LJA Engineering, Inc.

Texas Water Development Board
Final Engineering Report for City of Alice Master Drainage Plan

Prepared For:

The Texas Water Development Board
and
The City of Alice, Texas

STATE OF TEXAS
CHAD A. JOHNSON
91009
LICENSED
PROFESSIONAL ENGINEER

F-24411

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Prepared By:
LJA Engineering | We Seek Solutions ®
3600 W. Sam Houston Parkway S., Suite 600
Houston, Texas 77042
Telephone: 713.953.5200
Fax: 713.953.5026
LJA Job No. 7038-2201
LJA Firm Registration No. F-1386

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Executive Summary

LJA Engineering, Inc. (LJA) was selected to perform a Master Drainage Plan for the City of Alice to identify possible alternatives to reduce the frequency and severity of flooding within the City. This project was funded by the Texas Water Development Board (TWDB) through the Flood Infrastructure Fund (FIF) as a Category 1 project. Category 1 funding is applicable for Flood Protection Planning for Watersheds. The City of Alice is anticipating continued population growth and urban development and wishes to alleviate current flooding issues within the City.

Project tasks included collection of baseline information and field data, performing hydrologic and hydraulic modeling of the study area, conceptual design of possible flood reduction alternatives, cost benefit analysis, and documentation of a final engineering report. An authorization to proceed was granted to LJA on June 27, 2022.

The City of Alice is located in Jim Wells County, Texas approximately 45 miles west of Corpus Christi. It is located in the Chiltipin Creek-San Fernando Creek HUC-10 watershed (1211020404), and totals to approximately 8,032 acres. The counties encompassing the Chiltipin Creek-San Fernando Creek watershed are Jim Wells, Duval, Nueces, and Kleberg.

The overall watershed is largely undeveloped. The City of Alice is the largest city within the Chiltipin Creek-San Fernando Creek watershed and encompasses 2.9% of the overall watershed area. Because the Rositas Creek – San Diego Creek HUC-10 watershed (1211020403) also flows into the San Fernando Creek, the watershed was included to properly reflect the flows in San Fernando Creek. The streams within the City outfall to San Fernando Creek, which then outfalls to Baffin Bay. Secondary drainage systems within the City consists of predominantly roadside ditch through the city and underground storm sewer in the downtown area.

The objective of this study was to determine viable alternatives to reduce the frequency and severity of flooding within the watershed. This involves modeling of the existing condition to determine the causes of flooding and the analysis of alternatives to determine what is required to obtain significant reductions. The results of the analysis were examined to determine significant problem areas within the watershed. As the majority of the watershed is relatively undeveloped with low concentrations of structures, the most significant areas impacted were determined to be in the City of Alice and near the downstream limit of the watershed near Kingsville. Based on the Nueces Regional Flood Plan draft, which includes the Chiltipin Creek- San Fernando Creek HUC-10, numerous projects are proposed or ongoing in the Kingsville area. In order to prevent duplication of effort, this study concentrated on problem areas in City of Alice area of the watershed.

The hydrological analyses for the study was performed with HEC-HMS (Version 4.10), and the hydraulic analyses were done using 2D HEC-RAS (Version 6.3.1) models. These softwares were used to develop the rainfall hyetographs and runoff hydrographs for use in dynamic 2D models of the HUC-10 watershed and separate models of the problem areas.

Two problem areas were identified based on discussions with City officials and review of historical flood data and the models. One area identified is along BU 281 in the southern portion of the City. This model is referred to in this report as the BU 281 problem area model. The second area is along an unnamed tributary to San Fernando Creek that is locally known as Pintas Creek. For the BU 281 area, the primary cause of the flooding is due to a relatively large drainage area draining to the unnamed tributary of Lattas Creek with no defined channel. This results in a broad area of shallow overland flow through existing developed areas. For the Pintas Creek area, the primary causes of flooding are the lack of a defined channel in the downstream reaches, and insufficient channel capacity in the upper reaches.

Four alternatives were examined for the Pintas Creek area in order to determine the most cost-effective solution to the flooding, and a single alternative was examined in the BU 281 area to determine the effects of a proposed channel to reduce the overland flow issues.

Benefits were calculated using the BCA Input Workbook_v1.2 spreadsheet from the Texas Water Development Board and the FEMA tool Kit version 6.0. A summary of all alternatives and their respective Benefit-Cost Ratio (BCR) is summarized in the table below.

Alternative	**Summary**	**Benefit Cost Ratio**
Pintas Creek Alt 1	Designed to contain the 1% frequency storm event.	0.3
Pintas Creek Alt 2	Portion of the channel within the City stays within the existing banks and the downstream portion was expanded to attempt to contain more flow.	0.2
Pintas Creek Alt 3	Portion of the channel within the City remains unchanged and the downstream portion was expanded to attempt to contain more flow.	0.2
Pintas Creek Alt 4	Same as Pintas Creek Alt 2 but all cross section were replaced with Bridges.	0.2
BU 281 Alt 1	Established a defined drainage path for overland runoff to flow into.	0.6

BU 281 Alternative 1 results in the highest BCR, however the proposed improvements do show water increases in undeveloped areas between BU281 and San Fernando Creek which would drive up the costs. Pintas Creek Alternative 1 removed all of the structures from the 100-year frequency storm event floodplain with no water surface increases and has the highest BCA compared to all the other Pintas Creek alternatives. Alternative 2 through 4 for Pintas Creek minimize the number of structures in the 100-year floodplain but it is not enough to have a higher BCA than alternative 1. Based on these results, it is recommended that the Pintas Creek Alternative 1 be included the Regional Flood Plan Ground (RFPG).

The problem areas within the City do not appear to have the ability to benefit from dedicated gages to be used for an early warning system. The BU 281 problem area has no defined channel or crossings or place gages. The Pintas Creek area has no road crossings which appear to be inordinately impacted in frequent events. In the problem areas, the flooding is more widespread and due to heavy rain events or events of high intensity. With the presence of USGS gages in the area, usage of the existing USGS Water Alert system appears the best procedure for warning systems within the City at this time.

When the next round of the Regional Flood plan is opened in the spring of 2024, we will coordinate with the Nueces River Authority to include the Pintas Creek Alternative 1 in the Region 13 –l Nueces Region Flood Plan (RFP). The next RFP cycle will be open in the spring of 2024.

1 Introduction

1.1 Purpose and Scope

LJA Engineering, Inc. (LJA) was selected to develop a Master Drainage Plan for the City of Alice to identify alternatives to reduce the frequency and severity of flooding within the City. This project was funded by the Texas Water Development Board (TWDB) through the Flood Infrastructure Fund (FIF) as a Category 1 project. Category 1 funding is applicable for Flood Protection Planning for Watersheds. The City of Alice is anticipating continued population growth and urban development and wishes to alleviate current flooding issues within the City. An authorization to proceed was granted to LJA on June 27, 2022.

The scope of the project includes collection of baseline information, collection and processing of field data, performance of hydrologic and hydraulic modeling and analysis, perform conceptual engineering design, development of cost- benefit analysis, public involvement, and development of the capital improvement program.

1.2 Location

The study area is the Chiltipin Creek- San Fernando Creek watershed that encompasses areas within the counties of Jim Wells, Duval, Nueces, and Kleberg. A map of the project area is provided in **Exhibit 1**. In the current condition of the Chiltipin Creek- San Fernando Creek watershed is primarily undeveloped agricultural properties. There are numerous flood control dams which have been constructed throughout the watershed, primarily in the portion of the watershed upstream of the City of Alice.

The City of Alice is located in Jim Wells County, Texas, approximately 45 miles west of Corpus Christi and is the largest city within the Chiltipin Creek-San Fernando Creek watershed. The City of Alice is comprised of primarily single-family residences, with commercial and industrial areas. Surrounding the City is primarily agricultural and undeveloped areas including rural lot single family development, open space, and grassland. Four of the major streams that are within the City include Chiltipin Creek, Lattas Creek, Pintas Creek, and San Diego Creek.

