of the City drains to existing storm drain systems. Recent construction between Padre Boulevard and Gulf Boulevard has included paving of several side streets and capturing stormwater at the downstream end via inlets at Padre Boulevard.

Capacity

Many of the existing storm drain pipes have outlets which are partially submerged below receiving water levels, mainly Laguna Madre or wetlands, and most pipes and inlets are partially filled with backwater and debris. Both of these factors contribute to capacity reductions in already under designed systems.

Wetlands

Many of the existing drainage structures, particularly those crossing under Padre Boulevard and Laguna Boulevard, discharge into wetlands. Since these wetlands are normally filled with water, an elevation head must be developed on the upstream end of the culvert sufficient to provide the force for the water to travel through the culvert. This situation can lead to flooding at the inlets on each end of the pipe which results in flooding on both sides of the street. Refer to **Chapter 5** (Design Recommendations) for additional consideration to wetland flooding and permitting.

Preliminary Storm Drain Map

Through field reviews, a desktop analysis, and information provided by the City, 203 existing inlets, manholes, and outfalls within the study area were located. Available record drawings and the City's storm drain inventory sketches along with the field review data were utilized to establish physical properties of storm drain infrastructure, including storm drain sizes and geometry. A Preliminary Storm Drain Map was developed to show the locations of the existing drainage pipes and structures and the approximate limits of the study area relative to the City's street layout. This map is located in **Appendix A** (Preliminary Storm Drain Map). Prior to final design detailed survey of storm drain facilities should be performed to confirm preliminary information shown in the map.

Storm Drain Inventory

The field review data was also collected and organized into a document for use of City staff. Refer to **Appendix F** (Storm Drain System Inventory) for locations, descriptions, and photos of the existing structures. **Figure 8** through **Figure 21** provide examples of drainage structures from the consultant team field reviews.

Figure 8. Example Outfall Degradation

Figure 9. Example Curb Inlet Full of Water and Trash

Figure 10. Example Outfall to Wetlands, Padre Boulevard

Figure 11. Example Outfall to Wetlands, Padre Boulevard

Figure 12. Example Ponding Water

Figure 13. Example Ponding Water

Figure 14. Example Vacant Lot, Gulf Boulevard

Figure 15. Example Grate Inlet, Laguna Boulevard

Figure 16. Example Grate Inlet, Laguna Boulevard

Figure 17. Example Curb Inlet, Padre Boulevard

Figure 18. Example Curb Inlets, Padre Boulevard

Figure 19. Example Parking Lot Curb and Grate Inlet, Laguna Boulevard

Figure 20. Example Outfall to Laguna Madre

Figure 21. Example Culvert, Laguna Boulevard

Storm Drain Profiles

As described in the 1983 study, the analysis of the existing storm drain structures revealed that, in most cases, at least one portion of the main line in each system is either flat or has a negative grade, which requires the water to travel uphill before reaching Laguna Madre. A negative grade in the pipe would cause the water to flow backwards until sufficient head accumulates on an inlet in the system to force the water through the pipe and into Laguna Madre. This situation causes a large quantity of water to pond at each inlet and to cause flooding of the streets. Existing storm drain system profiles were previously developed and can be found in the 1983 study. These profiles could be updated as a part of Phase 2, and further consideration and analysis of the existing storm drain system is mentioned in **Chapter 5** (Design Recommendations).

Drainage Area Map

The study area was divided into drainage basins based on stormwater flowing into each storm drain structure. These areas were delineated using contour data from TNRIS and engineering judgement. Due to the flat topography in this area, supplemental survey data is recommended for future design projects in order to verify these drainage basins and better define existing flow patterns. A Drainage Area Map was developed to show these drainage areas. Refer to **Appendix G** (Drainage Area Map) for the basin delineations.

Rational Method

The Rational Method was used to estimate preliminary stormwater runoff peak flows for the design of gutter flows, drainage inlets, storm drain pipe, culverts, and ditches. Runoff computations were based upon fully developed watershed conditions in accordance with the ultimate land use projections in the City's Comprehensive Plan. The preliminary flows for the delineated drainage areas are located in **Appendix G** (Drainage Area Map).

The peak discharge rate was computed by the following methodology:

Rational Method

$$Q = CIA$$

Where:

Q	=	Peak discharge rate (cubic feet per second)
C	=	Runoff coefficient from **Table 3-1** for given area (dimensionless)
I	=	Average rainfall intensity during the time of concentration for a given storm event from the Intensity Duration Frequency curve in the 1983 study (in/hr)
A	=	Drainage area contributing runoff to the design location (acres)

Runoff Coefficient (C)

Runoff coefficients were based on the ultimate land use (refer to the City's Land Use Map within the Comprehensive Plan) and the respective runoff coefficient from the 1983 study provided in **Table 3-1**. A minimum runoff coefficient of 0.60 was used for areas not covered by the Land Use Map. For a site with two or more land uses, a weighted runoff coefficient may be used if it is more representative of site conditions using the following equation:

Weighted Runoff Coefficient

$$C_W = \frac{C_1A_1 + C_2A_2 + \ldots + C_nA_n}{A_1 + A_2 + \ldots + A_n}$$

Where:

C_W	=	Weighted runoff coefficient (dimensionless)
C	=	Runoff coefficient from **Table 3-1** for given area (dimensionless)
A	=	Drainage area contributing runoff to the design location (acres)
n	=	Number of drainage areas

Table 3-1. Land Use Runoff Coefficients

Land Use	Runoff Coefficient (C)
Commercial Areas	0.90
Industrial Areas	0.70
Residential Areas	0.45
Apartment Condominium Areas	0.70
Park Areas	0.35

Rainfall Intensity (I)

Rainfall intensities for the design return periods in the Rational Method came from the Intensity Duration Frequency curve in the 1983 study which is based on Technical Paper No. 4. As discussed in Chapter 2, NOAA has recently released updated precipitation estimates for Texas in *NOAA Atlas 14, Volume 11: Precipitation-Frequency Atlas of the United States.* A letter from TxDOT is located in **Appendix H** (TxDOT Updated Rainfall Data Letter) that explains that TxDOT is adopting the updated rainfall data from Atlas 14. The new data will be incorporated into the TxDOT *Hydraulic Design Manual* by May 2019. Refer to **Figure 22** and **Figure 23** for partial duration series (PDS)-based IDF curves for the City of South Padre Island from the current edition of the *NOAA Atlas 14, Volume 11, Texas, Precipitation-Frequency Atlas of the United States* and the Precipitation Frequency Data Server for various average recurrence intervals or design storms.

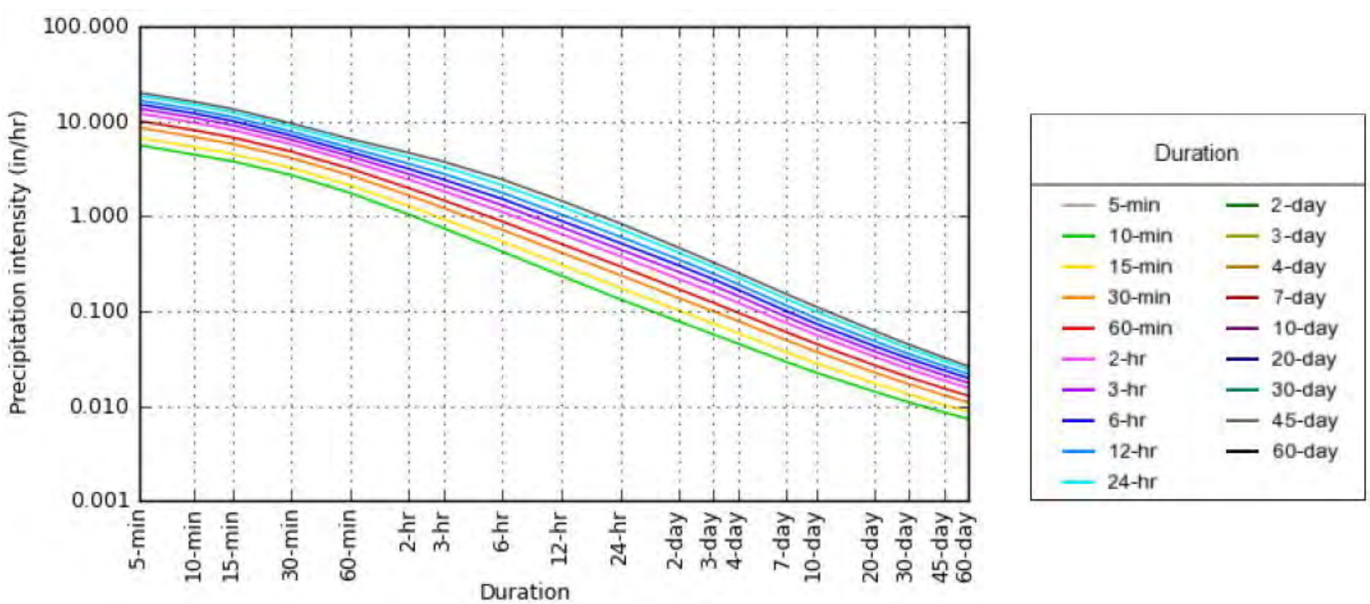


Figure 22. Intensity-Duration-Frequency (IDF) Curve Duration

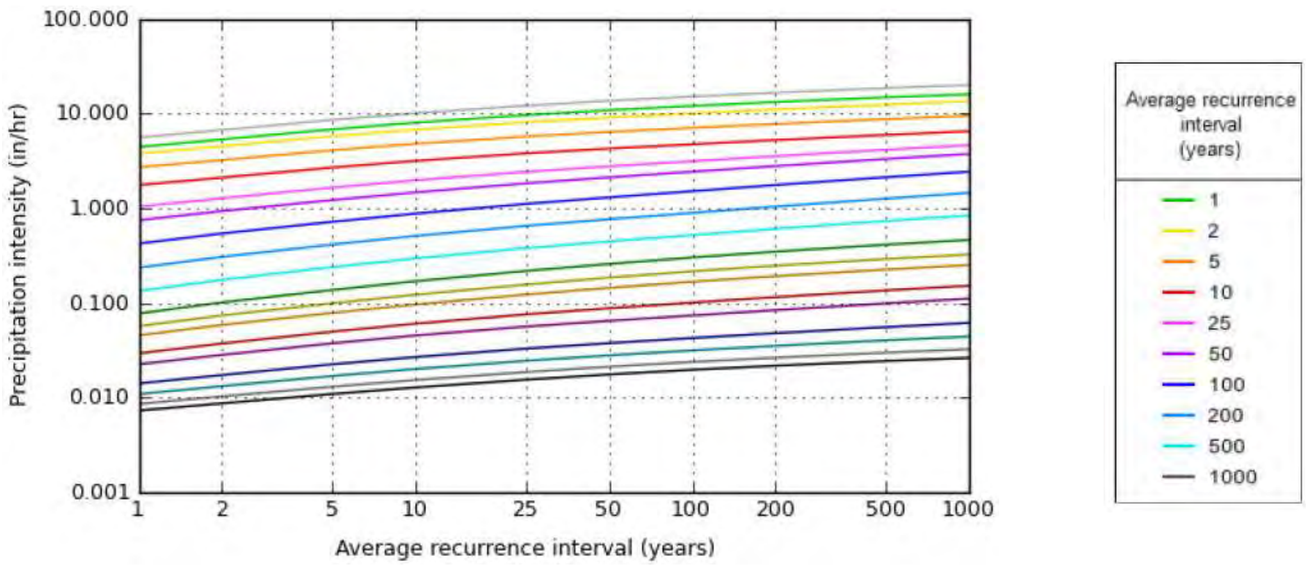


Figure 23. Intensity-Duration-Frequency (IDF) Curve Average Recurrence Interval

Table 3-2 shows Precipitation Frequency Estimates for the 2-year, 5-year, 10-year, and 25-year storm from the NOAA Atlas 14, Volume 11, Version 2. The rainfall intensity estimates in **Table 3-2** are based on data at the time of this study.

Table 3-2. Precipitation Intensity Estimates 24-hour Duration

Storm Event (years)	Precipitation Frequency (PF) Estimates[1,2,3] (inches/hour)
2	0.175 (0.137-0.213)
5	0.239 (0.189-0.298)
10	0.296 (0.231-0.376)
25	0.379 (0.285-0.497)

1. Estimates taken from the NOAA Atlas 14 Precipitation Frequency Data Server (PFDS).
2. Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values
3. Please refer to NOAA Atlas 14 document for more information.

The NOAA Atlas 14, Volume 11, Version 2 PF estimates are compared to the rainfall frequencies provided in the U.S. Department of Commerce Weather Bureau Technical Paper No. 40 as shown in

Table 3-3. The rainfall intensities provided in Technical Paper No. 40 were utilized for the City's *Storm Drainage Master Plan* in 1983 as well as this study.

Table 3-3. Precipitation Depth Estimates 24-hour Duration

Storm Event (years)	Technical Paper No. 40 PF[1] (inches)	NOAA Atlas 14, Volume 11 PF[2,3,4] (inches)
2	4.60	4.21 (3.30-5.12)
5	6.40	5.74 (4.54-7.14)
10	7.70	7.11 (5.54-9.03)
25	9.10	9.10 (6.84-11.9)

1. Approximate estimates based on the 2-, 5-, 10-, and 25-year 24-hour rainfall frequency maps.
2. Estimates taken from the NOAA Atlas 14 Precipitation Frequency Data Server (PFDS).
3. Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against PMP estimates and may be higher than currently valid PMP values.
4. Please refer to NOAA Atlas 14 document for more information.

Drainage Area (A)

The drainage areas within the study area basin contributing stormwater runoff to the system were delineated, and the map of these areas is located in **Appendix G** (Drainage Area Map).

CHAPTER 4: EXISTING CONDITIONS ASSESSMENT

General

The data collected through the field review and public meetings were evaluated to develop an Existing Conditions Assessment to prioritize existing drainage issues within the City.

Identified Problem Areas

The existing drainage problem areas identified through the Community Drainage Survey and Public Meeting Comment Sheets were compiled, evaluated, and summarized. A map was developed to illustrate the problem area location within the City and is located in **Appendix D** (Drainage Problem Areas Map). The information was also organized in a document which is located in **Appendix C** (Drainage Complaints).

Based on the community input received through this study, the following problem areas in **Table 4-1** have been identified as drainage and flooding concerns. Individual home addresses have been concealed for privacy, and the entire streets have been identified. Businesses identified in the Community Drainage Survey as problem areas are also included in **Table 4-1**. The list in **Table 4-1** is in order of highest to lowest frequency of complaints collected during this study. The identified problem areas in **Table 4-1** validate the Community Drainage Survey responses and community input received during the time of this study and help refine the list of problem areas to prioritize capital improvements.

Table 4-1. Identified Problem Areas

Location	Number of Drainage Complaints Received[1]
Padre Boulevard	111
Gulf Boulevard	22
Laguna Boulevard	9
Hibiscus Street	20
West Oleander Street	13
West Sunset Drive	13
Capricorn Drive	6
Swordfish Street	5
West Atol Street	5
East Morningside Drive	5
East Polaris Drive	5

West Lantana Street	4
East Acapulco Street	3
East Palmetto Drive	3
East Retama Street	3
West Cora Lee Drive	3
Red Snapper Street	2
Huisache Street	1
East Campeche Street	1
Post Office parking lot	8
Suites at Sunchase area	3
Blue Marlin Supermarket parking lot	3
Padre Island Brewing Company parking lot	2
Padre Oasis Condos parking lot	1
North Plaza parking lot	1
Ocean Motion parking lot	Additional Feedback
Various home and condo driveways and yards	Additional Feedback
1. Drainage Complaints received from the Community Drainage Survey, August-September 2018.	

The record of community drainage concerns shown in **Appendix C** (Drainage Complaints), demonstrates the main drainage issues the community is currently experiencing are flooding, ponding water, and blocked or lack of drainage. Examples of flooding from fall 2018 storm events are included in **Figure 24** through **Figure 28** below to demonstrate the significant flooding the City streets are currently experiencing.