The overall watershed is largely undeveloped. Alice is the largest city within the Chiltipin Creek-San Fernando Creek watershed and encompasses 2.9% of the overall watershed area. Because the Rositas Creek – Diego Creek HUC-10 watershed (1211020403) also flows into the San Fernando Creek, this watershed was included in order to properly reflect the flows in San Fernando Creek. Four major streams serve as primary drainage pathways within the City of Alice; these include Chiltipin Creek, Lattas Creek, Pintas Creek, and San Diego Creek. These streams outfall to San Fernando Creek, located east of Alice, which then outfalls to Baffin Bay. Baffin Bay ultimately outfalls to the Gulf of Mexico. Secondary drainage systems within the City consist of underground storm sewer in the downtown area and the rest of the city is primarily served by roadside ditch drainage systems. The storm sewer and roadside ditches outfall to the four streams within the city.

2 Project Background

2.1 Historic Flooding

Alice has experienced twenty-two (22) recorded historic flood events, with ten (10) occurring since 2000. Due to the Chiltipin Creek-San Fernando watershed being largely undeveloped, the impacts are not as widespread or devastating when looking at the overall watershed. A summary of the historic flooding dates and damage caused is included in **Table 2-1**.

Table 2-1 Historic Flooding Dates and Damages.

Date(s) of Event	Summary of Damages
8/23/17 – 9/15/17	Flooding of streets, homes, and vehicles.
5/4/15 – 6/22/15	Flooding of streets, homes, and vehicles.
9/17/10 – 9/21/10	One flash flood fatality, flooding of streets, homes, and vehicles.
9/6/10	Flooding of streets, homes, and vehicles.
6/30/10	Flooding of streets, homes, and vehicles.
7/24/08	Flooding of streets, homes, and vehicles.
7/20/05	Flooding of streets, homes, and vehicles.
9/6/02 – 9/30/02	Flooding of streets, homes, and vehicles.
6/29/02 – 7/31/02	Flooding of streets, homes, and vehicles.
3/1/00 – 3/31/00	Flooding of streets, homes, and vehicles.
10/17/98 – 11/15/98	Flooding of streets, homes, and vehicles.
10/9/97	Two flash flood fatalities, flooding of streets, homes, and vehicles.
6/27/97	Flooding of streets, homes, and vehicles.
4/2/97	Flooding of streets, homes, and vehicles.
10/28/95	Flooding of streets, homes, and vehicles.
10/30/84	Flooding of streets, homes, and vehicles.
8/11/80	Flooding of streets, homes, and vehicles.
9/10/71	Flooding of streets, homes, and vehicles.
9/20/67	Flooding of streets, homes, and vehicles.
9/11/61	Flooding of streets, homes, and vehicles.
8/26/45	Flooding of streets, homes, and vehicles.
9/14/19	Flooding of streets, homes, and vehicles.

The citizens expressed concerned on an area north of SH44 and west of N Aransas St. This area has problems with localized flooding. The neighborhood north of FM 1554 and the neighborhood north of Cecilia Street are affected due to the elevation of the local geography, the points of lower elevations are located within the neighborhood. As result, rainfall in the surrounding region drains towards the neighborhood.

2.2 Proposed and Ongoing Projects

Ongoing projects and projects that have been proposed in the Regional Flood Plan (RFP) can be viewed in **Appendix A**. The RFP includes 18 projects within the Chiltipin Creek- San Fernando Creek watershed. This study does not duplicate any of the efforts involved in the projects listed in the RFP. There are current and proposed projects that would benefit from the proposed alternatives that are in the City of Alice: Virginia Street Area Drainage Project (130000032) and Drainage Improvements Project (13000027). The City of Alice: Virginia Street Area Drainage

Project (130000032) is a GLO disaster mitigation project that is to mitigate the existing storm water ponding in Virginia Street, South Reynolds Street, Old Kingsville Road, Mora Street, Prado Street, Oliver Street, Mary Vera Street, Gardenia Street, Violeta Street and Hughes Street. These improvements will provide a defined pathway for run off to be conveyed. Part of the improvements include street reconstruction, new curb and gutter and valley gutters, sidewalks, and Americans with Disabilities Act (ADA) compliant ramps reshaping/regarding the existing roadside ditches, replacing existing culverts and driveways, and installation of safety end treatment structures. The proposed Drainage Improvement Project (13000027) is a drainage improvement project for Alice. The improvements will be done on Pintas Creek at Sunset Drive and Virginia Street. The goal for these projects is to identify, evaluate and recommend ways to mitigate flooding in flood prone areas.

There were no other studies that were collected or provided to analyze in the area. Attempts were made to obtain the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) models within the HUC but they were unavailable.

2.3 Data Collection

Data was collected from various sources that aided in the development of models for the City of Alice Master Drainage Plan. This data includes data describing the physical characteristics of the watershed such as LiDAR, aerials and hydraulic soil data, as well as information on other studies in the watershed and previous flooding issues. The best available data was utilized in all analyses of existing conditions. Data collected from a variety of sources aided in the development of models for the Chiltipin Creek – San Fernando Creek watershed Master Drainage Plan.

The following are the sources utilized to develop the hydrologic and hydraulic models:

- Terrain was developed using 2018 South Texas Light Detecting and Ranging (LiDAR) from the Texas Natural Resources Information System (TNRIS). The horizontal projection
- is NAD83(2011)/UTM zone 14N, horizontal datum is NAD83 (National Spatial Reference System 2011) and vertical datum NAVD88.
- Aerial imagery from the United States Department of Agriculture (USDA) Texas National Agricultural Imagery Program (NAIP). The aerials are from 2020 agricultural growing season through the spring and winter of 2020. Having a 60-cm (2-foot) pixel resolution.
- Hydraulic soils data was obtained from the United States Geological Survey (USGS) Web Soil Survey (WSS) for the Chiltipin Creek-San Fernando Creek watershed. Soil survey data was obtained on February 2023. This data was used in development of the hydrology to account for the loss parameters.
- Precipitation data for the 24-hour and 4-day synthetic storm was determined from NOAA Atlas 14, Volume 11, Version 2, point precipitation frequency estimate for Alice, Texas. Data was collected for the 2-, 10-, 25-, 100- and 500-year frequency storm events.

2.3.1 Survey

Based on discussions with the City of Alice staff, it was determined that the major flooding issues within the City were along Pintas Creek in the northeast portion of the City, and along BU 281 in the southwest portion of the City. In order to create adequately detailed models of these areas, field survey was conducted. This included survey of cross sections, roadway ditches and hydraulic structures along Pintas Creek and in the BU 281 area. A map of the locations surveyed is included in **Exhibit 2A** for BU 281 and **Exhibit 2B** for Pintas Creek.

Submitted data included sketches of the cross culverts, photographic images, a KMZ file and an AutoCAD file. Survey data can be found in **Appendix B**. Survey data is on horizontal datum NAD83 and vertical datum NAVD88.

3 Existing Condition Analysis

3.1 Hydrologic Analysis

No previous studies were available in the area which included the study area. So new models were created for the analysis of the Chiltipin Creek-San Fernando watershed and Rositas Creek – San Diego Creek watershed was performed using USACE HEC-HMS, version 4.10. The hydrologic analysis was used to develop hydrographs and precipitation hyetographs for the hydraulic models. The Rositas Creek - San Diego Creek HUC-10 watershed (1211020403) flow was included in order to accurately represent the flows in San Fernando Creek. Detailed information about the hydrologic analysis methodology is provided below.

3.1.1 Basin Delineation

Drainage areas were developed using the South Texas LiDAR from 2018 based on visual examination of the topography and utilizing ArcHydro. ArcHydro uses an elevation map to identify flow patterns based on elevations. The drainage area boundaries were refined by manual delineation based on results from a 2D Rain On Mesh (ROM) hydraulic model, created to evaluate overland flow. A single drainage area was utilized for the hydrology of the entire watershed, as only a precipitation hyetograph was required.