Figure 24. Example Flooding Event, Fall 2018

Figure 25. Example Flooding Event, Fall 2018

Figure 26. Example Flooding Event, Fall 2018

Figure 27. Example Flooding Event, Fall 2018

Figure 28. Example Flooding Event, Fall 2018

The frequency of flooding issues based on the results of the Community Drainage Survey is shown in **Figure 29.** The split in results indicates a wide variety of flooding frequency issues. Thus, a variety of storm events are recommended for further drainage analysis.

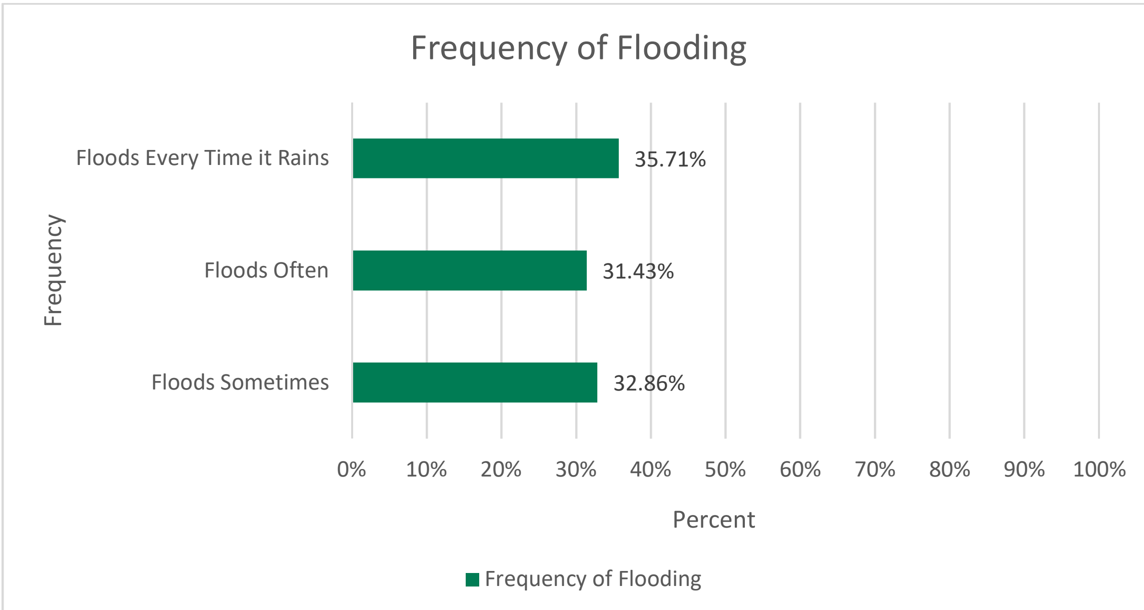


Figure 29. Frequency of Flooding from Community Drainage Survey

The typical duration for persistent ponding of water to drain after it rains is reflected in the results from the Community Drainage Survey as shown in **Figure 30.** Based on the results, shorter storms, which typically have a high intensity, result in the most problematic and nuisance flooding. Others noted that it is common for flooding to persist for one or two days. Some of this flooding could be attributed to storms during higher tide (higher tailwater) conditions that impact the City's storm drain infrastructure capacity. The flooding persistence indicates an issue in either storm drain capacity, hydraulic gradient, roadway and terrain grading, an increase in impervious area, tailwater condition, or a combination thereof. This study intends to evaluate some of those possible issues and propose recommendations that may improve the existing storm drain system inadequacies.

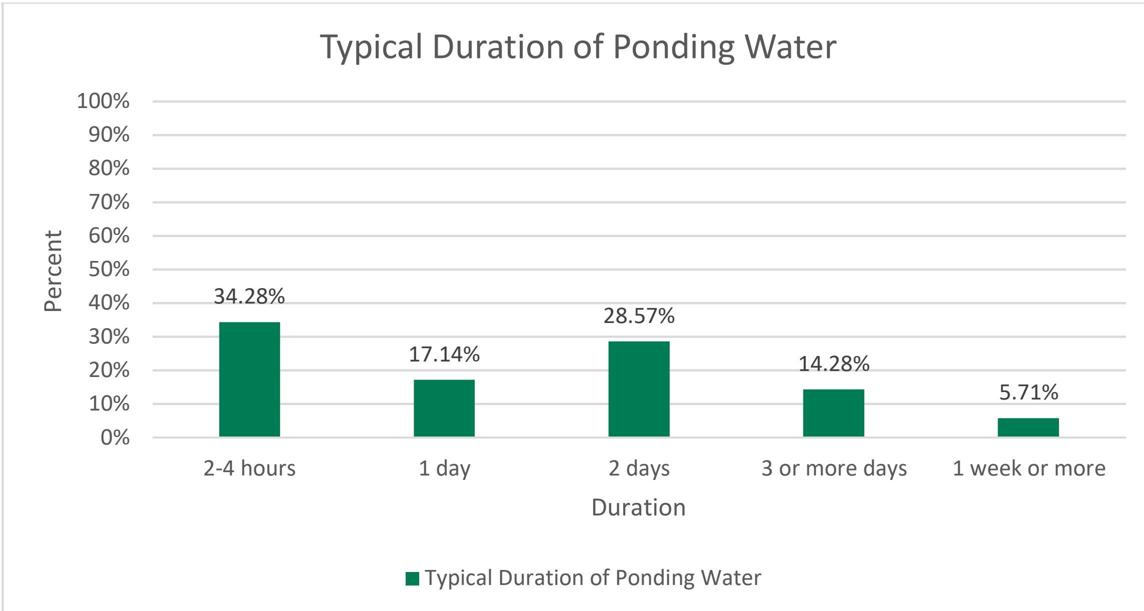


Figure 30. Typical Duration of Ponding Water from Community Drainage Survey

Suites at Sunchase Preliminary Proposed Alternatives

As a part of Phase 1 of this study, the City requested that a preliminary analysis and recommendation for proposed drainage facilities to an area of frequent flooding be performed. The Suites at Sunchase located at 1004 Padre Boulevard was identified as a priority area for drainage improvements in the City's 1983 *Storm Drainage Master Plan*. The Suites at Sunchase is in a sag location along Padre Boulevard, across from a wetlands area. These factors have contributed to flooding, which causes driving, traffic, and public safety concerns to the community. The City was provided with a memorandum including preliminary recommendations based on limited data available at the time of the analysis. The proposed improvements presented in the memorandum may be considered further and validated in Phase 2 of this study with detailed survey and modeling of the area. The memorandum is included in **Appendix I** (Suites at Sunchase Preliminary Memorandum).

CHAPTER 5: DESIGN RECOMMENDATIONS

General

The Phase 1 *Storm Drainage Master Plan* update was performed for the City as a planning tool to assess existing conditions and problem areas and to prioritize areas for future capital improvements for the City's storm drain system. Many of the City's streets are in need of drainage improvements to alleviate existing and future flooding concerns. This chapter includes preliminary design recommendations and alternatives to consider in Phase 2 of this study. These design recommendations should be further analyzed with modeling and additional detailed survey prior to final design to confirm proposed alternatives for each application on a case-by-case basis.

Goals of this Study

With the site conditions and specific City flooding concerns, the goal of this study is to minimize the limits and duration of flooding and improve vehicular and public safety during storm events. The responses from the Community Drainage Survey demonstrated the overall concerns of the community and how this study will help steer future development and alleviate drainage issues and flooding. Another goal of this study is to find reasonable solutions that are both practical and will provide immediate flood relief. The proposed recommendations provided herein will assist in improving the existing storm drainage system.

Site Conditions

The City's low-lying topography causes a limited change in elevation and limited head or pressure for gravity flow storm drain systems. Another challenge of the site conditions is tidal impacts on conventional storm drain systems. The City's storm drain system is at risk for additional debris collected in pipes due to backwater effects and wave action. The entire City is also within the FEMA 100-year floodplain and is statistically likely to flood. Padre Boulevard is the most represented area in the community's drainage concerns and complaints and is a TxDOT maintained roadway, which causes funding and design limitations. The City would benefit from a holistic, comprehensive drainage approach or solution. Improvements along problematic areas will help alleviate the drainage issues, and a full system analysis would greatly improve the storm drain network.

Recommendations and Methodologies

Additional storm drainage improvements may be considered in Phase 2 of this study. These alternatives could be considered to address the relatively flat topography of the City, high observed water levels, and inadequate storage in the existing storm drain system. Some of the storm drain system recommendations along with general recommendations to improve flooding conditions and overall drainage are outlined below.

Maintenance and Inspection Considerations

The Existing Conditions Assessment demonstrated the need for more frequent maintenance of the existing storm drain network. It is recommended that as part of the overall drainage improvements, all existing storm drains are cleaned out regularly and proper maintenance is performed to keep the systems clear of debris and allow for maximum storage capacity. As debris and trash accumulates, it obstructs the flow of water into the inlet. Proper maintenance and inspection may be performed for erosion and sediment control and clogging of outfalls. A Standard Operating Procedure for maintenance and inspection could be developed as a part of Phase 2.

Additional Detailed Survey

Due to the low-lying area of this study, additional detailed topographic survey is recommended to ensure the proposed flowlines and elevations are in line with the proposed alternatives. Additional detailed survey will also assist in pipe sizing and capacity calculations for each drainage area in the storm drain system. Additional detailed survey of all related storm drain structures is recommended to be performed by a Registered Professional Land Surveyor prior to final design to confirm flowlines and necessary elevations of pipes and inlets. Additional survey may include mobile LiDAR, aerial LiDAR, field topographic survey, orthoimagery, and 1-foot contour development. Additional survey of the drainage basin topography will provide more detail to better define drainage patterns within the basin and provide better data for the hydrologic analysis for flow determination.

Hydrologic and Hydraulic Analyses

Phase 1 analysis of this study utilized plan set data and limited preliminary surveys to establish existing storm drain sizes and geometry. It is recommended that Phase 2 of this study includes hydrologic and hydraulic analysis of the existing storm drain system capacities for the 2-year, 5-year, 10-year, and 25-year storm events. A study of this nature would better define which storm drain systems are undersized. Analyzing proposed improvement options would show the capacity needed to reduce flooding for the system.

For proposed improvements to the storm drain system, the system's hydraulic grade line (HGL) should be analyzed to determine if the system could accommodate design flows for the 2-, 5-, 10-, and 25-year storm events in the proposed drainage system without causing flooding. The preliminary drainage system limits will be defined by each drainage area outlined in **Appendix G** (Drainage Area Map). The Rational Method variables will be applied to the calculations as well as known elevations and slope of pipe from construction plans and field review data shown in **Appendix A** (Preliminary Storm Drain Map).

For the HGL analyses, flow capacity calculations using detailed topographic survey will be needed to better define the contributing drainage area limits. The HGL elevations will be compared to the top of structure elevations for the existing structures as the critical elevations of the existing drainage system. The probable water levels for the 2-, 5-, 10-, and 25-year design storms should not exceed the existing structures elevations.

Further consideration will be required for tailwater depth or elevation since tidal changes may adversely affect the efficiency of the system. Preliminary coastal tailwater conditions may be used for preliminary HGL calculations for each storm event as shown in **Table 5-1**. These values are a general rule of thumb estimate when exact tailwater data corresponding to particular storm events is not available.

Table 5-1. Preliminary Tailwater Conditions

Storm Event (years)	Tailwater Elevations (feet)
2	0.50
5	1.00
10	1.50
25	2.00
100	2.50

The preliminary coastal tailwater conditions assumed in **Table 5-1** are in line with coastal cities' tailwater elevations. To fully analyze the flow characteristics of the outfall channel for each drainage area, the appropriate tailwater elevations should be used as the basis for the HGL calculations if a full, detailed design is performed. Refer to **Chapter 2** (Data Collection) for existing tailwater and tidal elevations in the City.

Storage Design

Stormwater runoff may require additional storage for meeting water quality protection, downstream streambank protection, and flood control. Stormwater runoff storage may be provided through the use of structural stormwater controls and/or nonstructural features and landscaped areas.

- **Storm Drain Storage** – Additional storm drain storage may be considered where water currently collects and street flooding occurs. If downstream drainage facilities are undersized for the design flow, a structural stormwater control may be needed to reduce the possibility of flooding. The required storage volume can also be provided by using larger than needed storm drain pipe sizes and restrictors to control the release rates at manholes and/or junction boxes in the storm drain system.
- **Underground Detention** – Underground detention may be considered to provide additional storage when necessary during a storm or high tide event.

Flow Control Devices

Flow control devices, such as flow regulators and inline check valves, may be considered to alleviate flooding in the City. These devices may be recommended in conjunction with the existing storm drain system or proposed drainage improvements to control flow conditions and prevent backflow overloading in the system. Flow control devices may also be considered as a recommendation for controlling the flow in the system due to high tides, rain events, or water levels. Flow control devices are intended to keep the system empty and help to receive major storm events without reaching full capacity as quickly. The City has recently installed a backflow device at a storm drain outfall to Laguna Madre, and results from its use could be evaluated for Phase 2.

Stormwater Chambers

Stormwater chambers may be recommended for underground detention in place of stormwater management systems such as ponds, pipe, or concrete structures. Stormwater chambers may be considered to maximize the use of land area and storage capacity. Additional consideration can be given in Phase 2 regarding cost estimates, sizing and capacity calculations, and necessary approval for commercial and residential use. Stormwater chambers come in a variety of shapes and from a variety of manufacturers. These systems can be buried shallow with minimal cover. Stormwater chambers systems proposed within TxDOT ROW along Padre Boulevard would need approval from TxDOT.

Upsizing the Existing Storm Drain System

Upsizing existing storm drain structures with inadequate capacity could be considered in the Phase 2 analysis. This evaluation would consider the impacts of high tidal elevations and tailwater conditions, increased rainfall, and ultimate development on the storm drain system for designated storm events. This recommendation would require hydrologic and hydraulic analyses as described previously in this section.

Pumping System

The 1983 *Storm Drainage Master Plan* included an alternate method for conveying stormwater runoff which included a pumping system. The pumping system recommendation includes lined channels and sumps as well as stormwater pumping stations. This alternative could be further explored in Phase 2.

Spread Limits

During a particular design storm, the quantity of stormwater that is allowed to collect in the streets before being intercepted by a storm drainage system is referred to as the spread of water. In determining the limitations for carrying stormwater in the street, the ultimate development of the street should be considered. Limiting the use of the street for carrying stormwater to the spread criteria such as the limits shown in **Table 5-2** could be considered by the City. The City could also consider requiring a particular length of inlet opening for each cubic foot per second of gutter flow as shown in **Table 5-3**.

Table 5-2. Spread Limits

Type of Roadway	Spread Criteria
Major Thoroughfares (Divided)	One traffic lane on each side to remain clear
Thoroughfares (Not Divided)	Two traffic lanes to remain clear
Collector	One traffic lane to remain clear
Residential	6" depth of flow at curb

Table 5-3. Length of Inlet Opening

Roadway Grade	Length of Inlet Opening (feet/cubic feet per second)[1]
Less than 2%	1.0
2% to 3.5%	1.5
Greater than 3.5%	2.0
1. Inlets should be provided in increments of 5 feet and all capacities should round up.	

Other Proposed Alternatives

Other alternatives can be considered as needed, and as community input is received, in the Phase 2 analysis. These proposed alternatives for storm drainage improvements and stormwater management may include low impact development design or best management practices (BMPs).

Capital Improvement Recommendations

As part of Phase 2 for this study, a summary of needed improvements and a capital improvements recommendation plan could be provided for the City's consideration.

Recommendations and Prioritization

The Existing Conditions Assessment from Phase 1 as well as additional modeling, hydraulic and hydrologic analysis, and detailed survey could be utilized to develop capital improvement recommendations. The capital improvement alternatives would take into consideration storm drain structures with inadequate capacity, known flooding history, and outstanding drainage complaints. Planning level cost estimates would be provided as part of the capital improvements recommendation plan. A map of proposed alternatives in GIS or AutoCAD could be provided for the City's consideration and may include the proposed system improvements, proposed storm capacity, and flooding structure complaints.

Priority Areas

Priority areas for drainage improvements could be considered in Phase 2 of this study. In the priority alternative analysis, two proposed alternatives per priority location will be modeled. The priority areas will incorporate the community feedback received in Phase 1 and the Existing Conditions Assessment. Storm drain structures with inadequate capacity will be prioritized to meet the storm event designated by the City. The above recommendations and alternatives will be considered for evaluation for each priority area given the site constraints, probable cost estimates, downstream conditions, and storm event capacity.

Funding

The recommended improvements in Phase 2 will vary in cost depending on the necessary funds for project design, right-of-way/easement acquisition, and construction. If available, operation expenses could be allocated on an annual basis to enhance the existing infrastructure.

Permitting

Several of the storm drain systems outfall into existing wetland areas, and permitting should be considered in alternative solutions. If proposed improvements are located within wetlands or jurisdictional waters of the United States, Section 404 permitting and coordination with the United States Army Corps of Engineers may be required.

CHAPTER 6: INTRODUCTION TO *PHASE 2 STORM DRAINAGE MASTER PLAN*

Phase 2

This chapter is reserved for Phase 2 of the *Storm Drainage Master Plan* update.

APPENDIX A – PRELIMINARY STORM DRAIN MAP

No.	Structure
1	Outfall
2	Grate Inlet
3	Grate Inlet
4	Grate Inlet
5	Grate Inlet
6	Grate Inlet
7	Grate Inlet
8	Outfall
9	Outfall
10	Curb Inlet
11	Manhole
12	Curb Inlet
13	Curb Inlet
14	Grate Inlet
15	Grate Inlet
16	Outfall
17	Grate Inlet
18	Grate Inlet
19	Grate Inlet
20	Grate Inlet
21	Outfall
22	Grate Inlet
23	Manhole
24	Grate Inlet
25	Grate Inlet
26	Curb Inlet
27	Curb Inlet
28	Outfall
29	Culvert
30	Curb Inlet
31	Curb Inlet
32	Curb Inlet
33	Curb Inlet
34	Outfall
35	Culvert
36	Grate Inlet
37	Grate Inlet
38	Modified Inlet
39	Curb Inlet
40	Curb Inlet
41	Outfall
42	Grate Inlet
43	Manhole
44	Grate Inlet
45	Grate Inlet
46	Grate Inlet
47	Grate Inlet
48	Curb Inlet
49	Curb Inlet
50	Outfall
51	Curb Inlet
52	Curb Inlet
53	Curb Inlet
54	Outfall

No.	Structure
55	Grate Inlet
56	Outfall
57	Manhole
58	Grate Inlet
59	Modified Inlet
60	Culvert
61	Grate Inlet
62	Curb Inlet
63	Curb Inlet
64	Outfall
65	Grate Inlet
66	Blocked Outfall
67	Curb Inlet
68	Curb Inlet
69	Outfall
70	Grate Inlet
71	Grate Inlet
72	Grate Inlet
73	Grate Inlet
74	Curb Inlet
75	Curb Inlet
76	Outfall
77	Grate Inlet
78	Curb Inlet
79	Curb Inlet
80	Curb Inlet
81	Outfall
82	Grate Inlet
83	Manhole
84	Grate Inlet
85	Culvert
86	Curb Inlet
87	Curb Inlet
88	Outfall
89	Culvert
90	Grate Inlet
91	Culvert
92	Curb Inlet
93	Curb Inlet
94	Outfall
95	Grate Inlet
96	Culvert
97	Grate Inlet
98	Grate Inlet
99	Grate Inlet
100	Grate Inlet
101	Curb Inlet
102	Curb Inlet
103	Outfall
104	Grate Inlet
105	Grate Inlet
106	Grate Inlet
107	Grate Inlet
108	Curb Inlet

DRAINAGE AREA LEGEND

- XX — DRAINAGE STRUCTURE ID
- 12" STORM DRAIN
- 2-12" STORM DRAIN
- 18" STORM DRAIN
- 24" STORM DRAIN
- 2-24" STORM DRAIN
- SIZE AND LOCATION TO BE VERIFIED

NOTES

1. REFER TO THE MASTER DRAINAGE PLAN DATED DECEMBER 2018 FOR METHODOLOGY.

PRELIMINARY STORM DRAIN MAP - 1
EXHIBIT A

SHEET 1 OF 2

South Padre ISLAND

Kimley»Horn

2201 W. Royal Lane
Suite 275
Irving, Texas 75063
214-420-5600
State of Texas Registration No. F-928

MATCHLINE
SEE SHEET 2 OF 2

MATCHLINE
SEE SHEET 1 OF 2

NORTH

GRAPHIC SCALE IN FEET
0 125 250 500

No.	Structure
109	Outfall
110	Culvert
111	Culvert
112	Outfall
113	Curb Inlet
114	Curb Inlet
115	Outfall
116	Grate Inlet
117	Manhole
118	Grate Inlet
119	Culvert
120	Grate Inlet
121	Curb Inlet
122	Curb Inlet
123	Grate Inlet
124	Curb Inlet
125	Curb Inlet
126	Outfall
127	Grate Inlet
128	Culvert
129	Grate Inlet
130	Grate Inlet
131	Grate Inlet
132	Grate Inlet
133	Outfall
134	Grate Inlet
135	Manhole
136	Grate Inlet
137	Grate Inlet
138	Manhole
139	Curb Inlet
140	Curb Inlet
141	Grate Inlet
142	Outfall
143	Grate Inlet
144	Grate Inlet
145	Grate Inlet
146	Grate Inlet
147	Grate Inlet
148	Outfall
149	Grate Inlet
150	Grate Inlet
151	Grate Inlet
152	Grate Inlet
153	Curb Inlet
154	Curb Inlet
155	Curb Inlet
156	Manhole

No.	Structure
157	Outfall
158	Grate Inlet
159	Grate Inlet
160	Curb Inlet
161	Curb Inlet
162	Manhole
163	Grate Inlet
164	Grate Inlet
165	Outfall
166	Grate Inlet
167	Curb Inlet
168	Grate Inlet
169	Grate Inlet
170	Curb Inlet
171	Outfall
172	Grate Inlet
173	Grate Inlet
174	Grate Inlet
175	Curb Inlet
176	Curb Inlet
177	Outfall
178	Grate Inlet
179	Grate Inlet
180	Outfall
181	Culvert
182	Grate Inlet
183	Grate Inlet
184	Grate Inlet
185	Curb Inlet
186	Curb Inlet
187	Outfall
188	Grate Inlet
189	Grate Inlet
190	Curb Inlet
191	Grate Inlet
192	Curb Inlet
193	Outfall
194	Curb Inlet
195	Curb Inlet
196	Outfall
197	Junction Box
198	Grate Inlet
199	Grate Inlet
200	Grate Inlet
201	Grate Inlet
202	Curb Inlet
203	Curb Inlet

DRAINAGE AREA LEGEND

- XX — DRAINAGE STRUCTURE ID
- 12" STORM DRAIN
- 2-12" STORM DRAIN
- 18" STORM DRAIN
- 24" STORM DRAIN
- 2-24" STORM DRAIN
- SIZE AND LOCATION TO BE VERIFIED

NOTES

1. REFER TO THE MASTER DRAINAGE PLAN DATED DECEMBER 2018 FOR METHODOLOGY.

Plotted By: McGary, Hannah December 21, 2018 01:18:35pm K:\LAC_Civil\069234007_SPI Drainage Master Plan\CADD\Exhibits\Storm Drain Map Exhibit_v2.dwg

PRELIMINARY STORM DRAIN MAP - 2
EXHIBIT A

SHEET 2 OF 2

South Padre ISLAND

Kimley»Horn
2201 W. Royal Lane
Suite 275
Irving, Texas 75063
214-420-5600
State of Texas Registration No. F-928

NOTE: THIS PLAN IS CONCEPTUAL IN NATURE AND MAY HAVE BEEN PRODUCED WITHOUT THE BENEFIT OF A SURVEY OR CONTACT WITH THE CITY OR COUNTY.

APPENDIX B – COMMUNITY DRAINAGE SURVEY

South Padre Island Community Drainage Survey

Community Questions

The City of South Padre Island is beginning Phase 1 of the **Storm Drainage Master Plan** update to gather data and develop an existing conditions assessment to determine priority areas for further analysis.

Please take a moment to tell us about your personal experiences with drainage and flooding issues on South Padre Island. These responses will be instrumental in helping to establish the baseline goals for the City of South Padre Island Storm Drainage Master Plan.

These questions are entirely **optional**, and while your answers will be completely **anonymized**, you do not have to divulge any information you do not feel comfortable disclosing. However, we do encourage you to answer as many questions as possible to help us shape the future of our community in a truly representative fashion. We ask that you take this survey **only once**, as duplicates will be removed.

Please join your neighbors for a **Public Meeting at 4:00 p.m. on August 1, 2018, in the City Council Chambers** to share your views about possible improvements for the drainage system.

1. Have you experienced any issues related to drainage?

If yes, please provide examples and specific locations/addresses.

- ◯ Yes
- ◯ No

Examples and locations

2. **Have you experienced any improvements related to drainage?**

If yes, please provide examples and specific locations/addresses.

- ◯ Yes
- ◯ No

Examples and locations

3. **Does the street of your residence or business flood?**

If yes, please provide address.

- ◯ Yes
- ◯ No

Address

3a. **If yes, can cars pass?**

Please choose one.

- ◯ Yes
- ◯ No

3b. **Does your area remain flooded or have persistent ponding of water after it rains?**

If yes, for how long?

- ◯ Yes
- ◯ No

Please specify.

3c. Please specify the frequency of flooding issues you have experienced.

- ◯ Floods every time it rains
- ◯ Floods often
- ◯ Floods sometimes

3d. Has your property flooded or have any structures on your property flooded?

If yes, please provide details of flooding.

- ◯ Yes
- ◯ No

Please specify.

[ ]

3e. If yes, is there a storm inlet or outfall near your property?

- ◯ Yes
- ◯ No

Other (please specify)

[ ]

4. Please identify areas with drainage or flooding concerns.

Identify areas of high importance to you that are impacted by flooding. [ ]

Identify areas you would like to see drainage improvements. [ ]

5. **Are there intersections you consider dangerous during a storm?**

If yes, what is the specific intersection location and what alternate route is the best for driving during a storm?

- ◯ Yes
- ◯ No

Intersection locations and alternate route options

6. **Please provide any additional comments you would like to make about drainage or flooding on South Padre Island.**

7. **If you would like to stay in touch, what is the best email to reach you?**

By providing us with your email address, you are giving us permission to update you on the status, events, and opportunities associated with the drainage master planning process.

APPENDIX C – DRAINAGE COMPLAINTS

Drainage Complaints

Complaint ID	Date	Drainage Complaint	Street	Issue
1	8/1/2018	General Flooding	N/A	Sometimes I need to kayak to work.
2	8/1/2018	Flooding, House	East Swordfish Street	Water at the end of driveway.
3	8/1/2018	Flooding, Street	East Polaris Drive	No storm drains and no curbs on East Polaris. Where is the flood water supposed to drain to?
4	8/1/2018	Flooding, House	West Lantana Street	Driveway floods. Also, there is a very low ditch type thing in the back, which has been made worse since my neighbor built a new fence and boarded up the space underneath it, which effectively acts like a dam, preventing water from being able to drain toward the bay, which, we were told, is the way it was originally planned to drain (toward the rear of bayside lots, and west to the bay).
5	8/1/2018	Flooding, House	Swordfish Street	Water remains stagnant on driveway for days after it rains, like there's no where for it to go.
6	8/1/2018	Flooding, Business	East Bahama Street	Water drains from the east across my parking lot on E. Bahama, as it moves west to Padre Blvd.
7	8/1/2018	Flooding, House	West Campeche Street	No drainage pipe at Laguna and Campeche. The streets needs a storm drain pipe. Garage floods every time it rains.
8	8/1/2018	Flooding, Business	Padre Boulevard	Flooding at Suites at Sunchase every time it rains.
9	8/1/2018	Flooding, House	Padre Boulevard	Flooding at intersection between King's Landing and Sunset every time it rains. The water drains directly off Padre Blvd into a gutter that drains directly onto my property. There is no way to contain the water.
10	8/1/2018	Flooding, Street	Laguna Boulevard	The intersection between West Dolphin and Laguna floods often. Cleaning the drains helps but the drains clog easily. The preparation for Harvey should be a plan for keeping the storm drains clear.
11	8/1/2018	Flooding, Street	Gulf Boulevard	Gulf Blvd floods every time it rains. Put storm drainage in every time a west side street is repaved. There should be storm drainage system on every west side street. Keep the storm drains open.
12	8/1/2018	Flooding, Street	Padre Boulevard	The intersection between Kingfish and Padre floods every time it rains. Created flooding in all private lots and results in big mosquito issue.
13	8/1/2018	Flooding, Street	Padre Boulevard	The intersection between Palmetto and Morningside at Padre floods with heavy rains. Post Office exists also a drainage issue.
14	8/1/2018	Flooding, Street	West Bahama Street	Very minor flooding with heavy rain.
15	8/2/2018	Flooding, Street	N/A	General street flooding during major rainfall events.
16	8/2/2018	General Flooding	N/A	Drainage back ups, slow drainage, flooding
17	8/2/2018	Flooding, Street	Laguna Boulevard	Every time we get a medium to heavy rain, the streets flood, especially at intersections. How long it takes to drain depends on how much rain we received. I walk along Laguna and see a lot of it at intersections.
18	8/2/2018	Flooding, House	West Cora Lee Drive	When it rains, can't walk out of my driveway due to water. I have to place a pallet to make a bridge. Many homes on street have problem.
19	8/2/2018	Flooding, House	N/A	My home gets flooding on our bottom floor. Our home is old and the newer homes are built way higher. All the runoff comes into our driveway instead of the sewer system.
20	8/2/2018	Flooding, House	White Sands Street	N/A
21	8/3/2018	Flooding, Street	Padre Boulevard	Many corners where side streets meet the east side of Padre Blvd., but especially those on the more northern end (e.g. Morningside, Parade, Palmetto). The southern exits of the Post Office.
22	8/6/2018	General Flooding	N/A	During some of the heavier rains in early summer, there was a lot of standing water for days and an odor as if the sewer had backed-up on many areas of the island.