When the problem areas within the City were identified, smaller models were developed for those subareas. This would allow more detailed and manageable models to better examine alternatives for those areas. One area identified is along BU 281 in the southern portion of the City. This model is referred to in this report as the BU 281 problem area model. The second area is along an unnamed tributary that outfalls into San Fernando Creek. This tributary is locally known as Pintas Creek, shown in **Figure 3.1** by an orange arrow. This is separate from the USGS designation of Pintas Creek that appears to split off east of San Fernando Creek near the confluence of the unnamed tributary with San Fernando Creek, shown in **Figure 3.1** by a red arrow.

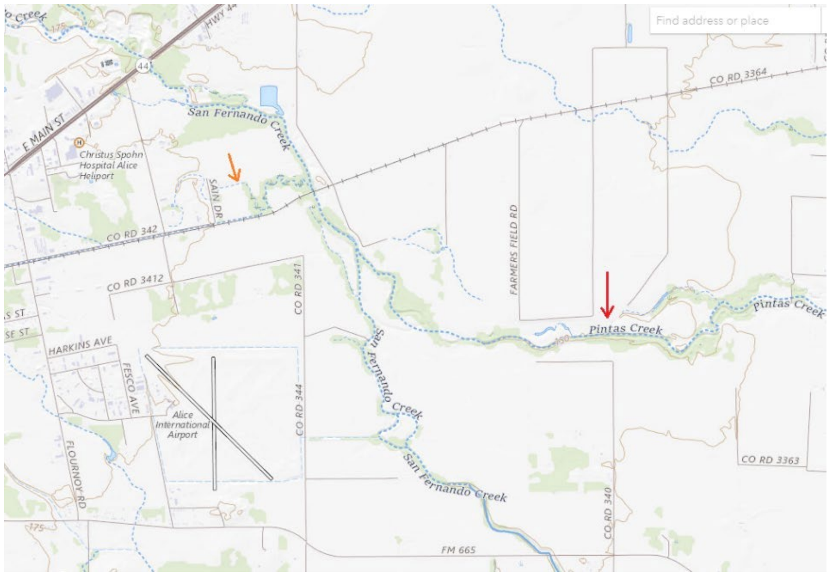

Figure 3.1 USGS Map

For the purpose of this report, the local designation is used, and the second problem area and models are referred to as Pintas Creek. An exhibit of the drainage areas is provided in **Exhibit 3A** for the overall watershed and **Exhibit 3B** for the BU 281 and Pintas Creek models.

3.1.2 Frequency Storm

Rainfall for the hydrologic analysis was developed using a frequency-based hypothetical storm, which is used to define an event for which precipitation depths for various durations within the storm have a consistent exceedance probability. A 4-day synthetic storm was used for the HUC-10 watershed as a 24- hour storm duration was not long enough for the watershed flows to peak. The 24-hour duration storm was used for the smaller models of the City of Alice problem areas. The rainfall depths were based on NOAA Atlas 14 Precipitation-Frequency, Atlas of the United States. The rainfall data used to develop the frequency storms are shown below in **Table 3-1**.

Table 3-1 NOAA Atlas 14 Rainfall Values.

Duration	Storm Event			
	2-Year	10-Year	25-Year	100-Year
15-Minutes	0.883	1.28	1.52	1.86
60-Minutes	1.57	2.27	2.70	3.32
2-Hour	1.91	2.83	3.41	4.30
3-Hour	2.11	3.18	3.86	4.95
6-Hour	2.48	3.79	4.67	6.11
12-Hour	2.88	4.44	5.51	7.33
24-Hour	3.33	5.12	6.38	8.57
2-Day	3.83	5.85	7.25	9.71
3-Day	4.16	6.32	7.82	10.4
4-Day	4.41	6.68	8.24	10.9

3.1.3 Runoff Loss Parameters

The Green and Ampt loss methodology was used for the runoff loss method in the hydrologic model. The parameters for the loss methodology used were based on the guidance provided in the Texas GLO River Basin Flood Study. Hydraulic soils data was obtained from USGS WSS for the Chiltipin Creek-San Fernando Creek watershed. The Green and Ampt runoff loss parameters by subbasin are summarized in **Table 3-2. Exhibit 4** shows the soils data for the Chiltipin Creek-San Fernando Creek watershed.

Table 3-2 Green and Ampt Loss Values by Soil Group.

Hydraulic Soil Group	Initial Content	Saturated Content	Suction (in)	Hydraulic Conductivity (in/hr)
A	0.05 (0.02- 0.44)	0.44	2	0.35 (0.30 – 0.45)
B	0.10 (0.04 – 0.45)	0.45	4	0.20 (0.15 – 0.30)
C	0.20 (0.07 – 0.46)	0.46	8	0.08 (0.05 – 0.15)
D	0.30 (0.09 – 0.47)	0.47	12	0.02 (0.00 – 0.05)

Table 3-3, Table 3-4, and **Table 3-5** summarize the loss parameters for the Pintas Creek, BU 281, and Chiltipin Creek-San Fernando Creek models. A composite value was determined for each drainage area. The calculations for loss parameters are provided in **Appendix C**.

Table 3-3 Pintas Creek Composite Green and Ampt Loss Values.

Drainage Area Name	Drainage Area (ac)	Initial Content	Saturated Content	Suction (in)	Hydraulic Conductivity (in/hr)
DA_1	185	0.20	0.46	8.04	0.08
DA_2	89	0.15	0.46	6.13	0.14
DA_3	273	0.20	0.46	7.8	0.09
DA_4	200	0.22	0.46	8.98	0.07
DA_5	211	0.24	0.46	9.61	0.07
DA_6	29782	0.27	0.46	10.81	0.05

Table 3-4 BU 281 Composite Green and Ampt Loss Values.

Drainage Area Name	Drainage Area (ac)	Initial Content	Saturated Content	Suction (in)	Hydraulic Conductivity (in/hr)
DA_1	175	0.21	0.46	8.45	0.09
DA_2	222	0.25	0.47	10.06	0.05
DA_3	509	0.22	0.46	8.87	0.07
DA_4	236	0.17	0.46	6.84	0.13
DA_5	588	0.20	0.46	8.18	0.09
DA_6	938	0.22	0.46	8.94	0.08
DA_7	377	0.24	0.46	9.4	0.07
DA_8	457	0.16	0.46	6.46	0.13

Table 3-5 Chiltipin Creek-San Fernando Creek Composite Green and Ampt Loss Values.

Drainage Area Name	Drainage Area (ac)	Initial Content	Saturated Content	Suction (in)	Hydraulic Conductivity (in/hr)
Chiltipin Creek-San Fernando Creek DA_1	276668	0.20	0.46	7.96	0.10
Rositas Creek-San Diego Creek DA_1	198537	0.16	0.46	6.45	0.14

3.1.4 Land Cover/Percent Impervious

Land use data for the Chiltipin Creek-San Fernando Creek watershed was developed based on aerial imagery obtained from the USDA. This was used to calculate the percent impervious that is dependent on the type of landuse. Runoff from precipitation was calculated using the percent impervious. Alice is composed largely of residential single-family areas, with some commercial developments, and undeveloped areas.

The Chiltipin Creek-San Fernando Creek watershed is largely undeveloped, resulting with a low percent impervious, thus a low runoff rate. Percent impervious values used are in **Table 3-6,** obtained from the HEC-RAS 2D User Manual. A map of the landuse for the Chiltipin Creek-San Fernando Creek watershed is provided in **Exhibit 05**.

Table 3-6 Percent Impervious.

Land Use	Percent Impervious Value
No Data	0
Mixed Forest	0
Deciduous Forest	0
Developed, Open Space	0
Evergreen Forest	0
Open Water	100
Shrub/Scrub	0
Pasture/Hay	0
Grassland/Herbaceous	0
Cultivated Crops	0
Development, Low Intensity	20
Emergent Herbaceous Wetlands	75
Woody Wetlands	50
Developed, Medium Intensity	40
Developed, High Intensity	60
Barren Land Rock/Sandy/ Clay	0

The percent impervious is summarized on **Table 3-7**, **Table 3-8**, and **Table 3-9**. Calculations on how the percent impervious was obtained is provided in **Appendix C**.

Table 3-7 Percent Impervious for 2D ROG Model.