23	8/6/2018	Flooding, Street	Padre Boulevard	Flooding and not being able to get out of our condo complex, being on Padre Blvd. And not being able to continue down the road.
24	8/6/2018	Flooding, Street	Padre Boulevard	Intersections with side streets on both sides of Padre Blvd flood when it rains, e.g., Sunset and Padre (east side), Morningside and Padre (east side), Padre and Capricorn (west side). This creates problems when walking or biking.
25	8/6/2018	Flooding, Street	Padre Boulevard	On Padre, many deep places along the street. Especially around Swordfish and Red Snapper.
26	8/6/2018	Flooding, House	Gulf Boulevard	Directly in front of our home pooling water in front drive.
27	8/6/2018	Flooding, House	East Campeche Street	East Campeche by the mailboxes we have some elderly folks that live on this block and they can't get their mail I know two are in their 80s with walkers and by the mailbox is always flooded.
28	8/6/2018	General Flooding	N/A	Yards built up impeding drainage on Morningside. Corner of Franke Plaza doesn't drain. Many areas on Padre Blvd.
29	8/6/2018	Flooding, Business	Padre Boulevard	Blue Marlin area.
30	8/6/2018	Flooding, House	N/A	Our street floods even with a five minute rain.
31	8/6/2018	Flooding, Street	Retama Street	Flooding constantly with left over water standing across the street from Moon Dancer Condo's and the end of street entry to Padre Blvd.
32	8/6/2018	General Flooding	N/A	Just the obvious fast accumulation of water and slow to drain scenarios.
33	8/7/2018	Flooding, Street	West Oleander Street	West Oleander has no drainage and there is standing water on the sides of the roads for two to three days after a storm.
34	8/7/2018	Flooding, Street	West Oleander Street	N/A
35	8/7/2018	Flooding, House	West Hibiscus Street	I live on West Hibiscus and all of the driveways, on this street, always has standing water, after it rains. I wish the city would let us do vents, on our driveways, we would totally fix ours at our expense. True, the water would still be there, but we wouldn't be able to see it. You would still be able to put a little pellets in there also.
36	8/7/2018	Flooding, House	Acapulco Street	The last time it rained significantly, we had a hard time pulling our vehicle's out of the driveway.
37	8/7/2018	Flooding, Business	East Morningside Drive	Water build up in front of east parking lot at Morningside Dr. in street. The water is blocked at Water District manhole directly in front and will not allow water to towards Padre Blvd.
38	8/7/2018	Flooding, Street	Gulf Boulevard	We live on Pike Street. Our parking lot floods with the slightest rain. Gulf Blvd becomes hard to pass through. Have to drive in the middle of the road in several spots.
39	8/7/2018	Flooding, Street	West Oleander Street	N/A
40	8/7/2018	Flooding, Business	Padre Boulevard	Post office entrances; heavier rains Padre Blvd intersections.
41	8/7/2018	Flooding, Business	Padre Boulevard	N/A
42	8/7/2018	Flooding, House	West Sunset Drive	When there is a heavy rain, the rain collects at the end of our 2 car garage drive way. It has come half-way up our drive way and reached one foot in depth.
43	8/7/2018	Flooding, Street	Padre Boulevard	High water on Padre Blvd, standing water on Padre Loop.
44	8/7/2018	Flooding, Street	Padre Boulevard	Primarily on Padre Blvd and side streets (Gulf Blvd side) when turning off Padre Blvd onto the side streets after a storm.
45	8/8/2018	Flooding, Street	Padre Boulevard	Padre Blvd can turn into a small river because the drains are plugged up with garbage.
46	8/8/2018	Flooding, House	East Capricorn Drive, East Corral Street	Typically the rain water stands in the front yard for days after almost any rain. The Corral Street location has almost every property in a 3 block radius and Gulf Blvd. water draining into it. The back yard floods in almost any rain.
47	8/9/2018	Flooding, Street	Laguna Boulevard	High water walking on Laguna Blvd after rains.
48	8/10/2018	Flooding, House	East Hibiscus Street	When sidewalks put in, my drainage in my driveway was removed. Now when it rains the water comes up my driveway making it impossible to walk through.

49	8/12/2018	Flooding, Business	Padre Boulevard	Water can fill up half the parking lot with a heavy downpour.
50	8/13/2018	Flooding, House	East Acapulco Street	My driveway and garage flood every time we get a steady rain for about 10 minutes.
51	8/13/2018	Flooding, Street	West Atol Street	West Atol Street does not drain.
52	8/13/2018	Flooding, House	West Esperanza Street	The bottom of my driveway, but many other locations as well.
53	8/16/2018	General Flooding	N/A	A few years ago, I can't remember exactly the date but I remember streets flooded and I couldn't leave back to Brownsville.
54	8/16/2018	Flooding, Street	East Redsnapper Street	E. Redsnapper St. all the water drains towards Padre Blvd which does not allow me to access my rental through Padre Blvd when flooding occurs.
55	8/17/2018	Flooding, Street	Padre Boulevard	Corner of W Sunset and Padre Blvd Corner of Pompano and Padre Blvd.
56	8/20/2018	Flooding, Street	Padre Boulevard	N/A
57	8/20/2018	Flooding, Street	Padre Boulevard	Flooding in multiple locations along Padre Blvd. Major pools of water at Georgia Ruth and Padre Blvd.
58	8/20/2018	Flooding, Business	Padre Boulevard	South exit from Post Office.
59	8/20/2018	Flooding, House	West Huisache Street	Primarily backyard but some flooding of front yard/driveway.
60	8/20/2018	Flooding, Street	Gulf Boulevard	Corner of East Hibiscus and Gulf Blvd has standing water after rain.
61	8/21/2018	Flooding, House	East Bahama Street	In front of my condo, every time it rains a pool of water collects at the dip at end of the driveway, where the street begins. It takes at least one whole day to drain off, sometimes more, depending on the amount of rain water. The pool/puddle is several inches deep and too wide to jump over.
62	8/21/2018	Flooding, Street	Padre Boulevard	Flooding on Padre Blvd. occurs rapidly, leaving only the center turning lane available for driving and in some spots no access at all.
63	8/21/2018	Flooding, House	West Sunset Drive	Our driveway floods every time it rains. There is no place for it to drain to.
64	8/21/2018	Flooding, Street	Gulf Boulevard	Street ditches on Saturn Ln and Gulf Blvd are clogged with sand. Grass is growing there.
65	8/23/2018	Flooding, Street	Padre Boulevard	Water from curb to curb . I drove in the passing lane on Padre Blvd to get where I was going. Water came up over my hood when I turned into a side street Hibiscus St and also when I turned into my driveway.

This is intended to be a summary of the results from the Community Drainage Survey and the Public Meeting Comment Sheets.

APPENDIX D – DRAINAGE PROBLEM AREAS MAP

NORTH

GRAPHIC SCALE IN FEET

0 125 250 500

PROBLEM AREAS LEGEND

(red)	ROADWAYS IDENTIFIED WITH DRAINAGE AND FLOODING ISSUES
(orange)	BUSINESSES AND PRIVATE FACILITIES IDENTIFIED WITH DRAINAGE AND FLOODING ISSUES (TWO OR MORE COMPLAINTS)
(yellow)	BUSINESSES AND PRIVATE FACILITIES IDENTIFIED WITH DRAINAGE AND FLOODING ISSUES (ONE COMPLAINT)

NOTES

1. REFER TO THE MASTER DRAINAGE PLAN DATED DECEMBER 2018 FOR METHODOLOGY.
2. PROBLEM AREAS WERE IDENTIFIED BY COMMUNITY MEMBERS AND CITY STAFF AS NOTED IN THE MASTER DRAINAGE PLAN.
3. PUBLIC ROADWAYS WERE IDENTIFIED WITH ONE OR MORE COMPLAINTS. BUSINESSES AND PRIVATE FACILITIES WERE IDENTIFIED WITH ONE OR MORE COMPLAINTS. PRIVATE RESIDENCES AND DRIVEWAYS WERE NOT INCLUDED, BUT ROADWAYS WITH PRIVATE RESIDENCE COMPLAINTS WERE IDENTIFIED.
4. PROBLEM AREAS INDICATE A VARIETY OF DRAINAGE ISSUES REPORTS. COMPLAINTS INCLUDE A RANGE OF FLOODING FREQUENCY AND SIGNIFICANCE. REFER TO THE MASTER DRAINAGE PLAN FOR EXAMPLES OF SIGNIFICANT, MODERATE, AND MINOR FLOODING ISSUES.
5. THE STUDY AREA WAS EXTENDED TO PADRE BOULEVARD LOOP FOR THIS EXHIBIT TO INCORPORATE THE SUITES AT SUNCHASE AREA THAT WAS IDENTIFIED AS A PROBLEM AREA BY CITY STAFF AND COMMUNITY MEMBERS.

DRAINAGE PROBLEM AREAS MAP - 1
APPENDIX D

South Padre ISLAND

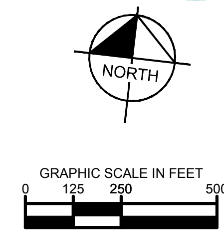
Kimley»Horn
2201 W. Royal Lane
Suite 275
Irving, Texas 75063
214-420-5600
State of Texas Registration No. F-928

NOTE: THIS PLAN IS CONCEPTUAL IN NATURE AND MAY HAVE BEEN PRODUCED WITHOUT THE BENEFIT OF A SURVEY OR CONTACT WITH THE CITY OR COUNTY.

MATCHLINE
SEE SHEET 2 OF 2

Plotted By: McGary, Hannah December 04, 2018 10:51:20am K:\LAC_Civil\069234007_SPI Drainage Master Plan\CADD\Exhibits\Problem Areas Exhibit.dwg

MATCHLINE
SEE SHEET 1 OF 2



PROBLEM AREAS LEGEND	
(red)	ROADWAYS IDENTIFIED WITH DRAINAGE AND FLOODING ISSUES
(orange)	BUSINESSES AND PRIVATE FACILITIES IDENTIFIED WITH DRAINAGE AND FLOODING ISSUES (TWO OR MORE COMPLAINTS)
(yellow)	BUSINESSES AND PRIVATE FACILITIES IDENTIFIED WITH DRAINAGE AND FLOODING ISSUES (ONE COMPLAINT)

NOTES

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DRAINAGE PROBLEM AREAS MAP - 2
APPENDIX D

SHEET 2 OF 2

South Padre Island

Kimley-Horn

2201 W. Royal Lane
Suite 275
Irving, Texas 75063
214-420-5600
State of Texas Registration No. F-928

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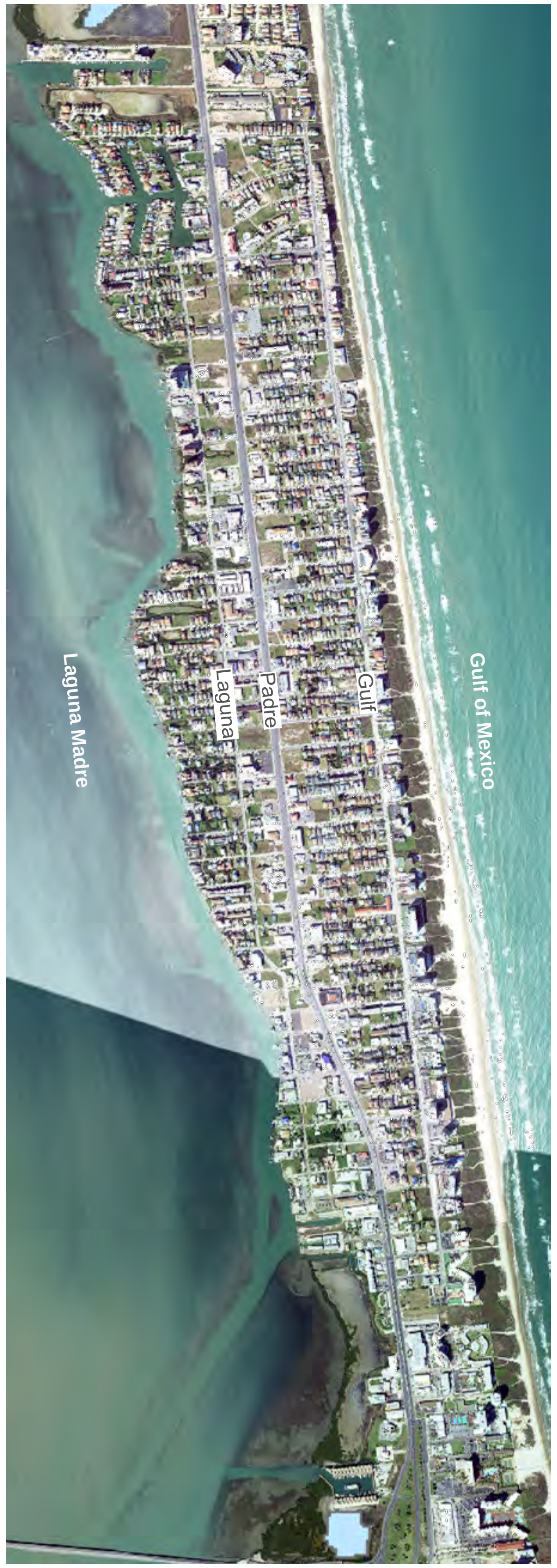
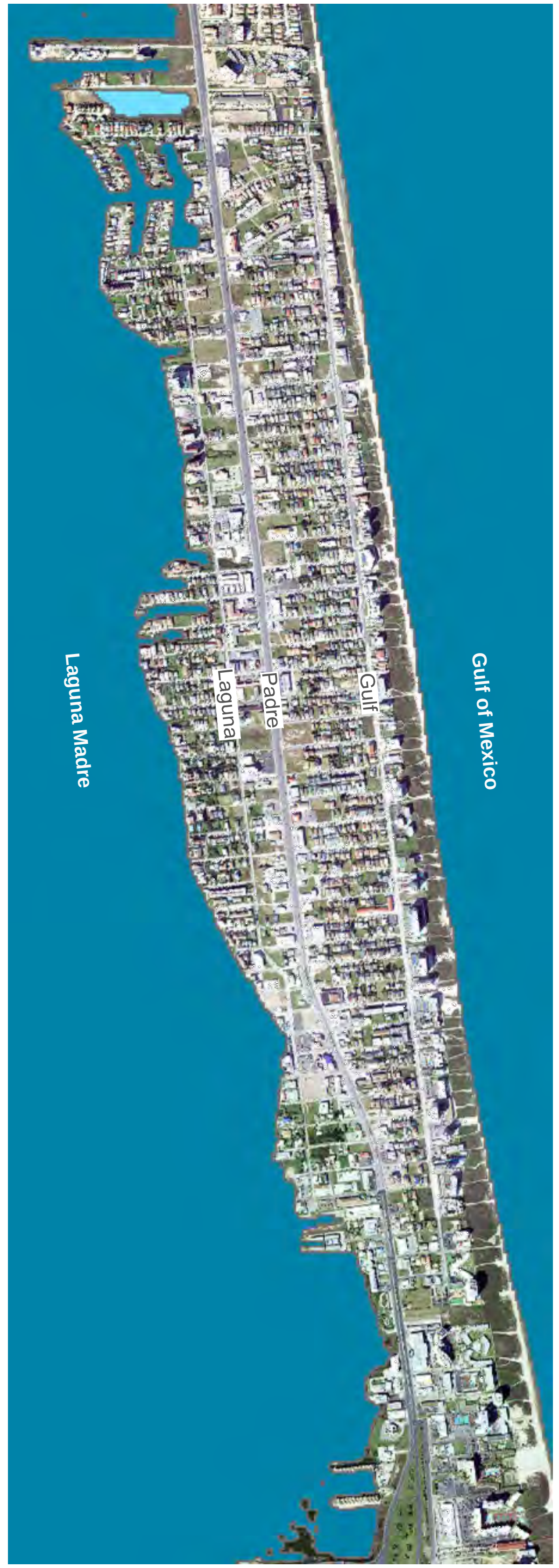
Plotted By: McGary, Hannah December 04, 2018 10:51:40am K:\LAC_Civil\069234007_SPI Drainage Master Plan\CADD\Exhibits\Problem Areas Exhibit.dwg

APPENDIX E – SEA LEVEL RISE INUNDATION MAP

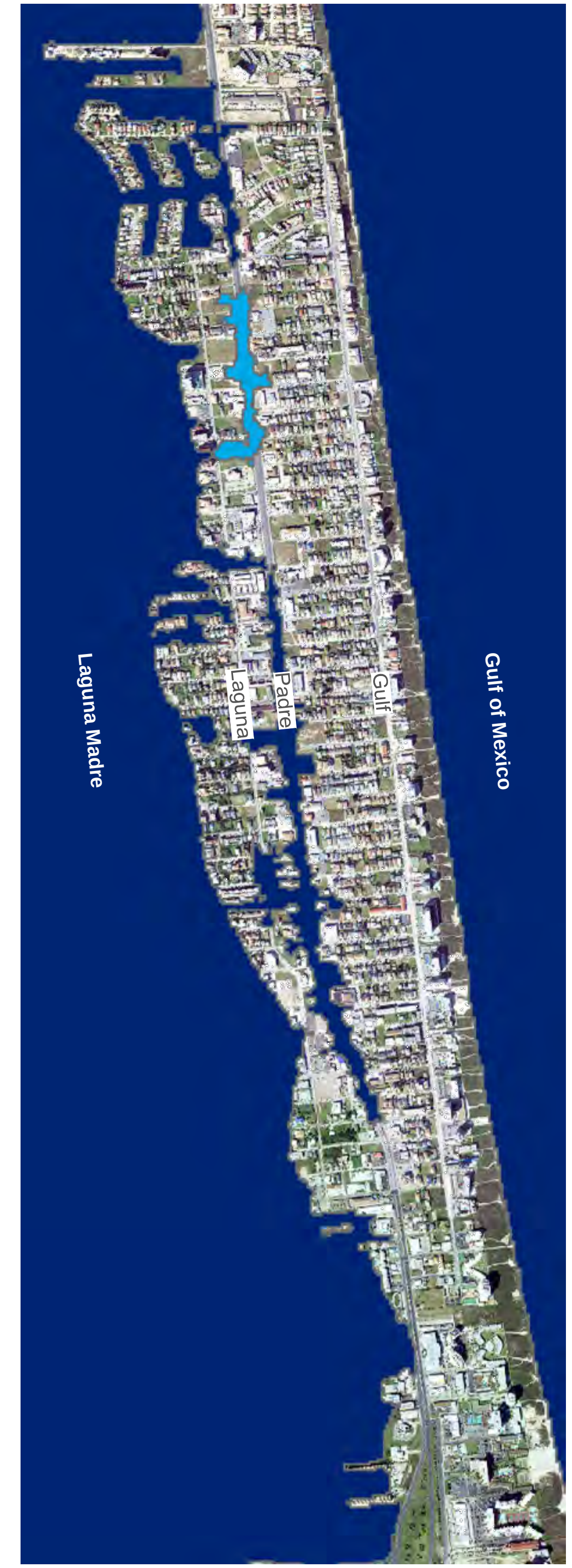


0' SEA LEVEL RISE



1' SEA LEVEL RISE

2' SEA LEVEL RISE



3' SEA LEVEL RISE

NORTH NTS

LEGEND

ANTICIPATED FLOODING BASED ON SEA LEVEL ELEVATION (TAILWATER CONDITION). DARKER BLUE INDICATES GREATER DEPTH.

NOTES

1. REFER TO THE MASTER DRAINAGE PLAN DATED DECEMBER 2018 FOR METHODOLOGY AND ASSUMPTIONS REGARDING HISTORIC SEA LEVEL RISE AND INUNDATION LIMITS.
2. IMAGES WERE DOWNLOADED FROM THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) SEA LEVEL RISE VIEWER (2018).
3. THE SEA LEVEL RISE VIEWER WAS USED TO SIMULATE WATER LEVEL RISE AND THE RESULTING INUNDATION FOOTPRINT OF FLOODING DURING DIFFERENT TAILWATER CONDITIONS.
4. WATER LEVELS ARE RELATIVE TO LOCAL MEAN HIGHER HIGH WATER (MHHW) DATUM. WATER LEVELS EXCLUDE WIND DRIVEN TIDES.
5. THE MAPPING MAY NOT ACCURATELY CAPTURE DETAILED HYDROLOGIC/HYDRAULIC FEATURES SUCH AS CANALS, DITCHES, AND STORMWATER INFRASTRUCTURE. A MORE DETAILED ANALYSIS MAY BE REQUIRED TO DETERMINE THE AREA'S ACTUAL SUSCEPTIBILITY TO FLOODING.
6. THERE IS NOT 100% CONFIDENCE IN THE ELEVATION DATA AND/OR MAPPING PROCESS. THE MAPS HEREIN ILLUSTRATE THE SCALE OF POTENTIAL FLOODING, NOT THE EXACT LOCATION, AND DO NOT ACCOUNT FOR EROSION, SUBSIDENCE, OR FUTURE CONSTRUCTION. THE INFORMATION PROVIDED SHOULD BE USED ONLY AS A PLANNING REFERENCE TOOL FOR MANAGEMENT DECISIONS AND SHOULD NOT BE USED FOR NAVIGATION, PERMITTING, OR OTHER LEGAL PURPOSES. ALL FEATURES SHOULD BE FIELD-VERIFIED.

SEA LEVEL RISE INUNDATION MAP - 1
APPENDIX E

SHEET 1 OF 2

South Padre ISLAND

Kimley»Horn
2201 W. Royal Lane
Suite 275
Irving, Texas 75063
214-420-5600
State of Texas Registration No. F-928

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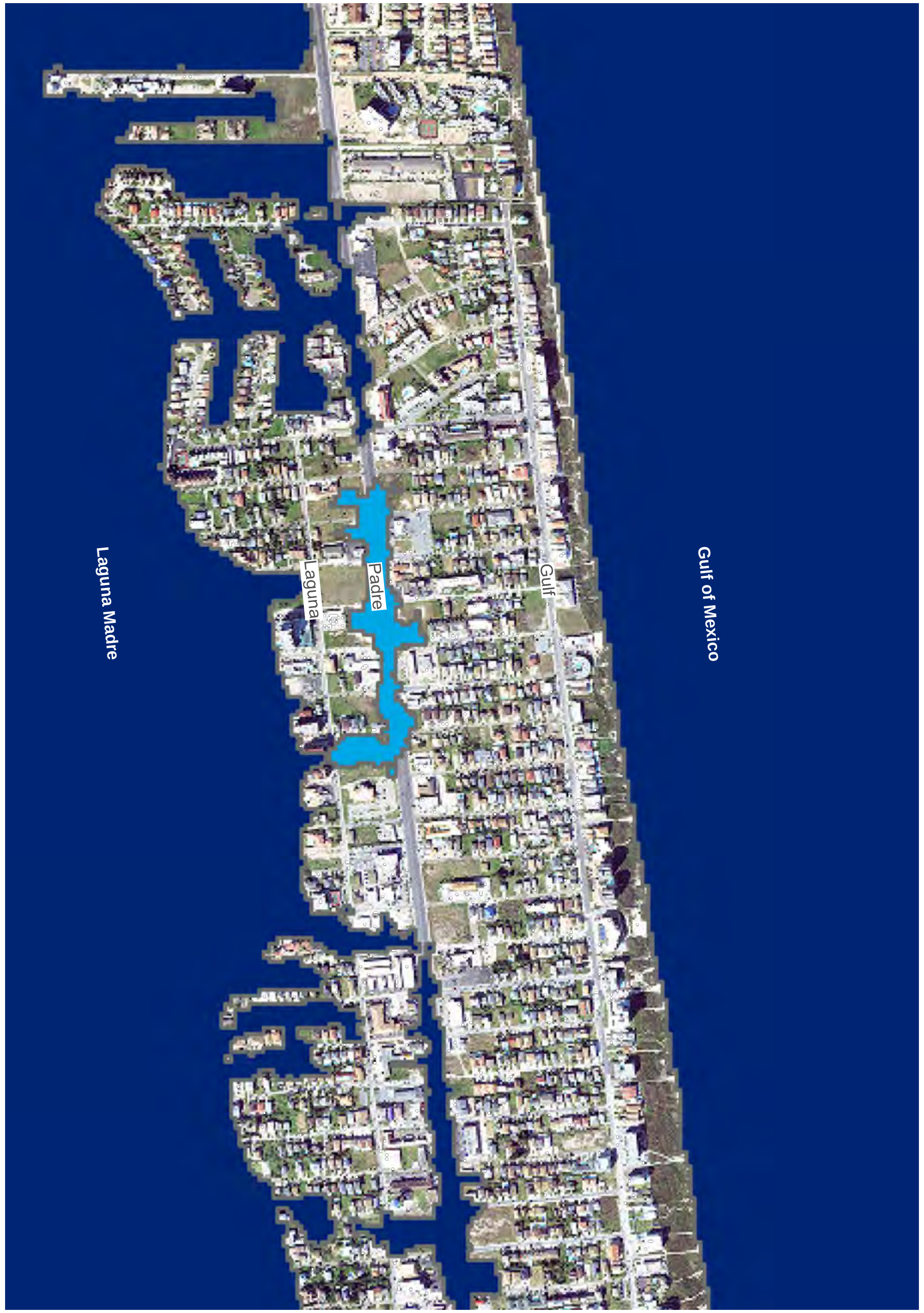

3' SEA LEVEL RISE
NORTH STUDY LIMITS

3' SEA LEVEL RISE
SOUTH STUDY LIMITS

NORTH NTS

LEGEND

ANTICIPATED FLOODING BASED ON SEA LEVEL ELEVATION (TAILWATER CONDITION). DARKER BLUE INDICATES GREATER DEPTH.

NOTES

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2. IMAGES WERE DOWNLOADED FROM THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) SEA LEVEL RISE VIEWER (2018).
3. THE SEA LEVEL RISE VIEWER WAS USED TO SIMULATE WATER LEVEL RISE AND THE RESULTING INUNDATION FOOTPRINT OF FLOODING DURING DIFFERENT TAILWATER CONDITIONS.
4. WATER LEVELS ARE RELATIVE TO LOCAL MEAN HIGHER HIGH WATER (MHHW) DATUM. WATER LEVELS EXCLUDE WIND DRIVEN TIDES.
5. THE MAPPING MAY NOT ACCURATELY CAPTURE DETAILED HYDROLOGIC/HYDRAULIC FEATURES SUCH AS CANALS, DITCHES, AND STORMWATER INFRASTRUCTURE. A MORE DETAILED ANALYSIS MAY BE REQUIRED TO DETERMINE THE AREA'S ACTUAL SUSCEPTIBILITY TO FLOODING.
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SEA LEVEL RISE INUNDATION MAP - 2
EXHIBIT E

SHEET 2 OF 2

South Padre ISLAND

Kimley»Horn
2201 W. Royal Lane
Suite 275
Irving, Texas 75063
214-420-5600
State of Texas Registration No. F-928

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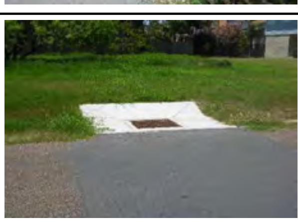
Plotted By: McGary, Hannah December 21, 2018 01:48:45pm K:\LAC_Civil\069234007_SPI Drainage Master Plan\CADD\Exhibits\SeaLevelInundationMap.dwg

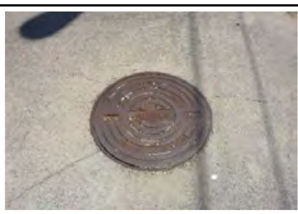
APPENDIX F – STORM DRAIN SYSTEM INVENTORY

Storm Drain System Inventory

Picture	Drainage Structure ID	Structure Description	Location
	1	Outfall Behind Houses	Sunset
	2	Grate Inlet	Sunset
	3	Grate Inlet	Sunset
	4	Grate Inlet	Sunset
	5	Grate Inlet	Sunset
	6	Grate Inlet	Sunset
	7	Grate Inlet	Sunset
	8	Outfall	Clipper
	9	Outfall for Parking Lot	Clipper

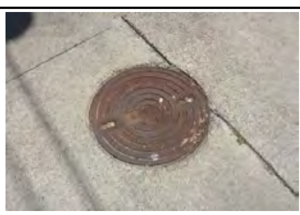
Storm Drain System Inventory

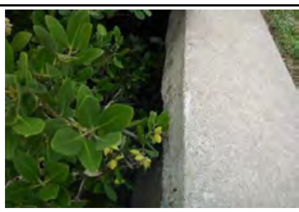
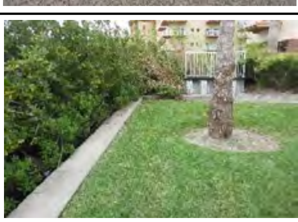
Picture	Drainage Structure ID	Structure Description	Location
	10	Curb Inlet	Clipper/Padre
	11	Manhole	Clipper/Padre
	12	Curb Inlet	Clipper/Padre
	13	Curb Inlet	Clipper/Padre
	14	Grate Inlet	Morningside/Laguna
	15	Grate Inlet	Morningside/Laguna
	16	Previous Outfall Picture – Proposed Outfall Location on Map	Morningside/Laguna
	17	Grate Inlet	Morningside/Laguna
	18	Grate Inlet	Morningside/Laguna

Picture	Drainage Structure ID	Structure Description	Location
	19	Grate Inlet	Morningside/Laguna
	20	Grate Inlet	Morningside/Laguna
	21	Outfall	Carolyn
	22	Grate Inlet	Carolyn/Laguna
	23	Manhole	Carolyn/Laguna
	24	Grate Inlet	Carolyn/Laguna
	25	Grate Inlet	Carolyn/Laguna
	26	Curb Inlet	Carolyn/Padre
	27	Curb Inlet	Carolyn/Padre

Picture	Drainage Structure ID	Structure Description	Location
	28	Outfall	Georgia Ruth
	29	Culvert	Georgia Ruth
	30	Curb Inlet	Georgia Ruth
	31	Curb Inlet	Georgia Ruth
	32	Curb Inlet	Georgia Ruth
	33	Curb Inlet	Georgia Ruth
	34	Outfall	Verna Jean
	35	Culvert	Verna Jean
	36	Grate Inlet	Verna Jean

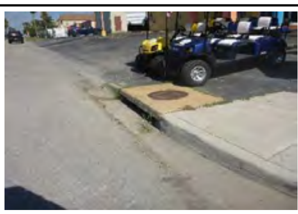
Storm Drain System Inventory

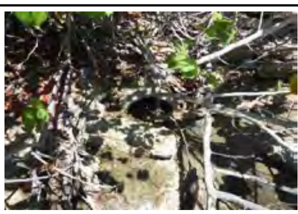
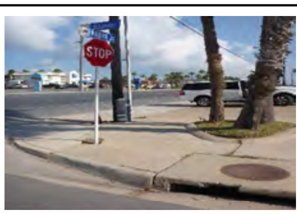
Picture	Drainage Structure ID	Structure Description	Location
	37	Grate Inlet	Verna Jean
	38	Modified Inlet	Verna Jean
	39	Curb Inlet	Verna Jean
	40	Curb Inlet	Verna Jean
	41	Outfall	Capricorn
	42	Grate Inlet	Capricorn/Constellation
	43	Manhole	Capricorn
	44	Grate Inlet	Capricorn/Constellation
	45	Grate Inlet	Capricorn/Constellation

Picture	Drainage Structure ID	Structure Description	Location
	46	Grate Inlet	Capricorn/Constellation
	47	Grate Inlet	Capricorn/Constellation
	48	Curb Inlet	Capricorn/Constellation
	49	Curb Inlet	Capricorn/Constellation
	50	Outfall	Constellation
	51	Curb Inlet	Constellation
	52	Curb Inlet	Constellation
	53	Curb Inlet	Constellation
	54	Outfall	Constellation

Storm Drain System Inventory

Picture	Drainage Structure ID	Structure Description	Location
	55	Grate Inlet	Constellation
	56	Previous Outfall Picture – Proposed Outfall Location on Map	Venus
	57	Proposed Manhole Location	Venus
	58	Grate Inlet	Venus
	59	Modified Inlet	Venus
	60	Culvert	Venus
	61	Grate Inlet	Venus
	62	Curb Inlet	Venus
	63	Curb Inlet	Venus

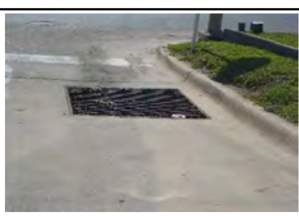
Picture	Drainage Structure ID	Structure Description	Location
	64	Outfall	Saturn
	65	Grate Inlet	Saturn
	66	Blocked Outfall	Saturn
	67	Curb Inlet	Saturn
	68	Curb Inlet	Saturn
	69	Outfall	Esperanza
	70	Grate Inlet	Esperanza
	71	Grate Inlet	Esperanza
	72	Grate Inlet	Esperanza