Drainage Area	Total Area (ac)	Existing Percent Impervious
Chiltipin Creek- San Fernando Creek	283774.28	4.79
Rositas Creek- San Diego Creek	193343.3	1.92

Table 3-8 Percent Impervious for BU 281 Model.

Drainage Area	Total Area (ac)	Percent Impervious				
		Existing	Proposed			
			Alternative 1	Alternative 2	Alternative 3	Alternative 4
BU 281 DA_1	175.75	14.45	3.23	N/A	N/A	N/A
BU 281 DA_2	221.89	33.86	3.54	N/A	N/A	N/A
BU 281 DA_3	510.55	12.54	1.44	N/A	N/A	N/A
BU 281 DA_4	236.64	30.10	2.25	N/A	N/A	N/A
BU 281 DA_5	588.52	42.86	5.50	N/A	N/A	N/A
BU 281 DA_6	907.79	10.89	2.30	N/A	N/A	N/A
BU 281 DA_7	377.88	9.99	3.50	N/A	N/A	N/A
BU 281 DA_8	457.27	34.66	3.89	N/A	N/A	N/A

Table 3-9 Percent Impervious for Pintas Creek Model.

Drainage Area	Total Area (ac)	Percent Impervious				
		Existing	Proposed			
			Alternative 1	Alternative 2	Alternative 3	Alternative 4
DA_1	185.14	37.22	37.22	37.22	37.22	37.22
DA_2	89.57	40.38	41.40	40.38	40.33	40.33
DA_3	273.98	44.17	46.09	44.39	45.42	45.42
DA_4	200.35	58.90	59.06	59.08	58.88	58.88
DA_5	211.62	19.30	21.88	22.59	19.03	19.03
DA_6	297.82	19.57	22.27	23.11	22.59	22.59

3.1.5 Transform Method

The Clark Unit Hydrograph method was used as the transform method to create the hydrographs that are input into the hydraulic model from the calculated excess precipitation. Input data for the Clark Unit Hydrograph include the time of concentration (Tc) and the basin storage coefficient (R). These parameters were calculated using the Kerby-Kirpich equations. **Table 3-9** summarizes the Kerby retardance coefficients obtained from the TXDOT Hydraulics Design Manual. The Kerby-Kirpich calculations are provided in **Appendix C**.

The Kerby equation is,

$$tt_{oooo} = KK(LL\ xx\ NN)^{0.467}SS^{-0.235}$$

Where:

tt_{oooo}= overland flow time of concentration, in minutes
K = a units conversion coefficient, in which K = 0.828 for U.S. Customary units
L = the overland-flow length, in feet or meters as dictated by K
N = a dimensionless retardance coefficient

The Kirpich Method equation is,

$$tt_{cch} = KKLL^{0.770}SS^{-0.385}$$

tt_{cch} = the time of concentration, in minutes
K = a units conversion coefficient, in which K = 0.0078 for U.S. Customary units
L = the channel flow length, in feet or meters as dictated by k
S = the dimensionless main-channel slope

The final time of concentration is the sum of the Kirpich and Kerby method.

Table 3-10 Kerby Equation Retardance Coefficient Values.

Terrain Description	**Dimensionless Retardance Coefficient (N)**
Pavement	0.02
Smooth, bare, packed soil	0.10
Poor grass, cultivated row crops, or moderately rough packed surfaces	0.20
Pasture, average grass	0.40
Deciduous forest	0.60
Dense grass, coniferous forest, or deciduous forest with deep littler	0.80

The storage coefficient were obtained using the R/(TC+R) ratio from the Texas GLO River Basin Flood Study. The City of Alice is in an area of relatively flat topography representative of the Texas coastal prairies. Therefore, a ratio value of 0.65 was used as determined in **Table 3-11**. **Appendix C** summarizes the transform parameters for each drainage area in Pintas Creek, BU 281, Chiltipin Creek-San Fernando Creek and Rosita Creek-San Diego Creek.

Table 3-11 Typical R/(TC+R) Values.

General Area Description	**R/(TC+R)**
Flat Coastal Prairies	0.65
Dallas/Fort Worth Metro Area	0.38
Steep Hill Country	0.27

3.2 Hydraulic Analysis

Hydraulic modeling was performed using the USACE HEC-RAS software, version 6.3.1. A 2D rain on mesh model was developed for the overall watershed. This was used to simulate rainfall and identify overland flow paths for water across the watershed and account for routing of runoff through the watershed. When the problem areas were identified, smaller and more-detailed models were developed for the BU 281 and Pintas Creek areas. The overall watershed model included two HUC-10s that drain into San Fernando Creek. The Chiltipin Creek-San Fernando Creek (1211020404) HUC-10 watershed and the Rositas Creek-San Diego Creek (1211020403) HUC-10 watershed.

3.2.1 Geometry

For the overall watershed model, it was decided to use a 2D Rain on Mesh model to account for routing within the watershed. A 2D Rain on Mesh model is one where precipitation is dropped onto the 2D cells which use elevations from LiDAR to determine how runoff is flowing and where flow gets trapped. This type of modeling is good when wanting to determine the flow patterns and localized flooding. Breaklines were used to better define the 2D mesh, placed along major channel and pond high banks, as well as roadway centerlines. This definition allows for more accurate flow calculations in areas where there are features which would affect flow patterns within the watershed. Using smaller cells allows for better classification of elevations that would otherwise not be captured by the larger cells at certain high points and low points.

Normal depth boundary conditions were utilized in the model. The downstream limits of the model were placed at a sufficient distance upstream of Baffin Bay to maintain the validity of the normal depth condition. The area of the watershed downstream of the limits of the model essentially drain directly to the tidally influenced areas of Baffin Bay.

Roadway structures within the smaller modeled areas were added using the 2D connection option. Culvert parameters, including sizing, number of barrels, composition and flowline information were obtained from survey information for the existing conditions. Weir elevations and culvert stationing were determined from aerial imagery and cut from the terrain surface.

The terrain for the HEC-RAS model was developed using the 2018 South Texas LiDAR data set obtained from the Texas Water Development Board Texas Natural Resources Information System. This data was obtained in 2018 and represents the most current topographic information. The terrain was modified as necessary to prevent blockage at road bridge and culvert crossings, and other topographic features that would improperly prevent overland flow.

3.2.2 Boundary Conditions

For the overall Watershed model, a Rain on Mesh methodology was used. The precipitation hyetograph determined in HEC-HMS was utilized for the precipitation pattern onto the 2D grids. The normal depth boundary condition was used at the downstream extents of the 2D mesh. The normal depth condition allows water to exit the model instead of becoming trapped by the boundary. The energy grade slope used was based on the terrain slope at the boundary. For the smaller Pintas Creek model, interior Boundary Conditions were used to input HEC-HMS runoff hydrographs into the hydraulic models.

3.2.3 Manning's Roughness Coefficient's

Land Use layers were created based on aerial imagery of the watershed. Calibration regions were added along the channels to assign the appropriate Manning's "n" value for existing and proposed condition models. The value used was 0.07 for the existing condition which is for natural channels with sluggish reaches and weeds. For the proposed channels, 0.045 was used, which is also for natural channels that are clean but still have some weeds and rocks. Values used were obtained from the HEC-RAS 2D User's Manual.

The assigned manning's values used are in **Table 3-12.** The values are based on recommendations in the HEC-RAS 2D User's Manual. These values take into consideration friction losses. **Exhibit 6A** and **Exhibit 6B** include the detailed land use layers for existing conditions for BU 281 and Pintas Creek respectively.

Table 3-12 Land Use Manning's Values.

Land Use	Manning's Value
No Data	0.035
Mixed Forest	0.12
Deciduous Forest	0.1
Developed, Open Space	0.035
Evergreen Forest	0.15
Open Water	0.035
Shrub/Scrub	0.05
Pasture/Hay	0.045
Grassland/Herbaceous	0.04
Cultivated Crops	0.05
Development, Low Intensity	0.08
Emergent Herbaceous Wetlands	0.045
Woody Wetlands	0.07
Developed, Medium Intensity	0.12
Developed, High Intensity	0.15
Barren Land Rock/Sandy/ Clay	0.03

3.3 Existing Conditions Results

3.3.1 The Chiltipin Creek-San Fernando Creek Watershed

The overall 2D model takes into account all of the Chiltipin Creek-San Fernando Creek HUC-10 watershed. In addition, the Rositas Creek-Sand Diego Creek HUC-10 watershed contributes significantly to the flows entering San Fernando Creek and was included in the analysis to properly account for them. The Rositas Creek-Sand Diego Creek HUC-10 watershed was not included in problem identification of alternative analysis.

As seen in **Exhibit 07**, several of the flood control dams in the watershed detain significant volumes of runoff in the upper portions of the watershed. There is also basin overflow transfer which occurs on the lower reaches of the watershed due to the flat topography of the coastal prairie and no significant elevation features separating the watersheds.

The results of the analysis were examined to determine significant problem areas within the watershed. As the majority of the watershed is relatively undeveloped with low concentrations of structures, the most significant areas impacted were determined to be in the City of Alice and near the downstream limit of the watershed near Kingsville. As shown in **Appendix A**, based on the draft Nueces Regional Flood Plan which includes the Chiltipin Creek-San Fernando Creek HUC-10, numerous projects are proposed or ongoing in the Kingsville area. In order to prevent duplication of effort, this study concentrated on problem areas in City of Alice area of the watershed.

3.3.2 Pintas Creek

While the overall model was a 2D rain on mesh model and used to identify potential problem areas, it makes identification of causes more difficult in some areas. The overall model identified significant issues along Pintas Creek within the City and within the County downstream of the City to the confluence with San Fernando Creek. However, it was not clear from that model if the issues were localized flooding issues or riverine. In order to separate localized flooding issues from riverine flooding issues this smaller problem area was modeled as a 2D model with input hydrographs along the stream. This assumes that all of the flow reaches the channels and allows us to determine if the channel capacity or crossing structures on the stream are the primary causes of flooding.

Examination of the overall model results and the topography show that while there is a defined man-made channel within the City, which has previously been upgraded by the City, there is a significant portion of Pintas Creek downstream of the City with no defined channel as can be seen in **Exhibit 08**. Due to the lack of channel definition downstream, the flow flows partially to the south of FM 342. The channel is unable to contain the 2year frequency storm event. At the City limits, the flow in Pintas Creek essentially becomes overland shallow flow with several small culvert road crossings. This is illustrated in **Figures 3-2 and 3-3** below. This lack of a channel affects the ability of the flow from the City to reach San Fernando Creek.

Figure 3.2 Road Crossing within City of Alice

Figure 3.3 Road Crossing Downstream of City

Based on the Pintas Creek model, there is riverine flooding occurring along the creek within the City. It appears that the primary possible cause of this flooding is due to inadequate channel and crossing structure capacity. Furthermore, the channel is not well defined starting from FM 342 to the San Fernando Creek confluence. This section of the channel is located outside of the City of Alice city limits. Locations of the road crossings are shown in **Exhibit 08.** Provided in **Exhibit 09** are the results from the existing model showing the analyzed inundation area.

Results from this model show that events in excess of the two-year event exceed the high bank elevations along the channel within the City. **Exhibit 10** shows the determined level of service along Pintas Creek. The level of service is based on the lowest frequency event which is contained within the channel banks.

In the existing condition approximately 565 acres within the City are inundated in the 1% event provided in **Table 3-13**. Approximately 65 structures experience flooding and there is flooding of approximately 3.6 miles of roadway. The depth map of the 1% event is shown in **Exhibit 09** and the number of flooded structures is shown in **Exhibit 9B**.

Table 3-13 Existing Pintas Creek Flooding.

Frequency Storm	Number of Flooded Structures	Inundated Area (ac)	Flooded Roadway (mi)
2-Year	13	233	1.5
10-Year	21	372	2.3
25-Year	31	457	2.9
100-Year	61	565	3.6
500-Year	104	698	4.5

3.3.3 BU 281

The City of Alice had identified areas to the east of BU 281 in the southern portion of the City as experiencing significant flooding issues. Based on the overall watershed model, it appears that this area experienced flooding due to overland flow from a significant drainage area to the west of BU 281. As there are no significant crossing structures under BU 281 to allow for flow from the west, we believe that it was previously assumed that the area to the west of BU 281 drained to San Fernando Creek as it was the closest waterway. With the acquisition of LiDAR in recent years and the 2D modelling techniques used, we determined a significant area that flows east across BU 281 and to San Fernando Creek via a shallow natural drainage way. There is no defined channel to carry this area to San Fernando Creek which results in widespread overland flow as the runoff makes its way to San Fernando Creek. Because the problems in this area are due to overland flow, a rain on mesh model was used for evaluation of the alternative analysis for this area.

Water accumulates in areas surrounding BU 281, primarily north of FM 1554 and north of Cecilia Street due to overland flow following low points of the terrain and not having a specific pathway to convey runoff. In the 2-year storm event, the neighborhood north of Cecilias Street, east of BU 281, shows ponding of approximately two feet in depth. A large amount of flow moves northeast from the east side of Highway 281, then starts moving southeast, south of Trevino Street, eventually outfalling to the Lattas Creek Tributary. **Exhibit 11** provides the extents of the 100-year frequency event inundation area. Before the flow reaches the Lattas Creek Tributary, the water passes through developed and undeveloped areas with no defined channel.

In the existing condition, approximately 1310 structures experience flooding and there is flooding of approximately 41 miles of roadway in the 1% event. The depth map of the 1% event is shown in **Exhibit 11** and the number of flooded structures is shown in **Exhibit 11A.** Provided in **Table 3-14** are the values for existing damages. **Exhibit 11B** shows the exiting cross culverts.

Table 3-14 Existing BU 281 Flooding.

Frequency Storm	Number of Flooded Structures	Flooded Roadway (mi)
2-Year	538	21.1
10-Year	587	29.4
25-Year	1310	34.2
100-Year	1310	41
500-Year	1310	47.9

Provided in **Exhibit 12** are the problem areas identified from the existing condition model and **Exhibit 11** provides the culvert crossings identified in the existing condition.

4 Alternative Analysis

4.1 Pintas Creek

Based on the results of the Existing Condition Analysis, four alternatives were determined for analysis to identify an adequate, cost beneficial plan to reduce the severity and frequency of flooding along Pintas Creek.

Because a large part of the alternatives which were examined are not located within the City but lie within the County, coordination with Jim Wells County would be needed to enact any of these alternatives. These alternatives would provide benefits to the County in the future in that it would provide an outfall for roadway drainage in the area, as well as any future development. For Pintas Creek, the area within the City is fully developed adjacent to the channel. As increasing the conveyance capacity of the channel would result in greater flows proceeding downstream, mitigation would be required to avoid increased water surface elevations downstream of the City. As there is no available open area within the City for mitigation, all of the alternatives include increased conveyance all the way to San Fernando Creek.

4.1.1 Alternative 1

Geometry

The first alternative analyzed was to determine the requirements to contain the 100-year event within the channel and eliminate riverine flooding along Pintas Creek within the City of Alice. Alternative 1 consists of channel modifications consisting of a 20-foot bottom width channel with 4:1 side slopes. The channel depth was increased by approximately 8 feet and a flowline slope of 0.15% was assumed. This alternative functions by increasing the conveyance capacity of the channel to contain the 1% event. The existing culvert crossings on Pintas Creek were replaced with bridges in order to maximize conveyance capacity of the crossings. The crossings requiring change are shown in **Exhibit 13**.

Results

With this alternative, the 1% event flows are contained within the channel. The 1% is event is contained within the channel. This removes flooding from all structures in the 1% event as shown in **Exhibit 13A**. The 1% event depth map of this alternative is shown in **Exhibit 13A.** The reduction in WSEL for the 1% event is shown in **Exhibit 13B**. **Table 4-1** provides the flood reductions with Alternative 1.

Table 4-1 Pintas Creek Alternative 1 Reductions.