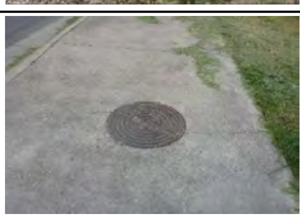
Picture	Drainage Structure ID	Structure Description	Location
	73	Grate Inlet	Esperanza
	74	Curb Inlet	Esperanza
	75	Curb Inlet	Esperanza
	76	Outfall	Oleander
	77	Grate Inlet	Oleander
	78	Curb Inlet	Oleander
	79	Curb Inlet	Oleander
	80	Curb Inlet	Oleander
	81	Outfall	Lantana

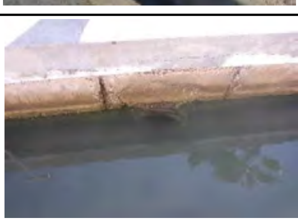
Picture	Drainage Structure ID	Structure Description	Location
	82	Grate Inlet	Lantana
	83	Manhole	Lantana
	84	Grate Inlet	Lantana
	85	Culvert	Lantana
	86	Curb Inlet	Lantana
	87	Curb Inlet	Lantana
	88	Outfall	Huisache
	89	Culvert	Huisache
	90	Grate Inlet	Huisache

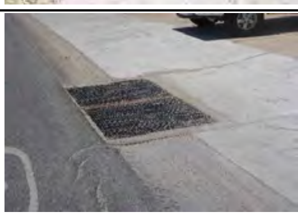
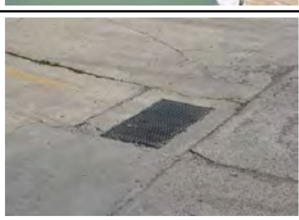
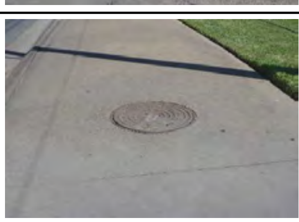
Picture	Drainage Structure ID	Structure Description	Location
	91	Culvert	Huisache
	92	Curb Inlet	Huisache
	93	Curb Inlet	Huisache
	94	Outfall	Mezquite
	95	Grate Inlet	Mezquite
	96	Culvert	Mezquite
	97	Grate Inlet	Mezquite
	98	Grate Inlet	Mezquite
	99	Grate Inlet	Mezquite

Storm Drain System Inventory

Picture	Drainage Structure ID	Structure Description	Location
	100	Grate Inlet	Mezquite/Retama
	101	Curb Inlet	Mezquite/Retama
	102	Curb Inlet	Mezquite/Retama
	103	Outfall	Retama
	104	Grate Inlet	Retama
	105	Grate Inlet	Retama
	106	Grate Inlet	Retama
	107	Grate Inlet	Retama/Padre
	108	Curb Inlet	Retama

Picture	Drainage Structure ID	Structure Description	Location
	109	Outfall	Campeche
	110	Culvert	Campeche
	111	Culvert	Acapulco/Campeche
	112	Outfall	Acapulco/Campeche
	113	Curb Inlet	Acapulco/Campeche
	114	Curb Inlet	Acapulco/Campeche
	115	Outfall	Acapulco
	116	Grate Inlet and Culvert	Acapulco
	117	Manhole	Acapulco

Picture	Drainage Structure ID	Structure Description	Location
	118	Grate Inlet	Acapulco
	119	Culvert	Acapulco
	120	Grate Inlet	Acapulco
	121	Curb Inlet	Acapulco
	122	Curb Inlet	Acapulco
	123	Grate Inlet	Acapulco/Kingfish
	124	Curb Inlet	Acapulco/Kingfish
	125	Curb Inlet	Acapulco/Kingfish
	126	Outfall	Kingfish

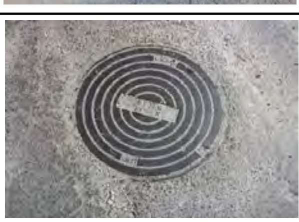
Picture	Drainage Structure ID	Structure Description	Location
	127	Grate Inlet	Kingfish
	128	Culvert	Kingfish
	129	Grate Inlet	Kingfish
	130	Grate Inlet	Kingfish/Padre
	131	Grate Inlet	Red Snapper
	132	Grate Inlet	Red Snapper
	133	Outfall	Swordfish
	134	Grate Inlet	Swordfish
	135	Manhole	Swordfish

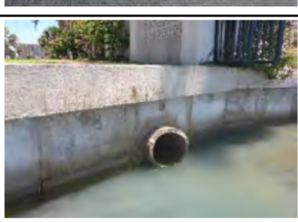
Storm Drain System Inventory

Picture	Drainage Structure ID	Structure Description	Location
	136	Grate Inlet	Swordfish
	137	Grate Inlet	Swordfish
	138	Manhole	Swordfish
	139	Curb Inlet	Swordfish
	140	Curb Inlet	Whiting/Amberjack
	141	Grate Inlet	Whiting/Amberjack
	142	Outfall	Amberjack
	143	Grate Inlet	Amberjack
	144	Grate Inlet	Amberjack

Picture	Drainage Structure ID	Structure Description	Location
	145	Grate Inlet	Amberjack
	146	Grate Inlet	Amberjack
	147	Grate Inlet	Amberjack
	148	Outfall	Pike
	149	Grate Inlet	Pike
	150	Grate Inlet	Pike
	151	Grate Inlet	Pike
	152	Grate Inlet	Pike
	153	Curb Inlet	Pike

Storm Drain System Inventory

Picture	Drainage Structure ID	Structure Description	Location
	154	Curb Inlet	Pike
	155	Curb Inlet	Pike
	156	Manhole	Pike
	157	Outfall Under Building	Ling
	158	Grate Inlet	Ling
	159	Grate Inlet	Ling
	160	Curb Inlet	Ling
	161	Curb Inlet	Ling
	162	Manhole	Ling

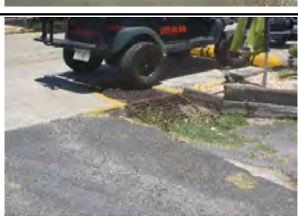
Picture	Drainage Structure ID	Structure Description	Location
	163	Grate Inlet	Marlin
	164	Grate Inlet	Marlin
	165	Outfall	Tarpon
	166	Grate Inlet	Tarpon
	167	Curb Inlet	Tarpon
	168	Grate Inlet	Tarpon
	169	Grate Inlet	Tarpon
	170	Curb Inlet	Tarpon
	171	Outfall	Pompano

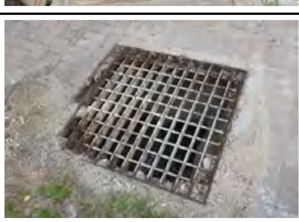
Storm Drain System Inventory

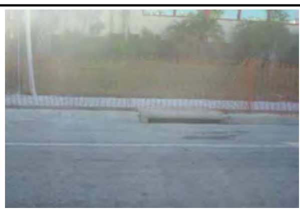
Picture	Drainage Structure ID	Structure Description	Location
	172	Grate Inlet	Pompano
	173	Grate Inlet	Pompano
	174	Grate Inlet	Pompano
	175	Curb Inlet	Pompano
	176	Curb Inlet	Pompano
	177	Outfall	Sheepshead
	178	Grate Inlet	Sheepshead
	179	Grate Inlet	Sheepshead
	180	Outfall	Corral

Kimley»Horn

Storm Drain System Inventory

Picture	Drainage Structure ID	Structure Description	Location
	181	Culvert	Corral
	182	Grate Inlet	Corral
	183	Grate Inlet	Corral
	184	Grate Inlet	Corral
	185	Curb Inlet	Corral
	186	Curb Inlet	Corral
	187	Outfall	Palm
	188	Grate Inlet	Palm
	189	Grate Inlet	Palm

Picture	Drainage Structure ID	Structure Description	Location
	190	Curb Inlet	Palm
	191	Grate Inlet	Palm
	192	Curb Inlet	Palm
	193	Outfall	Marisol
	194	Curb Inlet	Marisol
	195	Curb Inlet	Marisol
	196	Outfall	Sunny Isle/Harbor
	197	Junction Box	Sunny Isle/Harbor
	198	Grate Inlet	Sunny Isle/Harbor

Picture	Drainage Structure ID	Structure Description	Location
	199	Grate Inlet	Sunny Isle/Harbor
	200	Grate Inlet	Sunny Isle/Harbor
	201	Grate Inlet	Sunny Isle/Harbor
	202	Curb Inlet	Sunny Isle/Harbor
	203	Curb Inlet	Sunny Isle/Harbor
	Total[1]:	203	

1. Inventory based on study area and field review.

APPENDIX G – DRAINAGE AREA MAP

MASTER RATIONAL METHOD TABLE

Drainage Area No.	Area (ac)	C	Tc (min)	2-Yr Storm Q_2 (cfs)	5-Yr Storm Q_5 (cfs)	25-Yr Storm Q_{25} (cfs)
1	7.323	0.90	15	34.60	41.85	55.03
2	2.706	0.90	15	12.79	15.46	20.34
3	9.654	0.90	15	45.62	55.17	72.55
4	1.902	0.90	15	8.99	10.87	14.29
5	1.737	0.90	15	8.21	9.93	13.05
6	8.774	0.70	15	32.24	39.00	51.28
7	2.822	0.90	15	13.33	16.13	21.21
8	2.512	0.90	15	11.87	14.36	18.88
9	2.069	0.90	15	9.78	11.82	15.55
10	0.488	0.90	10	2.75	3.29	4.39
11	0.554	0.90	10	3.12	3.74	4.99
12	8.384	0.90	15	39.61	47.91	63.01
13	4.341	0.70	15	15.95	19.30	25.37
14	0.890	0.90	10	5.01	6.01	8.01
15	0.481	0.90	10	2.71	3.25	4.33
16	2.017	0.80	15	8.47	10.25	13.47
17	0.365	0.90	10	2.05	2.46	3.29
18	8.348	0.90	15	39.44	47.71	62.74
19	3.740	0.60	15	11.78	14.25	18.74
20	1.333	0.35	15	2.45	2.96	3.90
21	0.520	0.50	10	1.63	1.95	2.60
22	10.340	0.90	15	48.86	59.09	77.71
23	3.237	0.95	15	16.14	19.53	25.68
24	0.524	0.50	10	1.64	1.97	2.62
25	0.931	0.50	10	2.91	3.49	4.66
26	0.469	0.35	10	1.03	1.23	1.64
27	0.318	0.35	10	0.70	0.83	1.11
28	0.268	0.70	10	1.17	1.41	1.88
29	1.536	0.95	15	7.66	9.27	12.18
30	0.486	0.90	10	2.73	3.28	4.37
31	8.426	0.90	15	39.81	48.15	63.32
32	1.347	0.95	15	6.72	8.13	10.69
33	1.059	0.90	15	5.00	6.05	7.96
34	1.011	0.90	15	4.78	5.78	7.60
35	0.722	0.95	10	4.29	5.14	6.86
36	8.209	0.90	15	38.79	46.91	61.69
37	0.932	0.95	10	5.53	6.64	8.85
38	0.807	0.95	10	4.79	5.75	7.67
39	0.620	0.95	10	3.68	4.42	5.89
40	0.295	0.90	10	1.66	1.99	2.66
41	7.417	0.90	15	35.05	42.39	55.74
42	1.094	0.95	15	5.46	6.60	8.68
43	0.740	0.95	10	4.39	5.27	7.03
44	0.382	0.90	10	2.15	2.58	3.44
45	7.792	0.90	15	36.82	44.53	58.56
46	1.303	0.70	15	4.79	5.79	7.62
47	7.882	0.65	15	26.90	32.53	42.78
48	0.957	0.90	10	5.38	6.46	8.61
49	0.487	0.95	10	2.89	3.47	4.63
50	0.148	0.95	10	0.88	1.05	1.41
51	0.803	0.80	10	4.02	4.82	6.42
52	2.084	0.50	15	5.47	6.62	8.70
53	7.520	0.65	15	25.66	31.04	40.81
54	1.122	0.90	15	5.30	6.41	8.43
55	15.927	0.65	15	54.35	65.74	86.44
56	2.097	0.80	15	8.81	10.65	14.01
57	2.219	0.50	15	5.82	7.05	9.26
58	10.134	0.65	15	34.58	41.83	55.00
59	0.988	0.90	10	5.56	6.67	8.89
60	0.472	0.50	10	1.48	1.77	2.36
61	0.580	0.65	10	2.36	2.83	3.77
62	3.532	0.65	15	12.05	14.58	19.17
63	17.200	0.65	15	58.70	70.99	93.35
64	0.200	0.95	10	1.19	1.43	1.90
65	3.029	0.65	15	10.34	12.50	16.44
66	0.880	0.95	10	5.23	6.27	8.36
67	3.178	0.50	15	8.34	10.09	13.27
68	2.496	0.65	15	8.52	10.30	13.55
69	5.552	0.65	15	18.95	22.92	30.13
70	9.111	0.65	15	31.09	37.61	49.45
71	1.005	0.95	15	5.01	6.06	7.97
72	1.860	0.80	15	7.81	9.45	12.42
73	2.660	0.50	15	6.98	8.45	11.11
74	6.410	0.50	15	16.83	20.35	26.76
75	17.494	0.65	15	59.70	72.21	94.95
76	1.677	0.80	15	7.04	8.52	11.20
77	0.680	0.90	10	3.83	4.59	6.12
78	1.553	0.65	15	5.30	6.41	8.43
79	8.822	0.65	15	30.11	36.41	47.88
80	0.742	0.95	10	4.41	5.29	7.05
81	1.715	0.80	15	7.20	8.71	11.46
82	1.961	0.80	15	8.24	9.96	13.10
83	0.689	0.70	10	3.01	3.62	4.82
84	1.971	0.65	15	6.73	8.14	10.70
85	1.898	0.50	15	4.98	6.03	7.92
86	2.022	0.65	15	6.90	8.35	10.97
87	8.419	0.65	15	28.73	34.75	45.69
88	1.289	0.95	15	6.43	7.78	10.22
89	0.556	0.90	10	3.13	3.75	5.00
90	0.633	0.90	10	3.56	4.27	5.70
91	2.149	0.65	15	7.33	8.87	11.66
92	2.924	0.65	15	9.98	12.07	15.87
93	16.870	0.65	15	57.57	69.63	91.56
94	1.973	0.90	15	9.32	11.28	14.83
95	1.859	0.90	15	8.78	10.62	13.97
96	5.926	0.65	15	20.22	24.46	32.16
97	16.732	0.65	15	57.10	69.06	90.81
98	6.861	0.95	15	34.22	41.39	54.42
99	1.519	0.95	15	7.58	9.16	12.05
100	3.381	0.90	15	15.98	19.32	25.41
101	2.140	0.70	15	7.86	9.51	12.51
102	7.436	0.65	15	25.38	30.69	40.36
103	9.258	0.70	15	34.02	41.15	54.11
104	0.935	0.90	10	5.26	6.31	8.42
105	1.736	0.65	15	5.92	7.17	9.42
106	1.642	0.90	15	7.76	9.38	12.34
107	1.921	0.90	15	9.08	10.98	14.44
108	1.845	0.65	15	6.30	7.62	10.01
109	16.561	0.70	15	60.86	73.61	96.80
110	3.336	0.90	15	15.76	19.07	25.07
111	2.635	0.90	15	12.45	15.06	19.80
112	3.128	0.90	15	14.78	17.88	23.51
113	16.274	0.65	15	55.54	67.17	88.33
114	0.968	0.95	10	5.75	6.90	9.20
115	2.461	0.90	15	11.63	14.06	18.49
116	0.583	0.95	10	3.46	4.15	5.54
117	2.250	0.70	15	8.27	10.00	13.15
118	17.131	0.65	15	58.46	70.71	92.98
119	1.872	0.35	15	3.44	4.16	5.47
120	2.472	0.90	15	11.68	14.13	18.58
121	1.985	0.50	15	5.21	6.30	8.29
122	2.390	0.90	15	11.29	13.66	17.96
123	16.371	0.65	15	55.87	67.57	88.85
124	3.749	0.70	15	13.78	16.66	21.91
125	2.032	0.50	15	5.33	6.45	8.48
126	2.621	0.90	15	12.38	14.98	19.70
127	8.455	0.65	15	28.85	34.90	45.89
128	1.612	0.70	15	5.92	7.17	9.42
129	0.606	0.35	10	1.33	1.59	2.12
130	0.706	0.95	10	4.19	5.03	6.71
131	0.731	0.65	10	2.97	3.56	4.75
132	1.215	0.65	15	4.15	5.01	6.59
133	16.493	0.70	15	60.61	73.31	96.40
134	2.945	0.70	15	10.82	13.09	17.21
135	0.779	0.50	10	2.43	2.92	3.90
136	1.319	0.65	15	4.50	5.44	7.16
137	0.724	0.50	10	2.26	2.72	3.62
138	1.552	0.65	15	5.30	6.41	8.42
139	1.785	0.65	15	6.09	7.37	9.69
140	1.036	0.70	15	3.81	4.61	6.06
141	1.481	0.65	15	5.05	6.11	8.04
142	4.734	0.70	15	17.40	21.04	27.67
143	40.429	0.70	15	148.58	179.71	236.31
144	4.269	0.90	15	20.17	24.40	32.08
145	3.528	0.70	15	12.97	15.68	20.62
146	4.381	0.65	15	14.95	18.08	23.78
147	0.756	0.95	10	4.49	5.39	7.18
148	0.544	0.95	10	3.23	3.88	5.17
149	0.414	0.65	10	1.68	2.02	2.69
150	1.008	0.65	15	3.44	4.16	5.47
151	19.642	0.80	15	82.50	99.78	131.21
152	1.514	0.65	15	5.17	6.25	8.22
153	0.357	0.65	10	1.45	1.74	2.32
154	0.065	0.65	10	0.26	0.32	0.42
155	0.849	0.65	10	3.45	4.14	5.52