Frequency Storm	Number of Flooded Structures - Ex	Number of Flooded Structures - Prop	Inundated Area (ac) - Ex	Inundated Area (ac) - Prop	Flooded Roadway (mi) - Ex	Flooded Roadway (mi) - Prop
2-Year	13	0	233	0	2	0
10-Year	21	0	372	0	2	0
25-Year	31	0	457	0	3	0
100-Year	61	0	565	0	4	0
500-Year	104	0	698	0	5	0

4.1.2 Alternative 2

Geometry

The second alternative was to determine the possible reduction if channel modifications were performed within the existing channel footprint and using the existing road crossing structures. This involved division of the stream into six segments. This was done in order to allow the channel cross section to vary in order to fit within the existing footprint through the developed areas while maximizing capacity. In order to reduce costs concrete channel lining was not considered and so a minimum side slope of 3:1 was implemented.

The overall improvements vary along the stream in order to maintain the current footprint. The channel was divided into six segments. All six segments utilize a flowline slope of 0.19% in order to maintain a feasible depth. Segments 1 and 2 consist of 3:1 side slopes and a bottom width of five feet. Segment 3 consists of 5:1 side slopes on one side and 4:1 side slopes on the other with a bottom width of five feet. Segment 4 consists of 3:1 side slopes with a bottom width of five feet. Segments 5 and 6 have 6:1 side slopes with a 45-foot bottom width.

Results

This alternative primarily reduces the floodplain in the downstream portion of the channel which is primarily undeveloped. There is a minimal decrease in water surface elevations in the upper portion of the channel of approximately 0.3 feet in the 1% event. This removes approximately 31 structures from the 1% floodplain as shown in **Exhibit 14**.

With this alternative, the channel capacity of less than the 50% event. The 1% event inundates approximately 114 acres. This alternative leaves approximately 33 flooded structures in the 1% event as shown in **Exhibit 14A** along with flooding of approximately 2.2 miles of roadway. The 1% event depth map of this alternative is shown in **Exhibit 14AA.** The reduction in WSEL for the 1% event is shown in **Exhibit 14B**. **Table 4-2** provides the flood reductions with Alternative 2.

Table 4-2 Pintas Creek Alternative 2 Reductions.

Frequency Storm	Number of Flooded Structures - Ex	Number of Flooded Structures - Prop	Inundated Area (ac) - Ex	Inundated Area (ac) - Prop	Flooded Roadway (mi) - Ex	Flooded Roadway (mi) - Prop
2-Year	13	5	233	41	2	0.4
10-Year	21	10	372	72	2	1.2
25-Year	31	18	457	86	3	1.5
100-Year	61	33	565	114	4	2.2
500-Year	104	55	698	149	5	2.8

4.1.3 Alternative 3

Geometry

To determine if establishment of a defined channel from the city limits to San Fernando Creek would alleviate problems in the City, Alternative 3 examined channel improvements in that area. From the City limits to San Fernando Creek the proposed channel modifications consist of a 45-foot bottom width channel with 5:1 side slopes and a flowline slope of 0.20% as shown in **Exhibit 15.** The reason why the cross-sectional area for this alternative is larger, is due to the difference in depth. Alternative 1 is deeper because the upstream of alternative 3 was left with the same flowline elevation as existing.

Results

This alternative is able to contain the 1% event in the lower reach of the channel outside of the City, but there is little reduction in water surface elevation in the upper portions of the channel within the City. There is only approximately 0.25 feet of water surface reduction within the City with this alternative. This shows that the primary issue in the upper reaches is the conveyance capacity of the channel rather than the lack of a defined channel in the lower reaches.

With this alternative, the 50% event is not contained within the channel within the City. The 1% event inundates approximately 165 acres, with approximately 45 flooded structures in the 1% event as seen in **Exhibit 15A** along with flooding of approximately 2.9 miles of roadway. The 1% event depth map of this alternative is shown in **Exhibit 15AA**. The reduction in WSEL for the 1% event is shown in **Exhibit 15B**. **Table 4-3** provides the flood reductions with Alternative 3.

Table 4-3 Pintas Creek Alternative 3 Reductions.

Frequency Storm	Number of Flooded Structures - Ex	Number of Flooded Structures - Prop	Inundated Area (ac) - Ex	Inundated Area (ac) - Prop	Flooded Roadway (mi) - Ex	Flooded Roadway (mi) - Prop
2-Year	13	9	233	63	2	1
10-Year	21	17	372	104	2	1.7
25-Year	31	21	457	126	3	2.2
100-Year	61	45	565	165	4	2.9
500-Year	104	81	698	213	5	3.4

4.1.4 Alternative 4

Geometry

The fourth alternative is an expansion of Alternative 2. It is to determine the possible reductions if the existing channel footprint is maintained but the head losses are reduced at the road crossings. The Alternative 2 channel geometry was utilized as a base. To minimize the head losses at the roadway crossings, all of the culverts in Alternative 2 were changed to bridges. The Alternative 4 extents are shown in **Exhibit 16**.

Results

Reduction of the head losses through the roadway crossings does result in slightly more floodplain reduction than Alternative 2. With this alternative, the channel capacity is exceeded in the 50% event. The 1% event inundates approximately 107 acres. This leaves approximately 22 flooded structures in the 1% event as shown in **Exhibit 16A** along with flooding of approximately 2 miles of roadway. The 1% event depth map of this alternative is shown in **Exhibit 16A**. The reduction in WSEL for the 1% event is shown in **Exhibit 16B**. **Table 4-4** provides the flood reductions with Alternative 4.

Table 4-4 Pintas Creek Alternative 4 Reductions.

Frequency Storm	Number of Flooded Structures - Ex	Number of Flooded Structures - Prop	Inundated Area (ac) - Ex	Inundated Area (ac) - Prop	Flooded Roadway (mi) - Ex	Flooded Roadway (mi) - Prop
2-Year	13	4	233	32	2	0.1
10-Year	21	9	372	60	2	0.9
25-Year	31	15	457	79	3	1.4
100-Year	61	22	565	107	4	2
500-Year	104	43	698	146	5	2.8

An impact analysis was conducted and determined that there is no impact on San Fernando Creek due to the improvements on Pintas Creek. The analysis was conducted by creating an

HEC-HMS (version 4.10) model named "13_FIFID_Pintas_Impact_Analys", which includes the HUC-10 and Pintas Creek flows. The results are then compared at the junction downstream for the existing and proposed basin to be able to analyze the impact, if any, on San Fernando Creek. A table dictating the impacts can be found in **Appendix G**.

4.2 BU 281

The BU 281 flooding issues are primarily due to factors outside of the City. The large drainage area contributing to the overland flow through the City lies within the County to the west, and the primary drainage path south of the City to Lattas Creek and San Fernando Creek lie within the County to the south of the City. As the primary way to fix any of the flooding issues in this area is to provide a defined channel to convey the runoff, this will necessarily occur within the County. Coordination and cooperation with the County will be needed to solve issues in this area. However, the County will also see benefits of this project with the ability to provide an outfall for drainage improvements to the west of the City in areas with no clear outfall path. Establishment of a channel to convey the runoff also provide an outfall which can be used to enable storm sewers to be used in this area to improve local drainage.

Because the channel would be expanded all the way to San Fernando Creek, coordination with Jim Wells County will be needed to enact this alternative. Since conveyance capacity is increasing in the channel, greater flows proceed downstream towards San Fernando Creek. Mitigation would be required to avoid impacts on San Fernando Creek that are not accounted for in this alternative, this will be further analyzed in design.

4.2.1 Alternative 1

Geometry

One alternative was investigated for BU 281 to mitigate the amount of overland flow that flows overland through the neighborhood north of FM 1554 and north of Cecilia Street. Due to the lack of open space along in that area, and the problems created by the overland flow west of BU 281, it was determined that most applicable option would be establishment of a defined channel and flow path to pick up much of the overland flow west of BU 281 then convey it south where there is more open area. This channel would then turn east to convey flow to San Fernando Creek.