DRAINAGE AREA LEGEND

(XX)	DRAINAGE AREA NUMBER
dashed line	DRAINAGE AREA BOUNDARY

NOTES

1. REFER TO THE MASTER DRAINAGE PLAN DATED DECEMBER 2018 FOR METHODOLOGY.
2. REFER TO THE DRAINAGE AREA MAP SHEETS 2 AND 3 FOR MORE DETAIL AND STREET NAMES.
3. DRAINAGE AREA DELINEATIONS ARE BASED ON 2018 TNRIS LIDAR, RECORD DRAWINGS, AND FIELD OBSERVATIONS.

OVERALL DRAINAGE AREA MAP
EXHIBIT G

SHEET 1 OF 3

South Padre ISLAND

Kimley»Horn

2201 W. Royal Lane
Suite 275
Irving, Texas 75063
214-420-5600
State of Texas Registration No. F-928

NOTE: THIS PLAN IS CONCEPTUAL IN NATURE AND MAY HAVE BEEN PRODUCED WITHOUT THE BENEFIT OF A SURVEY OR CONTACT WITH THE CITY OR COUNTY.

Plotted By: McGary, Hannah December 21, 2018 04:34:44pm K:\LAC_Civil\069234007_SPI Drainage Master Plan\CADD\Exhibits\Roll Plot DAM_v2.dwg

MATCHLINE
SEE SHEET 3 OF 3

NORTH

GRAPHIC SCALE IN FEET
0 125 250 500

DRAINAGE AREA LEGEND	
XX	DRAINAGE AREA NUMBER
(dashed line)	DRAINAGE AREA BOUNDARY

NOTES

1. REFER TO THE MASTER DRAINAGE PLAN DATED DECEMBER 2018 FOR METHODOLOGY.
2. REFER TO THE OVERALL DRAINAGE AREA MAP FOR RATIONAL METHOD CALCULATIONS.
3. DRAINAGE AREA DELINEATIONS ARE BASED ON 2018 TNRIS LIDAR, RECORD DRAWINGS, AND FIELD OBSERVATIONS.

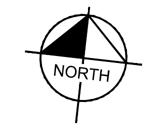
DRAINAGE AREA MAP - 1
APPENDIX G
SHEET 2 OF 3

South Padre ISLAND

Kimley»Horn
2201 W. Royal Lane
Suite 275
Irving, Texas 75063
214-420-5600
State of Texas Registration No. F-928

Plotted By: McGary, Hannah December 21, 2018 02:31:24pm K:\LAC_Civil\069234007_SPI Drainage Master Plan\CADD\Exhibits\Roll Plot DAM.dwg

MATCHLINE
SEE SHEET 2 OF 3



GRAPHIC SCALE IN FEET
0 125 250 500

DRAINAGE AREA LEGEND	
(XX)	DRAINAGE AREA NUMBER
(dashed line)	DRAINAGE AREA BOUNDARY

NOTES

1. REFER TO THE MASTER DRAINAGE PLAN DATED DECEMBER 2018 FOR METHODOLOGY.
2. REFER TO THE OVERALL DRAINAGE AREA MAP FOR RATIONAL METHOD CALCULATIONS.
3. DRAINAGE AREA DELINEATIONS ARE BASED ON 2018 TNRIS LIDAR, RECORD DRAWINGS, AND FIELD OBSERVATIONS.

DRAINAGE AREA MAP - 2
APPENDIX G

SHEET 3 OF 3

South Padre ISLAND

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State of Texas Registration No. F-928

NOTE: THIS PLAN IS CONCEPTUAL IN NATURE AND MAY HAVE BEEN PRODUCED WITHOUT THE BENEFIT OF A SURVEY OR CONTACT WITH THE CITY OR COUNTY.

Plotted By: McGary, Hannah December 21, 2018 02:31:45pm K:\LAC_Civil\069234007_SPI Drainage Master Plan\CADD\Exhibits\Roll Plot DAM.dwg

APPENDIX H – TxDOT UPDATED RAINFALL DATA LETTER

MEMO

November 29, 2018

To: District Engineers

From: Camille Thomason, P.E.
Director, Design Division

Subject: Updated Rainfall Data

The National Oceanic and Atmospheric Administration (NOAA) has released updated precipitation frequency estimates for Texas. They are published as *NOAA Atlas 14, Volume 11: Precipitation-Frequency Atlas of the United States*. The Volume 11 publication, specific for Texas, will be in two parts – 1) the rainfall data and supplementary maps are immediately available at https://hdsc.nws.noaa.gov/hdsc/pfds/, 2) accompanying documentation describing the data and methods will be published in Dec 2018.

TxDOT has been a contributing financial partner to this Atlas 14, Volume 11 update for Texas as well as a participant on the technical peer review panel. This updated study is considered the best available data for Texas rainfall frequencies. Reasons why it is considered best available include – 23 additional years of rainfall records (1995-2017, including Hurricane Harvey rainfall totals), evaluation and use of many additional rainfall gages, and improved statistical approaches.

Generally, significant increases have been observed for less frequent storms, like the 24-hr 100-yr event, in Central Texas and Coastal areas around Houston and Beaumont. The Rio Grande Valley, Del Rio and Eagle Pass area, and the Guadalupe Mountains, are other areas with observed increases. Other parts of the state have more varied results with even some decreases observed. Areas with significant rainfall increases are expected to indicate the need for larger hydraulic structures, such as bridges and culverts, which would increase construction costs. Correspondingly, areas with decreases will indicate the need for smaller hydraulic structures, which would decrease construction costs. It is important to review any specific area of interest to assess the degree to which the rainfall estimates have changed and thus how project costs may be affected.

Applicability – Use of this new rainfall data is considered best available data and will be incorporated into the Hydraulic Design Manual (HDM) by May 2019. However, this memo is considered equivalent policy to the HDM and will be publically available here - https://www.txdot.gov/inside-txdot/forms-publications/consultants-contractors/publications/design.html. As such, contracts that generally stipulate compliance with TxDOT policies, manuals, and procedures, such as professional services contracts, Design-Build contracts, or intra-agency agreements, are immediately subject to this memo, unless the work is complete or substantially complete. Any decision to revise or re-design projects, as a result of the update, is at the district’s discretion.

Project Timing – The updated data is available for immediate use on all TxDOT projects, including Alternative Delivery Projects. Current TxDOT projects are all at various stages of completion – planning, schematic, final design (i.e. PS&E preparation), letting, and construction. Projects in planning and schematic phases should be able to have the new rainfall data incorporated into the designs without significant difficulty. Changes for projects at the final design stage or later will need to be considered on a case-by-case basis. Those decisions will be at the districts' discretion.

The remainder of the memo describes specific approaches that can be used to incorporate the new rainfall data into TxDOT projects.

Statistical Flow Models – Statistical Stream Gage Analysis and Regression Equation procedures remain unchanged with the new rainfall values. This is because these methods are based on stream flow statistics, not rainfall statistics.

Rainfall-Runoff Models

- Rational Method – Software that facilitates Rational Method calculations, like GEOPAK, often has Intensity-Duration-Frequency (IDF) curves from prior rainfall data embedded into the software. Designers may continue to use these older values, but should evaluate the new NOAA rainfall changes for their project area and, if there are increases, estimate an appropriate level of freeboard for use. The freeboard amount and a description of how it was generated should be noted in both the plans and the drainage report. IDF point values are available from the new NOAA rainfall data, but linear interpolation or location-specific curve generation may be needed to obtain values between certain time increments. These new IDF values can be imported for each project into GEOPAK as an alternate approach. This same location-specific IDF curve approach can be used for Rational Method calculations performed outside of GEOPAK as well.

  TxDOT is currently working with Texas Transportation Institute (TTI) staff, as part of research project 0-6980, to update the IDF curve relationships for the state of Texas based on this newly released NOAA rainfall data. This work will include a refresh of the EBDLKUP-2015v2.1.xlsx file linked in the Hydraulic Design Manual (HDM) and is planned for completion in Oct 2019. Concurrently, TxDOT is transitioning from GEOPAK to Open Roads Designer (ORD) and Subsurface Utility Design and Analysis (SUDA). By the time TTI generates new IDF curve equations for Texas, these equations are expected to be provided as back-end files embedded in SUDA rather than GEOPAK later in 2019. Methods for determining freeboard amounts or alternate approaches should be coordinated with the District Hydraulic Engineer (DHE) and additional support may be provided by Design Division, Hydraulics staff.

- Hydrograph Methods – Software, like HEC-HMS, that facilitates hydrograph methods, like NRCS, utilizes Depth-Duration-Frequency (DDF) tabular data that is directly accessible from the new NOAA data. These DDF values can be determined at each project location through NOAA's Precipitation Frequency Data Server (PFDS) and may be used immediately.

  The Natural Resources Conservation Service (NRCS) National Engineering Handbook (NEH), Part 630, Chapter 4 includes a detailed discussion on updating the temporal distribution of rainfall based on the new NOAA Atlas 14 rainfall data from the older Type I-III distributions commonly used in Texas today. TxDOT is evaluating this proposed approach to temporal distribution of rainfall and further guidance may be forthcoming. Meanwhile, continued use of Type II and III temporal distribution of rainfall for Texas is considered appropriate.

Supplemental Data – Interested parties are encouraged to review other data available on NOAA's PFDS website. This includes GIS data, cartographic maps, and seasonality analyses, among other items. These additional items may be of use to other professionals such as environmental, construction, and maintenance personnel. For example, the seasonality analysis shows that extreme rainfall events in Texas are most likely in the months of May-June and Sep-Oct.

If you have questions or need additional information regarding this new rainfall data, please contact Saul Nuccitelli, P.E., CFM, Design Division-Roadway and Hydraulic Design Section, at (512) 416-2219.

CC: William L. Hale, P.E., ADM
Randy C. Hopmann, P.E., ADM
Brian R. Barth, P.E., ADM
C. Michael Lee, P.E., ADM
Graham Bettis, P.E., BRG
Gina E. Gallegos, P.E., CST
Carlos Swonke, ENV
Daniel L. Stacks, P.E., MNT
Peter Smith, P.E., TPP
Michael A. Chacon, P.E., TRF
Benjamin H. Asher, PFD
Directors of Transportation Planning and Development
District Design Engineers
Carl Highsmith, P.E., FHWA

APPENDIX I – SUITES AT SUNCHASE PRELIMINARY MEMORANDUM

Kimley»Horn

Texas Firm Registration No. F-928

This document is released for the purpose of interim review under the authority of Jennifer M. LaFoy, P.E. No. 97309 on October 22, 2018. It is not to be used for bidding, permit, or construction purposes.

PRELIMINARY MEMORANDUM

To:	C. Alejandro Sanchez, P.E., CFM Public Works Director City of South Padre Island 4601 Padre Boulevard South Padre Island, TX 78597
From:	Jenny LaFoy, P.E., CFM, ENV SP Kimley-Horn and Associates, Inc. Texas Registered Eng. Firm No. F-928
Date:	October 22, 2018
Subject:	***South Padre Island Storm Drainage Master Plan Update; Suites at Sunchase Preliminary Proposed Alternatives, 1004 Padre Boulevard, South Padre Island, TX 78597***

Dear Mr. Sanchez,

The City of South Padre Island requested Kimley-Horn's assistance in providing a preliminary recommendation for proposed drainage facilities to an area of frequent flooding. The Suites at Sunchase located at 1004 Padre Boulevard was identified as a priority area for drainage improvements in the City's 1983 Storm Drainage Master Plan. The Suites at Sunchase is located at the southern end of Padre Boulevard across from a wetland area. Padre Boulevard or Park Road 100 (PR 100) is maintained by the Texas Department of Transportation (TxDOT). It is Kimley-Horn's understanding that the City, Owner, and TxDOT have met to discuss proposed alternatives for this area. The proposed alternative provided by the City as shown in **Appendix A** was analyzed based on the following data from the City, survey field work, and appropriate sources:

- Location map/sketches of the proposed alternative and preliminary calculations
- 1983 Storm Drainage Master Plan
- Design plans for previous projects
- Records of drainage problem areas

The recommendations presented in this memorandum are preliminary and based on limited data available at the time of the analysis. Detailed design based on topographic survey is recommended.

Rational Method Calculations

The Rational Method was used to estimate stormwater runoff peak flows for the design of the storm drain system. The peak discharge rate was computed by the following methodology:

Rational Method

$$Q = CIA$$

Where:

Q	=	Peak discharge rate (cubic feet per second)
C	=	Runoff coefficient from **Table 1** for given area (dimensionless)
I	=	Average rainfall intensity during the time of concentration for a given storm event from **Table 2** (inches per hour)
A	=	Drainage area contributing runoff to the design location (acres)

1. *Runoff Coefficient (C)* – The runoff coefficient was based on the ultimate land use and the respective runoff coefficient provided in **Table 1**. Refer to the current Zoning Map and the Proposed Land Use Map in **Appendix B** and **Appendix C**. Kimley-Horn applied a runoff coefficient of 0.90 for commercial areas for the Rational Method calculations. A weighted average may be applicable for the runoff coefficient if a full, detailed design is performed.

Table 1: Land Use Runoff Coefficients

Land Use	Runoff Coefficient (C)[1]
Commercial Areas	0.90
Industrial Areas	0.70
Residential Areas	0.45
Apartment Condominium Areas	0.70
Park Areas	0.35

1. Runoff coefficients based on the City's 1983 Storm Drainage Master Plan.

2. *Average Rainfall Intensity (I)* – Rainfall intensities for the design return periods were based on rainfall intensity-duration-frequency curves for the City of South Padre Island and Cameron County developed in 1970 by TxDOT and used in the City's 1983 Storm Drainage Master Plan. Kimley-Horn utilized the rainfall intensities estimates for various recurrence intervals or design storms as shown in **Appendix D**. The rainfall intensities were based on a time of concentration of 20 minutes as shown in **Table 2**. The time of concentration and rainfall intensities were based on Rational Method calculations received from the City.

Table 2: Rainfall Intensities Estimates (inches/hour)

Design Storm (years)	Rainfall Intensities (inches/hour)[1]	Time of Concentration (minutes)
2-year	4.40	20
5-year	5.55	20
10-year	6.50	20
25-year	7.40	20

1. Approximate estimates based on South Padre Island Rainfall Intensity Curves, **Appendix D**.

3. *Time of Concentration (T_c)* – A time of concentration of 20 minutes was used for the drainage area and was based on Rational Method calculations received from the City. The time of

concentration is preliminary and will need to be evaluated if a full, detailed design is performed. A decrease in time of concentration will increase rainfall intensities for the design return periods.

4. *Drainage Area (A)* – Kimley-Horn utilized the City's 1983 Storm Drainage Master Plan Drainage Area Map for the Rational Method calculations. The drainage area applied for the identified problem area is 36 acres which was based on the City's 1983 Storm Drainage Master Plan drainage area delineation as well as Rational Method calculations received from the City. With further modeling and detailed survey data of the City of South Padre Island, the drainage area may change due to updated delineation if a full, detailed design is performed.

Hydraulic Grade Line Analysis

Kimley-Horn analyzed the system's hydraulic grade line (HGL) to determine if the system could accommodate design flows for the 2-, 5-, 10-, and 25-year storm events in the proposed drainage system without causing flooding. The drainage system limits were defined from the existing upstream inlets to the proposed outfall for the HGL preliminary calculations. The Rational Method variables were applied to the calculations as well as known elevations and slope of pipe from the 2007 TxDOT Town of South Padre Island Median Improvement Project (Park Road 100) plans. For preliminary analyses, it was assumed that half of the flow enters the system at the existing outfall and that the other half of the flow enters the system at the inlet upstream of the existing outfall.

The HGL elevations were compared to the top of structure elevations for the existing structures as the critical elevations of the existing drainage system. The probable water levels for the 2-, 5-, 10-, and 25-year design storms were shown to exceed the existing structures elevations.

Further consideration will be required for tailwater depth or elevation since tidal changes may adversely affect the efficiency of the system. The preliminary HGL evaluation applied two tailwater alternatives for each of the four storm events. The first alternative assumes the tailwater elevation is at sea level (or no tailwater impacts), and the second alternative assumes a preliminary coastal tailwater elevation for each storm event as shown in **Table 3**.

Table 3: Tailwater Conditions

Design Storm (years)	Tailwater Elevations (feet)
2-year	0.50
5-year	1.00
10-year	1.50
25-year	2.00

The coastal tailwater conditions were assumed based on prior Kimley-Horn coastal projects and are in line with peer cities tailwater elevations. To fully analyze the flow characteristics of the outfall channel, the appropriate tailwater elevations must be determined and used as the basis for the HGL calculations if a full, detailed design is performed.

Results

Based on the above results, Kimley-Horn's preliminary determination is that the proposed improvements as shown in **Appendix A** with a proposed 5'x3' box culvert will not adequately drain the 2-, 5-, 10-, and 25-year design storms and that the drainage system would likely still experience flooding issues. The preliminary recommendations shown in **Table 4** may reduce flooding in this drainage area pending final hydraulic grade line calculations and further modeling of the drainage area:

Table 4: Preliminary Recommendations

Design Storm (years)	Tailwater Conditions (feet)	Proposed Box Culvert Sizes[1]	Results[2]
2-year	0.00	Two 6'x3' box culverts	Flow contained
2-year	0.50	Two 6'x3' box culverts	Flow contained
5-year	0.00	Two 6'x3' box culverts	Flow contained
5-year	1.00	Two 6'x3' box culverts	HGL exceeds top of structures by 0.23 ft
10-year	0.00	Two 6'x3' box culverts	HGL exceeds top of structures by 0.07 ft
10-year	1.50	Three 6'x3' box culverts	HGL exceeds top of structures by 0.27 ft
25-year	0.00	Two 6'x3' box culverts	HGL exceeds top of structures by 0.48 ft
25-year	2.00	Three 6'x3' box culverts	HGL exceeds top of structures by 1.10 ft

1. Proposed box culverts to be placed from the existing outfall to the proposed junction box and the proposed outfall.
2. The amount of flow contained is an estimate of the amount of flow that may exceed the existing structures elevations based on the proposed box culvert sizes. Further analysis of the drainage area and detailed design of the system is needed to verify the amount of flow that is expected to enter the proposed system and resulting HGLs.

Conclusion

These preliminary results identify proposed box culvert sizes that could reduce flooding in the Suites at Sunchase area of South Padre Island for various storm events and tailwater conditions. Two 6'x3' box culverts would contain the flow for the 2-year storm event with a tailwater of 0 ft, the 2-year storm event with a tailwater of 0.5 ft, and the 5-year storm event with a tailwater of 0 ft. Further consideration and analysis is needed to validate these recommendations, such as the tailwater elevations, validating the drainage areas, pipe slopes, major and minor energy losses within the system, and existing infrastructure elevations. Additional alternatives and items to consider for implementing drainage solutions to the identified problem area include:

- Section 404 permitting requirements for wetland areas and discharge of dredged material;
- Pipe cover;
- Expanding box culverts to allow more storage;
- Backflow devices;
- Storage under Padre Boulevard;
- Improving existing inlets in drainage area;
- Routine cleanout of system;
- Detailed topography of the drainage area; and,
- 2D modeling of drainage area.

If you have any additional comments or questions, please do not hesitate to contact me at 214-420-5639 or jenny.lafoy@kimley-horn.com.

Appendices

Appendix A – Preliminary Sketch from City of Outfall Improvement at Suites at Sunchase

Appendix B – City of South Padre Island Zoning Map, 2016

Appendix C – South Padre Island Proposed Land Use Map, 1983

Appendix D – South Padre Island Rainfall Intensity Curves, 1983

Appendix E – Suites at Sunchase Drainage Complaints

APPENDIX A – PRELIMINARY SKETCH FROM CITY OF OUTFALL IMPROVEMENT AT SUITES AT SUNCHASE

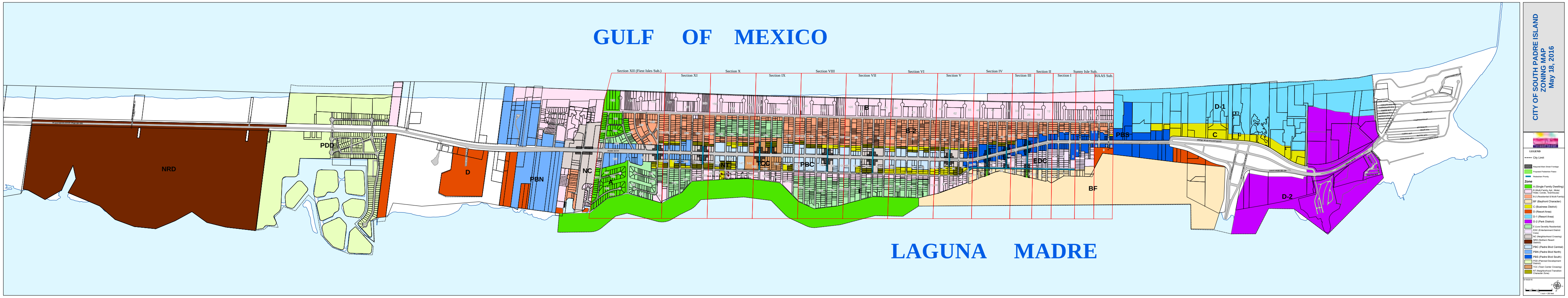
**PRELIMINARY SKETCH
OF
PADRE BLVD OUTFALL IMPROVEMENT
AT SUNCHASE**

South Padre
ISLAND, TEXAS

Kimley»Horn

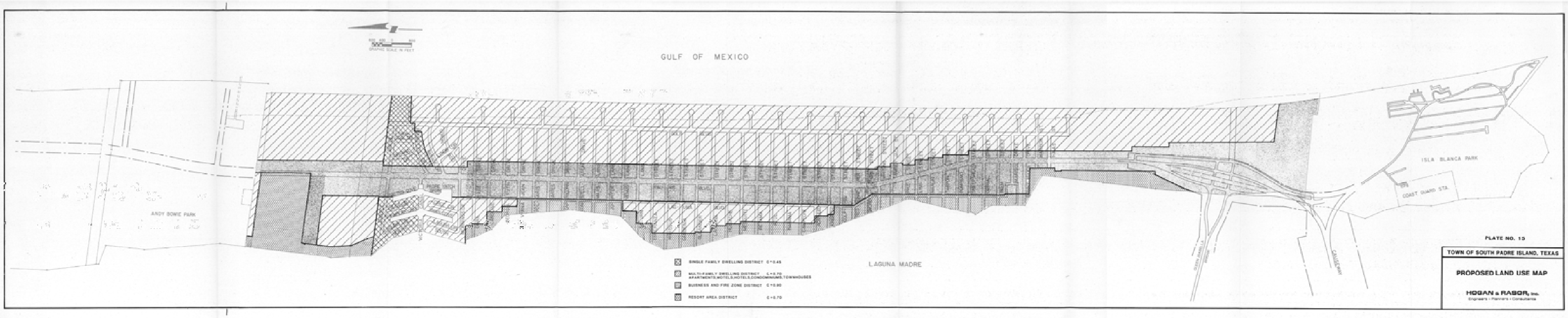
Texas Firm Registration No. F-928

APPENDIX B – CITY OF SOUTH PADRE ISLAND ZONING MAP, 2016

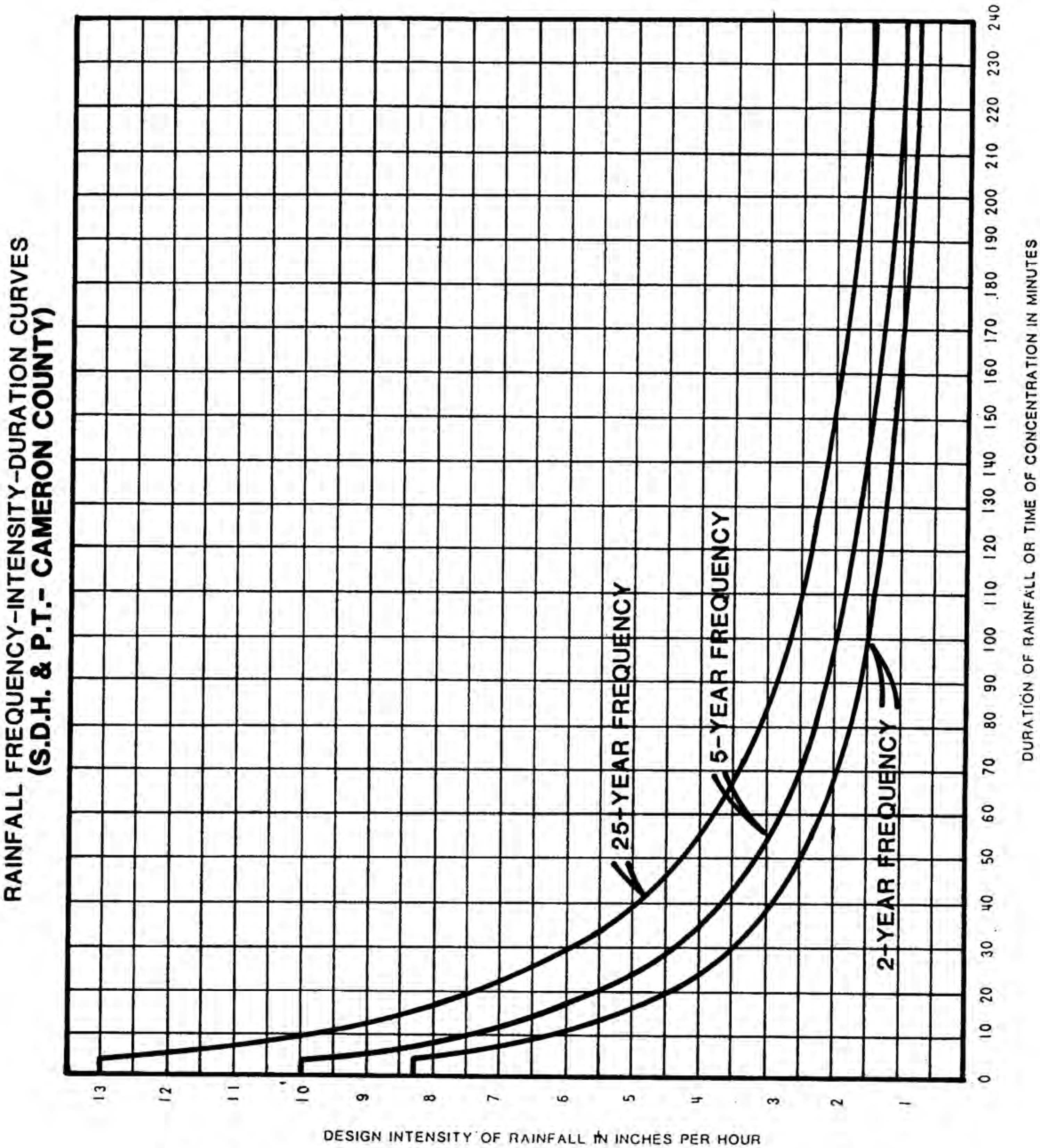


GULF OF MEXICO
LAGUNA MADRE
NRD
PDD
D
PBN
NC
PBC
B
B-2
E
A
EDC
BF
PBS
C
D-1
D-2
Section XII (First Isles Sub.)
Section XI
Section X
Section IX
Section VIII
Section VII
Section VI
Section V
Section IV
Section III
Section II
Section I
Sunny Isle Sub.
HAAS Sub.
CITY OF SOUTH PADRE ISLAND
ZONING MAP
May 18, 2016
LEGEND
Zone

APPENDIX C – SOUTH PADRE ISLAND PROPOSED LAND USE MAP, 1983


GULF OF MEXICO
ANDY BOWIE PARK
LAGUNA MADRE
ISLA BLANCA PARK
COAST GUARD STA.
SINGLE FAMILY DWELLING DISTRICT C=0.45
MULTI-FAMILY DWELLING DISTRICT C=0.70
APARTMENTS, MOTELS, HOTELS, CONDOMINIUMS, TOWNHOUSES
BUSINESS AND FIRE ZONE DISTRICT C=0.90
RESORT AREA DISTRICT C=0.70
PLATE NO. 13
TOWN OF SOUTH PADRE ISLAND, TEXAS
PROPOSED LAND USE MAP
HOGAN & RABOR, Inc.

APPENDIX D – SOUTH PADRE ISLAND RAINFALL INTENSITY CURVES, 1983



TOWN OF SOUTH PADRE ISLAND, TEXAS

RAINFALL INTENSITY CURVES

PLATE NO.1

APPENDIX E – SUITES AT SUNCHASE DRAINAGE COMPLAINTS

Complaint ID	Date	Drainage Complaint	Address	Issue	Proposed Alternative
1	8/1/2018	Flooding, Business	1004 Padre Blvd	Floods every time it rains. Significant flooding issues. No work done.	Proposed outfall improvements. Refer to Appendix A.
2	8/7/2018	Flooding, Business	1004 Padre Blvd	Some improvement once curbside drainage was made, previous drainage was up 3 feet in front of the Suites at Sunchase.	Proposed outfall improvements. Refer to Appendix A.
3	8/7/2018	Flooding, Business	1004 Padre Blvd	Entrance to Sunchase IV at south end of Suites at Sunchase, next the exit at North end of the Suites at Sunchase	Proposed outfall improvements. Refer to Appendix A.
4	8/7/2018	Flooding, Business	1004 Padre Blvd	Sometimes the entrance water can be too high to enter, need to enter on north side of the Suites at Sunchase	Proposed outfall improvements. Refer to Appendix A.