To accomplish this, a diversion channel was proposed south of Castillo Street to intersect the flow going east. The Lattas Creek Tributary was extended approximately 12, 130 linear feet upstream to Castillo Street. This will reduce the amount of flow through the developed areas within the City and establish a defined channel for runoff. This will have an additional benefit of providing an outfall for any other drainage improvements in the area as there is currently no outfall for this area. The alignment used for the analysis as shown in **Exhibit 17** was used only as a proof of concept to determine the benefits of this type of mitigation. The actual alignment would be determined during design phases if this alternative is implemented.

Results

As this model is rain on mesh the inundation area does not change as all areas get some water due to the precipitation. For the purposes of determination of flooded roadways, and agricultural areas, the areas were calculated for areas with depths of greater than 3 inches of depth, shown in **Exhibit 17A.** The inundation depths were reduced with the proposed channel as shown in

Exhibit 17B. As seen in the results, there are depth reductions in the developed areas of up to one-foot.

This leaves approximately 1310 structures experiencing flooding and there is flooding of approximately 39 miles of roadway. **Table 4-5** provides the flood reductions with Alternative 1.

Table 4-5 BU 281 Alternative 1 Reductions.

Frequency Storm	Number of Flooded Structures – Ex	Number of Flooded Structures - Prop	Flooded Roadway (mi) - Ex	Flooded Roadway (mi) - Prop
2-Year	538	535	21	19.7
10-Year	587	584	29	28.1
25-Year	1310	1310	34	32.6
100-Year	1310	1310	41	39
500-Year	1310	1310	48	45.3

4.3 Early Warning System

The problem areas within the City do not appear to have the ability to benefit from dedicated gages to be used for an early warning system. The BU 281 problem area has no defined channel or crossings ot place gages. The Pintas Creek area has no road crossings which appear to be inordinately impacted in frequent events. In the problem areas, the flooding is more widespread and due to heavy rain events or events of high intensity. With the presence of USGS gages in the area, usage of existing warning systems appears the best procedure.

WaterAlert is a system offered by the United States Geological Survey (USGS) that allows individuals to receive updates about changing water conditions at their gaging locations. City personnel can create alert subscriptions that will send a text message or email to a subscriber for changes in water conditions at a monitoring location.

There are two (2) USGS gaging locations located within the Chiltipin Creek-San Fernando Creek HUC-10 watershed (1211020404). These are the San Diego Ck at Alice, TX – 08211800 gage located on the Edin Drive bridge over San Diego Creek and the San Fernando Ck at Alice, TX – 08211900 gage located at the SH 44 Bridge over San Fernando Creek.

The WaterAlert system can send alerts for accumulated rainfall values for 1, 6, 12, and 24 hours. Shorter time durations are not available. Since the problem areas experience flooding for the 2-year event, it is recommended that a 2-year, 60-minute (1 hour) value of 1.57 inches be used as the alert threshold. This is the NOAA Atlas 14 value as shown in Table 3-1.

Accounts for the WaterAlert system can be created at https://accounts.waterdata.usgs.gov/accounts/login/?next=/wateralert/my-alerts/.

5 Benefit-Cost Analysis

5.1 Methodology

5.1.1 Benefits

Benefits are defined as a reduction in damages from a flood. For this analysis the expected damages were calculated using the BCA Input Workbook_v1.2 spreadsheet from the Texas Water Development Board and the FEMA tool Kit version 6.0. Damages calculated using these spreadsheets include residential structures damages, household dislocation costs, commercial structures damages, impacts of street flooding due to effects on life and reduced service, and agricultural damage. The major components and limitations of the damage calculations in the spreadsheet are;

- Residential structures can be added per structure or per group. The data to include is the location, structure type, existing and proposed flooded depth in inches. There can only be 3 storm events analyzed per spreadsheet.
- Commercial Structures can be added per structure or per group. The data to include is the address or business name, the structure type, basis of value, structure value, square footage and existing and proposed flooded depth in inches. Only 3 storm events can be analyzed with this spreadsheet.
- For flooded streets, the miles of roadway flooded above 6” and the hours that the road is impassible.
- For agricultural damage, the agricultural land is identified as either pasture, high value crop or low value crop. The area damaged per frequency storm is added in addition to the cost. The cost for the crop was obtained from the agricultural value published in the Jim Wells Appraisal District information.

As the project areas were relatively large, obtaining surveyed first floor elevations (FFE’s) of the structures within the analysis area would have been prohibitively expensive for a feasibility analysis. Therefore, a GIS based method was developed estimate the FFE’s of structures in the study area to be used for damage estimates and flooding depths. Rather than surveying the finished floor elevation of each structure, the finished floor elevation was estimated based on the 2018 LiDAR topographic information. Based on windshield survey of structures in the area during site visits, the structure elevation was calculated to be 1.5-feet for mobile homes 0.5-feet for all other structures, the elevation was taken above the LiDAR ground elevation at the centroid of each building to establish the finish floor elevation. This elevation was then compared to the water surface elevation for the 25-, 100- and 500-year event at that point as determined through the HEC-RAS analysis. This provided the depth of flooding for each frequency flood event for that structure. The structure value was determined by obtaining the property value stated in the Jim Wells County appraisal district website.

As the damages reported out of the spreadsheets are the present value of the expected annual benefits over the life of the project, the Benefit Cost Ratio is determined by dividing the reported benefit by the total project cost. The damages presented in this report are the present value of the expected damages over the life of the project. The spreadsheets utilize a discount rate of 7% in determination of the present value. We used a 30-year project life for each alternative based on guidance.

Due to the flat topography of the area, the flooding depths experienced in the problem areas are relatively shallow which limits the structural damages calculated as compared to areas that experience deeper flooding depths. Therefore, while we may see a significant number of structures in the inundation area, the damages associated with the structures may not be significant as the damages are based on depth-damage curves, with greater flooding depths resulting in higher damages.

5.1.2 Opinion of Probable Construction Costs

The overall project cost estimate for each alternative is not a detailed cost estimate as the alternatives were chosen to determine how different project extents compared and no design was performed of the alternatives. The construction cost estimates are based on the major construction components. In addition, consideration of design phase engineering, geotechnical engineering, environmental assessment and survey was based on an estimate of 20% of the construction cost for each alternative. Because these were high level preliminary cost estimates, a contingency of 30% was added to each estimate to cover various incidental construction costs, and issues that may be discovered in the design phases.

These total project cost estimates are used for comparison of the various alternatives to determine the most cost-effective alternative in the problem areas and aid in determination of the recommended plan. They are not intended to represent the true cost of the proposed alternatives.

5.2 Pintas Creek

5.2.1 Alternative 1

This alternative was designed to contain the 1% event within the channel and as expected provides the greatest reduction in damages. **Table 5-1** shows the remaining flooding impacts with this alternative for the studied frequencies.

Table 5-1 Pintas Creek Alternative 1 Residual Flooding.

Frequency Storm	Number of Flooded Structures	Inundated Area (ac)	Flooded Roadway (mi)
2-Year	0	0	0
10-Year	0	0	0
25-Year	0	0	0
100-Year	0	0	0
500-Year	0	0	0

This alternative results in total benefits of $11,965,929.00 with the reduction in flooding.

With the large amount of excavation, the cost to remove and replace the current structures, and the Right-of-Way Acquisition within the City. Alternative 1 is the most expensive alternative with a total cost of $42,869,143.00 as shown in **Table 5-2**.

Table 5-2 Pintas Creek Alternative 1 Construction Cost Estimate.

Construction Cost	**Design Phase Cost**	**Property Acquisition Cost**	**Total Project Cost** (With 30% Contingency)
$27,056,819.85.00	$5,411,36.00	$2,283,913.00	$42,869,143.00

5.2.2 Alternative 2

As expected, there is less damage reduction as this alternative was intended to increase the channel conveyance capacity within the existing channel footprint and minimize the need for acquiring additional property or revising existing road crossings within the City. **Table 5-3** shows the remaining flooding impacts with this alternative for the studied frequencies.

Table 5-3 Pintas Creek Alternative 2 Residual Flooding.

Frequency Storm	**Number of Flooded Structures**	**Inundated Area (ac)**	**Flooded Roadway (mi)**
2-Year	5	41	0.4
10-Year	10	72	1.2
25-Year	18	86	1.5
100-Year	33	114	2.2
500-Year	55	149	2.8

This alternative results in total benefits of $6,910,955.00 with the reduction in flooding.

With the reduction in property acquisition and roadway crossing cost, this alternative has significantly lower construction costs than Alternative 1. As shown in **Table 5-4** the total cost for Alternative 2 is $28,424,518.00.

Table 5-4 Pintas Creek Alternative 2 Construction Cost Estimate.

Construction Cost	**Design Phase Cost**	**Property Acquisition Cost**	**Total Project Cost** (With 30% Contingency)
$17,825,153.00	$3,565,030.00	$1,686,787.00	$28,424,518.00

5.2.3 Alternative 3

This alternative was evaluated to determine the benefits from expanding the downstream portion of Pintas Creek. **Table 5-5** shows the remaining flooding impacts with this alternative for the studied frequencies.

Table 5-5 Pintas Creek Alternative 3 Residual Flooding.

Frequency Storm	Number of Flooded Structures	Inundated Area (ac)	Flooded Roadway (mi)
2-Year	9	63	1
10-Year	17	104	1.7
25-Year	21	126	2.2
100-Year	45	165	2.9
500-Year	81	213	3.4

This alternative results in total benefits of $3,237,233.00 with the reduction in flooding.

Alternative 3 is the least expensive alternative with a cost of $17,360,659.00, shown in **Table 5-6**. This alternative is less cost effective due to only the downstream portion of the channel being modified, reducing property acquisition costs and excavation quantities. Flows are contained within the downstream portion of the channel and experience a significant water surface reduction. However, this does not alleviate the flooding issues within the developed upper portion of the channel. The upstream portion of the reach only sees a water surface reduction of approximately 0.25 feet. This removes 21 structures from the 100-year floodplain.

Table 5-6 Pintas Creek Alternative 3 Construction Cost Estimate.

Construction Cost	Design Phase Cost	Property Acquisition Cost	Total Project Cost (With 30% Contingency)
$10,606,794.00	$2,121,359.00	$1,450,468.00	$17,360,659.00

5.2.4 Alternative 4

This alternative is similar to Alternative 2 but replaces the roadway crossing to reduce head losses on the reach. **Table 5-7** shows the remaining flooding impacts with this alternative for the studied frequencies. Exhibit 19 shows the remining flooded structures.

Table 5-7 Pintas Creek Alternative 4 Residual Flooding.

Frequency Storm	Number of Flooded Structures	Inundated Area (ac)	Flooded Roadway (mi)
2-Year	4	32	0.1
10-Year	9	60	0.9
25-Year	15	79	1.4
100-Year	22	107	2
500-Year	43	146	2.8

This alternative results in total benefits of $7,808,231.00 with the reduction in flooding. Due to the cost to remove and replace the current structures, this alternative has a total cost of $36,193,209.00 as shown in **Table 5-8**.

Table 5-8 Pintas Creek Alternative 4 Construction Cost Estimate.

Construction Cost	**Design Phase Cost**	**Property Acquisition Cost**	**Total Project Cost** (With 30% Contingency)
$23,004,280.83	$4,600,856.00	$1,686,788.00	$36,193,209.00

5.3 BU 281

Only one alternative was analyzed for BU 281 as a check if it was possible to reduce flooding in this area. As there is no defined channel in this area, establishment of a defined drainage path would be necessary for any solutions in order to alleviate the overland flow through the existing development. The location of the proposed diversion channel allows flow to be intercepted and have a proper rouet and outfall into the Lattas Creek tributary. Provided in **Exhibit 18A** is the number of structures flooding in the 100-year frequency storm event. Due to limitations in the benefit calculation spreadsheets, structures were grouped together and an average depth for the group was used. The groupings used are shown in **Exhibit 18A**.

Table 5-9 shows the remaining flooding impacts with this alternative for the studied frequencies.

Table 5-9 BU 281 Alternative 1 Residual Flooding.

Frequency Storm	**Number of Flooded Structures**	**Flooded Roadway (mi)**
2-Year	535	19.7
10-Year	584	28.1
25-Year	1310	32.6
100-Year	1310	39
500-Year	1310	45.3

This alternative results in total benefits of $26,475,679.00 with the reduction in flooding.

With the large amount of excavation and Right-of-Way acquisition, the alternative has a total cost of $42,869,143.00 as shown in **Table 5-10**.

Table 5-10 BU 281 Alternative 1 Construction Cost Estimate.

Construction Cost	**Design Phase Cost**	**Property Acquisition Cost**	**Total Project Cost** (With 30% Contingency)
$24,286,694.00	$4,857,339.00	$6,419,134.00	$42,849,175.00

6 Conclusion

As seen in **Table 6-1**, none of the examined alternatives have a Benefit Cost Ratio (BCR) greater than 1.0 based on the damage methodologies used. These included damages to residential and commercial structures, damages associated with roadway flooding and flooding of agricultural areas. As we did not have information on impacts to emergency service in the flooded areas these impacts were not included in the determination of benefits. **Table 6-1** shows the Benefit to Cost Ratio for the analyzed alternatives along Pintas Creek.

Table 6-1 Pintas Creek Alternatives Benefit to Cost Ratio (BCR).

Scenario	Benefit	Cost	Benefit Cost Ratio
Pintas Creek Alt 1	$11,965,929.00	$42,869,143.00	0.3
Pintas Creek Alt 2	$6,910,955.00	$28,424,518.00	0.2
Pintas Creek Alt 3	$3,237,233.00	$17,360,659.00	0.2
Pintas Creek Alt 4	$7,808,231.00	$36,193,209.00	0.2

Based on the Benefit to Cost Ratio, all of the alternatives examined would cost more to implement than would be expected to be saved in damages over the assumed project life of 30 years.

While none of the alternatives examined have a BCR greater than 1.0, which would be required for several different grants, if it is decided that there are other benefits not defined in the FEMA BCA Toolkit methods, it could be decided to construct the project using other funding mechanisms.

As seen in **Table 6-2**, the Benefit to Cost Ratio for the alternative examined is 0.6. While this shows that the amount of damage reductions to the existing development is less than the construction cost, it does not take into account the benefits for future growth in the area with the establishment of a defined channel to provide outfall depth for future development without impacting existing development.

Table 6-2 BU 281 Alternative Benefit to Cost Ratio.

Scenario	Benefit	Cost	Benefit Cost Ratio
BU 281 Alt 1	$26,475,679.00	$42,849,175.00	0.6

Even though all of the alternatives have a BCR less than 1, implementing these alternatives can allow for outfall depth. The City is anticipating population growth and urban development. Improving the channels will become beneficial for future development and redevelopment specially for storm sewer. Pintas Creek Alternative 1 is the only alternative that removes all of the structures from the 100-year floodplain, contains all of the flow within the banks, and has the highest BCR compared to the rest of the Pintas Creek alternatives. Despite BU 281 Alternative 1 having the greatest BCR overall, there are impacts happening due to the proposed improvements. Pintas Creek Alternative 1 is the overall best alternative when the cost and improvements are taken into consideration. **Table 6-3** shows a summary of cost/structures removed demonstrating that although Pintas Creek Alternative 1 is the costliest to construct, there is a great benefit from implementing this alternative.

Table 6-3 Cost per Structure Removed.

Scenario	Cost
Pintas Creek Alt 1	$659,525.00
Pintas Creek Alt 2	$1,093,251.00
Pintas Creek Alt 3	$1,240,047.00
Pintas Creek Alt 4	$1,034,092.00
BU 281 Alt 1	$1,339,037.00

LJA will be coordinating with Nueces River Authority to include the Pintas Creek Alternative 1 in the Region 13 – Final Nueces Region Flood Plan (RFP). The RFP will be summited in the spring of 2024. The table that has been filled out for the submittal can be found in **Appendix H.**

EXHIBITS

APPENDIX A

APPENDIX B

APPENDIX C

APPENDIX D

APPENDIX E

APPENDIX F

APPENDIX G

APPENDIX H